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Ministry of Physical Infrastructure and  
Transport, Department of Roads



Government of Nepal



# **NAGDHUNGA TUNNEL CONSTRUCTION PROJECT**

**LOAN AGREEMENT No. (NE-P10)**

**CONTRACT No. DOR - NTCP -W-ICB-01**

## **BIDDING DOCUMENTS**

### **PART 2: WORKS REQUIREMENTS (SECTION VI)**

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## **PART 2 –Works Requirements**

### **Section VI. Works Requirements**

**VI-A: Scope of Works (SOW)**

**VI-B: Standard Specifications (SS)**

**VI-C: Special Provisions to Standard Specifications (SPSS)**

**VI-D: Drawings**

**VI-E: Personnel Requirements (PR)**

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## VI-A: SCOPE OF WORKS

### (1) Background of the Project

The Department of Roads conducted a feasibility study on tunnel construction projects in February 2013 for Nagdhunga - Naubise and Tokha - Gurje sectors.

Based on the feasibility study, the Japan International Cooperation Agency (JICA) conducted the Data Collection Survey on Thankot Area Road Improvement in Nepal aiming to gather information of existing road conditions and environmental and social consideration for the section between Kalanki and Naubise and submitted a report in July 2014. JICA also conducted a feasibility study, the Preparatory Survey for Nagdhunga Tunnel Construction in Nepal in 2014 - 2015.

Through the above three studies, Nagdhunga Tunnel Construction Project (the Project) constructing a tunnel under Nagdhunga Pass, which is located on Tribhuvan Highway connecting Kathmandu and the Indian border and the first road tunnel in Nepal.

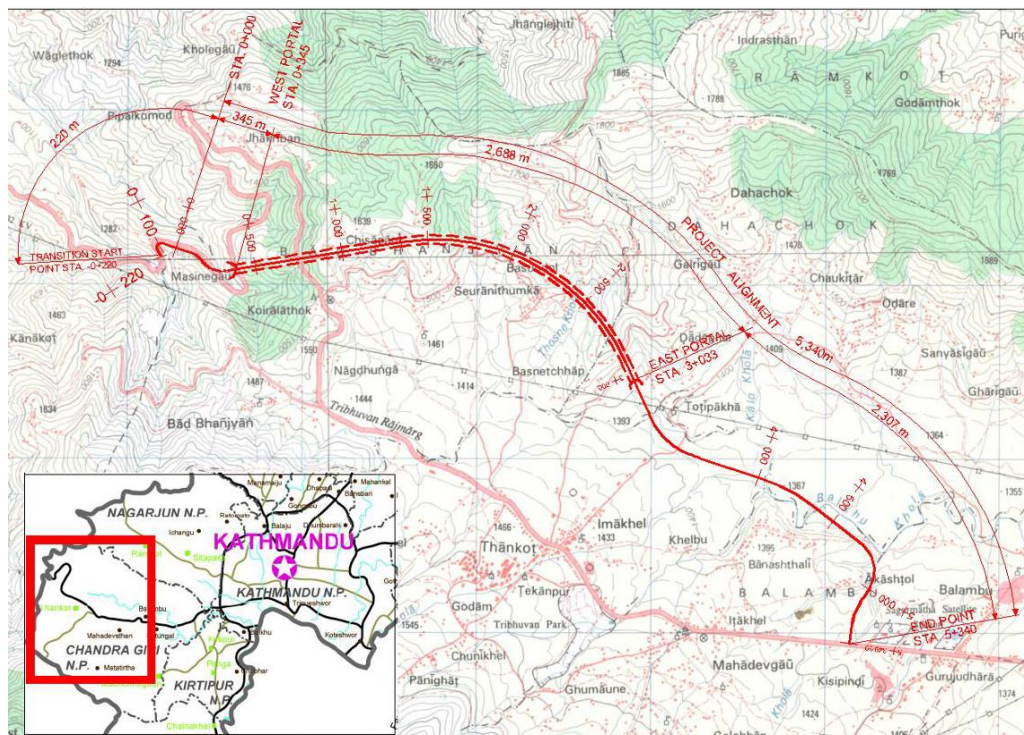
On 22 December 2016, a loan agreement was signed between the Government of the Federal Democratic Republic of Nepal and JICA to provide a Japanese ODA loan to implement the Project. .

### (2) Objectives

The objective of the Project is to improve the road condition around Nagdhunga pass by constructing a tunnel thereby contributing to smooth transportation network between Kathmandu and other principal cities and/or area in Nepal. The tunnel is expected to improve the alignment of the exiting road, reduce the travel time, improve the traffic safety and contribute to the economic development of the country.

### (3) Project Location

The location of the Project is shown in Figure 1.1.



**Figure 1.1 Location of the Project**

**(4) Key Components of the Project**

The Project has been composed of the following 8 components.

- Construction of a road-tunnel (2,688m in length, 2 lanes each of 3.5m, a median 1.5m wide, shoulders 0.5m wide at both sides, total carriage way of 9.5m wide).
- Construction of eastern approach road (2,307m in length) and western approach road (565m in length).
- Construction of 1 intersection and 1 interchange on Tribhuvan highway.
- Construction of 7 bridges and 11 box-culverts.
- Construction of toll-gate facilities.
- Construction of traffic monitoring/control and maintenance office buildings.
- Disposal area development (Construction of Roadside Service Station).
- Construction of transmission line.

**(5) Time for Completion (calculated from the Commencement Date)**

1,260 days for the works + 365 days of the Defects Notification Period.

## **VI-B: Standard Specifications (SS)**

## **Section VI-B: Standard Specifications (SS)**

The Standard Specifications for this contract shall be the “Standard Specifications for Road and Bridge Works – ASAD 2058”, edited by the Department of Roads, Ministry of Physical Structure and Transport, Government of Nepal.

The Standard Specifications may be purchased from the Department of Roads, Central Road Laboratory, Kupondole, Lalipur.

The Standard Specifications are linked with the Special Provisions to Standard Specifications (SPSS) referred to as Section VI-C by the corresponding numbering of Clauses so that Sections VI-B and VI-C together comprise the specifications that shall be respected for performing the works of the Project.

## **VI-C: Special Provisions to Standard Specifications (SPSS)**



**Section VI-C:****Special Provisions to the Standard Specifications (SPSS)**

The Special Provisions to Standard Specifications are set out below (the sub-clauses of the standard specifications that were not modified by these provisions shall remain and shall be respected).

The Special Provisions (Volume-I and Volume-II) contained herein shall be read in conjunction with the Standard Specifications and shall supplement, replace or supersede the Standard Specifications as appropriate. Where there is any ambiguity or discrepancy between the Standard Specifications and the Special Provisions; the Special Provisions shall have preference, prevail and shall govern.

[Refer to separate volumes as per the Section VI-C: Special Provisions to the Standard Specifications (SPSS) Volume-I and Volume-II]

## **VI-D: Drawings**

[Refer to a separate volume as per the Section VI-D: Drawings]

## **VI-E: Personnel Requirements (PR)**

## Section VI-E: Personnel Requirements (PR)

### (i) General Requirement:

The Contractor shall mobilize key personnel for at least the following key positions for the execution of the Works.

- ① Project Manager
- ② Tunnel Superintendent
- ③ Tunnel Facility Superintendent
- ④ Pavement Superintendent
- ⑤ Building Superintendent
- ⑥ Structure Superintendent
- ⑦ Quality Control Manager
- ⑧ Health & Safety Manager
- ⑨ Environment Protection Manager
- ⑩ Plant & Equipment Maintenance and Management Manager

The key personnel for the key positions stated above shall meet the following general requirements:

No.	Position	Total Work Experience (years)	Experience in Similar Works	
			years	works
1	Project Manager (P/M)	25	15	2 or more tunnel projects as P/M
2	Tunnel Superintendent (T/S)	15	10	2 or more tunnel projects as T/S
3	Tunnel Facility Superintendent	15	5	At least one project as same position
4	Pavement Superintendent	15	5	At least one project for concrete pavements as same position
5	Building Superintendent	15	5	At least one project for building construction as same position
6	Structure Superintendent	15	5	At least one project for construction of bridges or other structures as same position
7	Quality Control Manager	10	5	At least one project working at same position
8	Health & Safety Manager	10	5	At least one project working at same position, and/or experience with JICA guideline for safety control.
9	Environment Protection Manager	10	5	At least one project working at same position, and/or experience with JICA guideline for environmental protection.
10	Plant & Equipment Maintenance and Management Manager	10	5	At least one project working at same position.

**(ii) Specific Requirements for Key Personnel:**

Key personnel occupying the positions of Project Manager and Tunnel Superintendent shall meet all the specific requirements set forth as follows:

No.	Position	Specific Experience	Minimum Requirement
1	Project Manager	<ul style="list-style-type: none"> <li>Experience working in mountain tunnel construction projects as a project manager</li> </ul>	10 years or more in total
		<ul style="list-style-type: none"> <li>Experience working in mountain road tunnel (more than 75 sq.m in cross section) construction projects applying NATM method where support patterns were designed by the geological rock classification method based on spacing of cracks, elastic wave velocity and RQD</li> </ul>	2 projects or more
2	Tunnel Superintendent	<ul style="list-style-type: none"> <li>Experience working in mountain tunnel construction projects as a tunnel superintendent</li> </ul>	10 years or more in total and more than 2 projects
		<ul style="list-style-type: none"> <li>Experience working in mountain road tunnel (more than 75 sq.m cross section) construction projects applying NATM method where support patterns were designed by the geological rock classification method based on spacing of cracks, elastic wave velocity and RQD</li> </ul>	1 project or more

## **VI-F: Equipment Requirements (ER)**

## Section VI-F: Equipment Requirements (ER)

The Contractor shall mobilize equipment in accordance with the specifications of Section VIII: Particular Conditions of Contract, Part B: “Specific Provisions”, Sub-Clause 4.17: “Contractor’s Equipment”.

The following minimum requirements shall be specifically satisfied:

Item No.	Work Item	Equipment Type and Characteristics	Classification				Requirement						
							Manufacturer Certificate shall be provided	Requirement-1	Requirement-2	Requirement-3	Requirement-4	Requirement-5	Requirement-6
			For Tunnel		For Road & Structure			(Minimum)	Finance Act 2017, 22 Miscellaneous	Operational Experience	Exhaust Gas Level (Euro 3)	Exhaust Gas Level (Table 1)	Exhaust Gas Level (Table 2)
			On-Road	Off-Road	On-Road	Off-Road							
A. Equipment for Tunnel Excavation Works – Main Tunnel													
1	Perforation	Wheel Jumbo drill: 2 or 3 booms with basket		✓			✓	2	N/A	3 projects	N/A	Fulfilled	N/A
2	Finishing surface after excavation	Hydraulic large range breaker: 1,300kg class		✓				2	N/A	N/A	N/A	N/A	Fulfilled
3		Backhoe: Crawler-type		✓			✓	2	N/A	N/A	N/A	N/A	Fulfilled
4		Loading machine		✓			✓	2	N/A	N/A	N/A	N/A	Fulfilled
5	Mucking	Dump truck		✓			✓	10	N/A	N/A	Fulfilled	N/A	N/A
6	Shot-concrete	Concrete spraying machine: Wet type sprayer & robot integrated type		✓			✓	2	N/A	3 projects	N/A	Fulfilled	N/A
7		Truck mixer:	✓					2	N/A	N/A	Fulfilled	N/A	N/A
8		Concrete plant:	✓			✓		2	N/A	N/A	Fulfilled	N/A	N/A
9	Rock bolt and fore boring	Mortar injection machine:		✓				2	N/A	N/A	N/A	N/A	Fulfilled
10		Truck for mounting the mortar injector	✓					2	N/A	N/A	Fulfilled	N/A	N/A
11		Truck equipped with crane:	✓					1	N/A	N/A	Fulfilled	N/A	N/A
B. Equipment for Tunnel Excavation Works – Evacuation Tunnel													
12	Perforation	Wheel jumbo drill: 2 booms with basket		✓			✓	2	N/A	3 projects	N/A	Fulfilled	N/A
13	Loading	Loading machine		✓			✓	2	N/A	N/A	N/A	N/A	Fulfilled
14	Mucking	Dump truck		✓			✓	4	N/A	N/A	N/A	N/A	Fulfilled
15	Shot-concrete	Concrete spraying machine: Wet type sprayer & robot integrated type		✓			✓	2	N/A	3 projects	N/A	Fulfilled	N/A
16		Truck mixer:		✓				2	N/A	N/A	N/A	N/A	Fulfilled
17		Mortar injection machine:		✓				2	N/A	N/A	N/A	N/A	Fulfilled
18	Rock bolt and fore boring	Truck for mounting the mortar injector	✓					2	N/A	N/A	Fulfilled	N/A	N/A
19		Truck equipped with crane:	✓					1	N/A	N/A	Fulfilled	N/A	N/A
C. Equipment for Tunnel Construction Works													
20	Tunnel Construction	Bulldozer: 15ton class		✓				2	N/A	N/A	N/A	N/A	Fulfilled
21		Bulldozer: 20ton class		✓				2	N/A	N/A	N/A	N/A	Fulfilled
22		Tire roller: 8-20ton class		✓				2	N/A	N/A	N/A	Fulfilled	N/A
23		Mobile dust collector: Feeding and suction collection method, minimum capacity 2400m³/min.		✓			✓	2	N/A	3 projects	N/A	N/A	Fulfilled
24		Concrete pump:		✓			✓	4	N/A	N/A	N/A	N/A	Fulfilled
25		High elevation work vehicle: Basket type	✓					2	N/A	N/A	Fulfilled	N/A	N/A
26		High elevation work vehicle: Stage type	✓					2	N/A	N/A	Fulfilled	N/A	N/A
27		Rough terrain crane:	✓					1	N/A	N/A	N/A	N/A	Fulfilled
28		Pump equipment for injection (with flowmeter) for steel pipe forepiling system:		✓				3	N/A	N/A	N/A	N/A	Fulfilled
29		Sliding form for lining with automatic scaling equipment		✓				2	N/A	N/A	N/A	N/A	Fulfilled
D. Equipment for Earth Works and Structures Construction Works													
30	Road and Structures Construction	Crushing plant:		✓		✓		1	N/A	N/A	N/A	N/A	Fulfilled
31		Motor grader:		✓		✓		2	N/A	N/A	N/A	N/A	Fulfilled
32		Steel wheel vibratory / Static roller: 10-20ton class		✓		✓		2	N/A	N/A	N/A	N/A	Fulfilled
33		Pneumatic roller: 8-10ton class				✓		2	Fulfilled	N/A	N/A	Fulfilled	N/A
34		Asphalt mix plant:				✓		1	Fulfilled	N/A	N/A	N/A	Fulfilled
35		Asphalt-concrete finisher:				✓		1	Fulfilled	N/A	N/A	N/A	Fulfilled
36		Concrete paver:		✓		✓	✓	1	N/A	N/A	N/A	N/A	Fulfilled
37		Dump truck:			✓			5	Fulfilled	N/A	Fulfilled	N/A	N/A
38		Road cutting machine for rumble strips:		✓		✓		1	N/A	1 Projects	N/A	N/A	Fulfilled

**Requirement-1**

Number of equipment to be mobilized in the Project shall be in accordance with the Construction Programme and Method Statement.

**Requirement-2**

The equipment shall satisfy the requirements of Clause 22 Miscellaneous in the Finance Act 2017, GON when the Contractor import it.

**Requirement-3**

The equipment shall be of the same type or better (newest model) than those used in projects which have operational experiences in other similar projects.

**Requirement-4**

The equipment shall meet the requirements for exhaust gas condition of the Nepal Vehicle Mass Emission Standard 2012 (Euro 3).

**Requirement-5**

The equipment shall meet the exhaust gas requirements shown in following Table-1:

<b>Gas type</b>	<b>HC</b>	<b>NOx</b>	<b>CO</b>	<b>PM</b>	<b>Black smoke (Note)</b>
Engine power	(g/kw.h)	(g/kw.h)	(g/kw.h)	(g/kw.h)	(%)
15kw>P $\geq$ 7.5kw	2.4	12.4	5.7	-	50 (10)
30kw>P $\geq$ 15kw	1.9	10.5	5.7	-	50 (10)
272kw>P $\geq$ 30kw	1.3	9.2	5.0	-	50 (10)

**Note:**

The equipment used for tunnel construction shall be provided with a device for Black Smoke purification. Measurement method of HC, NOx, CO and PM shall be JIS B 8008. Measurement method of black smoke shall be JCMAS T 004-1995.

**Requirement-6**

The equipment shall meet the exhaust gas requirements shown in following Table-2:

<b>Gas type</b>	<b>HC</b>	<b>NOx</b>	<b>CO</b>	<b>PM</b>	<b>Black smoke (Note)</b>
Engine power	(g/kw.h)	(g/kw.h)	(g/kw.h)	(g/kw.h)	(%)
19kw>P $\geq$ 8kw	1.5	9.0	5.0	0.8	40 (8)
37kw>P $\geq$ 19kw	1.5	8.0	5.0	0.8	40 (8)
75kw>P $\geq$ 37kw	1.3	7.0	5.0	0.4	40 (8)
130kw>P $\geq$ 75kw	1.0	6.0	5.0	0.3	40 (8)
560kw>P $\geq$ 130kw	1.0	6.0	3.5	0.2	40 (8)

**Note:**

The equipment used for tunnel construction shall be provided with a device for Black Smoke purification. Measurement method of HC, NOx, CO and PM shall be JIS B 8008. Measurement method of black smoke shall be JCMAS T 004-1995.



## **VI-G: Tunnel Facilities Requirements (TFR)**

**Section VI-G:****Tunnel Facilities Requirements (TFR)**

The permanent tunnel facilities supplied and installed for the Project, shall require actual records and evidences of its installation and proper function in more than one tunnel currently under operation at least for the following items:

- Remote monitoring and control system (Refer to Clause 5400-3.7 of SPSS, Drawing No. TW-MS-020)
- Jet fans (Refer to Clause 5500-4.4 of SPSS, Drawing No. TW-VS-040)
- Inverter jet fan control board (Refer to Clause 5500-3.7 of SPSS, Drawing No. TW-VS-150)
- Air flow direction and velocity meter (Refer to Clause 5500-5.5 of SPSS, Drawing No. TW-VS-110)
- Carbon monoxide sensor (Refer to Clause 5500 of SPSS, Drawing No. TW-VS-100)
- Soot visibility measure (Refer to Clause 5500-5.3 of SPSS, Drawing No. TW-VS-080)
- Basic lighting lamp (Refer to Clauses 5200-2.6 and 4.2 of SPSS, Drawing No. TW-LS-020)
- CCTV system (Refer to Clause 5400-6.7 of SPSS, Drawing No. TW-CS-010)
- Alert displays (Refer to Clause 5300-2.6 of SPSS, Drawing No. TW-ES-120)
- Diesel generators (Refer to Clause 5100-5.5 of SPSS, Drawing No. TW-PS-350)

## **VI-H: Prefabricated Septic Tank Requirements**

**Section VI-H: Prefabricated Septic Tank**

The prefabricated septic tank (Capacity not less than 136m<sup>3</sup> per day) to be installed in Roadside Service Station shall be a product of which structure, specification and structural calculation has been certified by an official agency.

## **VI-I: Standard Specifications for Water Supply Works (SSWS)**

## **Section VI-I: Standard Specifications for Water Supply Works (SSWS)**

These Standard Specifications for Water Supply Works (SSWS) specifically cover the requirements for Construction of Water Supply Scheme(s) at Chandragiri Municipality as part of the Nagdhunga Tunnel Construction Project in accordance to the Loan Agreement No. NE-P10 of Japanese ODA to implement the Project.

They shall be read in conjunction with the Conditions of Contract, the Bills of Quantities (BOQ, Water Supply Works) and the Drawings (Drawings – Water Supply Works)

These Specification cover the Works (Water Supply Works) under the Contract. If the Contractor requires additional specifications for more explicit description of the Works or to supplement the existing specifications, or any other specifications to complete the Works, the contractor shall submit such additional or supplementary specifications for the approval by the Engineer. All costs incurred for the additional or specifications under the clause are deemed to be included in other unit rates quoted in the Bill of Quantities (Water Supply Works)

## **VI-J: Drawings – Water Supply Works**

[Refer to a separate volume as per the Section VI-J: Drawings - Water Supply Works]

Ministry of Physical Infrastructure and Transport,  
Department of Roads



Government of Nepal



# **NAGDHUNGA TUNNEL CONSTRUCTION PROJECT**

**LOAN AGREEMENT No. (NE-P10)**

**CONTRACT No. DOR - NTCP -W-ICB-01**

## **BIDDING DOCUMENTS**

### **PART 2: WORKS REQUIREMENTS (SECTION VI)**

#### **VI-C: Special Provisions to Standard Specifications (SPSS)**

#### **VOLUME-I: ROAD AND BRIDGE WORKS**





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## **VOLUME-II: TUNNELLING WORKS AND FACILITIES**

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## **Section VI-B:**

### **Standard Specifications (SS)**

The Standard Specifications for this contract shall be the “Standard Specifications for Road and Bridge Works – ASAD 2058”, edited by the Department of Roads, Ministry of Physical Structure and Transport, Government of Nepal.

The Standard Specifications may be purchased from the Department of Roads, Central Road Laboratory, Kuponhole, Lalipur.

The Standard Specifications are linked with the Special Provisions to Standard Specifications (SPSS) referred to as Section VI-C by the corresponding numbering of Clauses so that Sections VI-B and VI-C together comprise the specifications that shall be respected for performing the works of the Project.

## **Section VI-C:**

### **Special Provisions to the Standard Specifications (SPSS)**

The Special Provisions to Standard Specifications are set out below (the Clauses of the standard specifications that were not modified by these provisions shall remain and shall be respected).

The Special Provisions (Volume-I and Volume-II) contained herein shall be read in conjunction with the Standard Specifications and shall supplement, replace or supersede the Standard Specifications as appropriate. Where there is any ambiguity or discrepancy between the Standard Specifications and the Special Provisions; the Special Provisions shall have preference, prevail and shall govern.



## SECTION 100: GENERAL

### 101 OFFICES FOR ENGINEER

(1) Delete the full Sub-Section 101 and replace with the following:

### 101 SITE OFFICES FOR THE EMPLOYER

#### (1) Description

This work consists of the provision of the Site office for the Employer to be used by the Employer and the Engineer during the construction supervision stage.

#### (2) Requirements

Simultaneously with the preparation of the Contractor's facilities on Site, the Contractor shall provide with Site Offices (one for Western Portal Site and one for Eastern Portal Site) for the use by the Employer's Site Representatives, and for the Engineer, in accordance with the following characteristics:

Site Office	Tentative Location	Period (months)	Capacity (No. of Staff)
Western Portal	Nearby the Contractor's office and within 500m from the Site Laboratory	42	<ul style="list-style-type: none"> <li>♦ Employer Representatives</li> <li>♦ Engineer's Team Leader (T/L), Foreign and Local Experts, and Supporting Staff</li> </ul>
Eastern Portal		42	

Note: The layout shall be prepared by the Contractor and submitted for review and approval by the Engineer. The locations are tentative and shall be discussed and confirmed with the Engineer.

The basic layout of each site office shall be prepared by the Contractor and submitted to the Engineer for review and respective approval.

The building shall comply with Nepal's applicable specifications for architectural and structural works for buildings.

#### Basic Layout:

The layout shall be prepared in accordance with the number of staff indicated in the table shown above to accommodate properly the following (note: the plan area shown below are the minimum requirement to be considered):

- ♦ Minimum Area: (total building area excepting parking) .....260 sqm
- ♦ One office room for the Employers' representatives.....30 sqm
- ♦ One office room for Project Manager of the Engineer .....20 sqm
- ♦ One office room for Foreign and Local Experts.....50 sqm
- ♦ One weekly meeting Room capacity for 10 people (Western Site).....50 sqm
- ♦ One Working Room capacity for 10 people (Eastern Site) .....50 sqm
- ♦ One reception/administration office room.....20 sqm

- ♦ A kitchen (Pantry) plan area well equipped with sink, draining board, cupboards, shelving, etc. ....20 sqm
- ♦ Male (2) and Female (1) toilets with shower and wash-hand basin facilities for the sole use of the Employer's representative, Foreign Experts, Local Experts, and administration staff (office manager and secretaries) ( 1unit=7sqm) .....3 units
- ♦ Male (1) rest room with 3 toilets and one common wash-hand basin facilities for Supporting staff (1unit=8sqm).....2 units
- ♦ Corridor for connecting all rooms (1.5m width) .....40 sqm
- ♦ Parking area ..... 10 veh.

Basic Requirements:

The Contractor shall, not later than 7 days after the Commencement Date, submit full details of the Design Drawings to the Engineer, including floor plans, elevations, construction principles and materials, before commencing the erection of the facilities.

The Contractor shall be responsible for raising the ground (if necessary), grading and drainage in the vicinity of the building(s), with suitable access and walkways.

The Contractor shall construct a covered hard-standing parking area, for the exclusive use of the Employer, the Engineer and his visitors and respective access road to the parking area. The access road shall be paved and hard enough in order to be transited even during heavy rains. Outside lighting shall be installed around the buildings and the parking area, and appropriate signs shall be erected to indicate the purpose of the facilities.

All facilities shall conform to current fabrication standards for the required types. The facilities described above shall represent the minimum requirements. The Contractor shall provide all incidentals and necessary items, so that the facilities will be completely adequate and satisfactory in every respect for their intended use. Painting both the exterior and the interior shall be as agreed with the Engineer.

The building shall be complete with all services connected with clean water supply by water bowser (including elevated water tank and the tower for capacity of 3,000 liters), electricity and sewerage. Each room shall be provided with at least four electrical outlet sockets. All power shall be 220V-240V, 50Hz except where otherwise agreed by the Engineer. All rooms shall be illuminated by fluorescent lighting. Each toilet shall be provided with flushing toilets and warm water hand washing and shower facilities and extractor fans.

Offices and meeting room shall be air-conditioned. The air-conditioning may be either individual units or a central ducted system and shall be adequate to maintain temperature around 24°C (in summer or winter ) at a relative humidity of 50% during the hottest season of the year. The noise level of the air-conditioning while working should be sufficiently low to allow normal voice level discussions to take place.

Office rooms shall be capable of providing at all times environmental conditions

suitable for the operation of specified electronic office equipment.

The building shall be weather proof, fire protected, heat-insulated and secured. Windows shall give adequate light and ventilation and be protected with metal mosquito-proof gauze and have security bars and Venetian, or other approved sun blinds. Ceiling height above the floor level shall be at least 2.75 m. All internal walls shall be sound insulated. Floors shall be PVC tile covered. In toilets and other washing areas the floors shall have drains to assist cleaning.

Maintaining and Servicing of the Offices:

The construction of the new offices shall be completed within 60 days since the date of commencement of the Contract and shall be equipped and maintained by the Contractor to the satisfaction of the Engineer until 3 months after the issue of a Completion Certificate for the Works or such earlier time as instructed by the Engineer whereupon the furniture shall be removed and any internal partition walls modified as required by the Engineer.

The Contractor shall provide all laborers, materials and equipment for maintaining and cleaning offices, furniture and fittings. The Contractor shall replace and/or restore, as directed, any facilities or parts thereof that become damaged, worn out, lost or stolen. The Contractor shall provide an adequate stock of all expendable and consumable items including refreshments, clean water supply and drinking water, paper towels, toilet rolls, soaps, washing up liquid, brooms/mops and shall ensure proper and continuing functioning of all components and parts of the facilities during the contract period.

The Offices shall be provided with waste disposal material and these shall be emptied and disposed of daily by the Contractor.

Equipment and Expenses for Running-Off the Offices for Engineer

The Contractor shall provide the following furniture and equipment (one set per each office):

Item	Unit	Quantity	Remarks
Infocus + Screen	set	1	Large Size for meetings
Binding Machine A4 Size	unit	1	Type to be discussed
Stationary, Spears, Tonners, Consumables, etc.	month	42	To be confirmed in monthly basis
Desk + Chair + Side Table for experts	set	10	Type and number to be discussed
Desk + Chair + Side Table for Administrative Staff	set	2	Type to be discussed
Desk + Chair + Side Table for Supporting Staff	set	2	Type of working table shall be confirmed
Furniture for Conference Room (West)	set	1	Type to be discussed
Furniture for Meeting Room (East)	set	1	
Medium Size Wall White Board	set	1	
Refrigerator (deodorizer and no-frost system)	unit	1	300liters' minimum capacity

Item	Unit	Quantity	Remarks
Water Dispenser (19 liters capacity)	set	2	including bottles and 6 spares bottles / gallon
Electric Kitchen Stove	unit	1	Size and model shall be discussed
Electric Kettle	unit	1	
Diesel Generator Set (125KVA)	unit	2	Covering more than 10hr/day and backup

All of these equipment and furniture provided by the Contractor for the Engineer and operation of the Engineer's Office shall remain as the property of the Contractor during and after the Project completion, and shall be removed from the Site after termination of contract period. The Contractor shall accept any conditions of these equipment and furniture returned to him after the completion of the Project and shall not be entitled to claim the Engineer to remedy any defect of the equipment.

### (3) Measurement and Payment

Excepting the Items shown here below, no separate measurement nor payment shall be made for the works described in this Section.

The works for provision of the "Site Offices for the Employer" shall be measured and paid in "lump sum" in split instalment shown here below, which shall be the full and the final compensation to the Contractor as per Clause 112 including all costs for providing and installation of the site offices as herein described, and for the cost of all operations, materials, equipment, and any incidentals involved for completion of this item.

Payment shall be made on a "lump sum" according to the following instalments for each Portal Site:

- (i) Twenty percent (20%) upon completion of the Site offices and all installations herein described and approved by the Engineer.
- (ii) Fifty percent (50%) during the execution of the Works split in partial payments in proportion to the work progress subject to certification of achievement issued by the Engineer.
- (iii) Thirty percent (30%) upon issuance of the Taking-Over Certificate.

Item No.	Description	Unit
<b>101</b>	<b>Site Offices for the Employer</b>	
101-1	Site Office for the Employer at Western Portal Site	lump sum
101-2	Site Office for the Employer at Eastern Portal Site	lump sum

## 102 ACCOMMODATION OF TRAFFIC

### (3) Temporary Diversions

- (2) *Insert the following as per the 2<sup>nd</sup> and 3<sup>rd</sup> paragraphs of Sub-Clause 102 (3) (a) "Provision of Diversions":*

The works for diversions should include the construction and maintenance of

temporary road and temporary access roads to bridge construction sites, temporary safety barriers and fencings for traffic safety and stopping spilling of excavated material as per the specifications and instruction of the Engineer.

The Contractor shall secure the compliance with traffic management and safety provisions.

- (3) *Delete the full text of Sub-Clause 102 (3) (j) “Removal of Diversions” and replace with the following:*

**(j) Removal of Diversions**

When traffic is routed permanently onto the new road following the completion of construction, the diversions which are no longer required shall be removed and the ground reinstated to its original condition. This work shall include the establishment and maintenance for at least one year of suitable replacement vegetation to ensure full rehabilitation and protection of the disturbed area.

**(4) Accommodation of Traffic Where Road is Constructed in Half Widths**

- (4) *Delete the third and fourth paragraph of Clause 102(4) “Accommodation of Traffic where Road is Constructed in Half Widths” and replace with the following:*

Contractor shall ensure that the road is opened for the traffic full time. Should the road not be in a safe trafficable condition for two-way traffic over the whole width, at the end of each day’s work the Contractor shall adequate flagmen, signs, barriers, and the necessary staff at his own cost to ensure a reasonable free flow of traffic alternately in each direction.

The Contractor shall provide and maintain for the period of construction, traffic control and safety devices including Traffic Signs, Barricade, Boards, Traffic Cones, Lighting Devices etc., at all locations where work is in progress in accordance with “Safety at Road Works: A Code of Practice for Signing at Road Works” from the Department of Roads Traffic Signs Manual.

Material and equipment temporarily stored on, or adjacent to, the existing roadway shall be so placed, and the work at all times, shall be so conducted as to cause minimum disruption to the travelling public. Warning signs and barriers will be required to separate the Contractor’s material and equipment from the public.

The Contractor will not be permitted to have excavations open on both sides of the road at a particular chainage such that there is a step adjacent to public traffic which may create a danger to traffic, i.e. the excavation and backfilling with sub-base or base shall be flush with the existing road level on one side before excavation can proceed on the other side of the road.

During construction for operations which require one way traffic the Contractor shall be responsible for the removal of broken down vehicles including vehicles damaged in accidents and shall maintain one way uninterrupted traffic flow at all times (except at those times as agreed with the Engineer where it is necessary to temporarily close

the road).

The Contractor shall program his work so as to reduce disruption to all road users during construction of the Works and maintain traffic control measures for the safety of traffic at all times.

The Contractor shall propose the working procedures which will be subject to the Engineer's approval before implementation.

The approval of the Engineer shall be required before traffic is allowed to pass over newly constructed road. Any defects caused by traffic passing over the construction layers shall be remedied in accordance with these Specifications.

The Contractor shall be fully responsible for traffic control.

- (5) *Add the following new Clause 102(5) "Installation of Provisional Guard Fence" and renumber the remaining Clauses as follows:*

**(5) Installation of Provisional Guard Fence**

This work shall consist of the installation and on-completion of the work removal of provisional guard fence as described in Section 900: "Earthworks", Clause 905(2): "Installation of Provisional Guard Fence".

The works for Traffic Management at KM -0+240 to 0+240 along Tribhuvan Highway shall be performed in accordance with the requirements of Clause 905(2): "Installation of Provisional Guard Fence" as shown in the Drawings.

*Renumbering:*

(5) Traffic Safety and Control → **(6) Traffic Safety and Control**

(6) Measurement and Payment → **(7) Measurement and Payment**

**(7) Measurement and Payment**

- (6) *Delete the full text of the renumbered Clause(7) "Measurement and Payment" and replace with the following:*

Excepting for the items shown here below (and shown in the Drawings) and unless stated otherwise in the Contract, no separate measurement and /or payment shall be made for all materials and works required under this Clause. All costs in connection with the works specified in this Section shall be considered to be deemed included in the rates of the relevant main items of the Bill of Quantities.

The works comprised by the Item No.102-1 to No.102-5 shall be measured per unit, and shall be paid in "lump sum" which shall be the full and the final compensation to the Contractor and for the cost of all operations, materials and incidentals involved for completion of this item.

The unite rate established for payment of Item No.102-1 shall consider the rescue value of the temporary fence provided and constructed as shown in the Drawings, which shall be removed after work's completion, and will belong to the Contractor.

Item No.	Description	Unit
<b>102</b>	<b>Accommodation of Traffic</b>	
102-1	Traffic Management at KM -0+240 to KM 0+240 along Tribhuvan Highway	lump sum
102-2	Traffic Management at KM 3+160	lump sum
102-3	Traffic Management at KM 4+390	lump sum
102-4	Traffic Management at KM 5+000	lump sum
102-5	Traffic Management at KM 5+340 Tribhuvan Highway	lump sum

### 103 PUBLICLY AND PRIVATELY OWNED SERVICES

(7) *Delete the full text of Clause 103 (7) and replace with the following:*

- (7) The Contractor shall ascertain the location of all access paths, watercourses, irrigation channels, sewers, drains, water pipes, electricity and telecommunication cables and other services and structures which may be encountered during the execution of the works. He shall temporarily support or divert and subsequently reinstate all such services and structures as necessary and to the satisfaction of the Engineer. As soon as any such service or structure is encountered on, over, under, in or through the Site during the performance of the Contract, the contractor shall make a record of the location and description of such service or structure and shall send the same forthwith to the Engineer.

Where permanent diversion or support of such service or structure is rendered necessary as an unavoidable result of the execution and maintenance of the Works in accordance with the Contract, the Engineer after consultation with the Employer will instruct the Contractor as to the diversion or support to be provided. All operations necessary for the execution of the Works shall be carried out so as not to interfere unnecessarily or improperly with the convenience of the public, or the access to, use and occupation of public or private roads and footpaths or of properties whether in the possession of the Government or any other person.

- (8) Unless stated otherwise, no separate measurement nor payment shall be made for the work of temporarily supporting and protecting the publicly and privately owned services and/or for construction and maintenance of new services in lieu of them.

### 104 SURVEY AND SETTING OUT

(8) *Insert the following as per the 2<sup>nd</sup> paragraph of Clause 104 (6):*

If at any time the Contractor believes that there exists a discrepancy between the location of the works as defined by the setting out and the apparent location of the works as shown in the Drawings he shall immediately inform the Engineer and request clarification.

(9) *Delete full text of Clause 104 (7) and replace with the following:*



The Contractor shall check the existing profile and cross sections against the survey data and, should any changes be found necessary in the Survey Traverse Points and Bench Marks, after the procedures required in Clauses (1) and (2) above, the existing data set shall be amended accordingly. Should the Engineer consider that design modifications of the centreline and/or gradient is relevant or if the Contractor find that the existing survey data set is inadequate or inaccurate in any area of the works, the Engineer shall issue detailed instructions to the Contractor and the Contractor shall perform the necessary modifications in the field, as required, and modify the cross sections accordingly.

The final survey data set so obtained in combination with the final horizontal and vertical alignment of the road shall form the basis for the measurements and payments of earthworks. Measurement shall be either based on a Digital Terrain Model (DTM) generated from the agreed survey data set with the final designed road horizontal and vertical alignment and road cross section, applied or any other method approved by the Engineer. In case of DTM, the model will be used to generate cross-sections complete with cut and fill data at intervals not exceeding 2.50 meters in the hill areas. Measurement of volumes and areas of earthworks items shall be derived from these cross sections.

The software currently used for the preparation of survey and design data is SW-Roads developed by Softwel (P) Ltd. of Kathmandu Nepal. Should the Contractor wish to use alternative software he may propose this to the Engineer. He will be required to demonstrate that his proposed alternative is at least as accurate as and is functionally equivalent in all respects to SW-Roads. Should the Engineer agree to the use of the alternative software, the Contractor shall be entirely responsible for the adaptation. Under the supervision of the Engineer. Of all input data to the alternative software requirements and for the training of the Engineer's personnel in the use of the alternative software. In the event that alternative software is approved the Contractor shall supply the Engineer with two, fully licensed, copies of the alternative for the exclusive use of the Engineer.

## **106 DIVERSION BRIDGES**

(10) *Delete the first sentence of the Clause 106 (1) and replace with the following:*

- (1) Temporary diversion bridges shall be provided by the Contractor, upon previous approval by the Engineer, wherever required for the execution of the Works to maintain traffic.

(11) *Delete the full text of Clause 106 (3) and replace with the following:*

- (3) On completion of the works, the Contractor shall obtain the approval of the Engineer before removing the temporary bridges. Unless otherwise required by the Employer, the materials arising from the removal shall become the property of the Employer and they shall be removed to the Employer's premises and neatly stacked at no cost to the



Employer. If it is not so required, the Contractor shall remove the materials to an approved disposal area at no cost to the Employer.

**(4) Measurement and Payment**

- (12) *Delete the full text of Clause 106 (4): “Measurement and Payment” and replace with the following:*

No separate measurement nor payment shall be made for the work required under this Sub-Section. All costs in connection with the works specified in this Sub-Section shall be considered to be deemed included in the rates of the relevant main items of the Bill of Quantities.

**107 MAINTENANCE OF ROAD**

- (13) *Delete the fourth (4<sup>th</sup>) paragraph of the Clause 107 (1) and replace with the following:*

The Contractor shall perform the maintenance works as often as required to keep the carriageway, shoulders, adjoining structures and roadside slopes stable and in proper working order as required by the Engineer. The Contractor shall strictly adhere to the stipulations of the latest publication of the document “Road Maintenance Manual” published by the Department of Roads.

The basic criteria and requirements for materials and construction specified in Section 2900: “Maintenance Works” shall be applied in general for these works, as instructed by the Engineer. Particularly, the Sub-Section 2905: “Bituminous Patch Works”, Clause (2) Bituminous Patching shall be applied for those road sections or surfaces identified by the Engineer.

“Crusher-run base” shall conform the requirements for a base course specified in Sub-Section 1202: “Graded Crushed Stone Base and Sub-Base”.

**(2) Measurement and Payment**

- (14) *Delete the full text of Clause 107(2) “Measurement and Payment” and replace with the following:*

“Maintenance of road during construction period” as well as “Maintenance of road in Defects Notification Period” both quantified in kilometer-months shall be paid as per contract price on lump sum basis per month.

Bituminous Patching (Shallow and Deep) shall be measured in square metres of the areas actually repaired in accordance with these specifications, and as instructed by the Engineer.

“Crusher-run base” shall be measured in cubic metres of the sections actually repaired in accordance to the specifications and as instructed by the Engineer.

The contract price and/or unit rate shall be the full and the final compensation to the Contractor as per Clause 112.

Item No.	Description	Unit
<b>107</b>	<b>Maintenance of Roads</b>	
107-1	Maintenance of existing roads from KM-0+220 to Sisne Khola crossing and Tribuvan Rajpath in Balambu interchange during construction period	month
107-2	Maintenance of existing roads from KM-0+220 to Sisne Khola crossing and Tribuvan Rajpath in Balambu interchange during Defects Notification Period	month
107-3	Shallow Patching	sq.m.
107-4	Deep Patching	sq.m.
107-5	Crusher-run base	cu.m.

## 108 NOTICE BOARD

(15) Delete the full text of Sub-Section 108: “Notice Board” and replace with the following:

- (1) The Contractor shall erect, where directed by the Engineer or as shown in the Drawings, information boards (1.8m x 1.2m) at each end of the site giving details of the contract in the format and wording as directed by the Engineer. These boards shall be erected within 14 days after the Contractor has been given the Possession of Site.

The Contractor shall not erect any advertisement on or along the Project Site without the written approval by the Employer.

All information boards shall be removed by the Contractor by the end of the Defects Notification Period.

### (2) Measurement and Payment

Project signboards shall be measured as the number of signboards, satisfactorily provided, installed, maintained throughout the Contract period and subsequently removed. Payment shall be made at the stated unit rate per signboard. The contract price shall be the full and final compensation as per Clause 112 for all materials and labour required to perform the work described.

Item No.	Description	Unit
<b>108</b>	<b>Notice Board</b>	
108-1	Provision and installation of Project Signboards	No.

## 109 ENVIRONMENTAL PROTECTION WORKS

(16) Delete the third (3<sup>rd</sup>) and fourth (4<sup>th</sup>) paragraphs of the Section 109: “Environmental Protection Works” and replace with the following:

The Contractor shall take full responsibility for performing the work minimizing environmental pollution and damage that can occur pursuant to his construction operations.

The Contractor shall develop and implement a site-specific Environment Management Action Plan (EMAP) in complying with all applicable government/ local laws and regulations in the Country as well as the Environmental Impact Assessment (EIA) and Initial Environmental Examination (IEE) reports approved by Ministry of Population and Environment (MoPE), of this Project, which describe the requirements for environmental protection during the entire duration of this contract. The Contractor shall be primarily responsible and accountable for the actions and activities of his subcontractors and suppliers, and for their compliance with the EMAP.

The Contractor shall assume the responsibility of securing all the necessary licenses, permits, clearances and their attendant costs and fees prior to start of any construction activities. The Contractor may request the assistance of the Employer/ Engineer thereon on a best endeavor basis. The Contractor shall prohibit employees from any use of explosives, poaching of wildlife and cutting of trees or branches. The Contractor shall be responsible for the action of his employees.

The Engineer will notify the Contractor in writing of any observed noncompliance with relevant laws, regulations, permits and other elements of the Contractor's EMAP. The Contractor shall, after receipt of such notice, inform the Engineer of proposed corrective actions and take such actions, at his own cost, immediately when approved. If the Contractor fails to comply promptly, the Engineer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No time extension therefore shall be granted to the Contractor for any such suspensions.

The Contractor shall provide and maintain at his own cost the personnel, equipment and facilities necessary for a fulfilment of the requirements of the Environment Protection.

Submittals:

The Contractor shall submit the own EMAP to the Engineer for his approval within twenty-eight (28) calendar days after the date of the Letter of Acceptance. Any construction operation shall not begin until the EMAP has been approved by the Engineer. The EMAP shall include a series of management plans including (but not limited to) the following main items:

- Sediment and erosion control plan for each Site;
- Camps management plan for each camp;
- Waste management plan;
- Pollution control (water, air, noise) plan for each Site;
- Traffic management plan;
- Standard Operating Procedures for pollution spills, and management of fuels and hazardous substances.

The above referred plans shall be compiled by using the following information:

- a) Organization and lines of responsibilities including subcontractors and suppliers
- b) Methods of protection of features to be preserved such as trees/vegetation, soil, landscape features, air and surface/ ground water, fish and wildlife, historical,

- archaeological and cultural resources.
- c) Procedures to be implemented to provide the required environmental management, to comply with the applicable laws and regulations, and to correct pollution due to accident, natural causes, or failure to follow the procedures of the EMAP
  - d) Drawings showing locations of any proposed temporary excavations or embankments for haul roads, stream crossings, material storage areas, stockpiles of excess or spoil materials and sanitary facilities and solid waste disposal areas.
  - e) Training for Contractor's personnel during the construction period.

The approval by the Engineer shall not relieve the Contractor of any of his responsibilities for the Environment Protection pursuant to his construction operations. Furthermore, the Engineer shall have the right to require the Contractor to improve the approved EMAP whenever it is deemed necessary in the opinion of the Engineer.

Environment Monitoring Report

The Contractor, within 7 days after the last day of the period to which it relates, shall submit the Environmental Monitoring Report in monthly basis to the Engineer for his review.

Reporting shall continue until the Contractor has completed all work which is known to be outstanding at the completion date stated in the Taking-Over Certificate for the Works.

The Report shall include the items of environmental monitoring requested in this Section.

Relevant Statutes:

The Contractor shall at all times comply with all existing statutes in the Country concerning environmental protection, pollution control and abatement that are applicable to his construction operations and the **JICA Guidelines for Confirmation of Environmental and Social Considerations (2010)**

Assignment of Environment Protection Manager (EPM):

The Contractor shall designate an environment protection manager (EPM) with his staff. The name and qualifications including education and work experiences of the EPM shall be submitted for approval of the Engineer prior to the appointment.

Environmental Monitoring

The Contractor shall perform environmental monitoring for the duration of this contract and submit results to the Engineer. The minimum requirement for items, frequency and number of locations of sampling or measurement shall be as indicated here below, and the detail shall be confirmed in the latest approved EIA report.

### Frequency and Locations of Environmental Monitoring

Item	Monitoring Indicator	Place of Monitoring	Frequency(Period)
Air Pollution	NO2, PM10	(1) West Portal), (2) East Portal, (3) East end point of the east approach road	1 measurement in every month or urgent request / complain from local residents
Water pollution	BOD, TSS	(1) Sisne Khola , downstream of Soil Disposal Area, (2) Balkhu Khola, culvert bridge near medical college , downstream of east approach road work area	1 measurement in every month or urgent request / complain from local residents
Noise pollution	Noise	Just outside of the following work area: (1) Tunnel: West Portal, (2) Tunnel: East Portal, (3) Surface: West Approach Road / Soil Disposal Area, (4) Surface: East Approach Road	1 measurement in every month or urgent request / complain from local residents
Waste	• Soil Waste	Construction work areas Soil disposal site	Once in every month
	• Solid Waste	Contraction work areas	Once in every month
	• Liquid Waste	(1) West Plant discharge point (2) East Plant discharge point	
Water regime	• Surface water • Ground water • Springs	Construction work areas Soil disposal site Adjacent springs	1 measurement in every month or urgent request / complain from local residents
Geology	Slope stability	Construction work areas Soil disposal site	Every day (morning and evening)
Land use	• Land use, Local resource use, • Communal/Commo n resource use right	Construction work areas Soil disposal site	As occurrence of issues
Water Rights / Water use	• Surface water resource • Ground water resource • Spring water resource	Construction work areas Soil disposal site Adjacent springs	1 measurement in every month or urgent request / complain from local residents
Work Related Issues	• Sanitation, • Public Health condition, • Infectious disease such as HIV/AIDS • Industrial Safety and Health • Traffic accidents • Crime	Construction work areas Soil disposal site	As occurrence of issues

Note: the number and frequency only shows the minimum requirements.

The environmental protection works, among others, shall also include the following:

#### (1) Borrow / Quarry Sites

(17) Delete the fifth (5<sup>th</sup>) paragraph of Clause 109(1): “Borrow/Quarry Sites” and replace with the following:

The Contractor shall obtain approval from the Engineer of all material sources before

extraction, and before opening up any borrows pits or quarries. All sources of materials used under the Contract shall require such approval regardless of whether the material is obtained directly by the Contractor or supplied indirectly by others. The Contractor is not allowed to use the right of way for the borrow pit.

Such borrow pits and quarries may be prohibited or restricted in dimensions and depth by the Engineer where:

- (18) *Delete the paragraph of Sub-Clause 109(1) (iii): “they may be environmentally unsuitable” and replace with the following:*

(iii) they may lead to general environmental or instability problems or may be environmentally unsuitable in any other way.

- (19) *Insert the following as per the last paragraph of Clause 109 (1): “Borrow/Quarry Sites”:*

The Contractor shall not deposit excavated material on land in Government or private ownership except where approved by the Engineer in writing or by leave in writing of the authority responsible for such land in Government ownership or of the owner or responsible representative of the owner of such land in private ownership and only then in those places and under such conditions as the authority, owner or responsible representative may prescribe.

Any quarry operated as part of this Contract shall be maintained and at the end of the Contract left in a stable condition without steep slopes and be either refilled or drained and be landscaped by appropriate planting. Rock or gravel won from a river shall be removed over some distance so as to limit the depth of material removed at any one location and not to disrupt the river flow or damage or undermine river banks.

## **(2) Disposal of Spoil and Construction Waste**

- (20) *Delete the second (2<sup>nd</sup>) paragraph of Clause 109(2) “Disposal of Spoil and Construction Waste” and replace with the following:*

Under no circumstances whatsoever shall the Contractor allow spoil from any excavation or cut to fall or be pushed down the slope below. In any situation where this occurs by accident or by purpose, the Contractor shall, at his own cost, remove the debris to a location approved by the Engineer and make good the affected area through appropriate structures and re-vegetation as specified by the Engineer and following guidelines published in the Department of Roads’ manual “Roadside Bio-Engineering”. Failure in compliance with the Engineer’s instruction in respect of spoil disposal will lead to a reduction or with-holding of payment.

The Contractor shall plan his works in such a way that there is no spillage of POL products to the surface or sub-surface water.

Any construction waste that includes bitumen products, unused cement, fuel, oil or plastics shall be disposed of in a Government-approved landfill site. If this is not practical then it may be disposed of by burial in a specially excavated pit at a site approved by the Engineer. Land compensation shall be paid by the Contractor for the

area occupied by the pit as if for permanent construction. If the land is owned by the Government, then the Contractor must obtain written permission from the appropriate authority for its use in this manner, and must pay any royalties due. The pit shall be located at least 50 metres from any seasonal or permanent water course or spring. A hole shall be excavated below ground level so that, when the original surface profile is regained through backfilling, the disposed waste is covered by at least two metres of soil. Following the closure of the waste disposal site, the Contractor shall provide any structures necessary to prevent erosion and shall re-vegetate the topsoil with appropriate plants.

The Contractor shall treat the vegetative wastes and construction wastes separately at the dumps approved by the relevant local authorities and the Engineer. The Contractor shall be responsible for making necessary arrangements with private parties and with the relevant local authorities for the location of such dumps.

**(3) Provision and Maintenance of Camps, Offices, Stores, Equipment Yards and Workshops**

(21) *Insert the following after the first (1<sup>st</sup>) paragraph of Clause 109(3) “Provision and Maintenance of Camps,... etc.”:*

The Contractor shall provide and maintain such accommodation and amenities as necessary for all his staff and labour, employed for the purposes of or in connection with the Contract, including all fencing, water supply (both for drinking and other purposes), electricity supply, sanitation, cookhouses and other requirements in connection with such accommodation or amenities. On completion of the Contract, unless otherwise agreed with the Employer, all the temporary camps/housing provided by the Contractor shall be removed and the site(s) reinstated to its (their) original condition, all to the approval of the Engineer.

All accommodation facilities of whatsoever nature provided by the Contractor shall be provided with adequate sewage and wastewater collection and treatment facilities to a design and of a capacity approved by the Engineer. Under no circumstances shall untreated sewage or wastewater be discharged to the natural environment.

(22) *Insert the following the end of Clause 109(3) “Provision and Maintenance of Camps,... etc.”:*

Construction Equipment and Plants

- ♦ All construction plant and equipment provided by the Contractor shall, when brought to the Site, be deemed to be exclusively intended for the construction and completion of the Works, and the Contractor shall not remove the same or any part thereof without the consent of the Engineer. The equipment and plants shall not be measured nor paid separately but shall be deemed included in the rates for unit prices of the respective main items.

Contractor’s Site Office, Sheds, Stores, and Living Quarters

- ♦ Unless otherwise provided by the Employer within the Site, the Contractor shall



obtain, at his risk and cost, any additional rights of way or facilities outside the Site which he may require for the purpose of the Works.

Contractor's Workshop and Warehouse

- ♦ The Contractor shall have a suitable workshop in the Site, adequately equipped and provided with utilities, to allow for repairs of the equipment employed to carry out the Works. He shall also provide a warehouse for the equipment spare parts, mainly for the parts that frequently fail or are difficult to procure. A chief foreman qualified for mechanical repairs, with an adequate labour force shall be assigned for management and operation of the workshop.

Land for Construction Purposes, Detours, Plant, and Other Uses:

- ♦ The Contractor shall acquire all additional working areas or any additional areas required for construction purposes and access or other uses, as stipulated in the Specifications.
- ♦ Before entering the work site, the Contractor shall give a written notice to the Engineer. The Contractor shall give separate notices to each owner and occupier or authority having jurisdiction over the work sites.
- ♦ Before entering any additional work areas, the Contractor shall obtain, and forward to the Engineer, a copy of the written consent of the owner and occupier or authority having jurisdiction over the land, and shall state the purposes for which such land is to be used. The Contractor shall define the extent and period of occupation for which such consent is granted.
- ♦ The Contractor shall select, arrange for and, if necessary, pay for the use of sites for construction purposes, detours, plant, and other uses necessary for the execution of the Works.
- ♦ Before using any land belonging to the government or to a private landowner for any purpose in connection with the execution of the Works, the Contractor shall obtain the Engineer's prior consent for such use.
- ♦ If any utility passing through the temporary site is affected by the Works, the Contractor, at his own expense, shall provide an appropriate plan for re-alignment or relocation of such utility in full working order to the satisfaction of the owner of the utility and the Engineer, before cutting or removing or relocating the existing utility.
- ♦ Upon completion of the Contract, or earlier if so directed by the Engineer, all plant, temporary facilities and any other encumbrances shall be removed, the site and land use areas shall be properly cleaned, all damages shall be repaired, and, if necessary, the landowner shall be paid for the use of land.

**(6) Provision of First Aid/Medical Facilities**

(23) *Modify the title of Clause 109(6) "Provision of First Aid/Medical Facilities" as follows:*

**(6) Provision of First Aid/Medical Facilities and Prevention of HIV/AIDS**

(24) *Insert the following sub-title before the first paragraph of the renamed Clause 109(6):*

**(6-1) Provision of First Aid/Medical Facilities**



(25) *Insert the following after the renamed Sub-Clause 109(6)(6-1):*

**(6-2) Prevention of HIV/AIDS**

This Sub-Clause deals with the prevention of HIV/AIDS at workplace and surrounding local communities during the execution of the project.

This Clause described to herein shall be interpreted without detriment to the stipulations of Clause 6.7: “Health and Safety” of the Conditions of Contract.

Regarding the HIV/AIDS as the workplace issue (like any other serious illness/condition in the workplaces), the Contractor shall conduct an HIV/AIDS awareness program via an approved and elite service provider, and shall undertake to reduce the risk of the transfer of the HIV virus between and among the Contractor’s Personnel and the surrounding local community, to promote early diagnosis and to assist the affected individuals.

The requirements established in this section shall be minimum requirements, without detriment to, the responsibilities of the Contractor. However, it is not a requirement of this Clause for the Contractor to undertake or pay for treatment or medication for personnel found to be suffering from HIV/AIDS. Such personnel, however, shall not be discriminated in any situations but shall be referred to National AIDS Program of the respective township or to other International NGOs (INGOs) which provide further testing and treatment.

Scope of Work:

The Contractor shall prepare a detailed HIV/AIDS Prevention Plan (the Plan) indicating how he shall comply with the Contract requirements as well as requirements in the IEE report, for the Engineer’s Approval. The Plan shall contain the contents, methods, frequency and cost of the activities for HIV/AIDS prevention targeting all staff related to construction works as well as communities surrounding the Site.

The Contractor shall undertake to implement activities indicating in the Plan, including all necessary facilitation. The approved Plan shall be properly implemented by the Contractor throughout the contract period including the Defects Notification Period, and the activity record with attendee lists shall be submitted to the Engineer within ten (10) working days.

The Contractor shall assign a manager and appropriate number of staff who will work for preparation and implementation of the Plan.

The Contractor shall, within fifty six (56) calendar days, after the date of the letter of Acceptance, submit the Plan to the Engineer for his approval. In case the Contractor sublets any of his obligation under the Contract, it is required that the sub-contractor shall comply with the Plan as mandatory.

The Plan shall cover the following aspects but not limited to the following:

**i. HIV/AIDS Awareness and Education Program**

- (a) HIV/AIDS awareness and education program indicates the risks, danger and impact, and appropriate avoidance behavior with respect to Sexually Transmitted Diseases (STD) – or Sexually Transmitted Infections (STI) in general and HIV/AIDS in particular. The Contractor shall provide the program addressed to all the Site staffs and labours (including all the Contractor's employees, all Sub-Contractors and Consultants' employees and all truck drivers and crews to Site for construction activities). The HIV/AIDS awareness and education program shall be provided at least one time for all workers before commencement of their works.
- (b) HIV/AIDS awareness and education program to the surrounding local communities, at least every three months, concerning the risks, danger and impact, and appropriate avoidance behaviour with respect to Sexually Transmitted Diseases (STD) – or Sexually Transmitted Infections (STI) in general and HIV/AIDS in particular.
- (c) Arrangement for the providing of condoms for all Site staffs and labours on Site as appropriate place or other approved method of distribution throughout the contract period.
- (d) Arrangement for the hanging of the HIV/AIDS awareness posters in (A0 and A3 size) vinyl at the appropriate place of offices, work place and labour camps.
- (e) Arrangement of place, keeping and submission of record for the implementation of HIV/AIDS awareness and education program to the Engineer.

**ii. Peer Educators Program**

- (a) Selection sufficient number of the Peer Educators from all Site staffs and labours to be more effective in HIV/AIDS prevention program.
- (b) Implementation schedule of the peer educator program.
- (c) Arrangement for providing the necessary support to the peer educators.

**iii. HIV Testing**

- (a) Arrangement of STI and HIV/AIDS screening, diagnosis, voluntarily counselling/testing referral to a dedicated national STI and HIV/AIDS program, (Unless otherwise agreed) of all Site staffs and labours.
- (b) Confidentially keeping system of the testing results not to discriminate in working area.
- (c) Referring the staffs and labours found HIV positive in testing results to the National AIDS Program (NAP) of the relevant township or to other INGOs which provide further testing and treatment.

Relevant Statutes

The Contractor shall at all the time comply with the existing statutes in Nepal concerning Public Health Law for the implementation of the Works.

If the requirements stated in this document are less stringent than or in conflict with the country's applicable legislation, the latter shall apply.

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Code of Practice

The Code of Practice shall be in accordance with the Contract, based on a recognized standard and not less standards than those prescribed in the following code and standards:

- The International Labor Organization (ILO) Codes of Practice on HIV/AIDS and the world of work (Guidelines for the Construction Sectors)

Notice of Contravention:

The Engineer will notify the Contractor in writing as Notice of Contravention of any observed noncompliance with the responsibilities of Contractors' HIV/AIDS prevention plan. The Contractor shall, after receipt of such notice, inform the Engineer of proposed corrective actions and take such actions immediately.

**(9) Hazardous Materials**

- (26) *Delete the first (1<sup>st</sup>) paragraph of the Clause 109(9) "Hazardous Material" and replaced with the following:*

Hazardous Materials comprise such material as cement, lime, bitumen and emulsion, paint, fuels, oils, battery acids, pesticides and herbicides, and any type of toxic material.

Solid wastes containing hazardous material shall be placed in containers which can be emptied on a regular schedule. Handling and disposal shall be conducted to prevent contamination. Segregation measures shall be employed so that no hazardous material will become co-mingled with other solid waste.

Chemicals shall be dispensed ensuring no spillage to ground or seasonal / permanent water courses or springs. Periodic inspections of dispensing areas to identify leakage and initiate corrective action shall be performed and documented by the Contractor. Chemical waste shall be collected in corrosion resistant, compatible containers.

The Contractor shall take sufficient measures to prevent spillage of hazardous materials during dispensing and shall collect waste in suitable containers observing compatibility. Spills of hazardous materials shall be immediately reported to the Engineer. Clean-up and the costs arising there from due to spills shall be the Contractor's responsibility.

Provision of Safety Clothing and Equipment:

Besides the requirements for Hazardous Material, the Contractor shall provide all laborers, supervisors and site staff with suitable basic safety helmets, boots, clothing, etc.

All workers and supervisory staff when on any site shall wear the basic safety clothing specified. Where additional safety equipment is required by nature of the site, then all workers and supervisory staff when on any part of that site shall use the additional equipment in addition to the basic safety clothing specified.

In hot weather the Contractor shall provide appropriate lightweight safety equipment, such as cotton gloves in place of rubber gloves and canvas boots in place of rubber boots.

The Contractor shall be responsible for ensuring that all his employees and the employees of any Subcontractor and any visitor to the site complies with the Engineer's requirement to use safety clothing and equipment at all times. Failure in compliance with the Engineer's instruction in respect of safety clothing and equipment may lead to a suspension of works and a reduction or with-holding of payment until the Contractor complies.

#### **(10) Reinstatement of Environment**

(27) *Insert the following as the second paragraph of the Clause 109(10):*

The Contractor shall reinstate the environment of areas polluted by the use or spills of hazardous materials as defined in Clause 109(9). All such materials and polluted soil shall be removed to a safe disposal site as described in these Specifications. The site shall then be restored and revegetated as approved by the Engineer.

The Contractor shall reinstate the quarry sites at the completion of the works as mentioned in Clause 109(1) and/or as instructed by the Engineer.

#### **(11) Measurement and Payment**

(28) *Delete the full text of Clause 109(11): "Measurement and Payment" and replace with the following:*

#### **(11) Water Resources**

The Contractor shall keep construction activities under surveillance, management, and control to avoid pollution of surface and ground waters. Toxic or hazardous chemicals shall not be applied to soil or vegetation when such application may cause contamination of the fresh water reserve.

Proper treatment of water pollutants generated from construction works. Adequate preventive following measures shall be taken as necessary:

- Install cover sheet on bare lands, cut and fill areas and waste soil disposal sites if necessary.
- Surface runoff from the Site shall be directed to silt traps or sedimentation basin with the help of channels before discharge.
- To shelter scattering of soil mud from excavation work by applying preventive measure such as submerged fence in order to avoid increase in turbidity.
- Monitoring water quality during construction.

#### **(12) Air, Noise and Vibration**

The Contractor shall keep construction activities under surveillance and control to minimize environment damage by air contamination, noise, vibration, odors and/or other disturbances.

Dust particles pursuant to production and preparation of materials shall be controlled at all times. The Contractor shall maintain excavations, stockpiles, haul roads, permanent and temporary access roads, spoil areas, and other work areas within or outside the Site free from particulate which would cause a hazard or a nuisance to persons and/or damage crops, orchards, cultivated field and dwellings. A discharge of dust into the atmosphere shall be controlled during processing, handling and storing cement and cementitious materials.

Night-time operations producing a high level of noise and/or vibration shall be performed only at time and places approved by the Engineer. Temporary noise barriers, or acoustic screens or enclosures shall be used at the Site close to the residential houses to shield residences from the noise as necessary. The Contractor shall indemnify the Engineer from any liability for damages due to noise, vibration and/or other disturbances caused by his construction operations and also from all claims relating to such liability.

Equipment and vehicles shall be maintained and operated at all times in such a condition as not discharge excessive exhaust gases due to poor engine adjustments or other inefficient operating conditions. The Contractor shall likewise ensure that all equipment and machinery are in proper working condition so as to minimize the amount of noise and vibration generated. The Engineer may require, at his discretion, the Contractor to replace any equipment, machinery or vehicles emitting excessive exhaust gases, noise and/or vibration.

### **(13) Social Considerations**

The Contractor shall pay attention to the public morality of his staff and laborers including his subcontractors both on and off the Site.

In the interest of good community relations, the Contractor and his subcontractors shall be circumspect in dealings with people residing in the neighborhood of the Site and take adequate efforts to avoid any disturbance to them. The Contractor shall, in his responsibility, arbitrate any dispute arising between his personnel and persons in the neighborhood of the Site. Unskilled labour shall preferably be employed from the towns/villages affected by the Works. Also, the Contractor shall distribute prior information of construction works as following but not limited through installation of signboards informing the residents who live in and around the construction area.

- Starting and completion date of construction works
- Location of construction work (dredging and disposal work)
- Notices of the construction work etc.
- Method of grievance (contact person and contact number, etc.)

### **(14) Measurement and Payment**

Excepting the Items shown here below, no separate measurement nor payment shall be made for the works described in this Section but it shall be deemed included in the rates and unit prices of all related main items.

The works for provision of the Items No.109-1 and No.109-2 shall be measured and paid in “lump sum” in split instalment shown here below, which shall be the full and the final compensation to the Contractor as per Clause 112 including all costs for providing and installation of the site offices as herein described, and for the cost of all operations, materials, equipment, and any incidentals involved for completion of this item.

Payment of Item No.109-1 shall be made according to the following instalments:

- (i) Twenty percent (20%) upon completion of the site offices, camp, and all installations herein described and approved by the Engineer.
- (ii) Fifty percent (50%) during the execution of the Works split in partial payments in proportion to the work progress subject to certification of achievement issued by the Engineer.
- (iii) Thirty percent (30%) upon issuance of the Taking-Over Certificate.

Payment of Item No.109-2 shall be made according to the following instalments:

- (i) Fifty percent (50%) upon completion of the works, demobilizing of all plants herein described and issuance of TOR certificate and approved by the Engineer.
- (ii) Fifty percent (50%) upon completion of the Defects Notification Period and duly reinstatement of the areas used for the plants and stockpiling sites, and approved by the Engineer.

Noncompliance by the Contractor on any of the requirements specified in this Section will cause suspension of the payments of Items No.109-1 and No.109-2.

The works for provision of the Item No.109-3 for provision and installation of “Environmental Protection Works”, as herein described, shall be measured and paid in “lump sum” prorated in monthly basis in accordance with the approved Monthly Progress of the Works. The contract price and/or unit rate shall be the full and the final compensation to the Contractor as per Clause 112 including all costs for providing and installation of the Environmental Protection Works herein described, and for the cost of all operations, materials, equipment, and any incidentals involved for completion of this item.

Item No.	Description	Unit
<b>109</b>	<b>Environmental Protection Works</b>	
109-1	Providing and establishment of camps, adequate drinking water, firewood and toilets for Contractor's labors and staffs and demolish camp site and re-instate the ground in original condition as per specifications and Engineers instruction all complete	lump sum
109-2	Reinstatement of crusher plant, concrete mixing plant, asphalt concrete mixing plant and stock pile sites to the original stage at the completion of works as instructed by the Engineer	lump sum
109-3	All the works for Environmental Protection Works	month



## (15) Provision for Particular Environmental Mitigation Measures

This sub-section describes the works to be implemented as per particular measures for mitigation of impacts to the environment. The basic requirements described in these specifications shall apply for these works too; however, the following have been identified and classified for this provision as particular and are not included in other sections for measurement and payment:

- ◆ Tree planting
  - ◆ Relocation and repair of services
  - ◆ Emergency water supply to existing water supply network
- (a) Tree Planting: These works are not measured nor paid under Section 2800: “Bio Engineering Works”, and consist basically of a particular measures for mitigation of impacts on the environment that maybe will be observed during the execution of the Works.
- (b) Relocation and repair of services: These works are not measured nor paid under other sections, and consist basically of a particular measures for relocation and/or repair of those unforeseen services or utilities that maybe will be found during the execution of the Works.

These works shall include, inter alia, the following:

- ◆ Survey and inventory of the identified services or utilities
  - ◆ Method statement and drawings for the measures to be applied
  - ◆ Construction of the works
- (c) Emergency water supply to existing water supply network: These works are related to the works described on Sub-Section 103: “Publicly and Privately Owned Services” and other relevant specifications, but are not measured nor paid under that or any other section, and consist basically of a particular measures that might be necessary for rehabilitation of the system for Water Supply and recovery of water supply network, during the execution of the Works and after respective completion.

These works shall include, inter alia, the following:

- ◆ Survey and brief study on the existing conditions
  - ◆ Design and drawings for the measures to be applied:
    - ✓ Temporary Water Supply system to be used during execution of the Works.
    - ✓ Permanent works for Water Supply system to be installed after completion of the Works.
  - ◆ Construction of the works
    - ✓ Civil works
    - ✓ Pipe & Fitting Works
    - ✓ Electrical Work/Mechanical
    - ✓ Environmental Mitigation Measure
- (e) Measurement and Payment: These works provided by the Particular Environmental Mitigation Measures, shall be measured in a Lump Sum supported by a breakdown submitted by the Contractor, for review and approval

by the Engineer, when the mitigation measures are required to be applied. A Provisional Sum for payment is established for each main item, and the payments shall be made for the related items included in the breakdown in conformity with the Clause 13.5: “Provisional Sums” of the Conditions of Contract and all other relevant clauses. The contract price and/or unit rate shall be the full and the final compensation to the Contractor as per Clause 112.

Item No.	Description	Unit
<b>109</b>	<b>Environmental Protection Works</b>	
<b>109(15)</b>	<b>Provision for Particular Environmental Mitigation Measures</b>	
109-4	Tree planting	PS
109-5	Relocation and repair of services	PS
109-6	Emergency water supply and recovery to existing water supply network	PS

## 110 PHOTOGRAPHS

- (29) *Delete the full Sub-Section 110: “Photographs” and Sub-Section 111: “Supply of Video Cassettes” and replace both with the following two Sub-Sections: “110 Project Safety” and “111 Supply of Project Record”:*

## 110 PROJECT SAFETY

### (1) Description

This section consists of the requirements for planning, implementing, and maintaining the safety measures to be applied by the Contractor for the Project during the execution of the Works and Defects Notification Period.

The requirements for “Project Safety” described herein shall be interpreted, as supplemented by, and without detriment to the stipulations for safety described in Sub-Section 804 “Safety and Public Health Requirements” and other relevant Clauses of these Specifications, and the Conditions of Contract Sub-Clause 4.8: “Safety Procedures” and Sub-Clause 6.7: “Health and Safety”.

The following definitions shall be referred to, for proper interpretation of Specification Section:

Contractor’s Health and Safety Plan:	The Contractor shall prepare the Contractor’s “Safety Plan” in accordance with “ <b>The Guidance for the Management of Safety for Construction Works in Japanese ODA Projects</b> ”, JICA, Sep. 2014. It shall consist of a complete plan for implementation and monitoring of safety measures applied in the project inclusive of the site and all the related areas such as the construction plant, quarries, roads for materials transportation, etc.
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### (2) Requirements

#### (a) Scope of Work

The Contractor shall, throughout the period for execution and completion of the



Works and the Defects Notification Period, take full responsibility for the protection of the Works, the health and safety of all persons entitled to be upon the Site and the public or others concerned to the Works, and the security of the Site. Lighting at night and underground sites including installation of floodlights shall be covered as a part of Safety.

The requirements established in this Specification Section shall also supplement the requirements and provisions stated in the Section 102: “Accommodation of Traffic”, Section 108: “Site Information”, Section 109: “Environmental Protection Works” and all sections regarding safety that are included in the Contract.

**(b) Relevant Statutes**

The Contractor shall at all the time comply with all the existing and applicable statutes in Nepal concerning Safety, Security and Health for the implementation of the works.

**(c) Safety Plan and Security**

The basic principle of PDCA (Plan, Do, Check, Act) required by the JICA’s guideline for Safety shall be established for implementation of a proper safety management.

Planning of Safety and Security:

The Contractor shall within twenty-eight (28) calendar days after the date of the Letter of Acceptance submit to the Engineer, for his approval, a health and safety plan or similar plan in order to comply with the requirements set out in Sub-Clause 4.8: “Safety Procedures” of the Conditions of Contract.

The so-called safety plan shall be developed with utmost care and vigilance in compliance with the requirements referred in the applicable statutes for safety (laws, regulations and authorities) in Nepal.

The construction work shall not begin until the safety plan has been approved by the Engineer. The Safety Plan shall cover the following aspects:

- Statement of Contractor’s Safety and Security policy.
- Senior management responsibility for Safety and Security.
- Appointment, duties and responsibilities of Safety staff.
- Policy for identifying Hazards.
- Risk assessment and management plan for Safety and Security.
- Promotion, awareness and training for Safety and Security.
- Equipment for Safety and Security.
- Safety and Security of the Contractor’s construction and office equipment.
- Safety and Security of the staff and workers at Site
- Safety and Security of the public and third parties at Site.
- Safety and Security procedures for Subcontractors.
- Measures to avoid traffic accident on public roads.
- Disciplinary procedures.
- Accident reporting.
- Medical check-up to all project staff

- First aid system.
- Emergency evacuations plan
- Others.

The safety and security plan for each section or installation shall be submitted in the Method Statement specified.

The approval of Health and Safety Plan by the Engineer shall not relieve the Contractor of any of his responsibility for Health and Safety at the Site. Furthermore, the Engineer shall have the right to request the Contractor to improve the approved Safety Plan whenever it is deemed necessary in the opinion of the Engineer.

Implementation of Health and Safety Plan:

The Contractor shall develop and implement a site-specific Health and Safety Plan which includes, but not limited to, a statement of health and safety policy organization and lines of responsibilities including Subcontractors and suppliers, training, methods for enduring health and safety incentive programs and compliance monitoring, accident reporting and record-keeping, medical support, and operating procedures. The Contractor shall be responsible and accountable for the actions and activities of his Subcontractors and suppliers, and for their compliance with the Safety Plan.

Notice of Contravention:

The Engineer will notify the Contractor in writing as Notice of Contravention of any observed noncompliance with relevant laws, regulations, permits and other elements of the Contractor's Safety Plan.

The Contractor shall, after receipt of such notice, inform the Engineer of proposed corrective actions and take such actions, at his own cost, immediately when approved. If the Contractor fails to comply promptly, the Engineer may issue and order stopping, all or part of the work until satisfactory corrective action has been taken. No time extension therefore shall be granted to the Contractor for any such suspensions.

The Contractor may appeal to the Engineer for modification of the terms of any Notice of Contravention before the expiry of the notice. Upon such appeal the Engineer in his sole discretion may modify, withdrawal or confirm the notice.

**(d) Safety Management Committee (SMC)**

For implementing the SMC, the Contractor shall constitute a duly empowered SMC which shall convene monthly under the chairmanship of the Occupational Health and Safety Manager.

The SMC shall be comprised of the following members at least and shall be subjected to the approval of the Engineer, who may, if in his opinion the committee is not carrying out its duties with due diligence, order that a new committee be reconstituted.

- (i) The Employer
- (ii) The Engineer
- (iii) The Contractor (project manager, Site managers, Safety manager and officers

and so on)

(iv) Representatives of Subcontractors

The Committee shall execute the site inspection regarding the health and safety at the Site before the Committee meeting.

The Committee shall have authority to cease work if unacceptable health and safety conditions exists, and instruct the Contractor to take necessary action to re-establish and maintain safe working conditions.

**(e) Safety Manager (SM)**

The SM shall be a graduate with at least a bachelor course of environmental scientist/ engineering and have experiences of more than 15 years in health and safety works in construction. He or she shall have obtained a vocational qualification issued by the safety authorities or an equivalent institution.

The SM or his deputy or representative shall be available at Site on a 24H/ day basic and his or her deputies shall carry out regular and random checks of all parts of the Site where work is taking place.

The duties of the SM and his deputy are as follows, but not limited to:

- (i) Management and implementation of safety plan,
- (ii) Notification, investigation and recording of accidents,
- (iii) Ensuring healthy and safe working conditions and management of hazardous conditions in accordance with Section 109: “Environmental Protection Works”,
- (iv) Arrangement for frequency and occasions of routine and special meetings,
- (v) Arrangement for disseminating information, training and supervision,
- (vi) Participation in internal weekly inspection and auditing on safety measures at Site by the Contractor and Subcontractors,
- (vii) Participation in monthly safety inspection by the Employer and /or Engineer, and
- (viii) Other required duties in SM.

**(3) Special Requirements for Safety**

**(a) Rules and Responsibilities of Project Stakeholders**

Precedence:

The rules and responsibilities of Project Stakeholders specified in the contract documents shall take precedence over this safety specification.

Employer:

The rules and responsibilities of the Employer relating to the management of safety on construction sites are as follows:

- (i) The Employer shall endeavour to strictly comply with the relevant laws and regulations of Nepal to ensure the safety of the Project Stakeholders during construction works at site and protect nearby local residents, and any other third parties, from every potential accidental risk foreseen to arise from the

- construction works at site.
- (ii) The Employer shall, in collaboration with the Engineer, make sure the works carried out in accordance with the Safety Plan and the Method Statements on Safety prepared by the Contractor and provide notice, suggestion or guidance for improvement.
  - (iii) The Employer shall endeavour to create an environment where all the project Stakeholders positively participate in activities to promote safety on construction sites.
  - (iv) When two or more Contractors carry out work at the same construction site, the Employer shall establish an environment for mutual cooperation and coordination on safety management.
  - (v) The Employer shall notify the Contractor of natural conditions, social conditions or any other factors that may affect the management of safety for construction works at site.

Engineer:

The rules and responsibilities of the Engineer relating to the management of safety on construction sites are as follows:

- (i) The Engineer shall have a full understanding of the roles and responsibilities of the Employer on the management of safety for construction works at site and, together with the Employer, appropriately implement activities to manage safety, including these obligations specified in the contract documents.
- (ii) The Engineer shall, in collaboration with the Employer, review the Safety plan and the Method Statements on Safety prepared by the Contractor and provide notice, suggestion or guidance for improvement to the Contractor if there are any risks to safety.
- (iii) The Engineer shall, in collaboration with the Employer, make sure the work is carried out as per the Safety Plan and the Method Statements on Safety prepared by the Contractor and provide notice, suggestion or guidance for improvement.

Contractor:

The rules and responsibilities of the Contractor relating to the management of safety on construction sites are as follows:

- (i) The Contractor shall be responsible for the operation and management of safety on construction sites.
- (ii) The Contractor shall appropriately prepare the Safety Plan at the appropriate time in the pre-construction stage in accordance with the relevant laws and regulations of the Nepal and Health and Safety Plan. In the construction stage, the Contractor shall appropriately prepare the Method Statement on Safety, which shall specify the details of safe methods to implement safety measures prior to the start of each item of work and submit the document to the Employer and Engineer for review and approval must be obtained.
- (iii) The Contractor shall make appropriate revision or correction whenever any insufficiency or suggestion for improvement relating to safety is raised

- following the review of the Safety Plan and the Method Statements on Safety.
- (iv) The Contractor shall undertake work according to the Health and Safety Plan and the method Statement on Safety they prepared.
  - (v) The Contractor shall take into account the safety of nearly local residents and any other parties, as well as all Project Stakeholders of the construction project.
  - (vi) The Contractor shall carry out construction works for the safety of nearly local residents and any other third parties, as well as Project Stakeholders of the project.

Subcontractor:

The rules and responsibilities of the Subcontractor relating to the management of safety on construction sites are as follows:

- (i) Each Subcontractors shall carry out construction works in compliance with the relevant laws and regulations of the recipient country applicable to the construction work and these Guidance's.
- (ii) Each Subcontractors shall establish and maintain safe and sanitary site conditions according to the instructions of the Contractor.
- (iii) Each Subcontractors shall cooperate with other Subcontractors engaged on the construction site in accordance with the instructions of the Contractor.
- (iv) Each Subcontractors shall receive from the Contractor an explanation on the Safety Plan and the Method Statements on Safety prepared by the Contractor. Each Subcontractors shall pass on the explanation received from the Contractor to their Employees and have them fully comply with those explanations to ensure safety.

**(b) Safety of Public**

The Contractor shall be responsible for the safety of the public passing through the Site. All excavations, plant or items of potential danger to the public must be barricaded and sign-posted to the satisfaction of the Engineer, and the Contractor must provide sufficient watchmen to ensure the safety of the public at all times. All existing pedestrian routes shall be maintained in a safe condition unless an alternative route is provided to the satisfaction of the Engineer.

**(c) Safety Barricade and Signboard**

The Contractor shall provide and maintain adequate safety barricade and signboard around the dangerous area such as opening, excavate trench, heavy equipment, lifting work area, etc.

**(d) Handrail, Safety Belt and Safety Net**

The Contractor shall provide and maintain adequate handrail and safety net.

Handrail shall be installed for all the working places higher than 2.0m. Handrail shall be strong, enough with adequate height. When working at higher than 2.0m without handrail, safety belt and safety rope shall be used. The Contractor shall use adequate safety belt and safety rope.

In case there is a risk of materials or tools falling down, the Contractor shall provide and maintain safety net around the stage. Type of the handrail, Safety Harness and Safety Net shall be subjected to the approval of the Engineer.

**(e) Evacuation Route and Place of Refuge**

The Contractor shall provide and maintain the Evacuation route and place of the refuge in the site which can access to any location of the site by vehicle in case of emergency. Safety path for workers to access to their working location shall be provided in the site. The Contractor shall maintain safety path with safety condition. Emergency evacuation route and place of refuge shall be indicated by signboard.

**(f) Temporary Roads/Diversions/Construction Yard in the Site**

The requirements described herein shall be applied supplementary to the requirements described in Sub-Clause 102(3)(a) "Provision of Diversions".

Traffic lanes shall be clearly marked by safety cone, barricade and guide signs to prevent accidents and to ensure quality control of constructing roads.

The Contractor shall provide and maintain security fences around the site. Purpose of the fence is to prevent residence especially children from entering the site without any permission. Therefore, security fence shall be at least 2.4m high, dense and strong enough so that children cannot break it or slip through the fence. Type of the fence shall be approved by the Engineer prior to construction.

The Contractor shall check the fence condition every day and if any damage or opening is found, repair them immediately on his own responsibility.

Contractor shall install a detour information board to inform public vehicles and pedestrians of the need for diversions, and deploy flagmen as appropriate.

Notify local residents of the plan to work on public roads, so as to obtain their understanding and cooperation.

**(g) Workers Rest House**

Labour's rest house with first aid facility shall be provided and maintained by the contractor to prevent from lightening accident and sunstroke. Toilets, smoking corner and drinking water shall be set up in the worker's rest house.

**(h) Prevention of Fall (scaffolding)**

Where works are undertaken at a place more than two (2) meters above ground level, the Contractor shall construct scaffolding prior to the commencement of work. Where it is impossible to construct scaffolding, workers use protective gear to prevent themselves from falling, such as safety belts or fall arrestors. Where safety belts are used, the Contractor shall ensure that equipment is affixed.

**(i) Prevention of Public Accidents and Traffic Accidents**

- (i) When work is undertaken on a public road, the Contractor shall adopt appropriate measures, such as barricading the work site and stationing the

watch-personnel or traffic-control personnel, to prevent the entry of unauthorized personnel including third parties into the work area.

- (ii) Where buried utilities or facilities are located under the ground of a work site or where excavation is undertaken in the ground near a structure, then if damage to those utilities, facilities or structures by overturning or collapsing is likely, the Contractor shall take appropriate measures prior to the commencement of work, so as to prevent the risk, such as the relocation or reinforcement of the utilities, facilities or structures.
- (iii) When earth and sand is backfilled over buried utilities or facilities, the Contractor shall undertake backfilling according to the predetermined specifications, without applying unsymmetrical pressure or damaging the buried utilities or facilities.

**(j) Availability of Safety-related Documents**

The Contractor shall comply with the Engineer's requirements in so far as displaying in each of its site offices, workshops, and canteens a copy of such safety and industrial health posters, and keeping on Site copies of safety and industrial health regulations and documents. The minimum regulations and most important documents (selected by the Engineer from the approved Safety Plan) shall be translated into languages which are understood by the operators engaged by the Contractor or Subcontractors, and such translations shall be displayed or kept alongside with those in Nepal and English languages.

**(k) Safety Reports**

The Contractor shall submit regular safety reports to the Engineer as a requirement of the Safety Plan. A summary of this report shall be included in each Monthly Progress Report. Safety reports shall comprehensively address all relevant aspects of site safety and industrial health regulations and, in particular, shall report on all site safety audits undertaken during the period covered by the report.

**(l) Safety Information**

The Contractor shall ensure that safety, rescue, and industrial health matters are given a high degree of publicity to all persons, regularly or occasionally, at the Site. Posters, in both Nepal and English, drawing attention to site safety, rescue and industrial health regulations shall be made or obtained from the appropriate sources and shall be displayed prominently in relevant areas of the Site.

**(m) Safety Meeting and Patrol**

The Safety Manager of the Contractor shall perform regular safety meetings and patrol in accordance with the Health and Safety Plan, with the participation of the Employer and Engineer (or a representative delegated by him for the purpose), and representatives of Subcontractors if so requested by the Engineer. All safety meetings shall be notified to the Engineer at least three (3) days in advance. Minutes of all safety meetings shall be taken and sent to the Engineer within three (3) days after the



meeting.

**(n) Fire Extinguishers**

In supplement to the safety equipment stated in the Safety Plan, the Contractor shall provide in particular wall-mounted hand-held fire extinguishers of multi-purpose, nitrogen-pressured, or dry chemical type at the Employer's and Engineer's facilities and the Contractor's facilities as suitable in conformity of the law or the safety standard of the country. Individual fire extinguishers shall also be provided in all the vehicles being used in the Project. Fire extinguishers shall be replaced before the expiry period.

**(o) First Aid Base**

The Contractor shall, at his own expenses, establish and maintain a fully equipped first aid base as described in the approved Safety Plan, and satisfying the following conditions:

The first aid base shall be located at the Contractor's principal work area and shall consist of a treatment room fitted with a hand wash basin, two treatment couches and sterilizing equipment, and lockable cupboards to contain sufficient medical supplies for the Contractor's workforce, the Engineer's site supervisory staff and any visitors to the Site. In addition, three (3) stretchers shall be stored, available for instant use.

A qualified nurse and nurse aid shall be in attendance at the first aid base during all times when work is being undertaken at the Site, including work by any Subcontractor, and during periods when only emergency activities are being undertaken, such as periods of inclement weather.

All the costs for first aid shall be considered as a part of the unit price of the bid, and no additional payment will be made for it.

**(p) Notification of Accidents**

The Contractor shall notify the Engineer immediately when any accident occurs whether on site or off site in which the Contractor, his personnel or construction plant, or those of his Subcontractors are directly or indirectly involved and which results in any injuries to any persons. Such initial notification may be verbal and shall be followed by a written comprehensive report within 24 hours after the occurrence of the accident.

**(4) Measures for Safety**

The Contractor shall take the measures for health and safety at the Site listed below, but not limited to, in accordance with the Relevant Statutes and Code of Practices:

**(a) Personal Protective Equipment (PPE)**

The Contractor shall ensure his and his Subcontractor's personnel to wear appropriate PPE at the Site at all times and supply the Employer and the Engineer at his own cost with such safety equipment as requested.

No body without PPE is allowed to enter the Site.



Every person entering the Site in open air and underground shall wear PPE. A sufficient number of electric lamps shall be equipped to the workers working underground and supplied by the Contractor to the Employer's and Engineer's persons entering underground.

The Contractor ensures that appropriate safety-toe footwear is worn by all persons engaged in work with an inherent danger to the foot. Light footwear such as sandals, canvas shoes or the like shall not be permitted at any construction work site.

The Contractor shall ensure that ear protectors are worn by the workers engaged in the drilling work or in the work site where workers are exposed to harmful noise levels.

The Contractor shall ensure that protection glasses, goggles or masks are worn by the workers engaged in work with an inherent danger of eye or face injury. Likewise, protective clothing shall be worn by the workers where irritant or toxic substances can come in contact with the skin or clothing.

The Contractor shall ensure that safety harnesses and lifelines are used by the workers working on steep slopes with an inherent danger of falls not protected by fixed guardrails or safety nets.

**(b) Sanitary Arrangement**

The Contractor shall keep the Site in a clean and sanitary condition and shall provide and maintain sanitary conveniences for the use of persons working at the Site to the extent and in the manner and at such places as approved by relevant local authorities concerned and the Engineer. All persons concerned with the Works shall be obliged to use these conveniences when being at the Site.

**(c) Sewerage and Sanitation**

The Contractor shall supply, install, operate, maintain and subsequently remove the adequate treatment process for disposal of sewerage from all temporary buildings including houses, offices, camps, etc. to be constructed by the Contractor. The Contractor shall construct, operate and maintain at the Site temporary toilet facilities complete with adequate water closets, urinals and hand-basins, septic tanks, absorption trenches or other sewerage disposal installation for all of his personnel. The temporary toilet facilities shall meet the requirements of the Government health authority. The location of these facilities and their construction shall be as approved by the Engineer. Sewerage from temporary facilities shall be disposed of in hygienic manner as approved by the Engineer.

The Contractor shall remove all rubbish and shall provide an adequate number of covered garbage bins/containers placed at convenient points around his camp quarters and work sites. The Contractor shall establish, operate and maintain a regular garbage collection and disposal system, utilizing a covered vehicle for collection and transport of garbage to the place of disposal. Garbage shall be disposed of by burning, by burial or by other means approved by the Engineer. No waste of any kind shall be deposited

in any watercourse

**(d) Epidemics and Hazardous Substances**

The requirements established in this sub-clause shall also supplement the requirements and provisions stated in Section 109: “Environmental Protection Works”

In the event of any outbreak of illness of a highly contagious or epidemic nature the Contractor shall comply with and carry out such regulations, orders and requirements as may be made by the Country, or the local medical or sanitation authorities for the purpose of dealing with and overcoming the same.

The Contractor shall identify and keep records of all hazardous equipment, materials, or other substances and any other health hazards in his undertaking of the Contract. Newly created hazards or new hazardous equipment, materials or other substances brought on to Site shall be added to the record. The Contractor shall draft new, or adapt and modify existing codes of practice appropriate to the said hazards.

The Engineer shall be granted access to such records at all times.

The Contractor shall conduct and document at least weekly inspections of the storage areas for equipment, transport vehicles and hazardous materials and substances, especially for spillages and leaks. The Contractor shall take adequate precautions and make adequate provisions, to the satisfaction of the Engineer, to prevent such spillages of toxic materials and substances from entering natural stream or areas outside the Site.

**(e) Other Measures for Safety**

Safety measures shall be taken for the following items (but not limited to):

- (i) Training
- (ii) Reporting
- (iii) Medical check-up and First Aid
- (iv) Emergency Plans
- (v) Fire Prevention and Protection
- (vi) Material Handling, Storage, and Disposal
- (vii) Electrical Safety
- (viii) Walking and Working Surfaces
- (ix) Confined Spaces
- (x) Control of Hazardous Energy (Lockout/Tag out)
- (xi) Fall Protection and Rope Supported Work
- (xii) Hand Tools, Power Tools, Pressure Vessels, Compressors, and Welding
- (xiii) Slings and Rigging Hardware
- (xiv) Hoisting and Pile Driving Equipment
- (xv) Equipment and operation for tunnel and road excavation
- (xvi) Mobile and Stationary Mechanized Equipment
- (xvii) Hazardous Waste Site Operations

- (xix) Drilling and Blasting Operations
- (xx) Concrete, Masonry Construction and Formwork
- (xxi) Steel Erection

#### (5) Measurement and Payment

All provision for planning, implementing, and maintaining the safety measures described in this Section for “Project Safety” shall be quantified in months and shall be paid as per contract price on the basis of the split distribution of a lump sum.

The contract price and/or unit rate shall be the full and the final compensation to the Contractor as per Clause 112.

Item No.	Description	Unit
<b>110</b>	<b>Project Safety</b>	
110-1	Project Safety during the construction period	month
110-2	Project Safety during the Defects Notification Period	month

### 111 SUPPLY OF PROJECT RECORD

#### (1) Scope and Description

This Clause covers the supply of digital record of project events in digital format (DVD/ Flash Drive) including the following:

##### (a) Photographs

The Contractor shall take construction photographs by using digital cameras with an automatic setting on the records of the date-month-year, as described below:

Items	Time to Shoot a Photo	Submission Time
Photographs at intervals of no more than 50 meters or other intervals as agreed by the Engineer along the route of the Works	Each month throughout the Works before the commencement of the work	With monthly report or as otherwise required by the Engineer
Photographs of each entire site (each work front), all the structure sites, or pertinent features		
Record of quarry sites, plant sites, camp sites including labour camps, haul roads, access road etc. with progress report		
Record of all accidents		
The same views from same points as above	Upon completion of all construction activities	With the Contractor's application for final payment

- Photographs shall be consistent with the number of photographs to be specified by the Engineer.
- The Contractor shall supply both “hard” (mounted on albums to serve as a permanent record of the work needed for an authentic documentation) and

- computerized copies of photographs as required by the Engineer. The Contractor shall provide the necessary software to the Engineer for computerized storage, editing, and reproduction of photographs.
- Each photograph shall have suitable captions.

**(b) Video Recording**

The Video Recording shall be taken by a professional with a digital camera capable to video images inside the tunnel or anywhere in the Project, having facilities to record the date and back ground commentary. The Contractor shall keep separate discs/drives, one with the Engineer and the other with the Employer and update the data in these disc/drives as per instruction of Engineer or on monthly basics.

The Video Recording shall be edited and compiled, based on the following specifications:

Video System:	DVD
Recording Time:	90 minutes
Language:	Both in Nepali and English versions
Copies:	Five (5) for each version
Subjects:	<ul style="list-style-type: none"><li>① Preconstruction conditions of the Project area</li><li>② Mobilization and site preparation</li><li>③ Installation of equipment and facilities</li><li>④ Installation of plant and plant under operation</li><li>⑤ Earthworks</li><li>⑥ Tunnel works</li><li>⑦ Pavement works</li><li>⑧ Construction of bridges and other structures (Roadside Service Station)</li><li>⑨ Electrical and telecommunication utilities</li><li>⑩ Laboratory and testing for quality control</li><li>⑪ Commencement and completion ceremonies</li><li>⑫ Testing and inspection for acceptance of the Works</li><li>⑬ Others as required by the Engineer</li></ul>

The Contractor shall submit, for the acceptance of the Employer, the outline of the narration process prior to the compilation of the video record. The final video record shall be produced by a specialized company acceptable to the Employer, and submitted to the Employer and the Engineer within thirty (30) days after the issuance of the Taking-Over Certificate

**(2) Measurement**

This item shall be measured in number of sets. Each set consist of two copies of all digital records as described above and colour record photographs both in digital format as well as mounted in the albums and the video recording files.

**(3) Payment**

The contract unit rate shall include all expenses for supply of project record including video

recordings updated as per direction of Engineer and paid on lump sum monthly basis throughout the construction period shall be measured as single set.

This payment shall be the full and the final compensation to the Contractor as per Clause 112 and for the cost of all operations, materials, equipment, laboratories, transportation, and any incidentals involved for completion of this item.

Item No.	Description	Unit
<b>111</b>	<b>Supply of Project Record</b>	
111-1	Supply of Project Record during construction period	month
111-2	Supply of Project Record final edition (28 days before issuance of Taking Over Certificate (TOC)). Mandatory Condition for TOC.	lump sum

## 112 NOTES ABOUT MEASUREMENT AND PAYMENT

### (1) Measurement

(30) Delete the full text of Clause 112(1): “Measurement” and replace with the following:

Unless specified, all measurements shall be made in metric system. Different items of work shall be measured in accordance with the procedures set forth in the relevant Sections read in conjunction with the General conditions of Contract. The same shall not, however, apply in the case of lump sum contracts.

All measurements and computations, unless otherwise indicated, shall be carried nearest to the following limits:

(i)	Length and Width	10 mm
(ii)	Height, Depth or Thickness of:	
	✓ Earthwork, Subgrade	5 mm
	✓ Sub-base, Bases, Surfacing	5 mm
(iii)	Structural Members	2.5 mm
(iv)	Areas	0.01 sq.m.
(v)	Volumes	0.01 cu.m.

In recording dimensions of work, the sequence of length, width and height or depth or thickness shall be followed.

The tolerances given in these Specifications are for the evaluation of the accuracy to which work has been constructed and for determining whether work should be accepted or rejected. The measurement of work done shall be based on the actual measured quantity of acceptable work executed except that, where the actual quantity is greater than the quantity which would have resulted from the precise designed or instructed dimensions and/or levels then the payable quantity shall be limited to the quantity determined on the basis of calculation using the designed or instructed dimensions and/or levels.

Measurement and payments shall be made after the contractor has executed the works and has been accepted in place to the full satisfaction of the Engineer.

The Works listed in the Bill of Quantities (BOQ) shall be measured, and valued for

payment, in accordance with these Specifications and the Preambles to the BOQ.

## **113 NATIONAL SPECIFICATIONS**

(31) *Delete the third (3<sup>rd</sup>) paragraph and list abbreviations of Clause 113 and replace it with the following:*

In referring to Specifications, the following hierarchy shall be used:

- i. NS : Nepal Bureau of Standards and Metrology
- ii. JIS : Japan Industrial Standards
- iii. IRC : Indian Road Congress
- iv. IS : Indian Standards
- v. BS : British Standards
- vi. ASTM : American Society of Testing and Materials
- viii. AASHTO : American Association of State Highway and Transportation Officials
- ix. ACI : American Concrete Institute
- ix. BSCP : British Standard Code of Practice
- x. ISO : International Organization for Standardization
- xi. EN : European Norm
- xii. Others as approved by the Engineer

## **115 UNITS OF MEASUREMENT, ABBREVIATION AND TERMINOLOGY**

(32) *Modify the title of Section 115 “Units of Measurement, Abbreviation and Terminology” and replace it with the following:*

### **115 UNITS OF MEASUREMENT, ABBREVIATION, TERMINOLOGY AND DEFINITIONS**

(33) *Delete the full text of Clause 115(4) “The Sections, Clauses and/or .....etc.” and replace it with the following:*

#### **(4) Definitions**

The words such as Contract, Contractor, Engineer / Engineer in Charge, Drawings, Defect Liability Period (or Defect Notification Period), Employer, Government, Works and Site used in this Specification shall be considered to have the meaning as specified in definitions of these terms given in Section VII: “General Conditions of Contract”, and/or Section VIII: “Particular Conditions of Contract” of the Bidding Documents.

Words and expressions to which meanings are assigned in any section of the conditions of contract or the specifications shall have the same meanings in any other sections of the bidding documents except when the context otherwise requires.

- (5) The Sections, Clauses and/or Sub-Clauses mentioned in these Specifications deem to apply those of these Specifications only, if otherwise not specified.

## 116 PROGRAMME

(34) Delete the full text of Section 116 “Programme” and replace it with the following:

### (1) Scope and Description

This Specification Section prescribes the form and contents of the Program of Work (hereafter referred as “the Program”). The Program described herein shall be interpreted, supplementary to, and without detriment to the stipulations referred to in Sub-Clause 8.3 “Program” of the Conditions of Contract.

The following definitions shall be referred to for proper interpretation of this Specification Section:

Program:	The Program shall govern the execution of the whole Works, and shall consist of all the plans, schedules, statements on the methods and procedures for construction, assignments of equipment and personnel, testing and trials, drawings, submittals, and the like required or mentioned in the Specifications, or required by any other part of the Contract.
Time Schedule:	The time schedule that shall be incorporated in the Program to show, describe, and monitor the progress, using the Critical Path Method (CPM) presented in the form of bar chart and showing other data herein specified.
Cash Flow:	The cash flow schedule, in accordance with the requirements of Sub-Clause 14.4 “Schedule of Payment” of the Conditions of Contract, shall consist of non-binding estimate of the payment which the Contractor expects to become due during each quarterly period.

### (2) Requirements

#### (a) General

Failure of the Contractor to comply with the requirements of the Contract shall be considered as a serious default of the Contractor in meeting his contractual obligations, resulting in a delay in the commencement of the activities for execution of the Works.

Unless otherwise specified in the Contract, the delay caused by the Contractor and its effect on the work progress will be estimated by the Engineer and settled in accordance with the stipulations of Sub-Clause 8.7 “Delay Damages” of the Conditions of Contract, at the time of taking-over of the Works.

In the event that the Contractor requests a change in the sequence in the Program and such change is approved by the Engineer, the Contractor shall have no claim as per the Conditions of Contract for delay arising from such revisions to the program.

#### (b) Requirements for the Program’s Composition and Contents

##### The Program’s Composition and Contents:

- ♦ The Program shall incorporate in detail all activities related to the Works from their commencement to their completion, taking into account all the main items introduced in the Bill of Quantities for each component of the Works.
- ♦ The Program shall be detailed enough to give, in addition to construction activities, detailed network activities for the submission and approval of



materials, procurement of critical materials and equipment, fabrication of special products/equipment's if any their installation and testing, and for all activities of the Engineer that are likely to affect the progress of work.

- ♦ The program shall also include the Contractor's general requirements for any road closures pursuant to Section 102: "Accommodation of Traffic" to be agreed in principle with the Engineer. Such agreement shall not relieve the Contractor of his responsibility to obtain specific approval for each closure or series of closures.
- ♦ Any proposal for night working shall also be stated in the Program but discussed based on the Conditions of Contract.
- ♦ The Program shall include, but not be limited to, the following:
  - Schedule (showing the critical path);
  - Contractor's mobilization and demobilization plan (the Contractor's Mobilization described herein shall be interpreted, supplementary to, and without detriment to the stipulations referred to in these Specifications, the Conditions of Contract or any other related stipulations of the Contractual Documents);
  - Schedule of arrival of all construction equipment and facilities as well as the arrival of the Contractor and Subcontractors personnel as defined in Sub-Clauses 1.1.2.7 and 1.1.2.8 of the Conditions of Contract respectively.
  - Schedule for completion of all temporary facilities
  - All submittals and drawings;
  - All plans and schedules;
  - All activities for site investigation;
  - All surveys and laying out;
  - All key and milestone dates (such as the dates for submittals of schedule, the dates for mobilization, the commencement/completion dates for the works of soft soil treatment, bridge construction, sub-base, Engineers' accommodation, etc.);
  - All interface dates between the Contractor and sub-contractors for the Works;
  - All activities associated with the procurement, purchase, fabrication and shipment of goods, materials, and equipment to be incorporated into the Works;
  - All public and site holidays; and
  - Other activities that the Engineer may require for monitoring.
- ♦ The construction schedule (the Program) prepared by the Contractor and progress by the charts, Critical Path Method (CPM) and S-curve shall be made using the latest version of software (tools) "Primavera P6: Professional Project Management". For this purpose the Contractor shall provide the required software and licenses at least for 3 users selected by the Engineer.

The Schedule's Contents:

- ♦ The schedule shall include a narrative statement and a logical breakdown of major activities. The narrative statement shall comprehensively describe the work execution plan, the achievement of milestones and any intermediate dates, the outline method statements for the major work items, temporary works, and the



like. It shall fully explain the reasons for the main logic links in the schedule, and shall include particulars on how activity durations are established.

- ♦ The details and number of activities incorporated in the schedule shall be sufficient to manage the total Works and to identify restraints, delays, and effects on the Works by dependent activities.
- ♦ All the activities shall be organized in a logical work breakdown structure, indicating work stages and phases, and shall have a code number for identification related to the work breakdown structure as well as a unique description.
- ♦ The schedule shall show activity durations, activity descriptions, early and late start and finish dates (all of them expressed in calendar days), and activity float and activity dependencies, applying the critical path method (CPM) of scheduling with all activities tied to only one start date and only one end date.
- ♦ All activities shall be cost-loaded (as appropriate) with schedule costs equivalent to the “Cash Flow” (S-Curve):
  - All activities shall be resource-loaded (as appropriate), indicating all manpower and/or equipment necessary to accomplish the activity within the given time duration.
  - Any activity having or creating an imposed constraint to the schedule shall be clearly defined and fully described.
  - The schedule shall be prepared by using a computer application approved by the Engineer for programming, and that has been provided in software by the Contractor with relevant licenses for both the Contractor and the Engineer.

**(c) Requirements for Submittal and Approval of the Program**

- ♦ The Contractor shall comply satisfactorily and without delay to the requirements herein specified regarding the composition and contents of the Program.
- ♦ After the Program has been reviewed by the Engineer, the Contractor shall, within fourteen (14) days after receiving the Engineer’s comments on the Program, incorporate the required corrections or modifications into the Program and re-submit it to the Engineer for approval.
- ♦ No more than two (2) submittals of the Program are required for the Engineer’s review, provided however that:
  - If additional submittals are required by actions of the Contractor, any delays shall be the Contractor’s responsibility.
  - The Employer may, at any time, after advising the Contractor of such additional costs for submittal review, recover such costs from money due or will be due to the Contractor.

**(3) Requirements for Updating the Schedule and Cash Flow**

Updating of the Work Program and Cash Flow (S-Curve) shall be made for monitoring of progress of works and shall be referred to the approved version of the Program but not substitute it.

The Work Program and Cash Flow shall be updated on monthly basis to reflect the actual work accomplished by the end of each month, and to facilitate the monitoring of payments.

In addition, an activity report, generated by the schedule computer program, shall be attached as an appendix to the Contractor's monthly report.

The above referred report shall include the following information and data for each activity:

- ♦ Activity identification number and description;
- ♦ Activity duration expressed in calendar days;
- ♦ Early and late start and finish dates for each activity, as well as planned start and finish dates;
- ♦ Calculated total and free float for each activity;
- ♦ Predecessors(s) and successor(s), accompanying relationships and lag/lead duration(s) for each activity;
- ♦ Imposed time or date constraints on each activity;
- ♦ An activity calendar;
- ♦ Critical path delay; and
- ♦ All activities that have a negative float shall be identified and analysed to identify the impact on the timely completion of the Works.

#### (4) Measurement and Payment

Unless stated otherwise, no separate measurement and /or payment shall be made for all materials and works required under this Section. All costs in connection with the work specified herein shall be considered to be included with other related items of the work in the Bill of Quantities.

- (35) *Add the following new Sub-Section 117: "Contractor's Drawings" and Sub-Section 118: Insurance and Warranty" at the end of Section 100, after Sub-Section 116: "Programme" and before Section 200: "Site Clearance":*

## 117 CONTRACTOR'S DRAWINGS

### (1) Description

This section consists of the requirements for preparation of drawings by the Contractor.

Without detriment to the stipulations shown in the Conditions of Contract, and this Section 6(b): Special Provisions to the Standard Specifications, The Contractor shall prepare and submit the following documents:

<b>Shop Drawings:</b>	<p>The Contractor shall submit to the Engineer, for his check and approval, Shop Drawings of relevant works or components at least 28 days before the intended start of works or fabrication of components.</p> <p>These drawings shall show all necessary details required for execution of the Works including (but not limited to) the following:</p> <p>(a) Details as per site conditions for construction of the Works based on the Drawings comprised in Part 2: "Works Requirements", Section VI-D of the Bidding Documents, and in accordance with all pertinent stipulations of the General Conditions of Contract and Particular Conditions of Contract.</p> <p>(b) Fabrication details, including materials used for fabrication or workshops to use in fabrication of components necessary for the Works, Plant or other equipment to be</p>
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<b>Construction Drawings</b>	installed.
<b>Working Drawings:</b>	Those Shop Drawings approved by the Engineer as the Drawings “good for construction”
<b>As-Built Drawings:</b>	<p>(c) Detailed design calculations and drawings for all Temporary Works (such as from-work, staging, centring, specialized constructional handling and launching equipment and the like);</p> <p>(d) Detailed drawings for templates, support and end anchorage, details for pre-stressing cable profiles, bar bending and cutting schedules for reinforcement, material lists for fabrication of structural steel, works for tunnelling construction, etc.</p> <p>(e) Detailed drawings prepared based on the approved Shop Drawings and Working Drawings used for performing the Works, showing in detail all the works as actually constructed</p>

## (2) Requirements

### (a) General

- (i) The Contractor shall be responsible for the following:
  - Confirmation and correlation of all incorporated information;
  - Accuracy of all dimensions and quantities;
  - Information pertaining to the fabrication and construction method;
  - Handling and conservation of all the drawings in good condition; and
  - Delays in the submittals
- (ii) The Contractor shall provide all the necessary information to substantiate that all materials and/or plants incorporated into the Works, conform to and meet or exceed the requirements of the Specifications and/or the Drawings.
- (iii) The Contractor shall provide all necessary and/or required drawings, calculations, and certifications for all temporary works as required or described in the Specifications.

### (b) Requirements for the Contractor's Drawings Preparation

- (i) All the Contractor's Drawings shall be prepared using Auto-CAD 2016 or a later version, in a format previously approved by the Engineer.
- (ii) Notes shall be written in English.
- (iii) All dimensions shall be in the metric system.
- (iv) The format of the Contractor's Drawings shall be as approved previously by the Engineer.
- (v) The Contractor's Drawings shall be stamped “Submitted for Approval for Construction” and shall be signed by the Contractor's expert designated as the Quality Control Manager.
- (vi) Design notes, calculations, lists, reports, descriptions, catalogue cuts, and other non-drawing submittals shall be submitted in A4 size sheets, in lieu of the size mentioned above.
- (vii) Unless otherwise specified, each submittal of the Contractor's Drawings shall consist of three (3) copies and shall be submitted to the Engineer, one (1) set of which will be returned to the Contractor with revisions, if needed, noted thereon.
- (viii) Editable electronic files, in the approved application form for the Project,

of the Contractor's Drawings subject to the Engineer's approval, shall be provided to the Engineer after issuance of the respective approval.

- (ix) Submittals without the required signatures and seal will not be accepted and will be returned to the Contractor without action.

**(c) Requirements for Submittal and Approval**

**(i) Submittal Schedule (the Drawings' Schedule)**

- The Drawings' Schedule shall be prepared in close relation, and showing solid consistency with a program specified under Sub-Clause 8.1 of the Conditions of Contract and Sub-Section 116: "Programme" of these specifications.
- Incorporating in a program, the Contractor shall prepare and submit a submittal schedule (hereafter referred as the Drawings' Schedule), noting all required information and data required for the Contractor's Drawings.
- The Drawings' Schedule shall be used as the document for monitoring the submittals, and to register the approvals, throughout the Contract.
- The Drawings' Schedule shall contain, but not be limited to, the following:
  - ♦ A list of the Contractor's Drawings to be submitted well in advance of the construction activities shown on a program. Such drawings shall be classified by type (i.e., shop drawings, working drawings, as-built drawings or unclassified drawings);
  - ♦ A bar schedule of the main submittals showing the main work items of the critical path as the milestone of each submittal; and
  - ♦ A list and schedule of the main tests for materials and trials to be subject to approval by the Engineer for the main work items. This list shall include also the submittals of certifications from the suppliers.
- The registry of each submittal shall contain the following:
  - ♦ A description of each submittal and its contents, including applicable specification identification;
  - ♦ Statement if the submittal is for information, or to receive the Engineer's consent or approval;
  - ♦ The dates of the submittal: date of submittal to the Engineer and the expected date for return of the submittal;
  - ♦ In the event that a re-submittal is required, besides the new dates, it shall contain the status of the returned submittal (i.e., approved as noted, the comments, or rejected); and
  - ♦ In the event that a deviation regarding the requirements shown in the Drawings and the Specifications is detected, it shall be clearly stated by the Contractor in the respective submittal.
- The Drawings' Schedule shall be updated monthly or when required by the Engineer.
- The Contractor shall include in his monthly report, a summary

describing the existing conditions and the progress of his Drawings' Schedule.

(ii) Requirements and Procedure for the Approval

- Submittals of the Contractor's Drawings shall be made in complete packages according to the approved Drawings' Schedule, and shall include all necessary information to allow a verification of conformity with the requirements of the Contract, the Drawings and the Specifications.
- Upon receipt by the Engineer of a submittal package, it will be evaluated for completeness and the Contractor will be notified of any deficiencies therein.
- The Engineer will review the submitted drawings to determine that general conformity with the design concept and general compliance with the information given in the Contract Drawings and the Specifications have been accomplished.
- Any work done by the Contractor prior to the Engineer's review of the submitted drawings shall be at the Contractor's sole risk.
- The Engineer may request additional details and require the Contractor to make changes in the submitted drawings which are necessary to conform to the provisions shown in the Contract Drawings and the Specifications (without additional cost to the Employer).
- After review, the Engineer will return one (1) set of submitted drawings to the Contractor. Returned drawings will be stamped with the Engineer's review stamp to indicate the following:
  - ♦ **Approved:**  
The submitted Contractor's Drawings have been reviewed and do not require re-submittal
  - ♦ **Approved as Noted:**  
The submitted Contractor's Drawings have been reviewed and the Contractor shall incorporate the comments as noted in the drawings. The reviewed Contractor's Drawings do not require re-submittal.
  - ♦ **Reviewed and Resubmit:**  
The submitted Contractor's Drawings require corrections or redrawing and shall be resubmitted for further review. If the submitted drawings are returned for correction or redrawing, corrections shall be made and the Contractor shall resubmit them in the same manner as the first submittal. Specific notation shall be made on the resubmitted drawings to indicate the revisions made.
- The Contractor's Drawings that have been evaluated by the Engineer as "Approved as Noted" shall be registered for the update of the Drawings' Schedule and shall form part of the Construction Drawings that shall be available at the Site at all times.
- Any approval, check, certificate, consent, examination, inspection, instruction, notice, proposal, request, test, or similar act by the

Engineer (including absence of disapproval) shall not relieve the Contractor from any responsibility he has under the Contract, including responsibility for errors, omissions, discrepancies and non-compliances.

**(d) Particular Requirements for the “As-Built Drawings”**

- The requirements established in this Clause for completion of the Construction Drawings shall first be satisfied by the Contractor, and approved by the Engineer.
- Based on the above condition, the Contractor shall prepare in consultation with the Engineer, the final format to be used for preparation of the as-built drawings (including relevant documents such as drawings, completed quantities, and backup data).
- The completion and submittal of the “As-Built Drawings” is a mandatory condition for the issuance of the Taking Over Certificate. Therefore, it shall be made in accordance with these Specifications, and in accordance with Clause 4.1: “Contractor’s General Obligations”, Sub-Clause(d) of the Conditions of Contract, and all related procedures and stipulations of the contract.

The “As-Built Drawings” shall be submitted, for review and approval by the Engineer, 28 days before the commencement of Test on Completion (Clause 9: “Test on Completion” of the Conditions of Contract).

The procedure specified in Sub-Clause 10.1 of the Conditions of Contract for the issuance of the “Taking-Over Certificate”, may be suspended if the “As-Built Drawings” are not prepared and submitted as specified herein.

- The Contractor shall initially submit two (2) sets of quality prints of the as-built drawings to the Engineer for review, comments, and approval. As-built drawings shall be submitted in turn according to the completed schedule.
- After all corrections or comments as required by the Engineer have been addressed, and the “As-Built Drawings” have been approved, the Contractor shall submit to the Engineer the following:
  - ♦ One (1) original and six (6) clear photocopies, and
  - ♦ One (1) computer disk copy containing the electronic files of all drawings in an editable version by the approved application for the Project.

**(3) Drawing Copyrights**

The rights for using, copying, or reproducing, partly or entirely, all or any of the drawings prepared by the Contractor as herein specified, are reserved and belong to the Employer at any time or in any situation.

**(4) Measurement and Payment**

Excepting for the “As-Built Drawings” and unless stated otherwise, no separate measurement nor payment shall be made for all preparation and submittals of the



“Contractor’s Drawings” required under this Clause. All costs in connection with the work specified herein shall be deemed included in the rates and prices of other related items of the work in the Bill of Quantities.

The preparation and submittal of the “As-Built Drawings” shall be measured and paid in “lump sum” (single instalment to be made upon the approval of the Drawings by the Engineer) which shall be the full and the final compensation to the Contractor as per Clause 112 and for the cost of all operations, materials and incidentals involved for completion of this item.

Item No.	Description	Unit
117	Contractor’s Drawings	
117-1	As-Built Drawings (Mandatory Condition for TOC’s issuance).	lump sum

## 118 INSURANCE AND WARRANTY

### (1) Description

- These requirements shall be read and applied accordingly, and without detriment, to the requirements and provisions of Clause 18 “Insurance” of the Conditions of Contract.
- The Contractor shall provide an evidence of insurance policies prior to the start of the Works.
- With each application for Interim Payment Certificate under Sub-Clause 14.3 of the Conditions of Contract, the Contractor shall submit evidence consisting of receipts of payment or other verification as approved by the Employer that insurance policies are in effect.
- The Contractor shall be responsible for all the costs for the warranty period of the Works in accordance with the related provisions of the Conditions of Contract.
- The following securities shall be provided by the Contractor:
  - ♦ Performance Security
  - ♦ Insurance of the Works
  - ♦ Insurance of Contractor’s Equipment
  - ♦ Third-Party Insurance

The lump sum price for insurances includes all expenditures expected in providing and maintaining from Date of Commencement till end of Defect Liability Period, including expenditures resulting from administration work, dealing with and reporting of claim, stamps duties, taxes, etc.

In case of any damages to the works for which the payment has been made by the Employer, it’s the Contractor's obligation to reconstruct the same and claim for the payment from the insurance companies. No payment for the reconstruction of the damaged works shall be made by the Employer.

### (2) Measurement and Payment

Measurement and payment for provision and administration of the Insurances shall be on

“lump sum” basis for all expenditure with regard to the provision of Insurances.

Payment of the lump sums shall be made under the relevant items in the Bill of Quantities on submission to the Engineer of acceptable Insurance policies, as required by the Conditions of Contract, with proof of payment of Insurance premiums. Where premiums are for one year only, 35% of the quoted lump sum shall be paid for the first year of the Contract period with a further 35% being paid on presentation of proof of payment of premiums for the rest of the construction period and the remaining 30% being paid on presentation of proof of payment of premiums for the Defects Notification Period.

<b>Item No.</b>	<b>Description</b>	<b>Unit</b>
118-1	Performance Security	lump sum
118-2	Insurance of the Works	lump sum
118-3	Insurance of Contractor's Equipment	lump sum
118-4	Third-Party Insurance	lump sum



## **SECTION 200: SITE CLEARANCE**

### **201 CLEARING AND GRUBBING**

#### **(2) Description of Work**

(1) *Insert the following at the end of the Sub-Clause 201(2)(d) “Conservation of Flora”:*

##### **(e) Clearing of Landslides**

When instructed by the Engineer, the Contractor shall remove all debris from landslides as soon as possible after receiving instruction. The first priority will be the removal of material to maintain safe vehicular access and the second to remove material in order to continue construction of the works. The Engineer shall determine the amount of the material to be removed and/or any further work which may be required to stabilize the landslide.

Where a landslide has occurred in an area where the Contractor has commenced but not completed excavation works of any nature and such excavation works have, in the opinion of the Engineer, been the direct or indirect cause of the landslide, the responsibility for clearing and stabilizing the landslide shall rest entirely with the Contractor. Elsewhere the volume of material directed to be removed shall be measured in cubic meter.

##### **(f) Clearing of Debris**

The Contractor shall remove all debris from causeways, culverts and side drains as per the instruction of the Engineer.

#### **(4) Measurement**

(2) *Insert the following at the end of the Clause 201(4) “Measurement”:*

Works related with Conservation of Topsoil and Conservation of Flora including excavation, conservation (or disposal if so instructed by the Engineer), haulage within 2.0Km including all incidentals for a proper stockpiling in an area approved by the Engineer, shall not be measured separately but deemed included in the respective main items for earthworks. In case that, further works for topsoil or planting can reuse these material, respective measurement and payment shall be made under respective clauses of Section 2800: “Bio-Engineering Works” as applicable and as approved by the Engineer. In such case, the measurement for reuse shall include hauling from the stockpiles, and related works for placing in Site and incidentals, but not the cost for soil as material itself to be reused, and excluding all cost and incidentals already included in the measured items of this Section.

Landslides and debris removed as per this specification shall be measured in cubic meter. Debris clearance from causeways, culverts and side drains shall be measured for one time only at the starting of the contract. Afterwards, debris clearance shall be covered by the Routine Maintenance.

Clearance of debris from box and pipe culverts and side drainages including haulage and disposal within 2.0Km including all incidentals for a proper completion, and approved by the Engineer, shall be measured in cubic metres.

## (5) Payment

(3) *Insert the following at the end of the Clause 201(5) "Payment":*

No payment shall be made in respect of clearing and grubbing carried out at the sites of quarries, borrow pits, Contractor's facilities or any other area other than those areas specifically directed by the Engineer to be cleared and grubbed for the execution of the permanent works."

Clearing of Landslide and Debris shall be paid at their respective contract unit rates which shall be full and final compensation to the Contractor as per Section 112 herein described. However, for the works for "Cutting trees including stumps & roots removal of girth and compacted backfilling", the Contractor shall do an estimation of total number based on the information available regarding to Environment, or by himself. These quantities shall be verified and confirmed by the Contractor, and approved by the Engineer, during execution of the Works.

No payment shall be made for the removal of the landslide of less than 20 cubic meters nor for the first 20 cubic meters in any one occurrence.

Item No.	Description	Unit
<b>200</b>	<b>Site Clearance</b>	
<b>201</b>	<b>Clearing and Grubbing</b>	
201-1	Clearing and Grubbing and Conservation of Top-Soil	sq.m.
201-2	Cutting trees including stumps & roots removal of girth and compacted backfilling above 300 mm to 600 mm	No.
201-3	Cutting trees including stumps & roots removal of girth and compacted backfilling above 600 mm to 900 mm	No.
201-4	Cutting trees including stumps & roots removal of girth and compacted backfilling above 900 mm	No.
201-5	Clearance of debris from box and pipe culverts and side drainages including haulage and disposal within 1.0Km	cu.m.

## 202 DISMANTLING CULVERTS, BRIDGES, OTHER STRUCTURES AND PAVEMENT

### (1) Scope

(4) *Insert the following at the end of the Clause 202(1) "Scope":*

The Engineer shall designate all materials arising from dismantling as:

- (i) Scrap to be disposed of by the Contractor, or
- (ii) Salvageable material to be reused in the Works, or
- (iv) Salvageable material to be retained by the Employer

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**(3) Dismantling Culverts and Bridges**

- (5) *Add the following new Clause (3): “Submittals” after the last paragraph of Clause 202(2): “General” and renumber all Clauses from Clause 202(4) “Dismantling Culverts and Bridges”:*

**(3) Submittals**

The Contractor, prior to the commencement of any work, shall prepare and submit to the Engineer, for respective approval, the following:

- (a) Shop Drawings in accordance with the requirements herein described in Sub-Section 117: “Contractor’s Drawings”, including detailed information regarding to all bridges, drainage structures, curbs, pavements, buildings, etc. to be dismantled and removed in accordance with the provisions and indications these Specifications.
- (b) Complete details of the method, equipment, and schedule to perform the dismantling and removal work pertinent to this item.
- (c) Inventory of the materials that could be recovered from demolition work and stockpiling of suitable materials from stripping that the Contractor intend to use for other items.
- (d) Detailed drawings showing disposal areas for non-reusable materials arising within the Site, or areas for stockpiling of the recovered materials planned to be used for other items.

**(4) Dismantling Culverts and Bridges**

- (6) *Insert the following after the last paragraph of the renumbered Clause 202(4) “Dismantling Culverts and Bridges”:*

Particular Requirements:

- (i) Culverts, bridges and other drainage structures which still been used by traffic shall not be removed until satisfactory arrangements have been made to accommodate the traffic in accordance with the stipulations of Sub-Section 102: “Accommodation of Traffic” and other relevant specifications.
- (ii) The removal of existing culverts within embankment areas shall be required only as necessary for the installation of new structures. Abandoned culverts shall be broken down, crushed, and sealed or plugged.
- (iii) All culvert sections removed, which are not designated for stockpiling or relaying, unless otherwise directed by the Employer, shall become the property of the Contractor and shall be removed from the Project or disposed of in a manner approved by the Engineer.
- (iv) Unless otherwise directed, the substructures of existing structures shall be removed down to the natural stream bottom and those parts outside the stream shall be removed down to at least 300 mm below the natural ground surface.
- (v) Where such portions of the existing structures lie wholly or in part within the limits of a new structure, they shall be removed if necessary to accommodate the construction of the proposed structure. Where only a section of the existing structure is to be demolished, the Contractor shall execute the work in such a manner as to avoid

damage to the section designated to remain. All details of the Contractor's proposed working methods shall be submitted to the Engineer for approval.

- (vi) Any structures designated to become the property of the Contractor shall be removed from the right-of-way.
- (vii) Existing bridges or other structures, when specified by the Engineer to be salvaged, shall be carefully dismantled without damage. Salvaged members shall be match-marked before dismantling, unless the Engineer waives such match marking. All salvaged materials shall be stored as requested by the Engineer.
- (ix) Unless otherwise waived by the Engineer in writing, all concrete removed that is of a suitable size for rip-rap and not needed for such use on the Project, shall be stockpiled at locations designated by the Engineer, for use by the Employer.

**(5) Dismantling Other Structures and Pavements**

- (7) *Insert the following new Clause after the last paragraph of the renumbered Clause 202(5) "Dismantling Other Structures and Pavements", and renumber the Clauses for Back-filling, Measurement and Payment:*

**(6) Removal of Buildings and Structures**

In dismantling existing building and other structures (not included in previous Clause (5): "Dismantling Other Structures and Pavements"), the Contractor shall satisfy the following particular requirements:

Particular Requirements:

- (a) Upon receipt of notification by the Engineer, the Contractor shall take over all responsibility for the vacant buildings or buildings previously acquired, and shall proceed with the removal thereof as specified.
- (b) Unless otherwise indicated in the Drawings or directed by the Engineer, the Contractor shall complete the demolition and removal of buildings and structures together with all foundations and retaining walls, piers, partitions, and columns down to a plane 30 cm below the ultimate grade in the area.
- (c) Walls shall be broken into pieces not exceeding 60 cm<sup>2</sup> for any area of surface, mixed with previous backfill materials and placed in basement areas.
- (d) Basement floor slabs shall be broken and displaced into pieces not exceeding 60 cm<sup>2</sup> for any area of surface and shall be left in place. Excess debris shall be removed and disposed of. All other foundations, concrete floor slabs, sidewalks, signs, sheds, garages, and fences and all other incidental and collateral work necessary to fully complete the removal of buildings and appurtenances shall be removed and disposed of as directed.
- (e) The Contractor shall inspect each building to be removed and determine for himself the work involved and the equipment and materials required for such demolition work.
- (f) The Contractor shall arrange for the disconnection of all utility services that serve the building or buildings in accordance with the respective requirements and regulations of the relevant government authorities and utility agencies involved.
- (g) The Contractor shall disconnect and properly seal, in a manner approved by the relevant local government agency or agencies responsible and the Engineer, all sewer

- outlets that serve any building or buildings that the Contractor is directed to remove.
- (h) The Contractor shall keep the Engineer informed of his plans for the performance of any work in connection with the sealing off of such outlets in order that proper inspection may be provided at the time the work is performed.
  - (i) The Contractor shall conduct his operations in such a manner as to avoid potential hazards to persons and vehicles. Once a work on any building has commenced, the work shall be continued promptly and expeditiously until completion.
  - (j) All debris shall be removed from basement areas and concrete floors shall be broken. The area shall then be filled with previous backfill material simultaneously with the breaking of the foundation walls so that the previous backfill material will be well integrated with the pieces of broken concrete.
  - (k) Concrete slabs resting on earth and forming walks, driveways, or the first floor slabs of buildings without basements, except as indicated in the Drawings, shall be broken up and removed from the Site.
  - (l) The Contractor shall be responsible for the removal of any additional small buildings or miscellaneous structures which have not been indicated in the Drawings.
  - (m) Existing underground storage tanks on the Site or within the buildings shall be removed and disposed of by the Contractor. The Contractor shall take all necessary measures and precautions during the removal and disposal of the liquid, sludge or other waste materials from the tanks as well as the removal of the existing tanks. The Contractor shall backfill with fine aggregate the areas where the tanks are removed. This backfill shall be in accordance with the specifications herein described.
  - (n) Operations necessary for the removal of an existing structure or obstruction, which may damage new construction, shall be completed prior to placing the new work, unless otherwise stipulated in the Contract Documents.

**(7) Back-filling**

- (8) *After renumbering, delete the existing Clauses for Measurement and Payment, and insert the following revised Clause after Clause 202(7) "Back-filling":*

**(8) Measurement and Payment**

Prior to commencement of dismantling, the work of dismantling structures shall be measured in the units given here below.

Associated works like disposal, stockpiling, marking and numbering, etc., shall not be measured separately but deemed included in the respective main items.

Payment for dismantling shall be made after the completion of all the works herein specified and successful disposal of cleared materials.

The various dismantling works shall be paid at their respective contract unit rates which shall be the full and the final compensation to the Contractor as per Clause 112 and for the cost of all operations involved for completion of this item.

Item No.	Description	Unit
<b>202</b>	<b>Dismantling Culverts, Bridges, other Structures and Pavement</b>	
202-1	Dismantling brick masonry	cu.m
202-2	Dismantling stone masonry	cu.m
202-3	Dismantling concrete (Plain and reinforced)	cu.m
202-4	Dismantling gabion	cu.m
202-5	Dismantling steel structures	ton
202-6	Dismantling timber structures	cu.m
202-7	Dismantling pipes internal diameter less than 1200mm	lin.m
202-8	Dismantling kerbs and gutters	lin.m
202-9	Dismantling asphalt pavement and footpaths	cu.m

## **SECTION 300: BLANK**

(1) *Add in this Blank section, the following New Section 300:*

## **SECTION 300: SOIL IMPROVEMENT**

### **301 REINFORCED SOIL**

#### **(1) Scope**

The work covers construction of reinforced soil structures together with the construction of earthwork in layers, assembly and placing of reinforcing elements and facia elements during the construction process and all associated works.

The work shall include the design and construction of the reinforced soil structure and ground improvement measures required, if any.

The reinforced soil retaining structures can be used as, (i) Reinforced soil wall or (ii) Reinforced soil slope

Reinforced soil structures with slope face angles steeper than 70° are categorized as “reinforced soil walls” and those with slope face angle less than 70° are considered as “reinforced soil slopes”.

#### **(2) Design**

The following standards for design and construction of reinforced soil walls shall be applied:

- ♦ Standards for Design and Construction of Reinforced Soil Walls. Japan Road Association 2004.
- ♦ Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes. FHWA-NHI

or equivalent as approved by the Engineer.

#### **(3) Reinforcing Element**

The following Geotextile, Geogrids and other Geosynthetic materials might be used as Reinforcing Elements:

##### **(a) Reinforcing Geosynthetics**

High strength high tenacity geotextile fabrics used as reinforcement in the construction of reinforced slopes or in the base of reinforced soil structure as reinforcement, shall be considered as reinforcing element and shall satisfy all the requirements stipulated for geosynthetic reinforcing elements, in Clause 2407 and Clause 2408.

Geotextile fabric used for separation, filtration and/ or drainage shall satisfy the requirements given in relevant Clauses of Section 2400: “Miscellaneous Structures”.



The manufacturer of geogrids, geotextiles, geostrips, polymeric strips or straps, polymeric ties or any other geosynthetic material, including any proprietary geosynthetic material, for use as reinforcing element shall fulfil the following requirements:

- ♦ Shall have ISO (ISO-9001) or CE Certification for manufacturing process and quality control, and
- ♦ The product shall have certification for use as soil reinforcing material from an agency accredited for certifying geosynthetic reinforcement products like: BBA or NTPEP.
- ♦ The manufacturer shall provide test reports from an independent laboratory with valid accreditation, for all the tests needed to establish all the reduction factors listed below
  - RF<sub>CR</sub>: Reduction factor for creep.
  - RF<sub>ID</sub>: Reduction factor for installation damage
  - RF<sub>W</sub>: Reduction factor for weathering
  - RF<sub>CH</sub>: Reduction factor for chemical/ environmental effects.
  - f<sub>s</sub>: Factor for the extrapolation of data

All the above factors shall be determined in accordance with the provisions of ISO/TR 20432- “Guide to the determination of long-term strength of geosynthetics for soil reinforcement.” No default reduction factors shall be used in design.

#### **(b) Test and Standard of Acceptance**

Test for the ultimate tensile strength shall be carried out on a random sample for each grade of reinforcement as per ISO-10319: “Geosynthetics: Wide-width tensile test”. The test results shall be accompanied by stress-strain curves showing strength at 2% and 5% strain and strain/elongation at failure.

The manufacturer shall also provide the results of ultimate tensile strength for each lot and all grades of reinforcement proposed for use in the project.

Annual Average Daily Temperatures (AADT)/ design temperature of the project site shall be worked out and values of reduction factor for creep R<sub>FCR</sub> and for R<sub>FCH</sub> shall be provided as per procedures given in ISO/TR-20432: “Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement”.

The manufacturer / Supplier shall provide values of:

- ♦ Pull-out coefficient as per ASTM D6706: “Standard Test Method for Measuring Geosynthetic Pull-out Resistance in Soil” or EN13738 “Geosynthetics- Determination of pull out resistance in soil” and
- ♦ Coefficient of interaction between reinforced fill soil and geogrids as per ASTM D5321: “Standard Test method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear



method” or as per IS: 13326: Part 1-1992 “Method of test for the evaluation of interface friction between geosynthetics and soil: Part 1 Modified direct shear technique” for all types of geogrids.

Each roll shall have at least one identification label with roll number and product type.

#### (4) Earth fill

The fill in the reinforced soil zone shall have drained or effective angle of friction not less than 28°, measured in accordance with IS: 2720 (Part 13), by conducting a drained direct shear test. In case the fill material has 25 percent or more particles of 4.75 mm or larger, drained shear test using large shear box may be conducted (IS: 2720: Part 39: Section 1) . The gradation of fill soil shall be as per following limits.

Sieve Size.	Percentage passing (AASHTO T27 & T11)
40 mm	100%
425 micron	0 – 60%
75 micron	Less than 15%
PI	≤6

Materials with more than 15 percent passing 75 micron sieve, but less than 10 percent of particles smaller than 15 microns are acceptable provided that PI is less than 6 and angle of friction is not less than 30°.

Fly ash may be used as fill material in reinforced soil walls provided its angle of internal friction is not less than 30° and PI is less than 6. Grading requirements need not be completely satisfied. Reference may be made to IRC Guide lines on Use of Fly-ash in Road Embankments (IRC SP-58).

The fill material used in the reinforced soil zone shall be free from organic or other deleterious materials and shall not react adversely (chemically, electrically or biologically) with the reinforcement material and / or facia material.

Properties of fill soil in the reinforced zone, unreinforced zone (or retained/back fill) soil and the foundation soil shall be determined accurately during the construction phase, as per quality assurance plans and directions of Engineer so as to ensure that these are the same as those considered in the design phase.

The fill soil in the unreinforced zone shall conform to the requirements specified in the design.

#### Environmental Conditions of Fill:

Where geosynthetic reinforcement is used for reinforcing elements manufactured from polyester yarn, pH value of the fill material shall be between 3 and 9, and for reinforcing elements manufactured from PVA, PP and HDPE, the pH value shall be greater than 3.

#### (5) Material

##### (a) Facia Material

The facing system shall consist of Gabion with integrated reinforcement or Metallic prefabricated in different shapes including double twisted woven steel wire mesh, as shown in the Drawings or as approved by the Engineer.

Facing shall be sufficiently flexible to withstand any deformation of the fill and foundations.

♦ Gabion Facia:

Where gabion facia is used, it shall conform to the provisions of BS: 8006-1: 2010 and EN-14475 and made of mechanically fabricated and mechanically selvedge double twisted hexagonal mesh. Wire used for the double twisted mesh shall be hot dip galvanized as per NS-163, with wire and mesh properties in accordance with EN 10223 with minimum Zn or Zn-Al alloy coating as per EN 10244 and 0.5 mm nominal thick polymeric (e.g. PVC, PA6, etc.) coating as per EN 10245.

♦ Woven Steel Wire Mesh:

Where mechanically woven steel wire mesh in wrap around form is used for facing, the steel wire mesh as per IS: 16014, shall be with mechanical selvedging and bottom panel shall continue as an integrated tail mesh.

**(b) Connection between the Facia and Reinforcement**

In case of gabion facia and woven steel wire mesh facia, where the reinforcement is held by friction between the facia block and the primary reinforcement, the results of pull-out test as per EN-13738 : “Geosynthetics- Determination of pull out resistance in soil”.

**(6) Construction Details**

**(a) Depth of Foundation**

Foundation shall be prepared as shown in the Drawings, and provided at founding level to receive the facia or the bottom most reinforcement.

For gabion around facia the strip footing is not required but the foot print shall be compacted to 95 % of maximum proctor density and/or a coarse gravel base shall be provided.

The depth of embedment below the finished ground level at the foot of the wall shall not be less than 1000 mm. In case rock is met above founding level, the depth of embedment shall be adjusted as per ground conditions.

**(b) Laying of Reinforcement**

Reinforcing elements such as geogrids, shall be stretched and held taut by driving nails or pegs at the farther end.

**(c) Drainage**

Drainage bay shall be provided as shown in the Drawings. The width of the drainage bay shall be 600 mm behind the facing element, or as shown in the Drawings.

Alternatively geosynthetic drainage composite can be used which shall meet filter criteria and flow requirements.

The drainage material shall conform to the specifications of the filter media as per Clause 3110 of this Specifications.

Where reinforced soil retaining walls are provided to support hill cuts, the face of the hill cut is to be considered as a retained fill. To ensure that the runoff and surface water is drained, a drainage bay should be provided between the retained soil and the reinforced soil to ensure proper drainage. The drainage bay should be designed to carry the discharge and should be provided vertically or parallel to the face at the back of the retained fill and continued in a horizontal extent to a depth well below the toe of the Reinforced soil retaining wall and lead to a drain meant to carry the discharge away from the Reinforced soil retaining wall.

#### **(d) Laying and Compaction**

The reinforcing elements shall be laid free from all kinks, damage and displacement during placing, spreading, levelling and compaction of the fill. The programme of filling shall be such that no construction plant moves directly on the reinforcement.

All construction plant having a mass exceeding 1500 kg shall be kept at least 2.0 m away from the face of slope or wall.

In the area up to 2.0 m from the face of slope or wall, the following compaction plant shall be used:

- ♦ Vibratory roller having a weight per metre width not exceeding 1300 kg with total weight not exceeding 1500 kg
- ♦ Vibratory plate compactor of maximum weight 1000 kg
- ♦ Vibro-tamper having a weight not exceeding 75 kg

Before allowing the movement of vehicles over the reinforcement, a minimum compacted thickness of 150 mm shall be provided over the reinforcement and the speed of the vehicles shall be restricted to 10 km/hr.

During construction of reinforced fill, the retained material beyond the reinforcement at the rear of the structure shall be maintained at the same level as reinforced fill.

Fill shall not be placed on surface that contains mud, organic soil or area that have not met compaction requirement.

The thickness of compacted layer shall not be more than 300 mm, compacted to 97 per cent of maximum laboratory density measured as per IS: 2720 (Part 8).

#### **(e) Rock Anchor and Connecting Fittings**

- ♦ Rock Anchor shall consist of the construction of re-bar and grout as shown in the Drawings, and shall meet the requirements of Section 2014: "Reinforcement" of these Specifications.

- ♦ Connecting fittings shall have sufficient tensile strength and also shall have the function to connects the geotextile with panel skin wall/anchor bar properly

## (7) Measurement

Filling embankment shall not be measured nor paid under this Section. All works and materials for filling embankment for Soil Reinforcement shall be measured in cubic metres and paid under Section 900: "Earthworks", Pay Item 900-4: "Filling in Reinforced Soil Zone".

Sub-surface drains used in reinforced walls shall not be measured nor paid under this Section. All works and materials for sub-surface drains shall be measured and paid accordingly under Section 2404: "Sub-surface Drains".

### (a) Reinforced Soil Wall

The measurement for payment for reinforced soil wall shall be in square metres of finished work of each face and shall be measured in the plane of final inclination specified in the drawings. The measurement of length shall be the finished work along the length of the road. The measurement of height along the slope shall be done from the top level of the footing on which the fascia element is placed to the top of the capping beam.

### (b) Reinforced Soil Slope

The measurement for payment for reinforced soil slope shall be in square metres of finished work of each face and shall be measured in the plane of final inclination specified in the drawings. The measurement of length shall be the finished work along the length of the road. The measurement of height along the slope shall be done from the top of the levelling pad where provided, to the top of the embankment. Where levelling pad is not provided, the height shall be measured, in the final plane of inclination specified in the drawings, from the bottom of the slope face.

## (8) Payment

Reinforced Soil Wall and Reinforced Soil Slope actually completed and approved by the Engineer, measured as stated above, shall be paid at the respective contract unit rates. In addition to Clause 112, the Contract unit rate shall be full and final compensation for cost of investigation, design and construction of ground improvement measures, including all materials such as fascia, reinforcing elements, any incidental to complete the works as shown in the Drawings and as specified herein.

Item No.	Description	Unit
<b>300</b>	<b>Soil Improvement</b>	
<b>301</b>	<b>Reinforced Soil</b>	
301-1	Reinforced Soil Wall, Type-1 (expanded metal 1:0.1)	sq.m.
301-2	Reinforced Soil Wall, Type-2 (gabion unit mesh 1:0.3)	sq.m.
301-3	Reinforced Soil Wall, Type-3 (reinforced concrete panel)	sq.m.

301-4	Rock Anchor, dia.25mm, L=2.0m (for expanded metal 1:0.1)	No.
301-5	Rock Anchor, dia.25mm, L=3.0m (for expanded metal 1:0.1)	No.

Geosynthetics used for reinforced soil walls construction, shall be performed, measured and paid, respectively in accordance with the relevant Sub-Sections of these specifications such as:

- ♦ 2407 “Geosynthetics for Road and Bridges Works”
- ♦ 2408 “Geotextile for Filtration, Drainage and Separation”
- ♦ 2409 “Geosynthetics for Earth Reinforcement” (Geogrid)
- ♦ 2410 “Geo-composite drains”, etc.

As applicable, and as approved by the Engineer.

## SECTION 400: FENCING

### 406 MEASUREMENT

- (1) *Delete the full text of the Sub-Section 406 “Measurement” and replace with the following:*

The Works for providing and installation of permanent fencing shall be measured in linear meters inclusive of all excavations, concrete Class D (M20/20), installation of posts and standards, barbed wires, painting if any, entry gates and other requirements necessary to complete the work as per this Specification, and as shown in the Drawings.

Sliding Gates, including all materials, railing, installation and incidentals shall be measured per number and classified by its width.

Temporary fencing shall not be measured nor paid separately but shall be deemed included in the rates and prices entered for the related main items.

### 407 PAYMENT

- (2) *Delete the full text of the Sub-Section 407 “Payment” and replace with the following:*

Permanent fencing, measured as stated above, shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112.

Item No.	Description	Unit
<b>400</b>	<b>Fencing</b>	
400-1	Fence type-A (Net, H=1.80m)	lin.m
400-2	Fence type-B (Grid, H=1.80m)	lin.m
400-3	Fence type-C (Net, H=1.80m with barbed wire)	lin.m
400-4	Fence type-D (Grid, H=1.80m with barbed wire)	lin.m
400-5	Fence type-E (Barbed wire, H=1.80m)	lin.m
400-6	Fence type-F (Net, H=0.80m on bridge guard wall)	lin.m
400-7	Fence type-G (Round barbed wire)	lin.m
400-8	Fence type-H (Movable, H=1.80m)	nos.
400-9	Fence type-I (Movable, H=0.90m)	nos.
400-10	Gate type-A (Sliding gate, W=8.00m)	nos.
400-11	Gate type-B (W=6.00m)	nos.
400-12	Gate type-C (W=5.00m)	nos.

All costs in connection with the temporary fencing work shall be considered to be included with other related items of work in the BOQ.

## SECTION 500: QUALITY CONTROL

### 501 SCOPE

- (1) *Insert the following as per the last paragraph of Sub-Section 501 “Scope”:*

This Section shall be interpreted, supplementary to, and without detriment to the stipulations of Sub-Clause 4.9: “Quality Assurance” and Sub-Clause 7.4: “Testing”, and all relevant stipulations of the Conditions of Contract.

### 502 CONTRACTOR RESPONSIBLE FOR THE QUALITY OF THE WORKS

- (2) *Delete the last two (2) sentences of the second paragraph of the Sub-Section 502 “Contractor Responsible for the Quality of the Works” commencing at “The list of laboratory equipment .....” and replace with the following:*

The Contractor shall obtain timely, and in accordance with the approved Programme, the approval by the Engineer for the laboratory facilities to be provided and the list of equipment to be purchased.

In designing the facilities and equipping the laboratory, the Contractor must himself make allowance for the need to be able to conduct all the tests required by these Specifications in regard to the works or materials itemized or implied in the drawings and the Bill of Quantities.

The Contractor remains responsible for the supply of all equipment of whatsoever nature and in whatsoever quantity required for carrying out all of the tests specified at the frequency specified.

- (3) *Insert the following after the last paragraph of the Sub-Section 502 “Contractor Responsible for the Quality of the Works”:*

#### ***Laboratory Check by the Engineer:***

##### **(a) Rights to Check Testing Laboratories:**

The Engineer shall at all times have full right and power to check the Laboratory installations and equipment for verifying their due compliance with the Specifications, and to confirm the adequacy of the Laboratory technicians’ testing procedures and techniques.

##### **(b) Engineer’s Access and Use of Laboratory Facilities:**

The Engineer shall at all times have full right and power to access the Laboratory and the respective laboratory records related to the Project. The Engineer may, at any time, use the Laboratory facilities to conduct independent testing, or require the Laboratory personnel employed by the Contractor, to conduct such testing.

### 509 ACCEPTANCE TESTS FOR COMPLETED WORKS OR PARTS OF THE WORKS

- (4) *Add the following Clause after the Clause 509(2): “Other Works and Equipment” and*

before Sub-Section 510: “Recapitulative Schedule of Tests”:

### (3) Testing and Commissioning

Testing and Commissioning of the completed installation of lighting system, transmission lines, facilities, etc., or those works indicated by the Engineer, shall include a working demonstration of satisfactory performance for the Engineer and Employer.

- (a) Without detriment of the stipulations of the Contractual Documents (Condition of Contract and Specifications), a Taking-Over Certificate may be issued by the Engineer when, in conformity with Clause 10: “Employer’s Taking-Over” of the Conditions of Contract:
  - ♦ The installation has been satisfactorily completed.
  - ♦ “As-built” documents including drawings and records have been submitted to an acceptable standard.
  - ♦ Certification of any records has been made as required by the Engineer.
- (b) The Contractor shall provide a test and commissioning report to be approved by the Engineer. All tests and commissioning information shall be delivered in hard copy and soft copy together with advice on, software required for accessing the soft copy. All information delivered to the Employer has to be checked and approved by the Employer based on the recommendations by the Engineer.
- (c) The Contractor shall conduct testing and commissioning of the complete installation with good industrial practice. The Contractor shall carry out continuity tests on all cables and devices for termination and pair integrity. All records of tests shall be kept and submitted to the Engineer in the suitable tabulation for the inspection and acceptance.
- (d) Any item that found to be defective and damage during testing and commissioning shall be replaced by the Contractor at his expense.

## 511 LABORATORY

### (4) Ownership

- (5) *Delete the full text of the Clause 511 (4): “Ownership” and replace with the following:*

Unless otherwise stated in the Contract, excepting the laboratory facilities which shall be removed by the Contractor after the Project completion, the ownership of all laboratories and equipment shall revert to the Contractor.

### (6) Measurement

- (6) *Delete the full text of Clause 511(6): “Measurement” (sub-clauses a, b and c) and replace with the following:*

Unless otherwise stipulated in these Specifications or in the Conditions of Contract, measurement and payment for all Clauses of this Section 500 shall be made only and exceptionally for the items shown here below:

- ♦ Laboratory: which has been set up and equipped in accordance with the requirement of these Specifications, including the laboratory building, services, essential supplies like



water, electricity, sanitary services and all equipment, tools, materials, labour and incidentals to perform tests and other operations of quality control according to the Specification requirements shall be measured for payment in number;

- ♦ Laboratory Equipment: The laboratory equipment provided to perform all testing required by these specifications shall be measured for payment in lump sum.

The salaries, allowances, accommodations, transportation and all incidentals related to the Contractor's Laboratory Staff shall be deemed included in, or distributed among, all the rates and prices entered for the unit prices of the Bill of Quantities which will need the use of laboratory for testing and quality monitoring. Therefore, separate measurement shall not be made and shall not be listed in the BOQ.

## (7) Payment

- (7) *Delete the full text of Clause 511(7): "Payment" (sub-clauses a, b and c) and replace with the following:*

The Laboratory and Laboratory Equipment, measured as stated above, shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112.

- ♦ Laboratory: shall be paid in number of the laboratory's installations actually set-up for the Project and approved by the Engineer;
- ♦ Laboratory Equipment: shall be paid on a "lump sum" according to the following instalments for each laboratory:
  - (i) Thirty percent (30%) upon completion of mobilization, installation, satisfactorily completion and equipping and upon occupation and use of the Laboratory to the extent that the staff can properly perform their duties under the Contract to the satisfaction of the Engineer
  - (ii) Fifty percent (50%) during the execution of the Works split in partial payments in proportion to the work progress subject to certification issued by the Engineer.
  - (iii) Twenty percent (20%) upon issuance of the Taking-Over Certificate and respective removal of installations, reinstated the site to the satisfaction of the Engineer and demobilization following the Engineer's certification that these facilities are no longer required

Item No.	Description	Unit
<b>500</b>	<b>Quality Control</b>	
500-1	Laboratory	No.
500-2	Laboratory Equipment	lump sum

## SECTION 600: MATERIALS AND TESTING OF MATERIALS

### 607 TRADE NAMES AND ALTERNATIVES

- (1) *Insert the following before the first paragraph of the Sub-Section 607: "Trade Names and Alternatives":*

These specifications shall read and interpreted accordingly and without detriment to the requirements stated in Clause 13: "Variations and Adjustments"; Sub-Clause 13.1: "Value Engineering" of the Conditions of Contract.

### 612 SOIL AND GRAVELS

#### (2) Standard Methods of Testing

- (2) *Delete the title of Table 6.4 in Clause 612 (2): "Standard Methods of Testing" and replace with the following:*

**Table 6.4: Tests Procedures Applicable to Disturbed and Undisturbed Samples of Soils and Gravels**

### 613 STONE, AGGREGATE, SAND AND FILLERS

#### (1) Sampling and Preparation of Samples

- (3) *Delete the full text of Clause 613 (1): "Sampling and Preparation of Samples" and replace with the following:*

Sampling and sample preparation shall comply with the standards IS: 2430 and the standards for test procedures shown in Table 6.5.

### 627 GEOTEXTILES

- (4) *Delete the title of Sub-Section 627: "Geotextiles" and replace with the following:*

### 627 GEOTEXTILES AND GEOGRIDS

#### (1) Geotextiles

*(the text for Clause 627(1): "Geotextiles" remains without modifications)*

- (5) *Add the following Clause after the last paragraph of Clause 627(1): "Geotextiles" and before Sub-Section 628: "Timber for Structural Works":*

#### (2) Geogrids

Geogrids shall be made of high tenacity polymer yarn jointed at cross points by weaving. Unless otherwise shown on the Drawing, all geogrids shall meet the minimum strength in terms of Minimum Average Roll Value (MARV) as specified in Table 6.16

**Table 6.16 Specification for Geogrids**

Property	Test Method	Unit	Requirement
Stiffness at 0.5% strain	ISO 10319	KN/m	$\geq 350$ , both in machine and cross machine direction
Tensile strength @ 2% strain	ASTM D6637	KN/m	$\geq 15\%$ of Tilt : both in machine and cross machine direction
Tensile strength @ 5% strain	ASTM D6637	KN/m	$\geq 20\%$ of Tilt : both in machine and cross machine direction
Junction Efficiency for extruded geogrids	GRI-GG2-87 or ASTM-WK 14256	-	90% of rib ultimate tensile strength
Ultraviolet stability	ASTM D4355	-	70% after 500 hrs. exposure

## SECTION 700: PIPE DRAINS, PIPE CULVERTS AND CONCRETE CHANNELS

### 701 PIPE DRAINS AND PIPE CULVERTS

#### (9) Pipes Bedding and Encasing

- (1) *Delete the Sub-Clauses 701(9)(b) “Concrete Bedding” and (c) “Concrete Encasing” and replace with the following:*

##### (b) Concrete Bedding

Where indicated on the Drawing, concrete bedding shall be made on Concrete Class-E confirming the requirements of Section 2000 so that the bottom of the pipe rests on concrete of the specified thickness. The thickness of the concrete below the pipe and the height to which it extends upwards shall be as shown on the Drawing.

##### (c) Concrete Encasing

As shown on the Drawing, encasing of pipe culverts shall be as shown in the Drawings for the following two types:

- ♦ 90° Encasement: Partial encasement with Concrete Class D without steel reinforcement
- ♦ 360° Encasement: Full encasement with Concrete Class D with steel reinforcement as shown in the Drawings

In carrying out this work the Contractor shall take care to pack the concrete under and around the pipes to ensure even bedding and solidity in the concrete; in no instance shall the concrete be thrown directly on the pipes. The concrete shall be placed in such a way that all spaces around the pipe are completely filled with concrete. Concrete casing shall be cast in one continuous operation until completed. The upper surface of the concrete shall be struck off with a wooden screed and neatly finished off.

#### (15) Measurement

- (2) *Delete the full text of Clause 701(15): “Measurement” and replace with the following:*

The diameter of pipe culverts shown in the BOQ for payment shall be measured by the internal surface of item of pipes.

Pipes shall be measured along their centre between the inlet and outlet ends in linear meters of individual pipe element of each size, completed and accepted in place.

The following shall not be measured nor paid separately but shall be deemed included in the rates and unit prices of the main item established for pipe drainages:

- ♦ Collar
- ♦ Concrete bedding
- ♦ Concrete for encasing
- ♦ Steel reinforcement

The works for excavation, backfilling and ancillary works such as head walls, wing walls, etc. shall be measured separately as provided for in the respective Sections of these Specifications.

## (16) Payment

- (3) *Delete the full text of Clause 701(16): "Payment" and replace with the following:*

Pipes, measured as provided above, shall be paid for at the contract unit rates per linear meter of each particular size measured by the internal surface of pipes which shall be the full and the final compensation for compliance of all requirements herein specified in addition to those specified in Clause 112, including furnishing, producing, all materials and for furnishing all labour, materials, tools, equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specification Sections, and/or as directed by the Engineer..

Cost for cement jointing shall deemed to be included in the contract unit rate of pipe.

Ancillary works such as excavation, backfilling, granular bedding (if any) and masonry shall be paid for separately, as provided under respective Clause of these Specifications.

Item No.	Description	Unit
<b>700</b>	<b>Pipe Drains, Pipe Culverts and Concrete Channels</b>	
<b>701</b>	<b>Pipe Drains and Pipe Culverts</b>	
701-1	Concrete pipe class NP3 internal diameter 900mm with 90degree concrete foundation	lin.m
701-2	Concrete pipe class NP3 internal diameter 900mm with 360degree concrete foundation	lin.m
701-3	Concrete pipe class NP3 internal diameter 600mm with 90degree concrete foundation	lin.m
701-4	Concrete pipe class NP3 internal diameter 600mm with 360degree concrete foundation	lin.m
701-5	Concrete pipe class NP3 internal diameter 900mm (Re-used) with 90degree concrete foundation	lin.m

## 702 CONCRETE CHANNELING

- (4) *Insert the following as per the last paragraph of the Sub-Section 702(5): "Measurement":*

Concrete covers shall be measured as the number of covers satisfactorily installed by the Contractor as shown in the Drawings and approved by the Engineer.

- (5) *Insert the following as per the last paragraph of the Sub-Section 702(6): "Payment":*

Item No.	Description	Unit
<b>702</b>	<b>Concrete Channeling</b>	
702-1	Masonry U-shaped drain 475x450 type-1 (MU1-475x450)	lin.m

Item No.	Description	Unit
702-2	Masonry U-shaped drain 475x500 type-2 (MU2-475x500)	lin.m
702-3	Masonry U-shaped drain 450x500 (MU-450x500)	lin.m
702-4	Masonry U-shaped drain 775x450 (MU-775x450)	lin.m
702-5	Masonry U-shaped drain 775x500 (MU-775x500)	lin.m
702-6	Masonry U-shaped drain 1000x1000 (MU-1000x1000)	lin.m
702-7	Masonry vertical drain 600x700 (MV-600x700)	lin.m
702-8	Masonry vertical drain 400x400 (MV-400x400)	lin.m
702-9	Concrete U-shaped drain 300x300 (CU-300x300)	lin.m
702-10	Concrete U-shaped drain 350x350 (CU-350x350)	lin.m
702-11	Concrete U-shaped drain 400x400 (CU-400x400)	lin.m
702-12	Concrete U-shaped drain 450x450 (CU-450x450)	lin.m
702-13	Concrete U-shaped drain 500x500 (CU-500x500)	lin.m
702-14	Concrete U-shaped drain 500x700 (CU-500x700)	lin.m
702-15	Concrete U-shaped drain 600x600 (CU-600x600)	lin.m
702-16	Concrete U-shaped drain with cover for light vehicle 300x300 (CU(LC)-300x300)	lin.m
702-17	Concrete U-shaped drain with cover for light vehicle 400x400 (CU(LC)-400x400)	lin.m
702-18	Concrete U-shaped drain with cover for light vehicle 450x450 (CU(LC)-450x450)	lin.m
702-19	Concrete U-shaped drain with cover for light vehicle 500x500 (CU(LC)-500x500)	lin.m
702-20	Concrete U-shaped drain with cover for light vehicle 500x700 (CU(LC)-500x700)	lin.m
702-21	Concrete U-shaped drain with cover for heavy vehicle 300x300 (CU(HC)-300x300)	lin.m
702-22	Concrete U-shaped drain cover for heavy vehicle 400x200 (CU(HC)-400x200)	No.
702-23	Concrete U-shaped drain with cover for heavy vehicle 500x500 (CU(HC)-500x500)	lin.m
702-24	Concrete U-shaped drain with cover for heavy vehicle 500x600 (CU(HC)-500x600)	lin.m
702-25	Concrete U-shaped drain with cover for heavy vehicle 500x700 (CU(HC)-500x700)	lin.m
702-26	Concrete cover for pedestrian 500x1100x100	No.
702-27	Sewage casting catch basin cover 600 diameter (Re-used) for pedestrian with concrete slab 1700x1700x250	No.
702-28	Sewage casting catch basin cover 600 diameter for pedestrian with concrete slab 1700x1700x250	No.
702-29	Concrete slab catch basin cover 2no.- 300x700 for pedestrian with concrete slab 1400x1400x200	No.
702-30	Concrete slab catch basin cover 2no.- 300x700 for pedestrian with	No.

Item No.	Description	Unit
	concrete slab 1700x1700x250	
702-31	Steel grating catch basin cover 600x600 for heavy vehicle with concrete slab 1400x1400x250	No.
702-32	Steel grating catch basin cover 600x600 for heavy vehicle with concrete slab 1700x1700x300	No.
702-33	Sewage casting catch basin cover 600 diameter for heavy vehicle with concrete slab 1400x1400x250	No.
702-34	HDP pipe 160mm	lin.m
702-35	Catch pit cover (500x500) of welded MS bar of dia. 20mm with opening 50mmx50mm	No.

## SECTION 800: QUARRIES, BORROW PITS, STOCKPILE AND SPOIL AREAS

### 802 DEFINITIONS

- (1) *Insert the following as first item of the list shown in the Sub-Section 802: "Definitions", and renumber the other items of the list accordingly:*

#### (1) Rock from Tunnel Excavation

The rock material extracted from the tunnel excavation, performed in accordance with the requirements of Section 4000, and stockpiled in an area approved by the Engineer.

This material shall be processed in appropriated crushing-plant(s) mobilized and installed by the Contractor for the Project exclusively, and approved by the Engineer. The produced material shall be for the following:

- (i) Concrete pavement (CRCP: Continuously Reinforced Concrete Pavement, JRCP: Jointed Reinforced Concrete Pavement and JCP: Jointed Concrete Pavement),
- (ii) Asphalt concrete pavement
- (iii) Concrete for structures
- (iv) Base Course and Sub-Base Course
- (v) Improved Subgrade: Capping layer (upper subgrade) and lower layer (lower subgrade)
- (vi) Road embankment
- (vii) Structural filling/backfilling

as shown in the Drawings or as instructed by the Engineer.

The rock material extracted from tunnel excavation is a property belonging to the Employer, and its use shall be reserved exclusively for the Project, or for the works authorized by the Employer.

The works for rock excavation and initial-stockpiling shall be measured and paid under the respective section for tunnel excavation. However, further operations for hauling the rock material from the stockpile to the embankment or to the crashing plant (for crashing properly in accordance with pertinent requirements), hauling and placing on its final destination, etc. shall not be measured nor paid separately but shall be deemed included into the rates and unit prices for the respective main pay item where it is finally used (refer to the above mentioned list of 7 items).

The ratio between the granular material obtained from tunnel or roadway excavation (with or without crushing) and those material procured from other approved sources located outside the Project area, which will be used for the above referred 7 items, shall not be measured. Therefore, the cost due to variations on such ratio shall not be paid separately but shall be deemed included into the rates for the unit price of the above referred 7 main items. The Contractor shall, at his risk and responsibility, to perform an estimation for establishment of respective unit prices.

[renumbering: (2) Rock Quarry; (3) Quarry; (4) Alluvial Deposit; (5) Stockpile Area; (6)



Spoil Area]

### 803 LOCATING MATERIAL SOURCES

(2) *Delete the full text of Sub-Section 803: “Locating Material Sources” and replace with the following:*

- (1) The Contractor shall be responsible of a proper extraction of rock material from tunnel excavation (without contaminating with unsuitable soils), processing of the rock in crushing plants properly installed and approved by the Engineer, and stockpiling the resulting material in proper locations approved by the Engineer.

In addition, the Contractor shall be responsible for locating all material sources and for the acquisition or renting of all land required for rock quarries (if required other than those material obtained from tunnel excavation), quarries, alluvial deposit, borrow pits, spoil and stockpile areas and for access thereto in accordance with the Conditions of Contract.

The location and size of rock quarries, quarries, alluvial deposit borrow pits, spoil and stockpile areas proposed by the Contractor shall be subject to the approval by the Engineer.

The Engineer shall withhold his approval, if in his opinion the rock quarry, quarry, alluvial deposit, borrow pit, spoil and stockpile area, or access into them:

- (a) will have a detrimental effect on the environment;
  - (b) would be very difficult to acquire;
  - (c) is in or near an urban centre;
  - (d) will require an access road which is excessively long;
  - (e) has excessively thick layers of overburden;
  - (f) covers too large an area;
  - (g) would constitute a danger to the public;
  - (h) is an excessive distance from the location where the material is to be used or removed from; or
  - (i) a source of suitable material is closer
- (2) Not later than 30 days after the issuance of order to commence the Works, the Contractor shall submit for the Engineer’s review and approval full information regarding the proposed location for stockpiling the processed rock material obtained from the tunnel excavation, and for all material sources of rock quarries, quarries, and alluvial deposits, borrow pits, spoil and stockpile areas that the Contractor will require for the whole the works.

The Contractor’s proposal shall include but not limited to the following;

- (a) A plan of the Site in a suitable scale of proposed location of material source showing, but not limited to, the following:
  - ♦ plot boundaries;
  - ♦ owners names and addresses, and if appropriate identification numbers;
  - ♦ the district, location, registration section and number for each plot;

- ♦ local details such as building, fences, types and areas of cultivation and services, all agreed with the land owners; and
  - ♦ areas to be used for working areas, stockpile areas, etc.
  - (b) Cadastral maps covering the areas to be acquired when available.
  - (c) Detail of the proposed access road route.
  - (d) Technical supporting information relevant to rock quarries, quarries, alluvial deposits, borrows pits, including:
    - ♦ Summary of geophysical surveys (electric, and/or seismic), geotechnical survey, indicating for alluvial deposit the thickness of layers, thickness of overburden, lenticular beds depth and configuration of the bedrock, etc., and in addition for rock quarries, the discontinuity families, the intervals between discontinuities, thickness and nature of the infilling, the Weathering Index.
    - ♦ Laboratory results including petrographic identification, and for alluvial deposit material, grading, tests on the fine fraction (PI, SE, Methylene Blue test, Mica content, Organic matters), tests on the coarse fraction (LAA, AIV, ACV, Micro Deval, FI, Adhesively test), CBR test, or for quarry material, LAA, AIV, ACV, Micro Deval, Adhesively test, Specific Gravity, Water Absorption.
    - ♦ Conclusions on qualities and quantities.
  - (c) Other relevant information
- (3) Where the Contractor uses a material herein defined, as identified or instructed by the Engineer, he shall obtain the Engineer's approval of the areas required for the material and of the siting of the access roads into these respective locations. The Engineer, at any time during the construction period, may require the Contractor to modify his requirements for any of the reasons in accordance with the Conditions of Contract.
- Where the material herein defined, available for inspection at the time of the Tender, are instructed by the Engineer, the Contractor shall satisfy himself as to the quality and quantity of materials available before providing the information required in this Clause. Should such investigations reveal that there is insufficient suitable material for the use for which such material sources were intended, the Contractor shall immediately inform the Engineer in writing and the Engineer shall either direct that such sources are extended or that new sources shall be used.
- (4) When the material has insufficient suitable quantity or area for the use for which it was intended, the Contractor shall propose in writing that either material be extended or that a new source shall be used. The approval and acquisition of such new or extended source shall be in accordance with all the above provisions of this Clause for the acquisition of the original material.

## SECTION 900: EARTHWORKS

### 902 DEFINITIONS AND GENERAL REQUIREMENTS

(1) Delete the full text of Sub-Clause 902(2)(ii) “Suitable Material” and replace with the following:

- (ii) “Suitable Material” shall comprise all material extracted from tunnel excavation, roadway excavation or borrow excavation (if required and approved by the Engineer) which satisfies the requirements shown here below and which is capable of being compacted in the manner specified in Clause 909 and 910 to form a stable fill having side slopes as indicated in the Drawing.

Sieve Size	Percentage passing (AASHTO T27 & T11)
75 mm	100%
25.0 mm	70 – 100%
4.75 mm	30 – 70%
75 micron	Less than 5%
Limit Liquid	30 max.

The material prepared by crushing rock material from tunnel excavation, or crushing rock material from roadway excavation should have the sole condition of maximum size of 75mm only.

High embankment performed using material from crashing plants shall conform the requirements of Sub-Section 909: “Forming of Embankment and others Areas of Fill”.

(2) Add the following at the end of Sub-Section 902: “Definitions and General Requirements”:

(11) Backfilling: The following types of backfilling works are defined:

- ♦ Structural Filling/Backfilling: Suitable, free draining material conforming to the following:
  - ✓ Maximum particle size: 40mm
  - ✓ Material passing sieve No. 200 (75-µm) AASHTO T27 and AASHTO T11: 15.0% max.
  - ✓ Plasticity index, AASHTO T 90: 6 max.
- ♦ Granular Backfilling (Crusher-run):
  - ✓ Maximum particle size: 40mm
  - ✓ Soil classification, AASHTO M 145 A-1, A-2, or A-3
- ♦ Granular Backfilling for reinforced soil slopes:
  - ✓ Maximum particle size: 40mm
  - ✓ Soil classification, AASHTO M 145 A-1, A-2, or A-3
- ♦ Backfilling (Sand) for Tunnel Inspection Passage:
  - ✓ Backfilling mainly composed by a sand approved by the Engineer
- ♦ Gradation and Properties for Structural and/or Granular Backfilling:

Sieve Size.	Percentage passing (AASHTO T27 & T11)
40 mm	100%
425 micron	0 – 60%
75 micron	Less than 15%
PI	≤6

- (12) Prior to perform the earthworks herein defined (minimum 28 days before commencement of earthworks), the Contractor shall submit for review and approval by the Engineer, a “Plan for Earthworks” detailed by sections showing the cutting and embankment with respective hauling distances, quantities and location of the re-usable material and respective spoil-banks for wasting of unsuitable material, not re-usable material or exceeding material (from the balance between tunnel excavation, cutting excavation and fill embankment works), and respective time schedule. The Plan for Earthworks shall be updated and reviewed periodically every 3 months or when required by the Engineer.
- (13) The following requirements shall be satisfied for the proper implementation of Spoil-Banks:
- ♦ The Contractor shall submit, at least 15 days before commencing the works for any Spoil-Bank, for review and approval by the Engineer a detailed plan for implementation of the Spoil-Banks that are being considered in his “Plan for Earthworks” showing the location, capacity, time schedule and method statement for construction
  - ♦ The Spoil-Banks shall be constructed applying the same technical specifications used for road embankment construction regarding to clearing and grubbing, preparation of the ground, leveling, thickness and compaction of each layer, slopes arrangement, etc. as approved by the Engineer.
  - ♦ The drainage to be implemented in the Spoil-Banks shall be constructed following the applicable standards for road drainage and in accordance with the drawings prepared by the Contractor and submitted to the Engineer for review and approval.

## 904 EXPLOSIVES AND BLASTING

### (1) General

- (3) *Add the following at the end of Clause 904(1): “General”*

Compliance with Regulations for Explosives: The Contractor shall comply with all relevant ordinances, instructions and regulations which the Government, or other person or persons having due authority, may issue from time to time regarding the handling, transportation, storage and use of explosives.

Permission for Blasting: The Contractor shall at all times maintain full liaison with and inform well in advance, and obtain such permission as is required from all Government authorities, public bodies and private parties whatsoever concerned or affected, or likely to be concerned or affected by blasting operations.

**(6) Account**

- (4) *Delete full Clause 904(6): “Account” and replace with the following:*

**(6) Account and Records**

A careful and day to day account of the explosive, including those brought to the Site and all explosives consumed in the Works, shall be maintained by the Contractor in a register and manner approved by the Engineer and with the acceptance of police and military authorities, which shall be open to inspection by the Engineer at all times.

Records must be kept by the Contractor of all drilling and blasting operations showing holes diameters and depths, drilling pattern, explosive charge and type per hole, detonator delay times and total charge per blast. These records must be submitted to the Engineer on completion of charging.

The Contractor shall remove all unused explosives from the Site on completion of the Works or shall dispose of such explosives in a manner acceptable to the police and military authorities.

**905 EXCAVATION IN CUTTING**

- (5) *Delete the full text of Sub-Section 905: “Excavation in Cutting”, and replace with the following:*

**(1) General Requirements for Excavation in Cutting**

- (a) Cleaning and grubbing shall be performed as specified in Section 200.
- (b) While executing excavations, the Contractor shall take adequate precautions against soil erosion and water pollution.
- (c) All suitable excavated materials shall be used in construction of the roadway to the extent as required.
- (d) Hauling of material from cutting or borrow pits to embankments other areas of fill shall proceed only when plant or labour is operating at the place of deposition to ensure that adequate spreading and compaction of material can take place.
- (e) Over-excavation shall not be permitted. Any excess depth excavated below the formation levels as specified shall be made good by the Contractor at his own expense by backfilling with suitable material of similar characteristics to those of moved materials with compaction as specified in Clauses 909 and 910.
- (f) The slopes of cutting shall be cleared of all rock fragments which move when prized by a crowbar, unless otherwise directed by the Engineer. Where the Engineer considers that the slope, immediately after dressing, shall not be permanently stable, he shall direct the Contractor as to the stabilization measures required. The Contractor shall carry out these measures soon after Engineer’s instruction.

When completed, the excavation slopes shall be true to the lines and levels as shown on the Drawing or directed by the Engineer. When completed, no point on slopes shall vary from the designated slopes by more than 150 mm measured

at right angles to the slope, except where excavation is in rock, no point shall vary more than 300 mm from the designated slope.

- (g) If slips, slides, over breaks or subsidence occur in cutting, they shall be removed. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction.
- (h) If water is encountered in excavations due to seepage, springs, or other causes, it shall be removed by suitable diversions or bailing out and the excavation shall be kept dry. The drained water shall be discharged into suitable outlets as not to damage to the works, crops or any other property. If any such damage is caused due to any negligence of the Contractor, it shall be the sole responsibility of the Contractor to repair/restore to the original condition at his own cost or compensate for the damage.

## **(2) Installation of Provisional Guard Fence**

This work shall consist of the installation and, on-completion of the work, removal of provisional guard fence against rocks falling into the existing Road.

The Contractor shall calculate the required fences based on the following standards:

- ♦ Standards for Design and Construction of Rock-Fall Countermeasures. Japan Road Association 2004.
- ♦ Technical Manual for Design and Construction of Rock-Fall Countermeasures. Railway Technical Research Institute 2003, Japan.

Not later than 30 days prior to commence these works, the Contractor shall submit the above referred calculation book and shop drawings of the provisional guard fence to the Engineer for review and acceptance. All the drawings made by the Contractor shall be submitted to the Engineer, for review and approval, prior to the commencement of any work.

The Contractor shall maintain the provisional guard fence to be functional at any time. The Contractor shall remove any remaining material from excavation material and/or debris deposited behind the fence.

The provisional guard fence shall be installed to appropriate lines and grades under the Engineer's instructions. The provisional guard fence shall be set plumb and in alignment. The posts shall be set in concrete to the planned depth.

The provisional guard fence shall remain during slope cutting and slope protection works.

## **907 EXCAVATION FOR FOUNDATION**

### **(6) Public Safety**

- (6) *Delete the first paragraph of the Clause 907(6): "Public Safety", and replace with the following:*

Where required, trenches and foundations pits shall be securely fenced, provided with proper caution signs and marked with red lights at night to avoid accident as per Clause

102(6): “Traffic Safety and Control”.

## 909 FORMING OF EMBANKMENT AND OTHERS AREAS OF FILL

(7) *Delete the full text of the Clause 909(7), and replace with the following:*

- (7) Rock use in “rock fill embankments” shall be deposited in horizontal layers not exceeding 600 mm each extending up to the full width of the embankment. The maximum size of the rock material shall be 400 mm.

Material shall be spread, levelled and compacted in accordance with a compaction method approved by the Engineer based on the results obtained from a trial-section for compaction proposed and performed by the Contractor for determining the appropriated equipment and number passes. The compaction test shall be repeated one time every 5,000m<sup>3</sup> or every time that the characteristics of the rock material varies.

Each layer shall consist of reasonably graded rock and all surface voids shall be filled with broken fragments before the next layer is placed. The top surface and side slopes of embankments so formed shall be thoroughly blinded with approved well graded material to seal the surface.

A transition layer of 300 mm shall be provided on the top of the rock fill embankment before placing the next layer composed by soil material in order to avoid losing of fine into the rock cavities.

## 910 COMPACTION OF EMBANKMENT AND OTHER AREAS OF FILL/BACKFILL

(8) *Delete the full text of the Clause 910(2), and replace with the following:*

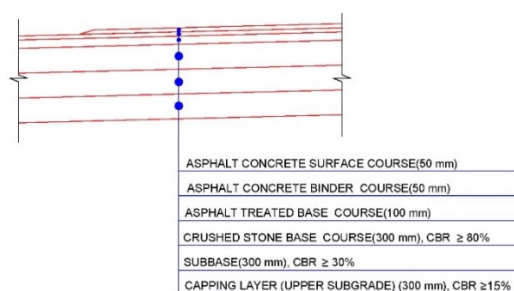
- (2) All fill shall be placed in layers’ thickness and compaction degree specified in Table 9.2, as described in Figure 9.1 or as shown on the Drawing. This requirement applies whether the specified zone is in fill or in existing ground, except for any part which may fall within rock or rock fill.

Formation Level shall mean the lower level of the Improved Subgrade.

**Table 9.2: Compaction Requirements**

Location	Depth below Formation Level (mm)	Minimum Compaction Degree (%) (% of Minimum Dry Density (MDD). Heavy Compaction)
Roadway Embankment	300	95
Roadway Cut	300	95
All other roadway fills and backfill not separately specified	(as instructed by the Engineer)	93





**Figure 9.1: Typical Cross Section of Subgrade Improvement**

## 917 MEASUREMENT

(9) *Insert the following after the last paragraph of the Sub-Section 917: "Measurement":*

- (5) The earthworks to be measured for payment shall be classified into the following categories:
- (i) Roadway Cutting Excavation:  
Cutting excavation for road construction including all types of soil with haulage and disposal up to 2km distance, all complete.  
The works for "Installation of Provisional Guard Fence", including all materials, labours, and any incidentals to complete the work as shown in the Drawings shall not be measured nor paid separately but shall be deemed included under Sub-Section 102: "Accommodation of Traffic".
  - (iii) Cutting Excavation for Improved Subgrade:  
Excavation below embankments and below formation level in all types of soil with haulage and disposal up to 2km distance, all complete. Cutting excavation for Improved Subgrade shall not be measured nor paid separately, and shall be deemed included in the relevant items for Earthworks.
  - (iv) Structural Excavation  
Excavation for foundation of structures (cross drainage, retaining wall, box-culvert and bridge) in all types of soil including hard rock, including dewatering
  - (v) Filling Embankment:  
Forming road embankment (beneath the improved subgrade level) using material from roadway cutting excavation and/or, if approved by the Engineer, borrowed material from quarries.  
This includes also the following:  
High Embankment using material from tunnel excavation:  
Forming road high embankment (beneath the improved subgrade level) using material extracted from tunnel excavation (preferable).
  - (vi) Filling in Reinforced Soil Zone:  
Forming road embankment located on those sections or zones where Reinforced Soil is performed in accordance with the requirements of Sub-Section 301: "Reinforced Soil".
  - (vii) Structural Filling/Backfilling  
Backfilling for structures, foundation pits etc. with suitable material including



compaction, all complete.

(viii) Granular Backfilling (Crusher-run)

Backfilling for structures, foundation pits etc. with granular material provided from Crushing, including compaction, all complete.

(ix) Backfilling (Sand) for Tunnel Inspection Passage

Backfilling mainly composed by a sand approved by the Engineer, for tunnel inspection passage, with material provided from Crushing, including compaction, all complete.

Topsoil: Construction of topsoil shall be performed, measured and paid under Sub-Section 2813: “Topsoil” of these Specifications.

## 918 PAYMENT

(10) *Insert the following after the last paragraph of the Sub-Section 918: “Payment”:*

- (3) All earthworks, excepting “Topsoil” (to be paid under Sub-Section 2813: “Topsoil”), shall be subject for payment only after completion and testing results approved by the Engineer.
- (4) Payment for temporary fence described in Clause 905(2) shall not be made separately but shall be deemed included under the pay Item 102-1: “Traffic Management at KM -0+240 to KM 0+240 along Tribhuvan Highway”

The Earthworks to be paid under this Section are the following:

Item No.	Description	Unit
<b>900</b>	<b>Earthworks</b>	
900-1	Roadway Cutting Excavation	cu.m
900-2	Structural Excavation	cu.m
900-3	Filling Embankment	cu.m
900-4	Filling in Reinforced Soil Zone	cu.m
900-5	Structural Filling/Backfilling	cu.m
900-6	Granular Backfilling (Crusher-Run 40-0mm)	cu.m

## SECTION 1000: SUBGRADES

### 1002 DEFINITIONS

#### (2) Subgrade

- (1) *Delete the title and full text of Clause 1002(2): “Subgrade”, and replace with the following:*

#### (2) Improved Subgrade (Lower Subgrade)

- (a) Improved Subgrade (Lower Subgrade):

Subgrade layer constructed using same material and conforming all requirements for construction specified in Section 900: “Earthworks” for fill embankment.

- (b) Basic Requirements:

700mm thick layer, selected material with CBR>5% and compacted to 95% of MDD (heavy compaction), maximum particle size = 75mm, placed 1000mm below formation level (immediately beneath the capping layer).

The term “improved subgrade” shall be understood as replacing the word “subgrade” in all other sections of these Specifications.

Construction of the Improved Subgrade by using material from other sources such as borrow pits will not be allowed unless otherwise approved by the Engineer upon a request and technical justification by the Contractor.

#### (3) Capping Layers

- (2) *Delete the title and full text of Clause 1002(3): “Capping Layers”, and replace with the following:*

#### (3) Capping Layer (Upper Subgrade) for Improved Subgrade

Capping Layer (Upper Subgrade) constructed using material obtained from tunnel excavation and/or roadway cutting excavation, or from other approved source, including crushing and sieving, preparation of material, hauling, forming, watering and compaction, all completed as herein specified.

#### Basic Requirements:

300mm thick layer, selected material with CBR>15% and compacted to 95% of MDD (heavy compaction), maximum particle size = 40mm, and conforming to Clause 609, Table 6.2, laid on the completed and approved surface of the Improved Subgrade (“lower subgrade”).

Capping layer can be applied on weaker road accesses or other areas as required by the Engineer.

Construction of the Capping Layer by using material from other sources such as borrow pits will not be allowed unless otherwise approved by the Engineer upon a request and technical justification by the Contractor.

## 1007 MEASUREMENT

- (3) Capping Layer .....,etc.
- (3) *Delete the full text of Clause 1007(3) and replace with the following:*
- (3) Improved Subgrade (Lower Subgrade), defined in Clause 1002(2), shall be measured and paid specified under the Section 900: “Earthworks”, Pay Item No. 900-3: “Filling Embankment”.
- Upper Subgrade (Capping Layer) shall be measured in cubic metre calculated by the “end area” method as described in Sub-clause 1007 (1), and shall be paid under this Section.

## 1008 PAYMENT

- (4) *Insert the following after the last paragraph of the Sub-Section 1008:”Payment”:*
- (7) Subgrades shall be subject for payment only after completion and testing results approved by the Engineer. The subgrades to be paid are the following:

Item No.	Description	Unit
1000	Subgrades	
1000-1	Upper Subgrade (Capping Layer)	cu.m.

## SECTION 1100: ROADWORKS OVERALL REQUIREMENTS

### 1104 CARE OF WORKS

- (1) *Delete the opening sentence of Sub-Section 1104: “Care of Works”, and replace with the following:*

These Specification shall be applied without detriment, and supplementary to the stipulations of the Sub-Clause 17.2: “Contractor’s Care of the Works” of the Conditions of Contract, and shall include, inter alia, the following:

- (2) *Insert the following after the last paragraph of the Sub-Section 1104: “Care of Works”:*
- (4) The provision of temporary drainage works such as drains, open channels, banks, etc. and the furnishing and operation of temporary pumps and such other equipment as may be necessary to adequately drain, protect and de-water the Works and Temporary Works. This shall be considered as supplementary work for any permanent drainage works specified and installed, and to any temporary drainage works specifically paid separately.
  - (5) Care shall be exercised not to allow material in borrow pits to become excessively wet, to keep all completed layers properly drained, to avoid dumps of material on completed layer work that shall inhibit surface drainage or form wet spots under and around dumps, and to protect all parts of the Works against erosion by floods and rain.
  - (6) Fill and cut slopes shall be promptly repaired whenever damaged by surface water.
  - (7) Excavations for pipe drains, culverts, service ducts and similar structures shall be adequately protected against possible ingress of water during rainstorms
  - (8) The Contractor shall inform the Engineer of damage or defects to any work before repair or maintenance and the Engineer shall instruct the extent and method of repair. The previously constructed layer shall be thoroughly cleaned of all foreign material and the Contractor shall request its inspection by the Engineer before construction of the following layer or application of a prime coat, surfacing or surface treatment. In the case of a worked bituminous layer needs to be thoroughly broomed and all dung, clay, and other deleterious material completely removed. Where necessary the surface shall be sprayed with water before, during and after brooming to remove all foreign material.

## SECTION 1200: SUBBASE, BASE, HARD SHOULDER AND GRAVEL WEARING COURSE

### 1204 SHOULDERS

#### (6) Measurement and Payment

- (1) *Delete the full text of Clause 1204(6): “Measurement and Payment” and replace with the following:*

#### (6) Measurement

Granular shoulder shall be measured in cubic meter by taking cross Sections at intervals of 20 meters or as directed by the Engineer in the original position before the work starts and after its completion and computing the volumes in cubic meters by average end area method.

Granular shoulder shall be constructed as shown in the Drawings and with material extracted from the tunnel excavation (or road excavation if approved by the Engineer), crushed properly, sieved and graded, stockpiled (if necessary) and satisfies the requirements of these Specifications, including preparation, hauling, forming, watering and compaction, testing for approval, all complete and approved by the Engineer.

#### (7) Payment

Granular Shoulder shall be paid at their respective contract unit rate. In addition to state in Clause 112, the contract unit rate shall be the final compensation for all costs required to complete the work complying with the requirements of these Specifications

Granular Shoulders shall be subject for payment only after completion and testing results approved by the Engineer:

Item No.	Description	Unit
1204	Shoulders	
1204-1	Granular Shoulder (Subbase)	cu.m.

- (2) *Add the following new Sub-Section at the end of Section 1200: “Subbase, Base, Hard Shoulder and Gravel Wearing Course”:*

### 1208 CRUSHED AGGREGATE SUBBASE AND BASE

#### (1) Description

This work consists of supplying, processing, hauling, spreading, watering, and compacting crushed and graded aggregates on a prepared and accepted surface, in accordance with details shown in the Drawings or as directed by the Engineer. Processing shall include, crushing of rock material extracted from tunnel excavation, sieved and graded, stockpiled, hauling, forming, watering and compaction, testing for approval and any other operation

necessary to produce a material conforming to the requirements of this Specification Section.

**(2) Material Sources**

Base and Subbase courses shall consist of the graded aggregate prepared from the rock material extracted from the tunnel excavation, or from an approved source, and processed in an appropriate crushing-plant approved for the Project.

**(3) Crushing, Screening and Mixing**

Crushing shall be carried out in accordance with the method statement prepared by the Contractor subjected to a review and approval by the Engineer. The statement shall include details for crushing, screening and proportioning of materials and their subsequent mixing.

Mixing shall be made exclusively with rock aggregates prepared in the approved crashing plants, and using the rock material extracted from tunnel excavation.

**(4) Storage, Mixing, and Handling of Materials**

- (a) Materials shall be so stored and handled as to ensure the preservation of their quality and fitness for construction. Materials, even though approved before storage or handling, may again be inspected and tested prior to use. Stored materials shall be located to facilitate prompt inspection.
- (b) Handling and stockpiling of aggregates subjected to the approval by the Engineer, and always shall be made in a way to avoid contamination. To avoid segregation, graded crushed stone shall be moistened when being handled and shall not be stockpiled in heaps higher than 5 m.
- (c) Aggregate stockpiles for base course shall be protected from rain to prevent saturation of the aggregates, which would result in a reduction in the quality of the placed material or adversely affect the placement of the material.
- (d) Where materials of different sizes are to be blended to meet the gradation, such blending shall be as directed by the Engineer and shall be accomplished prior to delivery to the roadway. Mixing of separate materials on the roadway by motor grader will not be permitted by the Engineer.

**(5) Unacceptable Materials**

Unless otherwise instructed by the Engineer, all materials that do not comply with the requirements of this Specification Section shall be rejected and removed immediately from the Site, and replaced if necessary, at the Contractor's expense and without allowing any time extension to recover the delay due to this fault. Unacceptable materials of which defects can be corrected shall not be used until positive results of testing are obtained, and approval by the Engineer is provided.

**(6) Aggregate Material Requirements**

The aggregate subbase and base shall consist of hard, durable particles of fragments of rock crushed to the size and conforming to requirements of this Specification Section. The crushed aggregate prepared for subbase and base shall be cleaned and free from vegetable matters, lumps or balls of clay and other deleterious substances. The materials shall be of

such nature that it can be compacted readily to form a firm, and stable subbase or base.

The material for subbase and base shall conform to the grading requirements shown in Table 12-1:

**Table 12-1 Grading Requirements for Aggregate**

Sieve Designation (mm)	Mass Percent Passing (*)	
	Base	Subbase
	Dmax = 25mm	Dmax = 50mm
50	-	100
37.5	-	97-100
25	100	-
19	86-100	-
9.5	51-82	-
4.75	36-64	40-60
0.425	12-26	-
0.075	4-7	4-12

(\*): Standard specifications for aggregate subbase and base courses by FHWA-FP2014.

The aggregate subbase and base shall conform, through wet sieve testing, to the properties given in Table 12-2.

**Table 12-2 Aggregate Subbase and Base Properties**

Properties	Base	Subbase
Abrasion of Aggregate retained on 2.00 mm (No.10) sieve (AASHTO T96)	45% max	50% max
Plasticity Index of Aggregate passing 0.425 mm (No. 40) sieve (AASHTO T90)	6 max	6 max
Percent by weight of Aggregate retained on 2mm (No.10) sieve with one fractured face	-	-
Liquid Limit of Aggregate passing 0.425 (No. 40) sieve (AASHTO T89)	25 max	35 max
Soaked CBR (AASHTO T193) at maximum dry density according to AASHTO T180 Method D	for material passing 19 mm sieve 80% min.	30% min

## (7) Construction Requirements

### (a) Provision on the Commencement of the Works

The works for construction of the subbase and base courses, as well as all the works for pavement construction, shall not commence if the works for slope formation (in cutting and/or embankment sections) and slope protection have not been properly completed by the Contractor, and accepted by the Engineer.

### (b) Submittals

At least twenty-one (21) days prior to the proposed date of first use of the materials prepared with crushed rock from tunnel excavation for the aggregate subbase and base, the Contractor shall submit to the Engineer the following:

- ♦ Three (3) samples of 50 kg weight each of the material, one of which shall be retained by the Engineer for reference throughout the Contract Period;
- ♦ A statement of the origin and composition of the material proposed for use as

aggregate subbase and base, together with laboratory test data verifying that the material properties specified in this Specification Section are met.

- ♦ The Contractor shall submit the following in written form to the Engineer immediately following the completion of each section of the work and before any approval is granted for placing other materials on top of the aggregate subbase and base:
  - ✓ The results of testing as herein specified.
  - ✓ The results of surface measurement tests and survey data verifying that the surface and thickness tolerances shown in Table 12-3 are met.

**(c) Trial Sections**

- ♦ Before commencement of construction of permanent works, the Contractor shall spread and compact trial sections as directed by the Engineer. The purpose of the trial section is to check the suitability of the materials and the efficiency of the equipment and construction method proposed by the Contractor. Therefore, the Contractor shall use the same materials, equipment, and procedures which he proposes to use for the main work. One trial section about 500 m<sup>2</sup> shall be made for every type of material and/or construction equipment/procedure proposed for use.
- ♦ Density tests and other tests required as directed by the Engineer.
- ♦ If the materials are, in the Engineer's opinion, not suitable for base as observed through the trial, the materials shall be removed at the Contractor's expense, and a new trial section shall be constructed without consideration of time extension due to this delay.
- ♦ If the basic conditions regarding the type of material or procedure change during the execution of the work, new trial sections shall be constructed.

**(d) Rectification of Unsatisfactory Material**

- ♦ Areas with a thickness or surface uniformity not satisfying the tolerances herein specified, or which develop irregularities in the surface during or after construction, shall be rectified by loosening the surface and removing or adding material as required, followed by reshaping and recompacting.
- ♦ The aggregate subbase and base which is too dry for compaction, in terms of specified moisture content or as directed by the Engineer, shall be corrected by scarifying the material followed by sprinkling with an adequate quantity of water and thoroughly mixing by means of equipment approved by the Engineer, and recompacting.
- ♦ The aggregate subbase and base which is too wet for compaction as defined by the specified moisture content or as directed by the Engineer, shall be rectified by scarifying the material followed by intermittently working using motor grader or other approved equipment to air-dry the material under dry weather conditions. Alternatively, or if sufficient drying cannot be achieved by reworking the loose material, the Engineer may instruct to remove that material and to replace it with a suitably dry material.
- ♦ The aggregate subbase and base which becomes saturated by rain or flooding or otherwise after it has already been satisfactorily compacted according to this Specification Section will generally require no rectification work provided that



the material's properties and surface uniformity meet the requirements of this Specification Section.

- ♦ Rectification of the aggregate subbase and base which does not meet the density or material property requirements of this Specification Section, shall be as directed by the Engineer and may include additional compaction, loosening followed by moisture content adjustment and recompacting, removal, and replacement of the material, or the application of an additional thickness of material.

**(e) Equipment**

- ♦ Equipment and method used shall place the aggregate subbase and base to the lines, levels, grades, dimensions, and cross-section shown in the Drawings and as directed by the Engineer.
- ♦ The Engineer has the right, at any time, to stop the use of any equipment or plant which he deems to be inferior to the required quality, and to instruct the removal of such equipment, and to have it replaced by suitable equipment or to alter the method of operation. The Contractor shall immediately comply with such instructions without being entitled to any indemnities or time extensions as a result of such instructions.

**(f) Placing, Spreading, and Compacting the Aggregate Subbase and Base**

The aggregate for subbase and base shall not be placed, spread or compacted while rain is falling, and no compaction shall be carried out when the moisture content of the material falls outside the specified range

- ♦ Placing:
  - ✓ The aggregate subbase and base material shall be placed in accordance with the drawing requirements as a uniform mixture in a quantity which will provide the required compacted thickness.
  - ✓ When more than one layer is required, each layer shall be compacted as specified in Subsection 3.6.3 of this Specification Section, before the succeeding layer is placed.
  - ✓ The placing of material shall begin at the point designated by the Engineer.
  - ✓ The area being prepared for laying the material shall be completed and the approval of the Engineer obtained for at least 200 m ahead of the placing.
  - ✓ Hauling equipment may be routed over completed portions of the courses if no damage results and that such equipment is routed over the full width of the course to avoid rutting or uneven compaction. The Engineer has the right to stop all hauling over completed or partially completed subbase or base courses when in his opinion such hauling is causing damages
- ♦ Spreading:
  - ✓ Where the required thickness is 150 mm or less, the material may be spread and compacted in one layer of subbase or base, respectively. Where the required thickness is more than the foresaid requirement, the aggregate subbase and base shall be spread and compacted into two (2) or more layers of approximately equal thickness, and the maximum compacted thickness of

any one (1) layer shall not exceed for said requirement unless otherwise directed by the Engineer. All subsequent layers shall be spread and compacted in a similar manner. All aggregate subbase and bases shall be placed by a spreader.

- ✓ The aggregate subbase and base shall be delivered to the roadbed as a uniform mix and shall be spread at moisture content within the range specified in this Specification Section. The moisture shall be uniformly distributed throughout the material.
- ✓ The aggregate subbase and base shall be spread and shaped by any approved method, which does not cause segregation of the fine and coarse aggregate particles. Segregated materials shall be corrected or removed and replaced with a graded material.
- ✓ The aggregate subbase and base surfaces which are to receive a prime coat shall then be further compacted to produce a stable, tightly locked surface, without open pores, suitable for priming. All coarse aggregates shall be tightly locked in place. Under no circumstances shall any form of soil or fine aggregates be added to the surface to assist the locking process, which shall be achieved by compaction only. Vibration shall not be used in the final stages of the compaction of the surface. The Engineer may direct that pneumatic rollers be used for the final surface compaction, if static steel wheeled rollers are considered likely to cause excessive breakdown or degradation of the aggregate subbase and base.

**(g) Compaction**

- ♦ Compaction shall be carried out only when the moisture content of the material is within the range of 3% less than the optimum moisture content to 2% more than the optimum moisture content, where the optimum moisture content is as defined by the maximum modified dry density determined by AASHTO-T180, Method D.
- ♦ The minimum dry densities to be achieved as a percentage of the Maximum Dry Density (MDD) determined in accordance with AASHTO-T180, Method D shall be:
  - ✓ Base : 98% of MDD
  - ✓ Subbase : 95% of MDD
- ♦ Immediately following final spreading and smoothening, each layer shall be compacted to the full width by means of approved compaction equipment. Rolling operations shall begin along the edges and progress gradually towards the centre, in a longitudinal direction. On super-elevated sections rolling shall begin at the low side and progress towards the high side. The rolling operation shall continue until all roller marks are eliminated and the layer is uniformly compacted and the aggregates firmly keyed. Any irregularities or depressions that develop shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform. Along kerbs, headers, and walls, and at all places not accessible to the roller, the material shall be compacted thoroughly with approved tampers or compactors. At the end at

each shift, the surface of the base or subbase shall be shaped and sloped to prevent ponding of rain water.

- ♦ When the underlying material is soft or yielding the layer course, compaction shall be stopped and the underlying materials rectified as directed by the Engineer.
- ♦ During all the operations of spreading, compacting, and levelling of course material, care shall be taken so that the layers already compacted under the layer being executed are not affected, or that the finished subgrade, subbase or base surface is also not affected. Special attention shall be given in places where equipment makes turns in going back and forth. Any such damage resulting in mixing the various layers constituting the different subgrades, subbase and base courses shall be carefully made good by the Contractor and at his expense and to the satisfaction of the Engineer.
- ♦ If the layer of subbase or base material, or part thereof, does not conform to the required finish, the Contractor shall, at his own expense, make the necessary corrections.
- ♦ Compaction of each layer shall continue until a field density has been achieved. In-place density determination shall be made in accordance with AASHTO-T191. When aggregate subbase and base divides into layers for construction, the subsequent layers shall be placed only after execution of inspection and acceptance for compacted density of previous layer is done.
- ♦ Proof rolling shall be conducted after finishing by more than 25 tons weight roller on the place directed by the Engineer. If the deflection is more than 3 mm, the place shall be replaced as instructed by the Engineer.

#### **(8) Control of Traffic on Base Surfaces**

- (a) Construction traffic or other traffic shall not be permitted to travel on any aggregate layers, prior to the construction of the final surfacing, except where directed or permitted by the Engineer.
- (b) The aggregate subbase and base shall not be opened to traffic until shaping and compaction are substantially completed.
- (c) Pending the construction of the final surfacing, the aggregate subbase and base shall be maintained as follows:
  - ♦ The aggregate subbase and base shall be maintained always by drag blooming. The traffic shall be controlled by temporary speed restrictions and, during working hours, it shall be channelled by suitably defined traffic lanes, with frequent transverse shift of the defined lanes to obtain an even spread of traffic over the entire surface.
  - ♦ Where the pavement course is too dry, so that surface stability does not or is unlikely to improve under the effect of traffic and/or rolling and where rain is not imminent or has been insufficient, a uniform application of water shall be applied to the entire surface.

#### **(9) Testing**

- (a) The amount of supporting test data required for initial approval of the quality of the material shall be as directed by the Engineer, and shall include all the tests

- specified in this Section on at least three (3) representative samples from the proposed material source, selected to represent the range of material quality likely to be obtained from the source.
- (b) Following approval of the quality of a proposed material, the full range of material quality tests performed shall be repeated subsequently, at the discretion of the Engineer, in the event of observed changes in the material or in its source or in its method of production.
- (c) A programme of routine material quality control testing shall be carried out to control variability of the material being brought on site. The extent of the testing shall be as directed by the Engineer, but following test shall be conducted for every 3000 m<sup>3</sup>:
- ♦ Five (5) plasticity index tests
  - ♦ Five (5) particle grading tests
  - ♦ One (1) maximum dry density determination (AASHTO T180 Method D)
  - ♦ CBR Tests
- ✓ The density and moisture content of the compacted material shall be routinely determined, using AASHTO-T191. The test shall be made to the full depth of the layer at locations as directed by the Engineer, but not more than 200 m apart.
- ✓ All holes in the finished work made by density testing or otherwise shall be backfilled with the specified material by the Contractor without delay and compacted to the density and surface tolerance requirements of this Specification Section.
- ✓ Examination stage for acceptance of aggregate quality which was gathered at the Site for construction: tested sample is taken from material at the site and shall be conducted for every 1000 m<sup>3</sup> from each material supply source or when material quality is extraordinary. Material shall meet all physical properties specified in Tables 12-1 and 12-2 and compacting test conducted inside the Laboratory.
- (d) Examination during construction period: During construction period, the contractor shall regularly conduct tests and check the following contents:
- ♦ Moisture, aggregate material separation (observed by eyes and by checking sieve particle): Test on moisture and sieve particles shall be conducted for every 200 m<sup>3</sup> aggregate or every shift;
  - ♦ Compacted density: test shall be conducted for every finished aggregate foundation layer, according to the testing process; base aggregate's compacted density shall be certified by sand cone test according to equivalent process as required by the Engineer. At the final stage of compaction, test for checking compacted density shall be frequently performed and taken as basis for completion of compaction works; test for compactness shall be conducted for every 800 m<sup>2</sup> at each random position; and
  - ♦ Flatness, geometric factors: shall be checked according to the requirements specified in Table 12-3. These testing data will be the basis for acceptance

of works.

- (e) Checking and acceptance of construction works
  - ♦ As for compacted density, test shall be conducted for every 7000 m<sup>2</sup> at two (2) random positions;
  - ♦ For flatness, geometric factors: checking density shall account for 20% of quantity regulated in Table 12-3.
- (f) During conducting of finishing works, all holes made by density testing shall be backfilled with the specified material by the Contractor without delay, and compacted to the density and surface tolerance requirements of this Specification Section.

#### (10) Tolerances for Acceptance

The aggregate subbase and base shall be spread with the equipment that will provide a uniform layer which when compacted will conform to the designed thickness, level, and longitudinal grade and cross fall or camber as shown in the Drawings. The allowable tolerances after compaction shall be as shown in Table 12-3.

- (a) The surface of all aggregate subbase and base layers shall not have any irregularities which can hold moisture and the camber of all such surfaces shall comply with that shown in the Drawings.
- (b) When testing the irregularity of aggregate subbase and base surfaces to be treated with bituminous surfacing, all loose material shall be removed by hard blooming.

Note: Table 12-3 shows the tolerances for subbase and base courses.

**Table 12-3: Tolerances for Aggregate Subbase and Base**

Item Checking	Permitted Variation comparing with the Drawings		
	Base	Subbase	Description
Layer Thickness	+ 5 mm	+ 10 mm	Measurement of cross-section shall be conducted for every 40-50 m for straight section and 20 – 25 m for horizontal or vertical curves
Surface Level	+5 mm	+10 mm	
Width on Top	+50 mm	+100 mm	
Cross Fall or Camber	+ 0.2%	+ 0.3%	
Surface Irregularity by 3 m straight edge	< 5 mm	< 20 mm	One position for every 100 m along the route

#### (11) Measurement

Graded crushed aggregate Base and Subbase courses shall be measured in cubic metre of actually placed, compacted, tested and completed, and approved by the Engineer. The measurement shall be made by taking cross Sections at intervals of 10 metres, or as directed by the Engineer, in the original position before the work starts and after its completion and computing the volumes in cubic metres by average end area method.

#### (12) Payment

The graded crushed aggregate Base and Subbase, as measured above, shall be paid at their respective contract unit rate. In addition to requirements of Clause 112, the

contract unit rate shall be the full and the final compensation for all costs required to complete the work complying with the requirements of these Specifications, including crushing, stockpiling, hauling, supplying, placing, compacting, finishing and testing the materials, the supply and placing of running course, trials, maintenance of the surface under traffic, making arrangement for traffic control and for furnishing all labour, materials, tools, equipment, and any incidentals necessary to complete the work shown in the Drawings and as required in accordance with these Specifications and/or as directed by the Engineer.

The following shall not be measured nor paid separately, but deemed included in the related main items:

- ♦ The work for preparing and maintaining the subgrade or subbase on which the aggregate subbase or base is to be placed, respectively;
- ♦ Any running course gravel used for temporary protection of the surface of aggregate subbase and base exposed to traffic;
- ♦ Repairs to layers' damages caused by traffic or natural conditions;
- ♦ Extra material provided in the next course due to deficiency of the base course.

The Crushed Aggregate Subbase and Base shall be subject for payment only after completion, and testing results approved by the Engineer:

Item No.	Description	Unit
<b>1200</b>	<b>Subbase, Base, Hard Shoulder and Gravel Wearing Course</b>	
<b>1208</b>	<b>Crushed Aggregate Subbase and Base</b>	
1208-1	Crushed Aggregate Subbase	cu.m.
1208-2	Crushed Aggregate Base	cu.m.

## SECTION 1300: BITUMINOUS SURFACE AND BASE COURSE

### 1302 PRIME COAT AND TACK COAT

#### (8) Measurement

- (1) Delete the full text of the Clause 1302(8): “Measurement”, and replace with the following:

The applied Prime Coat and Tack Coat (both using MC30/MC70) shall be measured in square meters of work completed and accepted by the Engineer. Surface measurements shall be based on the width and length of the surface area, as shown in the Drawings or as approved by the Engineer.

The rates of binding material (litres per sq.m corrected to 15°C) shall be established based on the test results obtained from the trial sections, and approved by the Engineer.

#### (9) Payment

- (2) Delete the full text of the Clause 1302(9): “Payment”, and replace with the following:

Payment shall be for full and final compensation for compliance of all requirements of these Specifications in addition to those specified in Clause 112, including furnishing, producing, mixing and placing, all materials including additives (if needed), testing and trial sections, and for furnishing all labour, materials, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings and as required by these Specification Sections, and/or as directed by the Engineer.

- (i) Payment for the Prime Coat will be made at the Contract unit rate and shall include full compensation for cleaning the surface prior application, providing all materials, mixing where required, spraying and placement, labour equipment and all incidentals to complete the prime coat as specified in this Section.
- (ii) Payment for the Tack Coat will be made at the Contract unit rate and shall include full compensation for cleaning the surface prior application, providing all materials, mixing where required, spraying and placement, labour equipment and all incidentals to complete the prime coat as specified in this Section.

Item No.	Description	Unit
1302	Prime Coat and Tack Coat	
1302-1	Prime Coat	sq.m.
1302-2	Tack Coat	sq.m.

### 1308 ASPHALT CONCRETE

#### (1) Scope

- (3) Delete the full text of the Clause 1308(1): “Scope”, and replace with the following:

This Clause covers the materials, method of construction and requirements for the construction of Asphalt Concrete and Asphalt Treated Base Course



Asphalt Concrete:

This work shall consist of construction of Asphalt Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single layer of asphalt concrete on a previously prepared bituminous bound surface. A single layer shall be 40mm or 50mm thick.

Asphalt Treated Base (ATB) Course:

This work shall consist of construction of a ATB course using a bitumen type VG20, for the pavement works of the Project. This work shall consist of construction in a single layer of ATB on a previously prepared bituminous bound surface. A single layer shall be 100 mm thick.

**(4) Grading Requirements**

- (4) *Renumber the existing Table 13.18 as follows:*

**Table 13.18(a): Grading Requirements of the Mixture of Coarse and Fine Aggregates**

- (5) *Insert the following new table after the renumbered Table 13.18(a):*

**Table 13.18(b): Grading Requirements of Aggregates for ATB Course (Asphalt Treated Base Course)**

Grading	3 Asphalt Treated Base Course
Nominal aggregate size:	37.5 mm
Layer Thickness:	100 mm
Sieve (mm)	Cumulative % by weight of total aggregate passing
37.5	100
25	93 - 100
12.5	27 - 58
6.3	0 - 10
0.075	0 - 2

**(5) Requirements for Asphalt Concrete**

- (6) *Renumber the existing Table 13.19 as follows:*

**Table 13.19(a): Requirements for Asphalt Concrete**

- (7) *Insert the following new table after the renumbered Table 13.19(a):*

**Table 13.19(b): Requirements for Asphalt of ATB Course**

Description	Requirement
Bitumen content % by mass of total mix	1.5 – 4.0
Mixing Temperature Range	93°C - 135°C
Compaction Temperature Range	60°C - 93°C

**(9) Measurement**

- (8) *Delete the full text of the Clause 1308(9): “Measurement”, and replace with the following:*

Asphalt Concrete of specified grading in contract document, and Asphalt Treated



Base (ATB) course, shall be measured in square meters of work completed and accepted by the Engineer. Surface measurements shall be based on the width and length of the surface area, as shown in the Drawings or as approved by the Engineer.

# **(10) Payment**

- (9) *Delete the full text of the Clause 1308(10): “Payment”, and replace with the following:*

Asphalt Concrete of specified grading in contract document, and Asphalt Treated Base (ATB) course, shall be paid at the respective contract unit rate which shall be the full and the final compensation for compliance of all requirements herein specified in addition to those specified in Clause 112, including furnishing, producing, all materials including additives (if needed), placing, leveling and compaction, testing and trial sections, and for furnishing all labour, materials, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specification Sections, and/or as directed by the Engineer.

A bitumen tar-felt sheet shall be included as per water-proofing measure for bridge as shown in the Drawings, and as approved by the Engineer.

Item No.	Description	Unit
<b>1308</b>	<b>Asphalt Concrete</b>	
1308-1	Asphalt Treated Base (ATB) Course (100 mm thick)	sq.m.
1308-2	Asphalt Concrete Binder Course (50 mm thick)	sq.m.
1308-3	Asphalt Concrete Wearing Course (50 mm thick)	sq.m.
1308-4	Asphalt Concrete Wearing Course (40 mm thick)	sq.m.
1308-5	Asphalt Concrete for Leveling	cu.m.
1308-6	Bitumen Tar Felt (for bridge)	sq.m.

## SECTION 1400: KERBS AND FOOTPATHS

### 1401 CONCRETE KERBS

#### (2) Materials

- (1) *Delete the first paragraph of the Clause 1401(2): “Materials”, and replace with the following:*

The kerbs shall be provided in cement concrete Class C (M25/20) in accordance with Section 2000. All kerbs shall be pre-cast concrete blocks excepting the Cast-in-situ Kerb Type D shown in the Drawings.

#### (3) Laying

- (2) *Delete the full text of the Clause 1401(3): “Laying”, and replace with the following:*

The kerbs shall be laid on cement concrete as shown in the Drawings. The concrete shall be of grade 25/20 in accordance with Section 2000 laid to the exact lines, dimensions and levels as shown in the Drawings and well compacted by ramming or by other method previously approved by the Engineer.

#### (5) Measurement

- (3) *Delete the full text of the Clause 1401(5): “Measurement”, and replace with the following:*

All kerbs shall be measured for payment by the length in linear metres of the structures completed in place, as shown in the Drawings, and as approved by the Engineer. No deduction shall be made for drainage structures installed in the kerbs (if any), or for flattening of kerbs for entrances, or for kerb drainage inlets, or for flanged-end sections.

#### (6) Payment

- (4) *Delete the full text of the Clause 1401(6): “Payment”, and replace with the following:*

The precast concrete kerbs measured as above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 including cost for excavation and backfilling (if any), cutting of existing pavement (if any), leveling concrete and/or sand-gravel for bedding, mortar, labour, equipment, tools, and all incidentals to complete the work in accordance with the Drawings and Specifications, and as directed by the Engineer.

Item No.	Description	Unit
<b>1400</b>	<b>Kerbs and Footpaths</b>	
<b>1401</b>	<b>Concrete Kerbs</b>	
1401-1	Pre-cast Concrete Kerb Type-A; Concrete Class C (M25/20)	lin.m.
1401-2	Pre-cast Concrete Kerb Type-A (Re-used)	lin.m.

Item No.	Description	Unit
1401-3	Pre-cast Concrete Kerb type-B (Concrete Class C (M25/20))	lin.m.
1401-4	Cast -in-situ Concrete Kerb type-C (Concrete Class C (M25/20))	lin.m.

## 1402 CONCRETE/STONE FOOTPATHS

### (6) Payment

(5) Insert the following at the end of Clause 1402(6): “Payment”:

Item No.	Description	Unit
<b>1402</b>	<b>Concrete / Stone Footpaths</b>	
1402-1	Concrete block footpath (For service road, Roadside Service Station and O&M office)	sq.m.
1402-2	Natural stone footpath (For boundary parking area of Roadside Service Station and building)	sq.m.

## SECTION 1500: TRAFFIC SIGNS, ROAD MARKING, ROAD MARKER STONES AND DELINEATORS

### 1501 PERMANENT TRAFFIC SIGNS

#### (11) Payment

(1) Insert the following at the end of Clause 1501(11): “Payment”:

Item No.	Description	Unit
<b>1501</b>	<b>Permanent Traffic Signs</b>	
1501-1	Traffic sign type A-1 (Single post with foundation block)	No.
1501-2	Traffic sign type A-2 (Single post without foundation block)	No.
1501-3	Traffic sign type B (Two posts with foundation block)	No.

### 1503 ROAD MARKER STONE

#### (6) Payment

(2) Insert the following at the end of Clause 1503(6): “Payment”:

Item No.	Description	Unit
<b>1503</b>	<b>Road Markers Stone</b>	
1503-1	Road Markers Stone (1 Km)	No.
1503-2	Road Markers Stone (5 Km)	No.

(3) Add the following new Sub-Sections after Sub-Section 1504: “Delineator Posts” and before Section 1600: “Piling for Structures”

### 1505 OVERHEAD SIGN

#### (1) Scope

This Clause covers the supply and erection of overhead traffic signs along the roadside, over the carriageway and at the locations indicated on the Drawing or as directed by the Engineer.

The work shall consist of design review / updating, fabrication, supply and installation of overhead traffic signs on the roads. The details of sign shall be as shown in the Drawings or indicated in the DOR’s Standard drawings for Road element-August 2014.

The Contractor shall carry out the design review of the structure and foundation of the conceptual design shown in the Drawings, and update it as necessary as approved by the Engineer.

## **(2) Height**

Overhead signs shall provide a vertical clearance of not less than 5.0m over the entire width of the pavement and shoulders except where a lesser vertical clearance is used for the design of other structures. The vertical clearance to overhead sign structures or supports need not be greater than 300 mm in excess of the minimum design clearance of other structures.

## **(3) Lateral Clearance**

The minimum clearance outside the usable roadway shoulder for expressway signs mounted at the road side or for overhead sign supports either to the right or left side of the roadway shall be 1.80 m. This minimum clearance of 1.80 m shall also apply outside of an un-mountable kerb. Where practicable, a sign should not be less than 3 m from the edge of the nearest traffic lane. Large guide signs should be farther removed preferably 9 m or more from the nearest traffic lane, unless otherwise specified.

Lesser clearances, but not generally less than 1.80 m, may be used on connecting roadways or ramps at inter-changes.

Where a median is 3.6 m or less in width, consideration should be given to spanning over both roadways without a central support. Where overhead sign supports cannot be placed at a safe distance away from the line of traffic or in an otherwise protected site, they should either be so designed as to minimize the impact forces or protect motorists adequately by a physical barrier or guard rail of suitable design.

## **(4) Materials**

Aluminium alloy or galvanized steel to be used as truss design supports shall conform to NS: 163/IS: 4826. These shall be of sections and type as per structural design requirements as shown on the drawings.

After steel trusses have been fabricated and all required holes punched or drilled on both the horizontal truss units and the vertical and support units, they shall be galvanized in accordance with NS: 163/ IS: 4826 Specifications.

Where aluminium sheets are used for road signs, they shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS: 736- Material Designation 24345 or 1900. The thickness of sheet shall be related to the size of the sign with minimum thickness of sheet as 1.5 mm.

High strength bolts shall conform, to IS: 1367 whereas precision bolts, nuts etc. shall conform to IS: 1364.

Plates and support sections for sign posts shall conform to IS: 226 and IS: 2062. The overhead signs shall be of micro prismatic retro-reflective sheeting.

## **(5) Size, Locations. of Signs**

The size of the signs, letters and their placement shall be as specified in the Contract drawings and Specifications.

In the absence of details or for any missing details in the Contract documents, the signs shall be provided as directed by the Engineer.

#### **(6) Installation**

From safety and aesthetic considerations, overhead signs shall be mounted on overhead bridge structures. Where these are required to be provided at some other locations, the support system providing pleasing aesthetics, should be properly designed based on sound engineering principles, to safely sustain the dead load, live load and wind load on the completed sign system. For this purpose, the overhead signs shall be designed to withstand a wind loading of 150 kg/m<sup>2</sup> normal to the face of the sign and 30 kg/m<sup>2</sup> transverse to the face of the sign. In addition, dead load of structure, walkway loading of 250 kg concentrated live load shall also be considered for the design of the overhead sign structure.

The supporting structure and signs shall be fabricated and erected as per details given in the Drawings and locations directed by the Engineer.

Sign posts, their foundations and sign mountings shall be so constructed as to hold signs in a proper and permanent position to adequately resist swaying in the wind or displacement by vandalism.

The work of construction of foundation for sign supports including excavation and backfill, forms, steel reinforcement, concrete and its placement shall conform to the relevant Specifications given in these Specifications.

- ♦ The structures shall be erected with the specified camber and in such a manner as to prevent excessive stresses, injury and defacement.
- ♦ Brackets shall be provided for mounting signs of the type to be supported by the structure. For better visibility, they shall be adjustable to permit mounting the sign faces at any angle between a truly vertical position and three degree from vertical. This angle shall be obtained by rotating the front lower edge of the sign forward. All brackets shall be of a length equal to the heights of the signs being supported.
- ♦ Before erecting support structures, the bottom of each base plate shall be protected with an approved material which "will adequately prevent any harmful reaction between the plate and the concrete.
- ♦ The end supports shall be plumbed by the use of levelling nuts and the space between the foundation and base plate shall be completely filled with an anti-shrink grout.
- ♦ Anchor bolts for sign supports shall be set to proper locations and elevation with templates and carefully checked after construction of the sign foundation and before the concrete has set.
- ♦ All nuts on aluminium trusses, except those used on the flanges, shall be tightened only until they are snug. This includes the nuts on the anchor bolts. A thread lubricant shall be used with each aluminium nut.

- ♦ All nuts on galvanized steel trusses, with the exception of high strength bolt connections, shall be tightened only to a snug condition.
- ♦ Field welding shall not be permitted.
- ♦ After installation of signs is complete, the sign shall be inspected by the Engineer. If specular reflection is apparent on any sign, its positioning shall be adjusted by the Contractor to eliminate or minimize this condition.

#### (7) Measurement

Aluminium or steel overhead sign structure shall be measured by the specific unit (each) complete in place as indicated in the Bill of Quantities and the Drawings.

Flat sheet aluminium signs with retro- reflective sheeting thereon shall be measured in square metre.

#### (8) Payment

The quantities measured as above shall be paid at the respective contract unit rates. The contract unit rates shall be the full and the final compensation to the Contractor as per Clause 112. Rate shall be inclusive of painting of structural steel, fabrication, and installation, fixing in position, and furnishing of necessary test certificates, warranty and all other incidental cost to complete the work as specified.

Item No.	Description	Unit
<b>1505</b>	<b>Overhead Sign</b>	
1505-1	Overhead Sign (W=17.50m)	No.
1505-2	Overhead Sign (W=25.00m)	No.

### 1506 THERMOPLASTIC ROAD MARKING

#### (1) Scope

This Clause covers the hot applied thermoplastic marking of the road surface with white or yellow paint as indicated on the Drawing or instructed by the Engineer.

The colour of the compound shall be white or yellow ( IS colour No 356) , width and layout of road marking shall be in accordance with the Traffic Signs Manual (latest publication), Department of Roads as per specification in the Contract.

The thermoplastic compound shall be screeded/extruded on to the pavement surface in a molten state by suitable machine capable of controlled preparation and laying with surface application of glass beads at a specific rate. Upon cooling to ambient pavement temperature, it shall produce an adherent pavement marking of specified thickness and width and capable of resisting deformation by traffic

Where the compound is to be applied to cement concrete pavement, a sealing primer as recommended by the manufacturer, shall be applied to the pavement in advance of placing of the stripes to ensure proper bonding of the compound. On new concrete

surface any laitance and/or curing compound shall be removed before the markings are applied

## (2) Materials

Requirements of Thermoplastic material:

### (a) Composition:

The pigment, beads and aggregate shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements in the Table 15-1.

**Table 15-1: Proportions of Constituents of making Material (% by weight)**

Component	White	Yellow
Binder	18 min.	18 min
Glass Beads	30-40	30-40
Titanium Dioxide	10 min	-
Calcium carbonate and inert Fillers	42 max	See Note
Yellow Pigments	-	See note

Note: Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, provided all other requirements of this Specification are met.

### (b) Properties:

The properties of thermoplastic material, when tested in accordance with ASTM D36/BS 3262 (part I) shall be as below:

- ♦ Luminance:
  - White: Daylight luminance at 45 degrees- 65 per cent min. as per AASHTO M249.
  - Yellow: Daylight luminance at 45 degrees -45 per cent mm. as per AASHTO M249.
- ♦ Drying time :
 

When applied at a temperature specified by the manufacturer and to the required thickness, the material shall set to bear traffic in not more than 15 minutes.
- ♦ Skid resistance: not less than 45 as per BS 6044.
- ♦ Cracking resistance at low temperature : The material shall show no cracks on application to concrete blocks
- ♦ Softening point: 102.50 C ± 9.50 C as per ASTM D 36.
- ♦ Yellowness index (for white thermoplastic paint): not more than 0.12 as per AASHTO M 249

### (c) Storage Life:

The material shall meet the requirements of these Specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or non-melted particles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer/ supplier/Contractor.

### (d) Reflectorizing :



Shall be achieved by incorporation of beads, the grading and other properties of the beads shall be as specified in: Reflectorizing Glass Beads” below.

**(e) Marking :**

Each container of the thermoplastic material shall be clearly and indelibly marked with the following information:

- ♦ The name, trade mark or other means of identification of manufacturer
- ♦ Batch number
- ♦ Date of manufacture
- ♦ Colour (white or yellow)
- ♦ Maximum application temperature and maximum safe heating temperature.

**(3) Reflectorizing Glass Beads**

Type 1 beads are those which are constituent of the basic thermoplastic compound as per Table 15.1 and Type 2 beads are those which are to be sprayed on the surface. The glass beads shall be transparent, colourless and free from milkiness, dark particles and excessive air inclusions. These shall conform to the requirements spelt out in: application Properties of Thermoplastic material”.

**Specific Requirements of Reflectorizing Glass beads:**

**(a) Grading:**

The glass beads shall meet the following requirements of grading for the two types as given in Table 15-2.

**Table 15-2: Grading Requirements for Glass Beads**

Sieve Size	Percent Retained	
	Type-1	Typ-2
1.18 mm	0 to 3	
850 micron	5 to 20	0 to 5
600 micron	--	5 to 20
425 micron	65 to 95	--
300 micron	--	30 to 75
180 micron	0 to 10	10 to 30
Below 180 micron	--	0 to 15

**(b) Roundness:**

The glass beads shall have a minimum of 70 per cent true spheres.

**(c) Refractive Index:**

The glass beads shall have a minimum refractive index of 1.50.

**(d) Free Flowing Properties :**

The glass beads shall be free of hard lumps and clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow test

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**(4) Application Properties of Thermoplastic Material**

The thermoplastic material shall readily get screeded/ extruded at temperatures specified by the manufacturers for respective method of application to produce a line of specified thickness which shall be continuous and uniform in shape having clear and sharp edges.

The material upon heating to application temperatures, shall not exude fumes, which are toxic, obnoxious or injurious to persons or property.

**(5) Preparation**

The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material to avoid local overheating. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed to exceed the maximum temperature slated by the manufacturer. The molten material should be used, as expeditiously as possible and for thermoplastic material, which has natural binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.

After transfer to the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying.

**(6) Application**

Marking shall be done by machine. For locations where painting cannot be done by machine, approved manual methods shall be used with prior approval of the Engineer. The Contractor shall maintain control over traffic while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

The thermoplastic material shall be applied hot either by screeding or extrusion process. After transfer to the laying apparatus, the material shall be laid at a temperature within the range specified by the manufacturer for the particular method of laying being used. The paint shall be applied using a screed or extrusion machine.

The pavement temperature shall not be less than 10°C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the paint.

The material, when formed into traffic stripes, must be readily renewable by placing an overlay of new material directly over an old line of compatible material. Such new material shall so bond itself to the old line that no splitting or separation takes place.

Thermoplastic paint shall be applied in intermittent or continuous lines of uniform thickness of at least 2.5 mm unless specified otherwise. Where arrows or letters are to be provided, thermoplastic compound may be hand sprayed. In addition to the beads included in the material, a further quantity of glass beads of Type 2, conforming to

the above noted Specification shall be sprayed uniformly into a mono-layer on to the hot paint line in quick succession of the paint spraying operation. The glass beads shall be applied at the rate of 250 grams per square metre area.

**(7) Tolerance Requirement**

Road marking shall be constructed to an accuracy within the tolerance given below:

**(a) Width**

The width of the lines and other markings shall not deviate from the specified width by more than 5%.

**(b) Position**

The position of lines, letters, figures, arrows, and other marking shall not deviate from the true position specified by more than 20 mm.

**(c) Alignment of Markings**

The alignment of any edge or a longitudinal line shall not deviate from the true alignment by more than 10 mm in 15 m.

**(d) Broken Lines**

The length of segments of broken longitudinal lines shall not deviate from the specified length by more than 150 mm.

In broken lines, the length of segment and the gap between segments shall be as indicated on the drawings; if these lengths are altered by the Engineer, the ratio of the lengths of the painted sections shall remain the same.

**(8) Tests and Standard of Acceptance**

**Sampling and Testing of Thermoplastic Material**

The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Employer a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification

**Sampling and Testing of Reflecting Glass beads**

Free-flow test: Spread 100 grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250mm inside diameter desiccator, which is filled within 25 mm of the top of a desiccator plate with sulphuric acid water solution (specific gravity 1.10). Cover the desiccator and let it stand for 4 hours at 20 to 29 degree C. Remove sample from desiccator, transfer beads to a pan and inspect for lumps or clusters. Then pour beads into a clean, dry glass funnel having a 100 mm stem and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be essentially free of lumps and clusters and shall flow freely through the funnel.

The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per BS 6088 and BS3262 (Pan I).

The Contractor shall furnish to the Employer a copy of certified test reports from the manufacturer of glass beads obtained from a reputed laboratory showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification. However, if so required, these tests may be carried out as directed by the Engineer.

The minimum thickness specified is exclusive of surface applied glass beads. The method of thickness measurement shall be in accordance with Appendices B and C of BS - 3262 (Part 3).

#### **Properties of Finished Road Marking**

The finished lines shall be free from ruggedness on sides and ends and be parallel to the general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.

- ♦ The stripe shall not be slippery when wet
- ♦ The marking shall not lift from the pavement in freezing weather
- ♦ After application and proper drying, the stripe shall show no appreciable deformation or discoloration under traffic and under road temperatures up to 60 °C
- ♦ The marking shall not deteriorate by contact with sodium chloride, calcium chloride or oil dripping from traffic
- ♦ The stripe or marking shall maintain its original dimensions and position. Cold ductility of the material shall be such as to permit normal movement with the road surface without chopping or cracking.

#### **(9) Measurement**

The measurement of thermoplastic road marking shall be in square meter of actual area marked (excluding gap if any).

#### **(10) Payment**

The quantities measured as provided above shall be paid at the respective contract unit rate for each type of marking signs which shall be the full and the final compensation to the Contractor as per Clause 112 for carrying out the work as specified in these Specifications.

Item No.	Description	Unit
<b>1506</b>	<b>Thermoplastic Road Marking</b>	
1506-1	Thermoplastic road marking (Yellow and White)	sq.m.

### **1507 REFLECTIVE PAVEMENT MARKERS (ROAD STUDS) AND SOLAR POWERED ROAD MARKERS (SOLAR STUDS)**

## (1) Scope

The work shall consist of providing and fixing of Reflective Pavement Marker (RPM) or road stud, a device which is bonded to or anchored within the road surface, for lane marking and delineation for night time visibility, as specified in the contract.

## (2) Materials

Plastic body of RPM/ road stud shall be moulded from ASA (Acrylic Styrene Acrylonitrile) or HIPS (Hi –impact Polystyrene) or Acrylonitrile Butadiene Styrene (ABS) or any other suitable material approved by the Engineer. The markers shall support a load of 13,635 kg tested in accordance with ASTM D 2480.

Reflective panels shall consist of number of lenses containing single or dual prismatic cubes capable of providing total internal reflection of the light entering the lens face. Lenses shall be molded of methyl methacrylate confirming to ASTM D 788 or equivalent.

## (3) Design

The slope of retro reflecting surface shall preferably be  $35 \pm 50$  to base and the area of each retro – reflecting surface shall not be less than 13 sq. cm.

## (4) Optical Performance

### (a) Unidirectional and Bi Directional Studs

Each reflector or combination of reflector on each face of the stud shall have a Coefficient of Luminous Intensity (CIL) not less than that given in Table 15-3 or Table 15-4 as appropriate.

### (b) Omni- directional Studs

Each Omni directional stud shall have a CIL of not less than 2 mcd/lx

**Table 15.3 Minimum CIL values for category “A” Studs**

Entrance Angle	Observation Angle	CIL in mcd/lx		
		White	Amber	Red
0° U 5° L & R	0.3°	220	110	44
0° U 10° L & R	0.5°	120	60	24

**Table 15.4 Minimum CIL values for category “B” Studs**

Entrance Angle	Observation Angle	CIL in mcd/lx		
		White	Amber	Red
0° U 6° L & R	0.3°	20	10	4
0° U 10° L & R	0.5°	15	6.5	3

Note:

- 1) The entrance angle of 0o U corresponds to the normal aspect of the reflectors when the reflecting road stud is installed in horizontal surface.
- 2) The stud incorporating one or more corner cube reflectors shall be included in Category “A” The stud incorporating one or more bi-convex reflectors shall be included in Category “B”.

## **(5) Tests**

Co-efficient of luminance intensity can be measured by procedure described in ASTM E809 “Practice for Measuring Photometric Characteristics” or as recommended in BS: 873-part 4: 1973.

Under test conditions, a stud shall not be considered to fail the photometric requirements if the measured CIL at any one position of measurement is less than the values specified in Table 15.1 or 2 provided that

- ♦ The value is not less than 80 percent of the specified minimum and
- ♦ The average of the left and right measurements for the specific angle is greater than the specified minimum.

## **(6) Rumble Strips**

The road marking by Rumble Strips shall be made as shown in the Drawings, and as approved by the Engineer.

## **(7) Fixing of Reflective Markers**

### **(a) Requirements:**

The enveloping profile of the head of the stud shall be smooth and the studs shall not present any sharp edges to traffic. The reflecting portions of the studs shall be free from crevices or ledges where dirt might accumulate. Marker height shall not be less than 10 mm and shall not exceed 20 mm, and its width shall not exceed 130 mm. The base of marker shall be flat within 1.3 mm. If the bottom of the marker is configured, the outermost faces of the configurations shall not deviate more than 1.3 mm from flat surface. All road studs shall be legibly marked with name, trade mark or other means of identification of the manufacturer.

### **(b) Placement**

The reflective marker shall be fixed to the road surface using the adhesives and the procedure recommended by the manufacturer. No nails shall be used to affix the marker so that they do not pose safety hazard on the roads. Regardless of the type and adhesive used, the markers shall not be fixed if the pavement is not surface dry and on new asphalt concrete surfacing until the surfacing has been opened to traffic for a period of not less than 14 hours. The portions of the highway surface, to which the marker is to be bonded by the adhesive, shall be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint and any other material which would adversely affect the bond of the adhesive.

The adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the marker in a quantity sufficient to result in complete coverage of the area of contact of the marker with no voids present and with a slight excess after the marker has been lightly pressed in place. For epoxy installations, excess adhesive around the edge of the marker, excess adhesive on the pavement and adhesive on the exposed surface of the markers shall be immediately removed.

### (c) Warranty and Durability

The Contractor shall submit a two year warranty for satisfactory field performance including stipulated retro reflectance of the reflecting panel. To the Engineer. In addition, a two year warranty for satisfactory infield performance of the finished road marker shall also be given by the Contractor who carries out of the work of fixing of reflective road markers. In case the markers are displaced, damaged, get worn out or lose their reflectivity compared to stipulated standards, the contractor would be required to replace all such markers within 15 days of the intimation from the Engineer, at his own cost.

### (8) Measurement

Reflective road markers/ solar powered road studs shall be measured in number. Supply and erection of marker and accessories shall not be measured. They are deemed included in the measurement of reflective road marker/ solar powered studs.

### (9) Payment

Reflective road marker/ solar powered studs measured as above shall be paid at the contract unit rate. The contract unit rate shall be the full and the final compensation to the Contractor as per Clause 112 and also for the all other incidental costs so as to complete the work as specified.

Item No.	Description	Unit
<b>1507</b>	<b>Reflective Pavement Markers (Road Studs) And Solar Powered Road Markers (Solar Studs)</b>	
1507-1	Plastic reflective pavement markers (Road studs at madien edge in tunnel, shoulder of traffic island and nouse)	nos.
1507-2	Aluminum reflective pavement markers (Road studs at Center)	nos.
1507-3	Rumble strips (W=150mm, L=350mm, Depth=12mm @ 300mm) on concrete pavement	lin.m
1507-4	Rumble strips (W=150mm, L=350mm, Depth=12mm @ 300mm) on asphalt pavement	lin.m

## 1508 STEEL CRASH BARRIER

### (1) Scope

The work shall consist of furnishing/providing of all components of Steel W-Beam Crash Barrier and installation of steel beam crash barrier of dimensions as shown on the drawing(s) or as directed by the Engineer.

Steel W-beam crash barrier shall generally be located on approaches to bridge structures, at locations where embankment height is more than 3 meters and at sharp horizontal curves or as directed by the Engineer.

### (2) Materials

The metal beam rail shall be corrugated sheet steel beam of the class, type, section



and thickness indicated on the drawings. Railing post shall be made of steel of the section, weight and length as shown on the drawings. All complete steel rail elements, terminal sections, posts, nuts, hardware and other steel fittings shall be galvanized. All elements of railing shall be free from abrasions, rough or sharp edges and shall not be kinked, twisted or bent.

The design materials to be used and the location of metal beam crash barrier shall conform to relevant drawings or as otherwise directed by the Engineer.

**(a) Order for Materials and Manufactured Articles**

The Contractor shall, before placing any order for materials and manufactured articles for incorporation in the Works, submit to the Engineer the names of the firms from whom he propose to obtain such materials and manufactured articles, giving for each firm a description of the materials and manufactured articles to be supplied, their origin, the manufacturer's specification, quality, weight, strength and other relevant details ( details of projects where the product/ process/ system has been successfully used). The Contractor shall submit the samples of such materials and manufactured articles when requested by the Engineer and when appropriate, manufacturer's certificates of recent test carried out on similar materials and manufactured articles shall also be submitted.

**(b) Test Certificates**

When instructed by the Engineer, the Contractor shall submit to him all Test Certificates from the suppliers/manufacturers of the materials and/or manufactured articles to be used for the contract. Such certificates shall certify that the materials and/or manufactured articles concerned have been tested in accordance with the requirements of these Specifications. All Test results shall be enclosed along with such certificates. The Contractor shall provide adequate means of identifying the materials and/or manufactured articles delivered on the site with the corresponding certificates.

**(c) Technical Specification for Steel Crash Barrier and Accessories**

The "W beam type safety barrier shall consist of steel post and a 3 mm thick "W" beam rail element. The steel post and blocking out spacer shall both be channel section of 75 mm x 150 mm & 5 mm thick. The rail shall be 70 cm above the ground level and post shall be spaced 2m centre to centre Double "W "beam barrier shall be as indicated in IRC 5-1988.

The Thrie Beam Safety Barrier shall have post and spacer similar to ones mentioned above for "W "beam type. The rail shall be placed at 85 cm above the ground level.

The "W" beam, thrie beam, the posts, spacers and fasteners for steel barriers shall be galvanised by hot dip process (zinc coated 0.55 kg per square metre; minimum single spot) unless otherwise specified. The Galvanizing on all other steel parts shall be confirm to the relevant NS/IS specifications. All fittings (bolts, nuts, washers) shall confirm to the IS: 1367 and IS: 1364. All galvanizing shall be done after fabrication.



SN	Item	Requirement
1	W-beam guard rail :	<p><b>Base Metal:</b> The beam, end sections shall consist of sheet made of open hearth, electric furnace, or basic oxygen steel and shall meet the mechanical properties specified below:</p> <ul style="list-style-type: none"> <li>• Length of rail -- 4.318 m/ 2.318 m</li> <li>• Yield stress, minimum, 310 MPa; and</li> <li>• Elongation, in gauge length (5.65X (sqrt of cross sectional area)) minimum, 15 percent.</li> </ul>
2	C-Channel post:	<ul style="list-style-type: none"> <li>• Length of Post – 1800 mm.</li> <li>• Yield stress , minimum 410 MPa;</li> </ul>
3	C-Channel spacer	<ul style="list-style-type: none"> <li>• Length of Spacer– 330 mm.</li> <li>• Yield stress , minimum 410 MPa</li> </ul>
4	All fittings ( Bolt , Nuts, Washer)	<ul style="list-style-type: none"> <li>• Confirm to IS 1364 and IS 1367</li> </ul>

**(d) Packing of Steel W- Beam Crash Barrier and accessories**

The Steel W-Beam Crash Barrier and accessories shall be well packed after the verification of compliance with specification requirement to the acceptable standard by the Engineer/Inspection agent before dispatching from the manufacturer's premises. The packing shall facilitate safe transportation/shipment which ensures maintaining the true shape and zinc coating. The packing shall be tagged by the Engineer/Inspection Agent before dispatching from the manufacturer's premises and shall remain intact upon arrival at designated storage site.

**(e) Storage of Metal Beam Crash Barrier and accessories**

The Contractor shall be responsible for the safe storage of the Metal Beam Steel Crash Barrier and accessories in the storage yard. The Contractor shall be responsible for the safe keeping of the Metal Beam Crash Barrier and all accessories until the installation. The contractor shall submit details of storage facility for approval of the Engineer so as to ensure that the crash barriers imported will be stored satisfactorily.

**(3) Construction Operations**

- The line and grade of Steel Beam Crash Barrier shall be true to that shown on the plans. The railing shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled in place in the structure at proper grade and alignment.
- Splices and end connections shall be of the type and designs specified or shown on the plans and shall be of such strength as to develop full design strength of the rail elements.
- Concrete for bedding and anchor assembly shall conform to Section 2000. The minimum size of the concrete foundation block for embedding guard posts and grade of concrete shall be as shown in the drawing or as directed by the Engineer.
- Installation of Posts:** Holes shall be dug or drilled to the depth indicated on the drawings or post may be driven by approved method and equipment, provided

these are erected in proper position and are free from distortion and burring or any other damage.

All post holes that are dug or drilled shall be of such size as will permit proper setting of the posts and allow sufficient room for backfilling or tapping. Alternatively, the guard posts may be embedded in the concrete footing of size and grade of concrete along with the depth of the embedment of post or as indicated in the drawing.

Posts and the end section for steel w-beam crash barrier on bridges shall be bolted to the structure as detailed on the plans. The anchor bolts shall be set to proper location and elevation with templates and carefully checked.

- (e) **Erection:** The Contractor shall engage a qualified person having experience in installing metal crash barrier.

All guardrail anchors shall be set and attachments made and placed as indicated on the plans or as directed by the Engineer.

All bolts or clips used for fastening the guardrail or fittings to the posts shall be drawn up tightly. Each bolt shall have sufficient length to extend at least 6 mm through and beyond the full nut, except where such extensions might interfere with or endanger traffic in which case the bolts shall be cut off flush with the nut.

All railings shall be erected, drawn and adjusted so that the longitudinal tension will be uniform throughout the entire length of the rail.

The reflective sticker shall be at the spacing of 4m interval or as directed by the Engineer. Retro reflective sheeting / tape for sticking on to guardrails shall meet the retro reflective properties. Tape should be 10 cm wide with red and white colour and shall be pasted as per the instruction of the Engineer.

#### (5) **End Treatment for Steel Barrier**

End treatments shall form an integral part of safety barriers which should not spear, vault or roll a vehicle for head-on or angle impacts. The two end treatments recommended for steel barriers are "Turned-down guardrail" and "Anchored in back slope" as shown on the Drawings or as directed by the Engineer. Other treatment may be placed as shown in the drawing or as directed by the Engineer.

#### (6) **Tests and Standard of Acceptance**

The Contractor shall be responsible for testing and conforming compliance of the quality of Metal Beam crash barrier and all related accessories as specified in above table upon arrival in storage yard. The Contractor shall bear the cost related to all sampling and testing cost including any transportation cost of sample to the laboratory.

The Contractor shall inform when the delivery of Metal Beam Crash Barrier and its accessories to the storage yard is completed. The Engineer can take assistance of Inspection Agent for the verification while the Contractor makes arrangement of sampling and testing of compliance with specification requirement of Metal Beam Crash Barrier and its accessories from an independent laboratory accredited by

reputed accreditation agencies in the Employer's Country and their quantity

The material shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall be responsible for testing and conforming compliance of the quality of Steel W-Beam Crash Barrier and all related accessories before dispatching them from manufacturer's premises. The Contractor shall bear the cost related to all sampling and testing cost including any transportation cost of sample to the laboratory

**Frequency of sampling:**

One piece of Steel W-Beam Crash Barrier, end section, nut, bolt, washer, channel post, spacer from each 200 pieces in a lot or from each lot if less than 200 pieces shall be sampled for determination of compliance with specification requirement

From each lot the number of tests for the fulfilment of requirements for Nut and Bolts shall be as follows:

Number of Pieces in Lot	Number of Supplies
800 and under	1
801 to 8000	2
8001 to 22000	3
Over 22000	5

**Tolerance:**

The posts shall be vertical with a tolerance not exceeding 6 mm in a length of 3 meter. The railing barrier shall be erected true to line and grade.

**(7) Measurement**

All steel crash barriers shall be measured by linear metres of completed and accepted length in place.

Unless otherwise stated in other sections of these specifications, Terminals/ anchors, Retro reflective Stricker, drilling, excavation, preparation of foundation and backfill, supply and erection C channel post, C- channel spacer Bolt, nuts and accessories, and all incidentals to complete the work in accordance with the Drawings and Specifications, and as directed by the Engineer, shall neither be measured nor paid separately. They are deemed included in the measurement of crash barrier.

**(8) Payment**

Steel crash barrier measured as above shall be paid at the contract unit rate. The contract unit rate shall be the full and the final compensation to the Contractor as per Clause 112 and also for the cost of excavation, backfill, painting reflecting elements (where specified) including all other incidental costs so as to complete the work as specified.

Item No.	Description	Unit
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<b>1508</b>	<b>Steel Crash Barrier</b>	
1508-1	Steel crash barrier type-A set on earth shoulder	lin.m.
1508-2	Steel crash barrier type-B set on structure	lin.m.

## 1509 POLYETHYLENE TANK CRASH BARRIER

### (1) Scope

This Clause covers the supply and installation of Polyethylene Tank Crash Barrier at locations as shown in the Drawing or as directed by the Engineer.

### (2) Materials

The Polyethylene Tank Crash Barriers shall be supplied from an approved source. If painting is required, the paint shall be non-reflectORIZED type and shall confirm NS: 112.

The following types shall be provided:

- ◆ Polyethelene tank 1000 litre filed with sand
- ◆ Polyethelene tank 1000 litre filed with water
- ◆ Polyethelene tank 750 litre filed with water
- ◆ Polyethelene tank 500 litre filed with water

### (3) Submittals

The Contractor shall submit all information regarding to the Polyethylene Tank Crash Barriers listed above to be supplied including fabrication catalogues and manufacturer's specifications, fabricator name and certifications, installation manuals, including details of procurement and transportation for the Engineer's consent.

### (3) Construction

The Polyethylene Tank Crash Barriers, before be filled with water or sand as may correspond, shall first be located in its respective location in accordance with the Drawings, and as approved by the Engineer.

### (6) Measurement

All barriers shall be measured by linear metres as specified in contract for completed and accepted length in place.

### (7) Payment

The Polyethylene Tank Crash Barriers, measured as above, shall be paid at the contract unit rate. The contract unit rate shall be the full and the final compensation to the Contractor as per Clause 112 and also for painting reflecting elements (where specified) including all other incidental costs so as to complete the work as specified.

Item No.	Description	Unit
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<b>1509</b>	<b>Polyethylene tank crash barrier</b>	
1509-1	Polyethylene tank 1000 litre filled with sand	No.
1509-2	Polyethylene tank 1000 litre filled with water	No.
1509-3	Polyethylene tank 750 litre filled with water	No.
1509-4	Polyethylene tank 500 litre filled with water	No.

## SECTION 1600: PILING FOR STRUCTURES

- (1) *Add the following new Sub-Section at the end of Sub-Section 1617: “Payment” and before Section 1700: “Well Foundation”*

### 1618 SHINSO PILES (CAST-IN-SITU PILE BY MANUAL EXCAVATION)

#### (1) Description

The cast-in-situ piles (using manual excavation) defined in this Section consist of the piles constructed applying the construction method of Shinso piles for deep foundation (a method which works for concrete pouring are made by labours entering inside the excavated hole).

#### (2) Standards

The works for construction of the Shinso Piles shall conform with the following standards:

- ◆ Guideline for Management of Concrete Constructions. Nippon Expressway Company Limited. Japan 2017.
- ◆ Guideline for Management of Structures Constructions. Nippon Expressway Company Limited. Japan 2017.
- ◆ Standard Specifications for Roads and Bridges. Volume IV: Construction of Substructure. Japan Road Association.

#### (3) Materials

The requirements for concrete and steel reinforcement of Section 2000: “Concrete for Structures” and Section 2014: “Reinforcement” of these specifications shall be satisfied.

The materials for Liner-Plate regarding to the steel shall meet the requirements of the JIS standards, or equivalent upon the approval by the Engineer:

- ◆ JIS G3101-SS400 (steel plate/sheet for general purpose structural steels)
- ◆ JIS G3131-SPHC (steel plate/sheet for stamping and cold forming steels)
- ◆ JIS G3101- SS330 (Japanese Standard Common Structural Steel)
- ◆ JIS B1180 (Hexagon Head Bolt).

Specifically the material for Liner-Plate and Steel shall meet the following specifications:

- ✓ Liner plate: SS330 as specified in JIS G3101 or equivalent material.
- ✓ Bolt / Nut: Grades 4.6 and 8.8 specified in JIS B1180 or equivalent.
- ✓ Steel: SS400 as specified in JIS G3101 or equivalent material.

#### (4) Construction Requirements

- ◆ Prior to all activities described in this Section, the Contractor shall perform the respective boring investigation to confirm the existing conditions of the bearing ground in accordance with the requirements of Section 3000: “Subsurface Geotechnical

Investigation” and/or as directed by the Engineer.

- ♦ When a liner-plate (including reinforcement rings) is being used as a retaining plate for preventing the collapse of the excavated hole walls, it shall be buried and installed in accordance with the Drawings and as instructed by the Engineer, and omissions, deformities and loosening shall be avoided.
- ♦ In addition, when a mortar-lining is being used, the surface of the excavated hole shall be prepared carefully removing the loose material and the supports shall be installed properly as shown in the Drawings and as instructed by the Engineer, the construction shall be performed securing the use of adequate materials.
- ✓ The requirements for quality of the mortar for lining are the following:

Compressive strength after 15hr of curing <sup>(1)</sup>	Compressive strength after 28 days of curing <sup>(1)</sup>	Cement Type
More than 3 N/mm <sup>2</sup>	More than 24 N/mm <sup>2</sup>	Normal Portland Cement

Notes:

(1): Testing method in accordance with the standards of JSCE (Japan Society of Civil Engineering) for testing cores of d=5cm: JSCE F561-2005.

- ✓ If shotcrete and rock-bolts are used, it shall refer to the relevant sections of these specifications.
- ♦ In the sections where the liner-plate will be applied, it is necessary to set-up previously the grouting-pipe and prepare the mortar, and to carry out the back filling grout. The following requirements shall be satisfied for preparation of the grout mortar for back filling:

Material for Injection	Cement Content <sup>(2)</sup>	Mortar Flow	Air Content <sup>(3)</sup>	Compressive strength after 28 days of curing <sup>(1)</sup>
Mortar for back-filling	340 kg/m <sup>3</sup>	25±5 Seconds	4±1 %	More than 2.5 N/mm <sup>2</sup>

Notes:

(1): Testing method in accordance with the standards of JSCE (Japan Society of Civil Engineering) for testing cores of d=5cm: JSCE F561-2005.

(2): Cement type: Normal Portland Cement or Blast Furnace Cement Type-B

(3): Tested in accordance with the standards of ASTM C231: “Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method”.

- ✓ The approval by the Engineer on the materials shall be based on the standards of the “Guideline for Management of Structures Constructions” by Nippon Expressway Company Limited (Japan 2017) to perform the testing and supervision.
- ✓ In the case of injection, the system shall set up an apparatus for measuring the flow rate and pressure, and the measurement results must be submitted to the Engineer.
- ♦ The concrete used in these works shall be referred to the requirements of Section 2000: “Concrete for Structures”. The concrete shall be of Class-B.
- ♦ The reinforcement used in these works shall be referred to the requirements of Section

2014: “Reinforcement”.

- ◆ Once the excavation is completed, the Contractor shall request for an inspection by Engineer.
- ◆ In the event that an unforeseen material such a huge boulder, etc. is found during the excavation, the Contractor shall request the instructions from the Engineer regarding to how to handle this situation. In this case, if the Engineer considers that it will be necessary a modification on the design drawings, a Variation Order to modify the design and respective unit price shall be discussed with the Engineer.
- ◆ The treatment applied for the excavation shall be in accordance with these Special Provisions to the Standards Specifications.

#### **(5) Measurement**

- ◆ The works for “Shinso piles with steel lining” shall be measured for payment in cubic metres of excavation actually completed in Site as show in the Drawings for each diameter and plate thickness, and approved by the Engineer. The measurement of excavated volume shall be based on the nominals diameter and length of the liner-plate buried in Site and accepted by the Engineer.
- ◆ The Shinso Piles (Cast-in-Situ by manual excavation), of the sizes and types specified in the Drawings, shall be measured in cubic metres of excavation actually completed in Site, and approved by the Engineer. The measurement of excavated volume shall be based on the nominals diameter and length shown in the Drawings for each pile type, actually buried in Site and accepted by the Engineer.
- ◆ Quantities of Concrete Class B for Shinso Piles shall be measured in cubic metres of Concrete Class-B actually completed in Site, in accordance with the requirements of Section 2018(1): “Concrete” (Measurement), and as approved by the Engineer.
- ◆ Quantities of reinforcement shall be measured in tons of Reinforcement actually completed in Site, in accordance with the requirements Section 2018(4): “Reinforcement” (Measurement) and as approved by the Engineer.

#### **(6) Payment**

- ◆ General: The Shinso Piles measured as described above shall be paid at the contract unit rates which shall be the full and the final compensation to the Contractor as per Clause 112, including excavation, cleaning, and all ancillary works, and furnishing, producing, mixing and placing mortar, additives (if any), all materials and tests including transportation, furnishing all labour, materials, tools, machinery/equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specification Sections, and/or as directed by the Engineer.
- ◆ “Shinso piles with steel lining”: Payment shall include the cost for excavated quantities of the material for steel lining measured in accordance with the provisions of the preceding paragraph (general) and all works for installation of the Grouting-pipe and liner-plate in accordance with the design and Drawings, and as approved by the



Engineer.

- ♦ “Shinso Piles (Cast-in-Situ by manual excavation)”: Payment shall include the cost for excavated quantities of the material for Cast-in-Situ by manual excavation measured in accordance with the provisions of the preceding paragraph (general) and all cost for performing the process of manual excavation and Cast-in-Situ of concrete, mortar lining for soil fastening (shotcrete), installation of lining thickness inspection rods, etc.
- ♦ “Concrete Class-B for Shinso Piles”: Payment shall include the cost for providing and placing Concrete Class-B for Shinso Piles in accordance with the requirements of Section 2000: “Concrete for Structures for the works and Section 2019(1): “Concrete” (payment)
- ♦ “Reinforcement”: Payment shall include the cost for providing and installing Reinforcement in accordance with the requirements of Section 2014: “Reinforcement” for the works and Section 2019(3): “Reinforcement” (payment).

Payment for the following items for “Shino” Piles (Cast-in-Situ Pile by Manual Excavation) shall be made under Section 7500: “Steel Bridge for Flyover” in accordance with the requirements established in this Section:

- ♦ Pay Item 7503-1: Excavation of Shinso with Steel Lining (D=2.50m ~ 5.00m) ..... cu.m.
- ♦ Pay Item 7503-2: Excavation of Shinso with Shotcrete (D=2.50m ~ 5.00m, 100mm thick with steel net) ..... cu.m.
- ♦ Pay Item 7503-3: Excavation of Shinso with Shotcrete (D=2.50m ~ 5.00m, 150mm thick with steel net) ..... cu.m.
- ♦ Pay Item 7503-4: Concrete Class-B for Shinso Piles (D=2.50m ~ 5.00m).. cu.m.
- ♦ Pay Item 7503-5: Reinforcement for Shinso Piles ..... ton

## SECTION 1900: BEARINGS AND EXPANSION JOINTS

### 1901 EXPANSION JOINTS

#### (8) Payment

- (1) *Insert the following at the end of Clause 1901(8): “Payment”:*

Item No.	Description	Unit
<b>1901</b>	<b>Expansion Joints</b>	
1901-1	Expansion Joint Type-A (for Reinforced Concrete Bridge)	lin.m.

### 1902 BEARINGS

#### (6) Measurement

- (2) *Delete the full text of Clause 1902(6): “Measurement” and replace with the following:*

Regardless the material or type, all bearings shall be measured in numbers, inclusive of all ancillary and incidental works, according to their capacities and particular specifications given on the drawings.

#### (7) Payment

- (3) *Delete the full text of Clause 1902(7): “Payment” and replace with the following:*

The bearings measured as above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 including cost for bearing devices, material, labour, equipment, tools, and all incidentals used to complete the work in accordance with the Drawings and Specifications, and as directed by the Engineer.

Item No.	Description	Unit
<b>1902</b>	<b>Bearings</b>	
1902-1	Elastomeric Bearing 320 mm x 500 mm x 56 mm (without pins)	No.
1902-2	Elastomeric Bearing 200 mm x 320 mm x 40 mm (without pins)	No.
1902-3	Anchor bar and cap (for approach slab)	set

## SECTION 2000: CONCRETE FOR STRUCTURES

### 2003 MATERIAL FOR CONCRETE

#### (2) Cement

- (1) Delete the first paragraph of Clause 2003(2): “Cement” and replace with the following:

Cement shall be Ordinary Portland Cement (OPC) Grade-53 complying with the requirements of Clause 614, or other type of cement approved by the Engineer.

The cement to be used for construction of Continuously Reinforced Concrete Pavement (CRCP) shall be provided in the manufacturer bulk transported to the Project Site in containers.

### 2004 DESIGN OF CONCRETE MIXES

#### (1) Classes of Concrete

- (2) Rename the Table 20.3 “Concrete Classes and Strength” as follows:

**Table 20.3(a) Concrete Classes and Strength**

- (3) Insert the following table after Table 20.3 as per supplementary description of specific concrete classes to be used in the Project:

**Table 20.3(b) Composition and Strength of Specific Concrete Classes used in the Project**

Description	Concrete Class					
	A	B	C	D	E (Lean Concrete)	P (CRCP, JRCP)
Maximum Size of Coarse Aggregate <sup>(4)</sup> (mm)	20	20	20	20	20	20
Slump (cm) <sup>(1)</sup>	7.5±2.5	7.5±2.5 (15±2.5) <sup>(3)</sup>	7.5±2.5	8.0±2.5	7.5±2.5	3.5±1.5
Ratio of water/cement (%) <sup>(5)</sup>	49.4	61.4	65.0	65.0	76.0	42
Minimum Cement Content (kg/m <sup>3</sup> )	450	350	350	310	180	450
Minimum Strength at 28 days (MPa) <sup>(2)</sup>	Compressive Strength. Test method of AASHTO T22 using cylinders					Flexural Strength AASHTO T97 (ASTM C78)
	30	25	20	15	13	4.25
Minimum Strength at 28 days (MPa) <sup>(2)</sup>	Compressive Strength. Test method of IS 516.1959 using cubes					
	35	30	25	20	15	

Notes:

1) Slump shall be determined by AASHTO T119 or JIS A 1101.

2) Testing for concrete compressive strength using cylinders or cubes shall be subject of approval by the Engineer unless otherwise herein specified.

3) Requirements for Building Works

4) The aggregates for these Concrete Classes shall satisfy the requirements specified by AASHTO-M6 (for fine aggregates) and AASHTO M43 (for coarse aggregates)

5) The ratios shown for the w/c contents are as per initial reference. The Contractor shall determine the proper ratio based on the results obtained from the Mix Design approved by the Engineer.

**Table 20.3(c) Concrete Classes and its Application in the Project**

Concrete Class (C strength/size) <sup>(note)</sup>	Equivalent Type (Table 20.3a)	Description
A (C30/20)	M35/20	Concrete for bridges and structures: <ul style="list-style-type: none"> <li>♦ Footing of bridges</li> <li>♦ Abutment of bridges</li> <li>♦ Pier of bridges</li> <li>♦ Slab for bridges; RC Slab for Flyover</li> <li>♦ Railing and guard-wall for Flyover</li> </ul>
B (C25/20)	M30/20	Concrete for building and structures, <ul style="list-style-type: none"> <li>♦ Box culverts (basement/wall/slab)</li> <li>♦ Abutment of flyover</li> <li>♦ Pier of flyover</li> <li>♦ Shinso piles</li> <li>♦ Tunnel portal structures</li> </ul> <p>If additives for Air Entrance (AE) are used, Concrete Class B-AE can be established.</p>
C (C20/20)	M25/20	<ul style="list-style-type: none"> <li>♦ Gates (sliding and/or fixed)</li> <li>♦ Crib frames</li> <li>♦ Kerbs (precast or cast-in-place)</li> <li>♦ Footpaths</li> <li>♦ Transmission Line</li> </ul> <p>If additives for Air Entrance (AE) are used, Concrete Class B-AE can be established.</p>
D (C15/20)	M20/20	<ul style="list-style-type: none"> <li>♦ Foundations footing</li> <li>♦ Drainage works</li> <li>♦ Channels</li> <li>♦ Backside of breast wall</li> <li>♦ Foot protection blocks for river-bed protection</li> <li>♦ KM posts</li> <li>♦ Basement for fences and railings</li> <li>♦ Stone masonry walls</li> <li>♦ Foundations for the foot/base of cast-in-place crib works</li> <li>♦ Support's foundation for Traffic Information Boards (TIB).</li> <li>♦ Concrete pavement type JCP for tunnel</li> </ul>
E (C13/20)	M15/20	Lean concrete/leveling concrete. For all structures
P (f 4.25)	n/a	Concrete pavements: <ul style="list-style-type: none"> <li>♦ CRCP</li> <li>♦ JRCP</li> <li>♦ Terminal Anchors for CRCP</li> <li>♦ and any other concrete pavements</li> </ul>

Note: Example: A (C30/20) = Concrete Class-A (Compressive Strength of 30Mpa at 28 days tested by method of AASHTO T22 using cylinders, and maximum size of coarse aggregate of 20mm)

Before application of the designed mixes, the Contractor shall perform a complete set of testing of samples using cylinders (AASHTO T22) and cubes (IS 516.1959fdsf) in order to establish and confirm the ratio of correlation of the compressive strength between both

methods.

The composition and strength of concrete herein specified shall be considered without detriment to the stipulations described in other sections of these Specifications. In case of any discrepancy, the Engineer will provide a clarification.

## **(5) Quality Control of Concrete Production**

- (4) *Insert the following at the end of Clause 2004(5): “Quality Control of Concrete Production”:*

### **(c) Sampling and Testing for CRCP:**

Sampling and testing of concrete for CRCP shall be in accordance with the specification standards of AASHTO T97 (ASTM C78) for determining the Flexural Strength and AASHTO T22 for Compressive Strength.

The minimum frequency for sampling of concrete for CRCP shall be of 4 sets every 100 m<sup>3</sup> of concrete (i.e. one set every 25.0m<sup>3</sup>).

The quantity of concrete to be placed shall be in accordance with the construction statement and the daily construction program.

The set for sampling is defined as follows:

- ◆ Sampling for Flexural Strength Testing:

1 Set = 9 samples of beams L=70cm x H=15cm x W=15cm

To be tested at 3 days (3 samples), 7 days (3 samples) and 28 days (3 samples)

- ◆ Sampling for Compressive Strength Testing:

1 Set = 9 samples of cylinders d=15cm x H=30cm

To be tested at 3 days (3 samples), 7 days (3 samples) and 28 days (3 samples)

Testing at 3 days can be modified depending upon the schedule for continuation of concrete placing after every transversal construction joint (minimum 1 day, maximum 3 days or as approved by the Engineer). Early testing is acceptable to verify the strength achieved at the time that the works can be continued.

## **2005 MIXING CONCRETE**

- (5) *Replace the existing second paragraph of Sub-Section 2005: “Mixing Concrete”, starting with “Concrete for the works.....etc.” by the following:*

Concrete mixes shall be proportioned according to the Design mix or Prescribed mix as specified. All mixing operations shall be supervised by experienced supervisor. Cement and aggregate shall be batched by weight or by volume as specified in the contract. Water may be measured by weight or volume. The quantity of cement, each size of aggregate and water as indicated by the mechanism employed shall be within a tolerance of plus or minus three percent of the respective weight/ volume per batch agreed by the Engineer. The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Contractor by a method agreed by

the Engineer.

Concrete for the works shall be batched and mixed exclusively only in the Plants installed by the Contractor for the Project. The batching plants mobilized and installed for the Project shall be automatic and computerized of weighing (cement, aggregates, water, admixture) and mixing. All data for mixing (date, mixed volume, mixing time, weight of each materials, temperature) shall be recorded by computer hard disk and/or hard drive and shall be printed in daily basis to keep those documents properly compiled. The Contractor shall provide the mixing data to the Engineer before pouring operation is started.

- (6) *Insert the following at the end of Sub-Section 2005(3): “Mixing Concrete”:*

Hand mixing of concrete shall not be allowed. In any case that the Contractor requires to perform some specific small volumes of works using non-structural by hand-mixing may, the Contractor shall timely submit to the Engineer for review and approval all details of those works. These work shall not be measured nor paid separately, and it shall deemed included in the rates of the respective main items.

## **2007 PLACING OF CONCRETE**

- (7) *Insert the following paragraph immediately before of Clause 2007(1): “Consent of Placing”:*

Prior to any work for placing concrete is performed, the Contractor shall submit to the Engineer, for review and consent, the sequence of construction, and a method statement on the arrangements to supply, shop-drawings, handle and finish each intended pour area. The method statement shall contain comprehensive details of the operation necessary to produce the construction joints.

- (8) *Add the following new Sub-Section 2017: “Test and Standard of Acceptance” and renumber the remaining Sub-Sections as follows:*

*Renumbering:*

2017: “Measurement” → **2018: “Measurement”**

2018: “Payment” → **2019: “Payment”**

## **2017 TEST AND STANDARD OF ACCEPTANCE**

The requirements and procedures of this sub-section shall be applied as supplement, and without detriment, to other sections of these Specifications. In any case of discrepancies, a clarification by the Engineer shall be requested.

Testing of samples for CRCP shall be referred to Section 2050: “Concrete Pavements”.

### **(1) General:**

Concrete shall conform to the surface finish and tolerance as prescribed in these specifications for respective components.

Random sampling and lot by lot of acceptance inspection shall be made for the 28 days’ cube or cylindrical strength of concrete.

Concrete under acceptance shall be notionally divided into lots for the purpose of sampling, before commencement of work. The basis of delimitation of lots shall be as follows;

- (a) No individual lot shall more than 30 cu.m. in volume
- (b) Different grades of mixes of concrete shall be divided into separate lots
- (c) Concrete of a lot shall be used in the same identifiable component of the structure

## **(2) Sampling and Testing**

Concrete for making 3 test cubes/cylinders shall be taken from a batch of concrete at point of delivery into construction, according to procedure laid down in IS: 1199 or AASHTO T22 accordingly.

A random sampling procedure to ensure that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cubes 150 mm cubes shall be made, cured and tested at the age of 28 days for compressive strength in accordance with IS: 516. The 28-day test strength result for each cube shall form an item of the sample. Test at other age also shall also be performed, if specified.

Similar procedure shall be made for testing cylindrical samples in accordance with AASHTO T22.

## **(3) Test Specimen and Sample Strength**

Three test specimens shall be made from each sample for testing at 28 days. Additional specimens maybe required for various purposes such as to determine the strength of concrete at 7 days or for any other purpose.

The test strength of the sample shall be the average of the strength of 3 specimens. The individual variation should not be more that  $\pm 15$  per cent of the average. If variation is more, the test results of the sample are invalid.

The minimum frequency of sampling of concrete of each grade shall be in accordance with Table 5-1: "Testing Schedule" of Sub-Section 510: "Recapitulative Schedule of Tests".

## **(4) Acceptance criteria**

### **(a) Compressive Strength**

#### Cubes and/or Cylinders:

The concrete shall be taken as having the specified compressive strength when both the following conditions are met:

- ♦ The mean strength determined from any group of four consecutive non overlapping samples exceeds the specified characteristic compressive strength by 3 MPa.
- ♦ Strength of any sample is not less than the specified characteristic compressive strength minus 3 MPa.

The quantity of concrete represented by the test results include the batches from which the first and last samples were taken, together with all intervening batches

Cores:

When the concrete does not satisfy both the condition given in I above, representative cores shall be extracted from the hardened concrete for compression test in accordance with the method described in IS: 1199, or equivalent of AASHTO for cores' testing, and tested to establish whether the concrete satisfies the requirement of compressive strength.

Evaluation of compressive strength by taking cores may also be done in case of doubt regarding the grade of concrete used either due to poor workmanship or based on result of cube strength tests the locations from which core samples.

**(b) Chloride and Sulphate Content**

Where Chloride and Sulphate is specified. The total chloride and sulphuric anhydride ( $\text{SO}_3$ ) content of all the constituents of concrete as a percentage of mass of cement in the mix shall not exceed the values given in this Section of the specifications.

**(c) Density of Fresh Concrete**

Where minimum density of fresh concrete is specified, the mean of any four consecutive non-overlapping samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

**(d) Density of Hardened Concrete**

Where minimum density of hardened concrete is specified, the mean of any four consecutive non – overlapping samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

**(e) Permeability Test**

Where Permeability of concrete is specified, water Permeability test as per DIN: 1048 Part 5 – 1991 shall be carried out as described below

- ♦ A cylindrical test specimen 150 mm dia and 160 mm high shall be prepared
- ♦ After 28 days of curing, the test will be conducted between 28 and 35 days. The test specimen shall be fitted in a machine such that the specimen can be subjected to a water pressure upto 7 bars.
- ♦ The concrete specimen shall be subjected to a water pressure of  $0.5 \text{ N/mm}^2$  from the top for the period of 3 days. The pressure shall be maintained constant throughout the test period. If the water penetrates through to the underside of the specimen, the test may be terminated and the specimen rejected as fail.
- ♦ After 3 days, the pressure shall be released and the sample shall be taken out. The specimen shall be split in the middle by compression applied on two round bars on opposite sides above and below.
- ♦ When the split faces show signs of drying (after 5 to 10 minutes) the maximum depth of penetration in the direction of height shall be measured with the scale



and extent of water penetration established.

- ♦ The mean of maximum depth of penetration obtained from three specimens thus tested, shall be taken as the test result and it shall not exceed 25 mm.

If the concrete is not able to meet any of the standards of acceptance as prescribed, the effect of such deficiency on the structure shall be investigated by the Contractor as directed by the Engineer. Any additional work required by the Engineer for such acceptance shall be carried out by the Contractor at his cost. In such case payment for such work shall be made at reduced rate proportional to reduced strength rate. In case the concrete is not found to be acceptable even after investigation, the Contractor shall remove the rejected concrete forthwith.

## 2019 PAYMENT

### (1) Concrete

- (9) *Insert the following at the end of Clause 2019(1): “Concrete”:*

- (f) The following items for concrete works (including those for reinforced concrete) shall be paid under this Section and shall include the works for providing and placing the concrete, all materials, forms, falseworks & scaffolding (when needed), compaction, curing, testing etc., and tools, equipment, plants and all incidentals used to complete the work in accordance with the Drawings and Specifications, and as directed by the Engineer:

Item No.	Description	Unit
<b>2000</b>	<b>Concrete for Structures</b>	
2000-1	Concrete class A (M35/20, C30/20)	cu.m.
2000-2	Concrete class B (M30/20, C25/20)	cu.m.
2000-3	Concrete class C (M25/20, C20/20)	cu.m.
2000-4	Concrete class D (M20/20, C15/20)	cu.m.
2000-5	Concrete class E (Lean concrete)	cu.m.

### (2) Reinforcement

- (9) *Insert the following at the end of Clause 2019(3): “Reinforcement”:*

Item No.	Description	Unit
2000-6	Reinforcement Bar	ton

- (10) *Add the following new Sub-Section at the end of Section 2000: “Concrete for Structures” and before Section 2100: “Pre-Stressing”*

## 2050 CONCRETE PAVEMENTS

### 2051 CONTINUOUSLY REINFORCED CONCRETE PAVEMENT (CRCP) AND JOINTED REINFORCED CONCRETE PAVEMENT (JRCR)

This work includes the construction of Continuously Reinforced Concrete Pavement (CRCP) and Jointed Reinforced Concrete Pavement (JRCP) for the road inside the tunnel, and for the access roads out-side the tunnel respectively with required thickness and shape of the cross section shown on the Drawings or as instructed by the Engineer.

This work includes also the construction of the Reinforced Concrete Pavement (RCP) for the evacuation tunnel, with required thickness and shape of the cross section shown on the Drawings or as instructed by the Engineer.

These Specifications shall be interpreted as supplement of, and without detriment to, the Standards Specifications and respective Special Provisions herein described.

## **2052 MATERIALS**

### **(1) Aggregates, Cement, Water and others**

Aggregates, Cement, Water and others such as admixtures, material for curing, etc. shall be in accordance with requirements of Section 2000 “Concrete for Structures”, Sub-Section 2003: “Material for Concrete”.

### **(2) Concrete Class**

CRCP and JRCP shall use the concrete Class-P of Section 2000 “Concrete for Structures”, Sub-Section 2004; Table 20.3(b): “Composition and Strength of Concrete used in the Project”.

### **(3) Joint Sealer**

- (a) Joint sealer shall be in accordance with ASTM D6690-06 “Joint and Crack Sealants”, Hot Applied for Concrete Pavements.
- (b) Each lot or batch of sealing compound shall be delivered to the job site in the manufacturer's original sealed container. Each container shall be marked with the manufacturer's name, batch or lot number, and the safe heating temperature, and shall be accompanied by the manufacturer's certification stating that the compound meets the requirements of this specification.

### **(4) Steel Reinforcement**

Steel reinforcement shall be placed as shown on the Drawings, in accordance with Section 2000 “Concrete for Structures”, Sub-Section 2014.

The Contractor shall not weld reinforcement unless otherwise permitted by the Engineer.

### **(5) Dowels**

Dowels are specifically used for JRCP pavement type, and CRCP's terminal anchors.

Dowels shall be as shown on the Drawings and in accordance with Section 2000 “Concrete for Structures”. Dowel bars shall be round bars and shall be free from burring or other deformation. Plastic or epoxy coating shall be applied to the central part of the steel dowels as shown in the Drawings. Coated dowels shall conform to

the requirements of AASHTO M254. Where called for on the Drawings, coated dowels shall be lubricated with MC-70.

Expansion joints shall be provided with sleeves for dowel bars as shown in the Drawings.

**(6) Epoxy Resin**

Epoxy resin used to anchor dowel bars in pavements shall conform to the requirements of ASTM C881, Type I, Grade 3, Class C.

**(7) Material Acceptance**

Material Acceptance shall be in accordance with the requirements of Section 500: "Quality Control", Section 600: "Materials and Testing of Materials" and Sub-Section 2017: "Test and Standard of Acceptance" accordingly.

**(8) Concrete Mixes**

In addition to, and without detriment to the requirements of Sub-Section 2004: "Design of Concrete Mixes", the following requirements shall also be satisfied:

- (a) Prior to the start of paving operations and after approval of all materials to be used for concrete production, the Contractor shall submit a Mix Design to the Engineer, for review and approval, showing the proportions and flexural & compression strengths of concrete tested as herein specified.
- (b) The Mix Design shall include copies of test reports, including test dates, and a complete list of materials including type, brand, source, and amount of cement, coarse aggregate, fine aggregate, water, and admixtures. The fineness modules of the fine aggregate shall also be shown. Copies of the mix design shall be submitted to the Engineer at least 30 days prior to the start of operations.
- (c) The Contractor shall not begin the production of concrete until the Engineer approves the Mix Design in writing.
- (d) Should a change in sources be made, or admixtures added or deleted from the mix, copies of a new mix design must be submitted to the Engineer for validation.
- (e) Test specimens for Flexural and Compressive Strength shall be tested in accordance with Section 600: "Materials and Testing of Materials" and Sub-Section 2017: "Test and Standard of Acceptance".

## **2052 EQUIPMENT**

The Contractor shall furnish all equipment and tools necessary for handling materials and performing all parts of the work.

**(1) Mixers and Transportation Equipment**

Concrete may be mixed at a central plant according to the approved Construction Program prepared by the Contractor.

**(a) Central Plant Mixer**

The central plant mixer provided for construction of CRCP and JRCP shall be in accordance with the requirements of Clause 2005: "Mixing Concrete" and the special provisions herein specified.

Central plant mixers shall also conform to the requirements of ASTM C94. The mixer shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades. The pickup and throw over blades shall be replaced when they have worn down 19mm or more. The Contractor shall have a copy of the manufacturer's design on hand showing dimensions and arrangement of blades in reference to original height and depth.

**(b) Transportation of Concrete inside Project Site**

The Contractor shall detail the transportation system of concrete inside the project site, including details of equipment for transporting and method for concrete placing.

Truck mixers for mixing and hauling concrete and truck agitators for hauling central mixed concrete (if used), shall also conform to the requirements of ASTM C94.

**(2) Finishing Equipment**

The finishing equipment shall be of sufficient weight and power for proper finishing of the concrete. The finishing system shall be established and operated to strike off, screed and consolidate the concrete such that laitance on the surface is less than 3 mm thick.

**(3) Vibrators**

Vibrator shall be of either internal type with immersed tube or multiple spuds, or surface type vibrating pan or screed. For 20cm thick pavements or thicker, internal vibrators shall be used. They may be attached to the spreader or the finishing machine, or they may be mounted on a separate carriage. Operating frequency for internal vibrators shall be between 8,000 and 12,000 vibrations per minute. Average amplitude for internal vibrators shall be 0.06 to 0.13 cm.

**(4) Concrete Saws**

The Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions in the established time according to the approved Construction Program.

**(5) Side Forms**

Straight side forms shall be made of steel and shall be furnished in sections not less than 3m in length. Forms shall have a depth equal to the pavement thickness at the edge. Flexible or curved forms of proper radius shall be used for curves of 31 meters radius or less. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built up forms shall not

be used. The top face of the form shall not vary from a true plane more than 3mm in 3 metres, and the upstanding leg shall not vary more than 6 mm. The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting.

Wood forms shall not be used.

**(6) Pavers**

Pavers shall be fully energized, stable and designed for the specific purpose of placing, consolidating, and finishing the concrete pavement, true to grade, tolerances, and cross section. They shall be of sufficient weight and power to construct the maximum specified concrete paving lane width as shown on the Drawings, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. Pavers shall be equipped with electronic or hydraulic horizontal and vertical control devices.

**2053 CONSTRUCTION**

**(1) Preparation of Surfaces to be Paved**

The works for construction of pavement shall be started only after the previous layer (lean concrete base course) has been duly completed and the Engineer has authorized to proceed with the subsequent works accordingly with the approved Construction Program.

**(2) Preparation of Underlying Surface, Side Form and Fill in Lane Construction**

**(a) Form Setting**

- Forms shall be set sufficiently in advance of the concrete placement to insure continuous paving operation securing the completion of daily progress stated in the Construction Program.
- After the forms have been set to correct grade, the underlying surface shall be thoroughly cleaned at both the inside and outside edges of the base of the forms.
- Forms shall be staked into place sufficiently to maintain the form in position for the method of placement. Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 3mm at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment.
- Forms shall be cleaned and oiled prior to the placing of concrete. The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete.

**(b) Underlying Surface, Side Form and Fill in Lane Construction**

- In case of paving on a lean-concrete base course, the prepared surface shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete.
- Regardless the nature of the underlying surface, damage caused by hauling or

usage of other equipment shall be corrected and retested. If damage occurs to the base course, the Contractor shall correct before starting procedure for paving and as directed by the Engineer.

- A template shall be provided and operated on the forms immediately in advance of the placing of all concrete. The template shall be propelled only by hand and not attached to a tractor or other power unit. Templates shall be adjustable so that they may be set and maintained at the correct contour of the underlying surface. The adjustment and operation of the templates shall be such as will provide an accurate retest of the grade before placing the concrete thereon. All excess material shall be removed and disposed off. The template shall be maintained in accurate adjustment, at all times by the Contractor, and shall be checked daily.

**(c) Placement of Reinforcement**

Reinforcing steel, at the time concrete is placed, shall be free of mud, oil, or other organic matter that may adversely affect or reduce bond. Reinforcing steel with rust, mill scale or a combination of both will be considered satisfactory, provided that the minimum dimensions, weight, and tensile properties of a hand wire brushed test specimen are not less than the applicable ASTM specification requirements.

**(d) Handling, Measuring, and Batching Material**

- The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be constructed in such a manner that prevents segregation and intermixing of deleterious materials.
- Aggregates that have become segregated or mixed with soil or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched.
- Batching plants shall be equipped to proportion aggregates and bulk cement, by weight, automatically using interlocked proportioning devices of an approved type. When bulk cement is used, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, such as a chute, boot, or other device, to prevent loss of cement. The device shall be arranged to provide positive assurance that the cement content specified is present in each batch.

**(e) Mixing Concrete**

- Concrete may be mixed at the work site, in a central mix plant. The mixer shall be of an acceptable type and capacity. Mixing time shall be measured from the time all materials, except water, are emptied into the drum. All concrete shall be mixed and delivered to the site in accordance with the requirements of ASTM C94.
- Mixed concrete from the central mixing plant shall be transported by a previously approved system. The elapsed time from the addition of cement

material to the mix until the concrete is deposited in place at the work site shall not exceed 2 hours.

**(f) Limitations on Mixing and Placing**

- Visibility: Concrete shall be mixed, placed, or finished under natural light or artificial lighting system approved by the Engineer.
- Hot Weather: During periods of hot weather when the maximum daily air temperature exceeds 30°C, the following precautions shall be taken:
  - ♦ Concrete placing shall be made in accordance with the requirements of Sub-Section 2011: “Concreting in Hot Weather”.
  - ♦ The forms and/or the underlying surface shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 30°C.
  - ♦ The aggregates and/or mixing water shall be cooled as necessary to maintain the concrete temperature at or not more than the specified maximum. This can be done by covering with wet burlap or cotton mats, fog spraying with water, covering with protective housing, or by other approved methods.
  - ♦ Moreover, during placement, the concrete temperature can be maintained by using any combination of the following:
    - ✓ Shading the material storage areas or production equipment;
    - ✓ Cooling the aggregate by sprinkling; and
    - ✓ Cooling the aggregate and water by refrigeration or replacing a portion or all of the mix water with flaked or crushed ice to the extent that the ice completely melts during mixing of the concrete. For this purpose testing of the procedure shall be practiced previously by trials approved by the Engineer.
  - ♦ The finished surfaces of the newly laid pavement shall be kept damp by applying a water fog or mist with approved spraying equipment until the pavement is covered by the curing medium.
  - ♦ When conditions are such that problems with plastic cracking can be expected, and particularly if any plastic cracking begins to occur, the Contractor shall immediately take such additional measures as necessary to protect the concrete surface. Such measures shall consist of windscreens, more effective fog sprays, and similar measures commencing immediately behind the paver. If these measures are not effective in preventing plastic cracking, paving operations shall be immediately stopped.

**(g) Placing Concrete**

- The Contractor shall prepare and submit to the Engineer, for review and approval, an specific plan and method statement properly supported by shop-drawings including all necessary details for concrete placing for Continuously Reinforced Concrete Pavement (CRCP) and showing details on the equipment (batching plant, trucks for transportation, finisher and compaction, etc.);



materials (concrete: cement, coarse and fine aggregates, sand, water approved in terms of quality and quantity); approved reinforcement placed on-site, and preparation and location of the construction joints, materials and equipment for curing, etc.

The Contractor has the option of placing the concrete with either side (fixed) forms or slip forms. At any point in concrete conveyance, the free vertical drop of the concrete from one point to another or to the underlying surface shall never exceed 1 metre.

Side Form Method:

- For the side form method, the concrete shall be deposited on the surface prepared for underlying to require as little re-handling as possible. Unless truck mixers, truck agitators, or non-agitating hauling equipment are equipped with means for discharge of concrete without segregation of the materials, the concrete shall be placed and spread using an approved mechanical spreading device that prevents segregation of the materials.
- Placing shall be continuous without the use of intermediate bulkheads (unless transverse joints approved by the Engineer or shown in the Drawings). Necessary hand spreading shall be done with shovels not rakes. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.
- Concrete shall be deposited as near to the joints as possible without disturbing them but shall not be dumped from the discharge bucket or hopper onto a joint assembly unless the hopper is centered above the joint assembly.
- Concrete shall be thoroughly consolidated against and along the faces of all forms and previously placed concrete and along the full length and on both sides of all joint assemblies by means of vibrators inserted in the concrete.
- Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than 20 seconds in any one location, nor shall the vibrators be used to move the concrete.

Slip Form Method:

- For the slip form method, the concrete shall be placed with an approved crawler mounted, slip form paver designed to spread, consolidate and shape the freshly placed concrete in one complete pass of the machine so that a minimum of hand finishing will be necessary to provide a dense and homogeneous pavement in conformity with requirements of the Drawings and Specifications.
- The concrete shall be placed directly on top of the joint assemblies to prevent them from moving when the paver moves over them. Side forms and finishing screeds shall be adjustable to the extent required to produce the specified pavement edge and surface tolerance. The side forms shall be of dimensions, shape, and strength to support the concrete laterally for a sufficient length of time so that no edge slumping exceeds the requirements



for acceptance. Final finishing shall be accomplished while the concrete is still in the plastic state.

- In the event that slumping or sloughing occurs behind the paver or if there are any other structural or surface defects which cannot be corrected within permissible tolerances, paving operations shall be immediately stopped until proper adjustment of the equipment or procedures have been made. In the event that satisfactory procedures and pavement are not achieved after one day of paving works, the Contractor shall complete the balance of the work using standard metal forms and its respective method of placing and curing.

Any concrete not corrected by the Contractor to permissible tolerances shall be removed and replaced at his own expense, and the time required for this correction shall be counted and registered to be taken into account when the contractual period is near to last.

### **(3) Joints**

- Joints shall be constructed as shown on the Drawings and in accordance with these requirements. All joints shall be constructed with their faces perpendicular to the surface of the pavement and finished or edged as shown on the Drawings.
- Joints shall not vary more than 13mm from their designated position and shall be true to line with not more than 6mm variation in 3 meters.
- The surface across the joints shall be tested with a 3 metre straightedge as the joints are finished and any irregularities in excess of 6 mm shall be corrected before the concrete has hardened.
- All joints shall be so prepared, finished, or cut to provide a groove of uniform width and depth as shown on the Drawings.

#### **(a) Construction Joints**

- Longitudinal construction joints shall be slip formed or formed against side forms with or without keyways, as shown on the Drawings.
- Transverse construction joints shall be installed in the places specified in the Drawings, or included in the approved Construction Program, or where instructed by the Engineer.
- In case of concrete pavement type CRCP, transverse construction joints shall be installed strictly as shown in the Drawings including the additional bar reinforcement. Any unplanned joint installation shall be rejected and the correction shall be made at the Contractor's own expense.

In case of concrete pavement type JRC, transverse construction shall be planned taking into account each day's placing operations and at any other points within a paving lane where concrete placement might be interrupted for more than 30 minutes.

In no case the installation of transverse joints due to delay in providing fresh concrete will be approved. In case a late concrete arrives, it shall be wasted in a determined area and it shall not be subject for payment and the expended time shall be counted as a delay without any compensation.

**(b) Keyways**

- Keyways shall not be applied.

**(c) Tie Bars**

- Tie bars shall consist of deformed bars installed in joints as shown on the Drawings.
- Tie bars shall be placed at right angles and symmetrically spaced along the longitudinal joint at intervals shown on the Drawings. They shall be held in position parallel to the pavement surface and in the middle of the slab depth, or as shown in the Drawings.
- The Contractor shall submit for approval a detailed procedure for installation of tie bars, including particular details for tie bars that will be installed on a joint where the concrete will be placed at different time for each contiguous slab.

**(d) Dowel Bars**

- Dowels are specifically used for JRCP pavement type, and CRCP terminal anchors.
- Dowel bars or other load transfer units shall be placed across approved transverse joints with the dimensions and spacing, and placed in the manner, as shown on the Drawings, and shall be held rigidly in the middle of the slab depth in the proper horizontal and vertical alignments by an approved assembly device to be left permanently in place.
- The dowel or load transfer and joint devices shall be rigid enough to permit complete assembly as a unit ready to be lifted and placed into position.
- Dowel bars shall be painted with rust preventative paint and coated as indicated in the Drawings.

**(e) Installation of Joints**

- All devices used for the installation of joints shall be as specified.
- The top of an assembled joint device shall be set at the proper distance below the pavement surface and the elevation shall be checked. Such devices shall be set to the required position and line and shall be securely held in place by stakes or other means to the maximum permissible tolerances during the pouring and finishing of the concrete.
- Dowel bars and assemblies shall be checked for position and alignment. During the concrete placement operation, it is advisable to place plastic concrete directly on dowel assemblies immediately prior to the passage of the paver to help maintain dowel position and alignment within maximum permissible tolerances.
- When concrete is placed using slip form pavers, dowels and tie bars shall be placed in longitudinal construction joints by bonding the dowels or tie bars into holes drilled into the hardened concrete. Holes approximately 3 to 6 mm greater in diameter than the dowel or tie bar shall be drilled with rotary type core drills that must be held securely in place to drill perpendicularly into the vertical face of the pavement slab. Rotary type percussion drills may be used provided that spalling of concrete does not occur. The Contractor shall repair any damage of

the concrete. Dowels or tie bars shall be bonded in the drilled holes using an epoxy resin material. Installation procedures shall be adequate to insure that the area around dowels is completely filled with epoxy grout. Epoxy shall be injected into the back of the hole and displaced by the insertion of the dowel bar. Bars shall be completely inserted into the hole and shall not be withdrawn and reinserted creating air pockets in the epoxy around the bar.

- The Contractor shall furnish a template for checking the position and alignment of the dowels.

**(f) Sawing of Joints**

- Joints shall be cut as shown on the Drawings.
- Equipment shall be as described in this section. The circular cutter shall be capable of cutting a groove in a straight line and shall produce a slot at least 3 mm wide and to the depth shown on the Drawings. The top portion of the slot shall be widened by sawing to provide adequate space for joint sealers as shown on the Drawings. Sawing shall commence as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing and before uncontrolled shrinkage cracking of the pavement occurs. Sawing shall be carried out both during the day and night as required. The joints shall be sawed at the required spacing, consecutively in sequence of the concrete placement.

**(4) Final Strike Off, Consolidation and Finishing**

**(a) Sequence**

The sequence of operations shall be the strike off, floating and removal of latency, straight edging, and final surface finish. The addition of superficial water to the surface of the concrete to assist in finishing operations shall not be permitted.

**(b) Finishing at Joints**

The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material; it shall be firmly placed without voids or segregation under and around all load transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated. After the concrete has been placed and vibrated adjacent to the joints, the finishing machine shall be operated in a manner to avoid damage or misalignment of joints. If uninterrupted operations of the finishing machine to, over, and beyond the joints, cause segregation of concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the screed is approximately 20cm from the joint. Segregated concrete shall be removed from the front of and off the joint; and the forward motion of the finishing machine shall be resumed. Thereafter, the finishing machine may be run over the joint without lifting the screed, provided that there is no segregated concrete immediately between the joint and the screed or on top of the joint.

**(c) Machine Finishing**

- The concrete shall be spread as soon as it is placed, and it shall be struck off and

screed by a finishing machine. The machine shall go over each area as many times and at such intervals as necessary to give proper consolidation and to leave a surface of uniform texture. Excessive operation over a given area shall be avoided.

- When side forms are used, the tops of the forms shall be kept clean by an effective device attached to the machine, and the travel of the machine on the forms shall be maintained true without lift, wobbling, or other variation tending to affect the precision finish. During the first pass of the finishing machine, a uniform ridge of concrete shall be maintained ahead of the front screed for its entire length. When in operation, the screed shall be moved forward with a combined longitudinal and transverse shearing motion, always moving in the direction in which the work is progressing, and so manipulated that neither end is raised from the side forms during the striking off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

**(d) Hand Finishing**

- Hand finishing methods will not be permitted, except under the following conditions:
  - ♦ in the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade;
  - ♦ in areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical.
- Concrete, as soon as placed shall be struck off and screed. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete when reinforcement is used. The screed for the surface shall be at least 0.6 meters longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and shall be constructed either of metal or of other suitable material covered with metal. Consolidation shall be attained by the use of suitable vibrators.

**(e) Floating**

After the concrete has been struck off and consolidated, it shall be further smoothed and trued by means of a longitudinal float using one of the following methods:

- ♦ Hand Method:

Long handled floats shall not be less than 3.6 meters in length and 15 cm in width, stiffened to prevent flexibility and warping. The float shall be operated from footbridges spanning but not touching the concrete or from the edge of the pavement. Floating shall pass gradually from one side of the pavement to the other. Forward movement along the centerline of the pavement shall be in successive advances of not more than one half the length of the float. Any excess water or latency in excess of 3 mm thick shall be removed and wasted.

- ♦ Mechanical Method:

The Contractor may use a machine composed of a cutting and smoothing float(s),

suspended from and guided by a rigid frame and constantly in contact with the side forms or underlying surface. If necessary, long handled floats having blades not less than 1.5 meters in length and 15cm in width may be used to smooth and fill in open textured areas in the pavement. When the crown of the pavement does not permit the use of the mechanical float, the surface shall be floated transversely by means of a long handled float. Care shall be taken not to work the crown out of the pavement during the operation. After floating, any excess water and latency in excess of 3mm thick shall be removed and wasted. Successive drags shall be lapped one half the length of the blade.

**(f) Straight Edge Testing and Surface Correction**

After the pavement has been struck off and while the concrete still being plastic, it shall be tested for trueness with a 5-meter straightedge swung from handles 1 meter longer than one half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the centerline and the whole area gone over from one side of the slab to the other, as necessary. Advancing shall be in successive stages of not more than one half the length of the straightedge. Any excess water and latency in excess of 3 mm thick shall be removed from the surface of the pavement and disposed of. Any depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished.

**(5) Surface Texture**

The surface of the pavement shall be finished with either a brush or broom finish applied when the water sheen has practically disappeared. The equipment shall operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 2mm in depth. It is important that the texturing equipment does not tear or unduly roughen the pavement surface during the operation. Any imperfections resulting from the texturing operation shall be corrected.

**(6) Curing**

The construction requirements for curing shall conform to requirements of Sub-Section 2009: "Curing of Concrete" and this Sub-section.

Immediately after finishing operations are completed and marring of the concrete does not occur, the entire area of the newly placed concrete shall be cured in accordance with the methods described below. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than an hour during the curing period.

The Contractor shall utilize one of the following types of curing methods:

**(a) Impervious Membrane Method**

- The entire surface of the pavement shall be sprayed uniformly with white

pigmented curing compound immediately after the finishing of the surface and before the concrete has set.

- The curing compound shall not be applied during rainfall. Curing compound shall be applied by mechanical sprayers under pressure at the rate of 4 litres to not more than 14 square metres.
- The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout. During application the compound shall be stirred continuously by mechanical means. Hand spraying of odd widths or shapes and concrete surfaces exposed by the removal of forms will be permitted.
- The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film become damaged from any cause, including sawing operations, within the required curing period, the damaged portions shall be repaired immediately with additional compound or by other approved means.
- Upon removal of side forms, the sides of the exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface.

**(b) Water Method**

- Keep the concrete surface continuously wet by ponding, spraying, or covering with material that is kept continuously and thoroughly wet.
- Covering material may consist of cotton mats, multiple layers of burlap, or other approved material that does not discolour or otherwise damage the concrete.
- Entirely cover the surface of the pavement and the edges of the slab with water saturated mats. Extend mats at least twice the thickness of the pavement beyond the edges of the slab.
- Place the mats in complete contact with the surface. Use weights or other approved methods to maintain contact.

**(c) Waterproof Cover Method**

- Thoroughly wet the surface using a fog mist applicator.
- Entirely cover the surface with a waterproof cover. Lap the cover at least 460 mm.
- Extend the cover beyond the edges of the slab at least twice the thickness of the pavement. Place the cover in complete contact with the surface.

**(7) Removing Forms**

Unless otherwise specified, forms shall not be removed from freshly placed concrete until it has hardened sufficiently to permit removal without chipping, spalling, or tearing. After the forms have been removed, the sides of the slab shall be finished, cleaned and protected. Major honeycombed areas shall be removed and replaced in accordance with respective specifications or as directed by the Engineer.

**(8) Sealing Joints**



**(a) Time of Application**

Joints shall be sealed as soon after completion of the curing period as feasible and before the pavement is opened to traffic, including construction equipment.

**(b) Preparation of Joints**

- Immediately before sealing, the joints shall be thoroughly cleaned of all latency, curing compound, and other foreign material.
- Sandblasting and/or wire brushing shall be used for cleaning. Upon completion of cleaning, the joints shall be blown out with compressed air.
- The joint faces shall be surface dry when the sealant is applied. Prior to resealing joints, any existing joint material shall be removed.

**(c) Installation of Sealant**

- Joints shall be inspected and approved by the Engineer for proper width, depth, alignment, and all preparation before sealing is authorized.
- Sealant shall be installed in accordance with the following requirements:
  - ♦ Hot Poured Sealant shall be applied uniformly solid from bottom to top and shall be filled without formation of entrapped air or voids.
  - ♦ The heating kettle shall be of an indirect heating type, constructed as a double boiler. A positive temperature control and mechanical agitation shall be provided.
  - ♦ The sealant shall not be heated below the safe heating temperature.
  - ♦ The safe heating temperature shall be obtained from the manufacturer's shipping container.
  - ♦ A direct connecting pressure-type extruding device with nozzles shaped for insertion into the joint shall be provided.
  - ♦ The concrete surface adjacent to the joint locations shall be protected from spillage of the sealant by adhesive tape or other approved means. Any sealant spilled on the surface of the pavement shall be removed immediately.

**(9) Protection of Pavement**

Protection of Pavement shall be made in accordance with the requirements of Sub-Section 2010: "Protection of Fresh Concrete" and this Sub-Section.

The Contractor shall protect the pavement and its appurtenances against all kind of traffic including traffic caused by the Contractor's employees and agents. This shall include watchmen to direct traffic and the erection and maintenance of warning signs, lights, crossovers, and protection of unsealed joints from intrusion of foreign material, etc.

Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor's expense. For any pavement areas that are uncovered, the Contractor shall have available at all times, materials for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of rolled polyethylene sheeting at least 0.1 mm thick of sufficient length and

width to cover the plastic concrete slab and any edges. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the plastic concrete surface. In any uncovered areas, when rain appears imminent, all paving operations shall stop and all available personnel shall begin covering the surface of the unhardened concrete with the protective covering.

**(10) Opening to Traffic**

The pavement shall not be opened to traffic until test specimens molded and cured in accordance with ASTM C31 have attained the required strength when tested in accordance with these Specifications. If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Prior to opening to traffic, the pavement shall be cleaned.

**(11) Rejection of Concrete Batches**

The Engineer may at any time, notwithstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to contamination, segregation, improper temperature of concrete or improper slump.

**(12) Acceptance of Pavement**

**(a) Acceptance Sampling and Testing**

- Acceptance Sampling and Testing shall be made in accordance with the requirements of Section 500: "Quality Control", Section 600: "Materials and Testing of Materials", Sub-Section 2017: "Test and Standard of Acceptance" and this Sub-Section. The Contractor's testing Laboratory shall perform all acceptance sampling and testing necessary to determine conformity with the requirements specified in this Specification Section.
- The Engineer will have the authority to direct locations for sampling and testing and will at all times have access to the Contractor's Laboratory and testing equipment for observing and checking results.
- Acceptance sampling and testing will be based on lot quantities. A lot will consist of 1500 m<sup>2</sup> of pavement or one day's placement (whichever is less).
- Testing organizations performing these tests shall meet the requirements of ASTM C1077. The Contractor shall bear the cost of providing curing facilities for the strength specimens and coring and filling operations.

**(b) Tested Strength**

The strength registered for tested samples shall satisfy the requirements of these Specifications for compressive and flexural strength.

**(c) Pavement Smoothness**

- As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a 5m straightedge or other specified device. Surface smoothness deviations shall not exceed 6 mm from a 5m straightedge placed in any direction, including placement along and spanning any pavement joint edge.



- Areas in a slab showing high spots of more than 6 mm but not exceeding 13 mm in 5 m shall be marked and immediately ground down with an approved grinding machine to an elevation that will fall within the tolerance of  $\pm 6$  mm. Where the departure from correct cross section exceeds 13 mm, the pavement shall be removed and replaced at the expense of the Contractor when so directed by the Engineer.

**(d) Tie and Dowel Bars Alignment:**

Tie and dowel bars and assemblies shall be checked for position and alignment. The maximum permissible tolerance on bar alignment in each plane, horizontal and vertical, shall not exceed 2 percent or 20mm per meter of the tie or dowel bar.

**(13) Trial length**

The Contractor shall submit to the Engineer at least one month prior to the date proposed for the initial trial length, a detailed description of the plant, equipment and method of construction.

The Contractor shall demonstrate the plant, equipment and method of construction by laying an initial trial length of 150m long at a location provided by the Contractor outside the permanent works, or where approved by the Engineer. Subsequent trial lengths may be instructed by the Engineer if any aspect of the initial trial proves unsatisfactory.

The Contractor shall not start the works for pavement construction if comprehensive trial has not been approved the Engineer.

**(14) Settlement Risks for Upper Layers (Sub-base, Base Course and Concrete Pavement)**

The Contractor shall be responsible for all risks for leveling and proper compaction of the sub-base, base course and concrete pavement to the level shown in the Drawings. Any regulation of the final surface to the level of sub-base course, base course and/or pavement due to settlement shall be made on the Contractor's own expenses.

**(15) Construction Method for the Reinforced Concrete Pavement (RCP)**

The construction of Reinforced Concrete Pavement (RCP) shall conform all the requirements herein specified for CRCP and JRCPP pavements.

**2054 MEASUREMENT**

Concrete pavement (CRCP: Continuously Reinforced Concrete Pavement, JRCPP: Jointed Reinforced Concrete Pavement and RCP: Reinforced Concrete Pavement) shall be measured by the square metres of the completed pavements at respective thicknesses in accordance with the Drawings, and as directed by the Engineer.

Terminal Anchors for CRCP shall be measured by the number of the completed terminal

anchors in accordance with the Drawings, and as directed by the Engineer. Terminal Anchors deemed include the construction of two concrete approach slabs, three transversal joints, all required steel reinforcement, tie and dowel-bars, respective chairs and steel supports, and all related incidental works.

Measurement shall be made only after all procedure and requirements for testing and acceptance are satisfied and the results are approved by the Engineer.

The steel reinforcement for pavements CRCP and JRCP type shall not be measured nor paid separately but shall be deemed included in the rates and unit price established for the main item of pavement CRCP and JRCP.

The wire mesh for RCP (Reinforced Concrete Pavement) shall not be measured nor paid separately but shall be deemed included in the rates and unit price established for the main item of RCP.

Therefore, Clause 2018(4): “Reinforcement” for measurement of reinforcement doesn’t applies to any type of concrete pavements.

## **2055 PAYMENT**

Concrete pavement (CRCP: Continuously Reinforced Concrete Pavement, JRCP: Jointed Reinforced Concrete Pavement and RCP: Reinforced Concrete Pavement) measured as above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 including cost for all materials labour, equipment, tools, equipment, plants and all incidentals to complete the work in accordance with the Drawings and Specifications, and as directed by the Engineer.

The concrete pavement type JCP [t=150 mm], Concrete Class-D, used in tunnel construction for “Inspection Path with Kerbs” and “Emergency Walkway with Handrails” shall meet the requirements of these Specifications. However, respective payment shall be made under the Special Provisions for tunnel’s technical specifications Section 4800: “Drainage System, Walkway & Path”, Item 4800-4: “Inspection Path with Kerbs” and Item 4800-5: “Emergency Walkway with Handrails”.

The unit rates shall deemed include, inter alia and in addition to other items previously stated (e.g. concrete, etc.), the following:

- ◆ preliminary trials and trial sections
- ◆ preliminary trial lengths not accepted as part of permanent works
- ◆ trials by the Contractor to demonstrate compaction methods
- ◆ supplying, laying and compaction of concrete
- ◆ forms
- ◆ protection of mixed materials in transit and while waiting tipping
- ◆ grading, measuring, mixing and depositing materials
- ◆ masking and unmasking of exposed concrete surfaces, etc.
- ◆ jointing works
- ◆ curing and protection of materials
- ◆ maintenance of surface and cleaning or removal and replacement of contaminated

layers

- ◆ making good up to design surface level
- ◆ sealing surfaces
- ◆ anchorages necessary for joints
- ◆ all necessary tools and material for surface finishing
- ◆ longitudinal and transversal reinforcement for CRCP and JRCP
- ◆ longitudinal construction joints for CRCP including tie bars, chairs, additional bars for supporting, etc.
- ◆ transversal construction joints for CRCP including tie bars, additional bars for load transfer, etc.
- ◆ transversal joints for JRCP including all dowels and material for stable installation
- ◆ wire mesh for RCP
- ◆ all expenses for material and placing of supplementary construction joints (i.e. joints that are not shown in the drawings, etc.), but approved by the Engineer upon the appropriated Contractor's proposal and supplementary drawings.

Therefore, Clause 2019(3): "Reinforcement" for payment of reinforcement doesn't applies to any type of concrete pavements and separate payment for reinforcement shall not be made, but shall be deemed included in the main items listed below:

Item No.	Description	Unit
<b>2050</b>	<b>Concrete Pavements</b>	
2050-1	Continuously Reinforced Concrete Pavement (CRCP) [t=300 mm] (Concrete Class P)	sq.m.
2050-2	Terminal Anchors for CRCP (Concrete Class P)	No.
2050-3	Jointed Reinforced Concrete Pavement (JRCP) [t=300 mm] (Concrete Class P)	sq.m.
2050-4	Jointed Reinforced Concrete Pavement (JRCP) [t=200 mm] (Concrete Class-P)	sq.m.

## 2060 CEMENT TREATED BASE COURSE (CTBC)

### (1) General

The work provided shall include the furnishing, placement and compaction of one course of plant mixed Portland Cement Treated Base Course (CTBC) to the lines, grades, dimensions, moisture, density and typical sections as specified in the Drawings and in accordance with the specifications, and as directed by the Engineer. The Contractor shall be solely responsible for the CTBC either batched at and/or delivered to the Site. A design mix for CTBC shall be certified in accordance with the requirements of these specifications.

Each design mix submitted and authorized for use under this specification shall be identified by a number, unique to that design mix and aggregate production plant/pit. If a change in material(s) from that specified in the design mix occur during a project, the Contractor shall submit a new design mix to include the changed materials for

authorization by the Engineer. A design mix shall not be used on the Project without authorization by the Engineer.

## (2) References

The following standards of American Society for Testing and Materials (ASTM), (Latest Edition) (or equivalent subjected to the Engineer's approval) shall be applied:

- ♦ C136 Standard Test Method for Sieve Analysis of Fine and Course Aggregates
- ♦ C150 Standard Specifications for Portland Cement
- ♦ D75 Standard Practice for Sampling Aggregates
- ♦ D559 Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures
- ♦ D1632 Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory
- ♦ D1633 Standard Test Method for Compressive Strength of Molded Soil-Cement Cylinders
- ♦ D2419 Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
- ♦ D2922 Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods
- ♦ D2940 Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports
- ♦ D3017 Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods
- ♦ D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

## (3) Materials

Portland cement to be used or furnished under this specification shall comply either with the requirements of ASTM C150, Type II, Low Alkali (LA) cement, or as specified herein, or as specified in the Drawings, or as approved by the Engineer. The Contractor shall submit certification of compliance signed by the cement manufacturer, identifying the cement Type and source (plant location), stating the Portland cement used in the cement treated base delivered to the project complies with this specification. If required, certification of the Portland cement used for each day's concrete placement, shall be submitted to the Engineer. Portland cement specified in an authorized design mix shall be of the same source and type for all cement treated base under that design mix identification number, as specified in the design mix.

Aggregates for CTBC shall consist of a combination of aggregates and sand prepared for a Base Course by crushed rock obtained from tunnel excavation conforming to the requirements of Section 1200: "Subbase, Base, Hard Shoulder and Gravel Wearing Course", and Portland cement,

Water used for preparation of CTBC shall be clean and free from injurious amounts of oil, acids, alkalis, salts, organic materials, or other deleterious substances. Non-

potable water shall not be used unless the requirements of ACI 318.3.4.3.2 are met.

Prime coat for surface sealing of compacted Cement Treated Base Course (CTBC) shall comply with the requirements of Section 1300: "Bituminous Surface and Base Course".

#### (4) Proportioning

The Contractor shall be solely responsible for the CTB design mix proportions and material batched and delivered to the site.

A CTB design mix shall be a blend of Portland Cement, aggregate base course and water. The design mix shall be prepared in a laboratory under the supervision by the Engineer.

- ♦ M Optimum moisture maximum dry density relationship and graph.
- ♦ N Compressive strength test results, average of three briquettes (each), at 2 days, 7 days, and 28 days

Portland cement shall be proportioned by percent of dry weight of aggregates. The amount of Portland cement shall be the minimum cement content that will provide an aggregate cement water mixture, when compacted at optimum moisture, as determined by ASTM D558, and that will comply with the following requirements:

**Table 20-4 Cement Treated Base Properties**

Description	Requirement
Weight Loss After 12 Cycles: Wetting and Drying Tests (ASTM D559)	15% max.
Compressive Strength (ASTM D558; ASTM D1632; ASTM D1633)	min. 5.2 MPa at 7 days

#### (5) Mixing

##### (a) Batching

When the CTB is proportioned and mixed in a central mixing plant, either weigh batching or volume batching; the plant shall be equipped with feeding and metering devices which will introduce the aggregates, cement and water into the mixer in the proportions specified in the authorized design mix. The plant shall be calibrated at the particular configuration, to include but not be limited to scales, belt speeds, gate settings, dispenser rates and mixing time, to proportion a specified mix. The production configuration required for a design mix shall be maintained on file at the plant for review by the Engineer. Certification by the supplier that the required configuration was used in the production of cement treated base for each days production shall be maintained at the batch plant for review by the Engineer. Batch weights of materials and/or daily production weights will be recorded at the batch plant and maintained on file for review by the Engineer.

##### (b) Mixing In-Place Method

- ♦ Equipment for Construction:

CTBC should be constructed by mix-in-place method of construction or as otherwise approved by the Engineer.

Manual mixing may be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs or corners.

The equipment used for mix-in-place construction shall be a rotavator/road bed aggregate mixer mounted to a tractor, or similar, approved equipment capable of pulverizing and mixing the granular material with additive and water to specified degree to the full thickness of the layer being processed, and of achieving the desired degree of mixing and uniformity of the stabilized material. If so instructed by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for work. The equipment (and the number of machines for pulverizing and mixing) provided for these works shall have a capacity to perform as minimum a total length of 300m/day per lane.

The thickness of the layer to be stabilized shall be not less than 150mm after compaction.

♦ Mix-in-Place Method of Construction:

Before deploying the equipment, the granular material after full process is completed in the Crashing-Plants shall be spread uniformly on the prepared subbase/subgrade in a quantity sufficient to achieve the desired compacted thickness of the stabilized layer. Where single-pass equipment is to be employed, the granular soil shall be lightly rolled at the discretion of the Engineer.

The equipment used shall either be of single-pass or multiple-pass type. The mixers shall be equipped with an appropriate device for controlling the depth of processing and the mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained as all times.

With single-pass equipment the forward speed of the machine shall be so selected in relation to the rotor speed that the required degree of mixing, pulverization and depth of processing is obtained. In multiple-pass processing, the prepared base layer shall be pulverized to the required depth with successive passes of the equipment and the moisture content adjusted to be within prescribed limits mentioned hereinafter. The blending or stabilizing material shall then be spread uniformly and mixing continued with successive passes until the required depth and uniformity of processing have been obtained.

**(6) Placement and Compaction**

**(a) Batching Construction Method**

Material shall be transported in suitable vehicles with a cover. Loads of material shall be covered immediately after loading and remain covered until unloading.

The Contractor shall provide to the Engineer with each load of material batched and/or delivered to the job site, before unloading at the site, a copy of a delivery ticket

on which is printed, stamped or written, all the information of each batch.

Material shall be placed on prepared subgrade, prepared in accordance with the requirements of Section 1000: "Subgrades", in lifts to provide a compacted thickness of not less than 100mm and not more than 150mm, to the required limits and sections specified in the Drawings and specifications or as authorized by the Engineer.

Compaction of the material shall be initiated within sixty (60) minutes from the time of mixing. The material shall be compacted to an equivalent dry density greater than ninety eight (98) percent of maximum dry density, at a moisture content range of optimum moisture to optimum moisture plus four (4) percent, as determined in accordance with ASTM D558. Compaction shall be completed within three (3) hours from the time of mixing as directed by the Engineer.

Upon completion of compaction, the surface of the compacted cement treated base shall be sealed with a prime coat as instructed in Section 1300: "Bituminous Surface and Base Course", and as approved by the Engineer. The prime coat shall be applied as required to provide a uniform coverage of the surface. Application shall be between 0.05 and 0.15 gallons per square yard of surface. If final surfacing is placed within 24 hours after completion of compaction, the prime coat may be waived as authorized by the Engineer. The surface shall be kept at compaction moisture until the next lift of material is placed in the event the prime coat is waived.

CTB shall not be placed on frozen subgrade or subgrade with a surface temperature less than 4°C. The material shall not be placed when the ambient temperature is less than 4°C.

Cement treated base shall be protected from freezing for a minimum of 7 days after placement. The material shall be cured during 7 days before opening to traffic, as approved by the Engineer.

#### **(b) Mix-in-Place Construction Method**

The moisture content shall not be less than the optimum moisture content.

Immediately after spreading, grading and levelling of the mixed material, compaction shall be carried out with approved equipment preceded by a few passes of lighter rollers if necessary. Rolling shall commence at edges and progress towards the centre, except at super-elevated portions where it shall commence at the inner edge and progress towards outer edge.

During rolling the surface shall be frequently checked for grade and cross-fall (camber) and any irregularities corrected by loosening the material and removing/adding fresh material. Compaction shall continue until the density achieved is at least ninety eight (98) per cent of the maximum dry density for the material.

Care shall be taken to see that the compaction of cement stabilized material is completed within two hours of its mixing or such shorter period as may be found necessary in dry weather.



The base course shall be suitably cured for 7 days. Subsequent pavement course shall be laid soon after to prevent the surface from drying out and becoming friable. No traffic of any kind shall ply over unless permitted by the Engineer.

#### **(5) MEASUREMENT**

Cement Treated Base Course (CTBC) shall be measured by the square metres of the completed base course of 150mm thicknesses in accordance with the Drawings, and as directed by the Engineer.

Measurement shall be made only after all procedure and requirements for testing and acceptance are satisfied and the results are approved by the Engineer.

Measurement of the Prime Coat shall be made in square metres as required in Section 1300: "Bituminous Surface and Base Course".

#### **(6) PAYMENT**

The CTBC measured as above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 including cost for all materials labour, equipment, tools, and all incidentals to complete the work in accordance with the Drawings and Specifications, and as directed by the Engineer.

The unit rate input into the BOQ shall be for the Mix-in-Place construction method. However, the Contractor should be free to use the method of Batching Plant for expediting time and securing the quality. Compensation for the differences in price shall not be considered.

Payment of the Prime Coat, as measured above, shall be paid under Section 1300: "Bituminous Surface and Base Course".

Item No.	Description	Unit
<b>2060</b>	<b>Cement Treated Base Course (CTBC)</b>	
2060-1	Mix-in-Place Cement Treated Base Course [t=150 mm] (for tunnel)	sq.m.



## SECTION 2400: MISCELLANEOUS STRUCTURES

### 2401 GABIONS

#### (5) Measurement

- (1) Delete the full text of Clause 2401(5): “Measurement” and replace with the following:

Gabions and/or mattresses shall be measured on the basis of number of cubic metres of completed gabions in place satisfy all tolerances for boxes and mattresses physically measured, and are verified and approved by the Engineer.

Stone filling in gabions including fixing of gabion in position, tying with binding wires and tension wires as specified, and the binding wires, selvedge wire and tension wires, diaphragms every 1.00m, gabion ends, etc. shall not be measured nor paid separately; they shall be deemed included in the measurement of the gabion and/or mattresses itself.

The following gabions will be used in the Project in accordance with these specifications:

Item	Mesh Type	Box Height (m)	Wire Type	Mesh Wire Diam. (mm)	Edge/Selvedge Wire (mm)	Lancing Wire Diam. (mm)
Gabion (H=1.0m)	10x12 Manually or mechanically woven.	1.00	Heavy Zn Coated GI	3.00	3.9	2.40
Gabion (H=0.5m)		0.50		3.00	3.9	2.40
Reno Mattress (W : H)	Double twisted hexagonal mesh	H		3.00	3.9	2.40

Geosynthetics used for gabion construction, shall be performed, measured and paid, respectively in accordance with the relevant Sub-Sections of these specifications such as:

- ♦ 2407 “Geosynthetics for Road and Bridges Works”
- ♦ 2408 “Geotextile for Filtration, Drainage and Separation”
- ♦ 2409 “Geogrid”
- ♦ 2410 “Geo-composite drains”, etc.

As applicable, and as approved by the Engineer.

#### (6) Payment

- (2) Delete the full text of Clause 2401(6): “Payment” and replace with the following:

Gabion boxes and gabion mattresses shall be paid as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work in accordance with these Specifications which shall include the costs for furnishing and producing materials, transporting, placing, stone filling, etc. and for furnishing all labour, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specifications, and/or as directed by the Engineer.

The unit prices established for these items will be applied regardless the mesh has been

woven manually or mechanically.

Item No.	Description	Unit
<b>2400</b>	<b>Miscellaneous Structures</b>	
<b>2401</b>	<b>Gabions</b>	
2401-1	Gabion (box height H=1.0m)	cu.m.
2401-2	Gabion (box height H=0.5m)	cu.m.

## 2402 CRIB WALLS

- (3) *Rename the Sub-Section 2402: “Crib Walls” as follows, delete the full text and replace with the following:*

## 2402 CAST-IN-PLACE CRIB WORKS

### (1) Description

These works shall be carried out in accordance with the requirements of these specifications and to the lines, grades, dimensions and other particulars shown on the Drawings or as directed by the Engineer.

This work shall consist of the construction of cast-in-place concrete crib and filling the cavities between the crib frames as described in this section.

### (2) Materials

#### (a) Concrete:

The concrete for the frames shall be in accordance with the relevant requirements of Section 2000: “Concrete for Structures”, Concrete Class C, of these Specifications, and as directed by the Engineer. The concrete for the foundations shall be of Class-D.

#### (b) Reinforcement and Anchor Bars

Reinforcement bars for concrete and the anchor bars for slope protection shall be in accordance with the relevant requirements of Sub-Section 2014: “Reinforcement” of these Specifications, and as directed by the Engineer.

#### (c) Wire Mesh

Wire mesh shall meet the relevant requirements of the Standard Specifications, as shown in the drawings and as approved by the Engineer. In addition, the following basic requirements shall be satisfied:

Item	Requirement
Wire diameter	φ2.00mm
Reticulation	50mm
Tension strength	500N/m2
Galvanization volume	More than 23g/m2

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**(d) Filling Material**

Depending on the slope conditions, the cavities in between the crib frames shall be filled with random boulders or cobbles, or with appropriate seeded soil, or seeded jute bags provided with weep-holes with Polyvinyl Chloride (PVC) pipes, as shown in the Drawings and as directed by the Engineer.

**(2) Construction Method**

**(a) Preparation of Slope Surface**

All loose rock, sharp protruding edges as well as dirt, grease, oil scale and other contamination shall be carefully removed. Any seepage of water entering locally shall be dealt with suitable methods approved by the Engineer, such as local sealing, drainage, etc. Weep holes with PVC pipes of 40 mm diameter shall be provided in random boulder set in concrete.

**(b) Foundation**

Prior to placing the foundation, the Contractor shall report the bedding conditions and obtain the direction of the Engineer.

**(c) Crib Works**

The concrete crib works shall be constructed complying duly the requirements of Section 2000: "Concrete for Structures" and Sub-Section 2014: "Reinforcement" of these Specifications, as shown in the Drawings and as directed by the Engineer.

The Contractor shall drill holes on the rock surface and install anchor bars as shown in the Drawings or as directed by the Engineer. The Contractor shall use suitable machines depending on geological conditions. The machines shall have enough ability to drill to the required depth to form holes of the required diameter.

**(d) Filling of the Cavities in Between the Crib Frames**

The cavities in between the crib frames shall be filled as follows:

♦ *Type-1: Crib Frames installed on a wet slope "With Spring" water*

After installation of the wire mesh, the cavities shall be filled with boulder stones set in a concrete Class D. The stones shall satisfy the requirements for material specified in Sub-Clause 2401(2)(a): "Stones", or cobbles, as approved by the Engineer.

♦ *Type-2: Crib Frames installed on a dry slope "Without Spring" water*

After installation of the wire mesh, the cavities shall be filled with appropriate seeded soil, or seeded jute bags (vegetation bags) as shown in the Drawings. The jute bags shall be filled with suitable soil for vegetation and sowed with approved grass or shrub seeds complying the relevant requirements of Section 2800: "Bio Engineering Works", as directed by the Engineer. The soil shall be placed and compacted to the specified thickness containing grass and/or shrub seeds as directed by the Engineer.

### (3) Measurement and Payment

Measurement of this item shall be in square meters based on the Drawings on which field survey data for measurement purposes are plotted.

The Cast-in-Place Crib Works shall be paid as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work in accordance with these Specifications which shall include the costs for furnishing and producing materials, transporting, placing, boulders or cobbles, vegetation bags, etc. and for furnishing all labour, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specifications, and/or as directed by the Engineer.

The works and materials for filling the cavities between crib frames with vegetation bags (or sowing) shall not be measured nor paid separately, and shall not be included in the pay items of Section 2800: "Bio Engineering Works".

Item No.	Description	Unit
<b>2402</b>	<b>Cast-in-Place Crib Works</b>	
2402-1	Cast-in-Place Crib Work Type-A (with Cobble)	sq.m.
2402-2	Cast-in-Place Crib Work Type-B (with Boulder mixed with concrete)	sq.m.
2402-3	Cast-in-Place Crib Work Type-C (with Vegetation bags)	sq.m.

## 2404 SUB-SURFACE DRAINS

### (5) Measurement

- (4) *Delete the full text of Clauses 2404(5): "Measurement" and 2404(6): "Payment" and replace with the following:*

### (5) Measurement

Unless otherwise specified, Sub-Surface Drains shall be measured shall be measured on the basis of the number of lineal metres of its actual length for the works completed in place as per planned dimensions as shown in the Drawings.

Overlapping at joints shall not be measured nor paid separately.

Excavation, back fill material, bedding or cover material, and all other material shall not be measured separately for payment.

### (6) Payment

The following items for Sub-Surface Drains shall be paid under this Section and shall include all the works for providing and installing the several types of Sub-Surface Drains, HDPE perforated pipes, geosynthetics, all materials, equipment and tools, and all incidentals used to complete the work in accordance with the Drawings and Specifications, and as directed by the Engineer:

Item No.	Description	Unit
<b>2404</b>	<b>Sub-Surface Drains</b>	
2404-1	Sub-surface drain 600x750 with perforated HDPE 350mm	lin.m.
2404-2	Sub-surface drain 1400x750 with two cell perforated HDPE 350mm	lin.m.
2404-3	Sub-surface drain 500x400 with perforated HDPE 150mm	lin.m.
2404-4	Sub-surface drain 620/350 x 450 with perforated HDPE 150mm	lin.m.
2404-7	Sub-surface drainage filter (9.5mm to 19mm well graded aggregate) back side reinforced soil wall type-3 concrete panel	cu.m
2404-8	Sub-surface drain by perforated PVC 160mm wrapped with geotextile	lin.m

- (5) *Add the following new Sub-Sections at the end of Sub-Section 2406: “Scour Protection and River Training Works” and before Section 2500: “Brickworks for Structures”:*

New Sub-Sections:

- ♦ 2407 “Geosynthetics for Road and Bridges Works”
- ♦ 2408 “Geotextile for Filtration, Drainage and Separation”
- ♦ 2409 “Geogrid”
- ♦ 2410 “Geo-composite drains”
- ♦ 2411 “Riverbed Protection”
- ♦ 2412 “Shotcrete for Slope Protection”
- ♦ 2413 “Dry Stone Packing and Soling”

## **2407 GEOSYNTHETICS FOR ROAD AND BRIDGES WORKS**

### **(1) Scope**

The specification covers the various applications of geosynthetic materials for use in road and bridge works including supplying and laying as per contract specifications.

### **(2) Terminology**

Geosynthetic is a general classification for all synthetic materials used in geotechnical engineering application. It includes geotextile, geogrids, ego-trips, geomembrane, geonets, geocomposites, geocells, geosynthetic mats, paving fabric and glass grid etc. Textiles made from natural fibers such as jute, and coir referred to herein under natural Geotextiles may also be used in different geotechnical engineering applications.

- (a) Geotextile: Any permeable synthetic textile used with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project, structure, or system.

The geotextile fabric shall be a woven or non-woven or knitted fabric consisting of long-chain polymeric filaments or yarns such as polypropylene, polyethylene or polyester or any combination thereof, formed into a stable network such that the filaments or yarns retain their relative position to each other.

There are several application areas for Geotextile requiring specific functions namely separation, filtration, drainage, reinforcement, protection or a combination thereof.

- (b) Geogrids: A deformed or non-deformed netlike polymeric material used with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of human-made project, structure, or system.

Geogrids have relatively high strength, high modulus, and low-creep-sensitive polymers with apertures varying from 10 to 100 mm in size or more. The openings/holes in geogrids are either elongated ellipse, near squares with rounded corners, squares or rectangles. Geogrids can be of uni-axial grid, bi-axial grid or three dimensional grids. Geostrip is another form of Geogrid, which is used in reinforced soil structures. It is primarily made of synthetic material in strips and is made from high tenacity polyester yarn and contained in a suitable low density polyethylen sheath.

These are used as reinforcement in pavements and reinforced soil walls and slopes.

- (c) Geomembrane: An essentially impermeable membrane (liner or barrier) used with foundation, soil, rock, earth, or in any other geotechnical application as an integral part of human-made project, structure, or system, used to control fluid migration.

Geomembrane are mostly made from HDPE, LDPE, PVC or polyethylene sheets, which are duly protected from ultraviolet exposure by carbon black or any antioxidants and thermal stabilizers.

Geo-clay-liners are also, in most cases, consider as geo membrane due to their low permeability performances and can be typically used as an alternative to Polymeric Geo-membrane under specific circumstances. These are used as capillary cut off in roads in water logged areas.

- (d) Geosynthetic Clay Liner: Geosynthetic clay liners (GCLs) are geocomposites that are prefabricated with a bentonite clay layer typically incorporated between a top and bottom geotextile layer or bonded to a geomembrane or single layer of geotextile. Geotextile-encased GCLs are often stitched or needle-punched through the bentonite core to increase internal shear resistance. When hydrated they are effective as a barrier for liquid or gas and are commonly used in landfill liner applications often in conjunction with a geomembrane.

- (e) Geonets: Geonets are used in combination with other types of geosynthetics. These are usually formed by continuous polymeric ribs or filament at acute angle to one another. When the ribs are opened relatively large size apertures are formed in a net like configuration

These are typically used in combination with other geosynthetic materials to form a composite material.

- (f) Geocomposite: A manufactured material, which could be a combination of any two or more synthetic materials like Geotextile, geogrids, geomats, geonets and geomembrane etc., in laminated or composite form. One of the popular forms of geocomposite is Drainage Composite. Drainage Composites are formed by

combining geotextile or geomembrane with a core of geonet, geomat or serrated/corrugated polymeric materials.

Prefabricated Vertical Drains (PVD)/Band Drains and Fin Drains come under the category of geocomposites

- (g) Geocell: It is a three dimensional structure with interconnected cells. The geocells are made of polyester/polypropylene/high density polyethylene stabilized with carbon black.

Geocells may be used in for soil containment purpose.

- (h) Geosynthetic Mats: These are two dimensional or three dimensional mats with specified thickness, made of multi-filaments, with apertures to allow vegetation growth for erosion control application. Geosynthetic mat consists of UV stabilized non-degradable polypropylene/polyethylene or similar polymer fibers that are extruded or heat bonded to provide a dimensionally stable matrix. A tension element like steel wire mesh or Geogrid shall be included in these mats as reinforcement, where these mats are required to possess more strength against erosive forces, like in steep slopes or in heavy rainfall areas.

These are used for erosion protection of slopes or when reinforced with geogrids or woven double twist wire mesh as reinforcement materials in soil veneer applications.

- (i) Natural Geotextile: These geotextiles are made of natural fibres like jute or coir. The blankets/mats/mesh made of these fibres are sometimes further reinforced with polymeric nettings to enhance its tensile strength and for holding the fibres intact. The polymer netting is securely stitched on both sides of the fabric to form a strong quilted mat. These fabrics have excellent drapability and aid in quick growth of vegetation and are used for erosion control applications.

- (j) Paving Fabric and Glass Grids: The paving fabrics are non-woven heat set material, consisting of at least 85% by weight of polyolefin, polyester or polyamides. They are heat bonded only on one side.

Glass grids are either a composite glass fiber reinforced Geogrid with continuous filament nonwoven geotextile chemically /mechanically bonded to the grid, or bituminous coated glass fibre geogrids with or without adhesive on one side of the grid.

The glass grids and composite of fabric and glass grids are used in bituminous pavements to act as stress relieving membrane and crack retarding layer within the pavement structure. The paving fabric also serves the function of water barrier.

### (3) Marking

Geosynthetic rolls shall be marked with the following information:

- (a) Manufacturer's name
- (b) Roll number
- (c) Grade
- (d) Length
- (e) Date of manufacture; and
- (f) Product identification details



**(4) Packing, Storage and Handling**

- (a) Each geosynthetic roll shall be wrapped with a material that will protect the geosynthetic from damage due to shipment, water, sunlight and contaminants. The protective wrapping with a tarpaulin or opaque plastic sheet shall be maintained during periods of shipment and storage.
- During storage, geosynthetic rolls shall be elevated off the ground and adequately covered to protect from site construction damage, precipitation, prolonged ultra-violet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 71°C, and any other environmental condition that may damage the physical properties of the geosynthetic.
- (b) If the outer layer of the geosynthetic is damaged, or exposed to sunlight for a period beyond that is permitted the outermost wrap of the rolls shall be discarded, and only the remaining undamaged/unexposed material shall be used. If the geosynthetic rolls become wet, the water proof cover shall be removed, the rolls shall be elevated off the ground and exposed to wind in order to dry the fabric. The paving fabric used with bitumen overlays shall be completely dry prior to installation.

**(5) Testing and Acceptance**

- (a) Geosynthetic Materials Shall be Tested and Certified in the following Manner.
- ◆ The manufacturer shall have ISO or CE certification for manufacturing process and quality control.
  - ◆ The manufacturer shall provide manufacturer's test certificate for every lot supplied from the factory.
  - ◆ The supplier shall provide third party test reports from an independent laboratory with valid accreditation for all the test values in Manufacturer's test certificate
  - ◆ Geosynthetic shall be tested in accordance with tests prescribed by BIS. In absence of NS codes, tests prescribed either by IS, ASTM, EN, or ISO shall be conducted.
  - ◆ The material shall meet the requirements as specified in the contract.

**2408 GEOTEXTILE FOR FILTRATION, DRAINAGE AND SEPARATION**

**(1) Scope**

The work covers the use of geotextile materials for drainage, separation/filtration and erosion control works including supplying and laying as per design, drawing and these specifications.

For drainage/filtration function, geotextile shall be able to convey water across the plane of the fabric throughout its design life.

For separation function the geotextile shall prevent intermixing of two layers of dissimilar materials, throughout the design life of the structure.

The geotextile as a filter material below erosion control measures like stone pitching



or stone filled mattresses over the slopes, shall allow the water to flow out and at the same time prevent the loss of soil under the protective measures.

## (2) Material

### (a) Strength Requirement

The minimum strength of geotextile in terms of MARV under different installation conditions shall be as specified in Table 24-5.

**Table 24-5: Minimum Geotextile Strength Property Requirements**

Installation Conditions	Type	Strength Property Requirement (MARV)							
		Grab Strength in Newton (N) as per IS: 13162, Part 5		Tear Strength in Newton (N) as per IS: 14293		Puncture Strength in Newton (N) as per IS: 13162, Part 5		Burst Strength in Newton (N) as per IS: 1966	
		Elongation at Failure							
		<50%	>50%	<50%	>50%	<50%	>50%	<50%	>50%
Hard	I	1400	900	500	350	500	350	3500	1700
Moderate	II	1100	700	400	250	400	250	2700	1300
Less Severe	III	800	500	300	180	300	180	2100	950

Note:

- (1) All numeric values in the above table represent Minimum Average Roll Value (MARV) in weaker principal direction. The MARV is derived statistically as the average value minus two standard deviations.
- (2) When the Geotextile are joined together by field sewing, the seam strength shall be at least 60 percent of the material's tensile strength. All field seams shall be sewn with thread as strong as the material in the fabric.
- (3) The puncture strength if determined in accordance with ASTM D 6241, the minimum requirement in terms of "Newton (N)" shall be as follows:

Installation Conditions	Strength Property Requirement (MARV)	
	Puncture Strength in Newton (N) as per ASTM D6241	
	Elongation at Failure	
	<50%	>50%
Hard	2800	2000
Moderate	2250	1400
Less Severe	1700	1000

### (b) Ultraviolet Stability Requirements

The material shall conform the following requirements for ultraviolet stability:

**Table: 24-6: Requirements for Ultra Violet Stability**

S.No.	Properties of Fabric	Requirement (Retained Strength)
1	Grab Strength	Not less than 70% after 500 hours of exposure
2	Tear Strength	
3	Puncture Strength	
4	Burst Strength	

### (c) Hydraulic Requirements for various applications

- ♦ Subsurface Drainage and filtration

The geotextile shall conform to the physical requirements specified in Table 24-7.

**Table: 24-7: Geotextile Requirements for Subsurface Drainage**

In-situ passing 0.075 mm sieve (%)	Permittivity, per sec ASTM D4491 / IS 14324-1995	Maximum Apparent opening size (mm) ASTM D4751 / IS 14294-1995
<15	0.5	0.43
15 to 50	0.2	0.25
>50	0.1	0.22

The type of geotextile shall be decided by the Engineer depending upon the installation conditions.

♦ Separation

The geotextile for different subgrade soil conditions shall conform to the requirements given in Table 24-8 and Table 24-9.

**Table: 24-8: Geotextile Requirements for Separation (Subgrade Soaked CBR>3)**

Sl. No.	Geotextile Property	Requirement
1	Permittivity as per ASTM D4491	0.02/sec
2	Maximum Apparent Opening Size as per ASTM D4751	0.60mm

**Table: 24-9: Geotextile Requirements for Separation (Subgrade Soaked CBR ≤3)**

Sl. No.	Geotextile Property	Requirement
1	Permittivity as per ASTM D4491	0.05/sec
2	Maximum Apparent Opening Size as per ASTM D4751	0.43mm

♦ Erosion Control

The geotextile for erosion control shall conform to requirements of Table 24-10.

**Table: 24-10: Geotextile Requirements for Erosion Control**

In-situ passing 0.075 mm sieve (%)	Permittivity, per sec ASTM D4491	Maximum Apparent opening size (mm) ASTM D4751
<15	0.7	0.43
15 to 50	0.2	0.25
>50	0.1	0.22

### (3) Construction

#### (a) General Requirement

Exposure of Geotextile to the elements between lay down and cover shall be a maximum of 14 days to minimize damage potential.

In trenches, after placing the backfill material, the geotextile shall be folded over the top of the filter material to produce a minimum overlap of 300mm for trenches greater than 300mm wide. In trenches less than 300mm wide, the overlap shall be equal to the width of the trench. The geotextile shall then be covered with the subsequent course.

Overlap at roll ends and at adjacent sheets shall be a minimum of 450mm, except when placed under water. In such instances, the overlap shall be a minimum of 1 m. Where seams are required in the longitudinal trench direction, they shall be joined by

either sewing or overlapping. All seams and overlaps shall be subject to the approval of the Engineer.

Care shall be taken during installation so as to avoid any damage to the geotextile. Damages, if any, during installation shall be repaired by placing a geotextile patch over the damaged area and extending it 1m beyond the perimeter of the tear or damage, or as approved by the Engineer.

**(b) Subsurface Drainage**

Construction shall conform to Clause 2404 of these specifications.

**(c) Separation**

After preparation of subgrade as per the specifications along the road alignment, geotextile shall be rolled out as indicated in the drawings. The entire roll shall be placed on the subgrade and unrolled as smoothly as possible. Wrinkles and folds in the fabric shall be removed by stretching as required.

Adjacent rolls of Geotextile shall be overlapped, sewn, or joined as required. For curves, the geotextile shall be folded or cut and overlapped in the direction of construction. Folds in the geotextile shall be stapled or pinned approximately 0.6m centre-to-centre. Before covering, the condition of the geotextile shall be checked for damage (i.e., holes, nips, tears, etc.) by the Engineer.

Before placing the first lift of granular sub-base on the geotextile, a trial stretch of 100m shall be laid as per roll width to establish a proper construction methodology of placing and compacting the sub-base in a manner that no damages are caused to the separation layer of geotextile.

**(d) Filter Layer Under Stone Pitching for Erosion Control**

The geotextile shall be placed in intimate contact of soil ensuring slight tension, to avoid wrinkles or folds and shall be anchored on a properly shaped surface as indicated in drawings and approved by the Engineer. It shall be ensured that the placement of the overlying material be placed in such a manner that it does not tear/puncture the geotextile. Anchoring of the terminal ends of the geotextile shall be accomplished as per drawings through the use of key trenches or aprons at the crest and toe of slope.

The geotextile shall be placed with the machine direction parallel to the direction of water flow. Adjacent geotextile sheets shall be joined by either sewing or overlapping.

The pitching shall begin at the toe and proceed up the slope. Big sized boulders shall not be allowed to roll down the slope.

Any geotextile damaged shall be either replaced or repaired with a patch, as directed by the Engineer, at the cost of the contractor.

**(4) Measurement**

The geotextile for separation and for filter layer shall be measured on the basis of the

number of square metres of the works completed in place as per planned dimensions as shown in the Drawings. Overlapping at transverse and longitudinal joints shall not be measured nor paid separately. Excavation, back fill, bedding and cover material shall be measured separately as per relevant Clauses of the Contract.

#### (5) Payment

Geotextiles for filtration, drainage, and separation shall be paid as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work in accordance with these Specifications which shall include the costs for furnishing and producing materials, transporting, placing, etc. and for furnishing all labour, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specifications, and/or as directed by the Engineer.

Item No.	Description	Unit
<b>2408</b>	<b>Geotextiles for Filtration, Drainage, and Separation</b>	
2408-1	Geotextile sheets	sq.m.

### 2409 GEOGRID

#### (1) Scope

The work covers the use of geogrids in sub-base of pavement, erosion control of slopes, reinforced soil slopes and reinforced soil walls including supplying and laying as per design, drawing and these specifications.

The use of geogrids as a component for reinforced soil slopes and walls shall be as per Sub-Section 301: "Reinforced Soil".

#### (2) Materials

##### (a) General

Geogrids shall be either made from high tenacity polyester yarn jointed at cross points by weaving or knitting or thermal bonding process with appropriate coating or from polypropylene or polyethylene or any other suitable polymeric material by an appropriate process. Geogrids manufactured by extrusion process are integrally jointed, mono or bi-directionally oriented or stretched meshes, in square, rectangular, hexagonal or oval mesh form. The geogrids manufactured by weaving/ knitting/ bonding process shall be formed into a stable network such that ribs, filaments or yarns retain their dimensional stability relative to each other including selvages.

##### (b) Earth Reinforcement

Geogrid for earth reinforcement shall meet the requirement as per the design subject to the minimum requirements as given in Table 24.11.

**Table: 24-11: Minimum Requirements for Geogrids**

Property	Test Method	Unit	Requirement
Stiffness at 0.5% strain	ISO 10319	kN/m	$\geq 350$ ; both in machine and cross-machine direction
Tensile strength@2% strain	ASTM D6637	kN/m	$\geq 15$ % of $T_{ult}$ ; both in machine and cross-machine direction
Tensile strength@5% strain	ASTM D6637	kN/m	$\geq 20$ % of $T_{ult}$ ; both in machine and cross-machine direction
Junction Efficiency for extruded geogrids	GRI-GG2-87or ASTM- WK 14256	-	90 % of rib ultimate tensile strength
Ultraviolet stability	ASTM D4355	-	70% after 500 hrs exposure

Note:

- 1) All numerical values in the Table represent MARV in the specified direction.
- 2) All geogrids shall be placed along machine direction parallel to the centre line of roadway alignment.

### (c) Erosion Control

The Geogrid for erosion control application shall have the minimum tensile strength of 4kN/m, when tested as per ASTM D5035 (Minimum Average Roll Value in Machine Direction). The aperture opening size shall be minimum 20mm x 20mm and average grid thickness shall be minimum 1.0mm. Geogrid for erosion control application shall be UV stabilized. The Geogrid shall have ultraviolet stability of 70 percent after 500hrs exposure as per ASTM D4355.

### (d) Reinforced Soil Slopes and Walls

The strength and other requirements shall be as per Sub-Section 301: “Reinforced Soil”.

## (3) Installation and Construction Operations

### (a) Sub-base Reinforcement

Prior to laying of Geogrid, the surface shall be properly prepared, cleaned and dressed to the specified lines and levels as shown on the drawings.

The Geogrid shall be laid within the pavement structure as shown on the drawings.

Geogrid reinforcement shall be placed flat, pulled tight and held in position by pins or suitable means until the subsequent pavement layer is placed.

No vehicle shall be allowed on Geogrid unless it is covered by at least 150mm thick sub-base material.

### (b) Erosion Control

The Geogrid for erosion control applications shall be installed in accordance with the manufacturer’s recommendation and relevant requirements of these specifications.

### (c) Reinforced Slopes and Walls

The Geogrid for reinforced slopes and walls shall be installed in accordance with the manufacturer’s recommendation and as per Section 300.

#### (4) Measurement

The geogrids for reinforced soil shall be measured on the basis of the number of square metres of the works completed in place as per planned dimensions as shown in the Drawings. However, these quantities shall be included in the unit rates measured for the pay items of Section 300: "Soil Improvement".

Overlapping at joints and anchoring at toe and crest of the slope shall not be measured nor paid separately. Excavation, back fill, bedding and cover material shall be measured separately as per relevant Clauses of the Specifications.

#### (5) Payment

Geogrids for reinforced soil shall not be paid separately but shall be deemed included in unit rates of the respective pay items of Section 300: "Soil Improvement", which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work in accordance with these Specifications which shall include the costs for furnishing and producing materials, transporting, placing, etc. and for furnishing all labour, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specifications, and/or as directed by the Engineer.

### 2410 GEO-COMPOSITE DRAINS

#### (1) Scope

The work covers the use of geocomposite drainage system for construction of "Fin Drains". These works shall be carried out in accordance with the requirements of these specifications and to the lines, grades, dimensions and other particulars shown on the Drawings or as directed by the Engineer.

Fin drains with plastic core shall be installed for affecting vertical and/or horizontal drainage.

#### (2) Materials

Fin Drains shall be made of light weight, three dimensional high compressive strength polyethylene cores; and heat bonded or needle punched polypropylene/polyester geotextile provided on one side or both sides of the core as per the requirements. Geotextile used in drainage composite shall meet the requirements as specified in Table 24-12.

**Table 24-12: Geotextile Requirements for Fin Drains**

In-situ soil passing 0.075 mm sieve (%)	Permittivity, per sec ASTM D 4491/ IS 14324 - 1995	Maximum Apparent Opening Size, mm as per ASTM D 4751/IS 14294-1995
< 15	0.5	0.43
15 to 50	0.2	0.25
> 50	0.1	0.22

The properties of the core material shall meet the requirements as indicated in Table 24-13.

**Table 24-13: Properties for Fin Drain Composite**

Property		Test method	Units	Minimum Average Roll value
Tensile strength		EN ISO 10319	kN/m	16
CBR Puncture Resistance		EN ISO 12236	N	3000
Mass per unit area		EN ISO 9864	g/m <sup>2</sup>	650
Thickness of Composite		EN ISO 9863	mm	4.5
In-plane permeability	Hydraulic Gradient, i=1 at 100 kPa pressure	EN ISO 12958	l/m	0.55
	Hydraulic Gradient, i=1 at 200 kPa pressure			0.45

### (3) Installation

The installation of fin drains shall be as per drawings. Where fin drains are assembled on site, the assembly area shall be clean and dry. No geotextile or core material shall be exposed to daylight (or any source of ultraviolet radiation) for a period exceeding 50 hours. Where fin drains are laid in a trench, the bottom of the trench shall be free of irregularities and shall be brought to the required level. Rock and other hard protrusions shall be removed and any excess cut in the trench bottom shall be filled and compacted back to the required grade with suitable excavated or imported material as directed by the Engineer. Fin drains shall be capable of being connected longitudinal or laterally into pipe systems or chambers for inflow and outflow purposes. Joints parallel to the direction of flow and any exposed edge shall be protected from the ingress of soil by a geotextile wrapping with a minimum overlap of 150mm or other measures as approved by the Engineer. The splicing of lengths of geotextile and minimum overlap shall be as per the drawing or as approved by the Engineer.

### (4) Measurement

The Geo-composite sub-surface drain 8mm x 300mm, as shown in the Drawings, shall be measured on the basis of the number of lineal metres of its length of the works actually completed in place and as approved by the Engineer.

Geo-composite planar drainage composed of drainage core material with one filtering non-woven geotextile, as shown in the Drawings, shall be measured in square metres of the actual covered surface, and as approved by the Engineer.

Overlapping at joints shall not be measured nor paid separately. Excavation, embankment, back fill, bedding or cover material shall be measured separately as per relevant Clauses of the Specifications.

The geocomposite measured for payment under this Section shall not be counted in any other sections such as Section 301: "Reinforced Soil", etc.

### (5) Payment

Geo-composite, measured as described above, shall be paid as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work in accordance with these Specifications which shall include the costs



for furnishing and producing materials, transporting, placing, etc. and for furnishing all labour, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specifications, and/or as directed by the Engineer.

Item No.	Description	Unit
<b>2410</b>	<b>Geo-Composite Drains</b>	
2410-1	Geo-composite sub-surface drain 8mm x 300mm	lin.m
2410-2	Geo-composite planar drainage composed of a drainage core material with one filtering non-woven geotextile	sq.m

## 2411 RIVERBED PROTECTION

### (1) Description

These works shall be carried out in accordance with the requirements of these specifications and to the lines, grades, dimensions and other particulars shown on the Drawings or as directed by the Engineer.

This work shall consist of the construction of the foot protection blocks installed in areas adjacent to culverts, piers and/or abutments, at outfalls of drainage, along the road side and elsewhere, where protection is required for ensuring safety of structures against damage by flood/flow of water as shown in the Drawing and as directed by the Engineer.

### (2) Materials and Construction Method

#### (a) Stones and Boulders

The stones or boulders shall satisfy the requirements for material specified in Sub-Clause 2401(2)(a): “Stones”, and Section 613: “Stone, Aggregate, Sand and Fillers”, as approved by the Engineer.

#### (b) Concrete

Concrete for the foot protection blocks shall be in accordance with the requirement of Section 2000: “Concrete for Structures” of these Specifications. Concrete Class-D.

#### (c) Reinforcement Bar

Reinforcement bar shall be in conformity with Sub-Section 2014: “Reinforcement” of these Specifications.

### (3) Measurement

Measurement of the item for the concrete Foot Protection Blocks shall be in number of blocks of 11,000mm x 1,000 mm x 500 mm constructed as shown in the Drawings, in accordance to these Specifications, counted and accepted by the Engineer at Site.

Measurement of the item for the boulders for Foot Protection Blocks shall not be measured nor paid separately but deemed included in the rates and unit price established for the main item.



#### (4) Payment

The works for Foot Protection Blocks shall be paid as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work in accordance with these Specifications which shall include the costs for furnishing and producing materials, transporting, placing, boulders or stones, concrete Class-D (M20) including reinforcement bars (connection bars and metal fitting), etc. and for furnishing all labour, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specifications, and/or as directed by the Engineer.

The concrete and reinforcement bars (connection bars and metal fitting) included in this section for payment shall not be included in the pay items of Section 2000: "Concrete for Structures" and Section 2014: "Reinforcement". The reinforcement bars for connection bars and metal fitting shall be deemed included in the price for Foot Protection Blocks.

Item No.	Description	Unit
2411	<b>Riverbed Protection</b>	
2411-1	Foot Protection Blocks (1,100mm x 1,000 mm x 500 mm)	No.

### 2412 SHOTCRETE FOR SLOPE PROTECTION

#### (1) Description

These works shall be carried out in accordance with the requirements of these specifications and to the lines, grades, dimensions and other particulars shown on the Drawings or as directed by the Engineer.

This work shall consist of the spraying of shotcrete on the prepared slope surfaces for strengthening the slope protection.

#### (2) Materials

The type of shotcrete to be used in a particular location shall be determined by the Engineer. The required mix proportions of cement, aggregates and suitable admixture for each type shall be proposed by the Contractor and shall be approved by the Engineer. Minimum compressive strength at 28 days (cylinder specimen tested in accordance with AASHTO T22) shall not be less than 15 N/mm<sup>2</sup> (Concrete Class D).

Shotcrete mixtures shall not be used prior to the Engineer's approval. Mix proportions shall be varied as directed to maintain minimum rebound.

##### (a) Cement

The range of cement content in the shotcrete shall be from 320 kg/m<sup>3</sup> to 400 kg/m<sup>3</sup>. For the cement content, a tolerance limit of +5% shall be allowed. Cement shall be Portland cement of approved type. The Contractor shall submit his proposal for the type of cement to be used to the Engineer for the approval.

### (b) Aggregate

Aggregate for shotcrete shall be uniformly graded, dense, with hard particles which are required to avoid crumbling and forming fine powder of the grains by passing the same through the nozzle. The size gradation of Concrete Class D (measured by weight), for the fine and coarse aggregates shall be modified as shown below:

Sieve Size (mm) (Square Mesh)	Fine Aggregate	Coarse Aggregate (Maximum size: 15mm)
15	-	90 - 100
10	100	20 - 55
5	90 - 100	0 - 10
2.5	80 - 100	0 - 5
1.2	50 - 85	-
0.6	25 - 65	-
0.3	10 - 35	-
0.15	2 - 10	-

Both cleanliness and uniformity of the fractions in accordance with appropriate standards shall be guaranteed through. The aggregate shall be stored in adequate and appropriate manner so that aggregate cleanliness and composition remain unchanged.

### (c) Additives

Additives are able to use for the improvement of workability and the development of strength and hardening pattern of the concrete. If the Contractor used additives, the Contractor shall report the category of additives and the purpose of use and obtain the Engineer's approval.

### (d) Water

The water used in shotcrete shall be fresh, clean and free from injurious amounts of sewage, oil, acid, alkali, salts or organic matter.

### (e) Wire Mesh

Wire mesh shall meet the relevant requirements of the Standard Specifications, as shown in the drawings and as approved by the Engineer. In addition, the following basic requirements shall be satisfied:

Item	Requirement
Wire diameter	$\phi$ 2.00mm
Reticulation	50mm
Tension strength	500N/m <sup>2</sup>
Galvanization volume	More than 23g/m <sup>2</sup>

### (f) Anchor bar and Anchor pin

Anchor bar and Anchor pin shall meet the requirements of SR295 of JIS G 3112 or equivalents. The dimensions are shown below:

Anchor bar: D16 x 400 x 30

Anchor pin: D9 x 200 x 30

**(g) Concrete Nail**

The Nail used for shotcrete shall meet the requirements for materials described in Section 302: "Soil Nail" and as shown in the Drawings or as instructed by the Engineer. The dimensions are shown below:

Item	Requirement
Nail diameter	$\phi$ 10 mm
Length	200 mm
Quantity to be installed	2 nails per each m2 of shotcrete surface

**(h) PVC drain pipes for weep holes**

The Contractor shall furnish and install polyvinyl chloride (PVC) drain pipes and necessary fittings as mentioned in the drawings or as directed by the Engineer. The PVC drain pipes to be used shall be 50 mm in diameter and un-elasticized polyvinyl chloride pipes or as approved by the Engineer.

**(3) Construction Method**

**(a) Preparation of slope surface**

All loose rock, concrete, sharp protruding edges as well as dirt, grease, oil scale and other contamination shall be carefully removed. Any seepage of water entering locally shall be dealt with suitable methods approved by the Engineer, such as by drainage, boring with grouted pipe nipples connected to pipe, or local sealing. Fresh shotcrete shall not be exposed to water until it has sufficiently set.

Weep holes with PCV drain pipes of 50 mm in diameter, if required as shown in the drawings or directed by the Engineer, shall be made in every 3 square meters of slope surface prepared for shot concreting. The slope surface to be treated shall be covered by wire mesh as approved by the Engineer. The wire mesh shall be fastened with anchor bars and anchor pins as shown in the drawings. Anchor bars shall be set in every 3 square meters. Anchor pins shall be set in 3 pins per 2 square meters. Where wire mesh is to be covered, it shall be held properly in place by expansion bolts or dowels anchored firmly in place.

**(b) Mixing**

Aggregate, cement, additive and water shall be thoroughly mixed for all shotcrete. The optimum mix shall contain water that is free to cause any sloughing, and just enough cement as required per desired water-cement ratio. The water-cement ratio of fresh shotcrete shall generally be between 0.35 and 0.50. The non-lift mixing process shall be used until it is applied. During handling, the mixed concrete shall be protected against dripping water. Concrete that has been prepared for more than one hour shall not be used.

**(c) Placing**

Shotcrete shall be sprayed using proper nozzle spacing and at correct spray angle.

Shotcreting shall not be executed to any surface prior to the approval of the Engineer.

The Contractor shall develop operating procedures and operations to the satisfaction of the Engineer, to give:

- Minimum rebound
- Rebound-free finished concrete
- Smooth finished surface as little as possible
- Minimum shrinking cracks and good adherence of the shotcrete to slope surface.

The quantities of shotcrete to be discharged by the nozzle shall be determined on the basis of the average thickness of shotcrete as mentioned in the drawings or as required by the Engineer, and also taking due account of rebound. Once the procedure for the placement of shotcrete has been established, subsequent work shall be carried out accordingly. When shotcreting is to be performed near existing structures, the Contractor shall protect the surface of the existing structure before injecting. Construction joints or stop joints shall be provided as approved or required by the Engineer, and shall be unlined at 45 degrees to the adjacent shotcrete surface in a clean and regular edge. Before placing to an adjoining work, the sloped portion and adjacent shotcrete shall be prepared as specified herein.

Before another layer of shotcrete is placed, the preceding layer shall be checked by the Engineer to maintain better quality. The Contractor shall repair any defective, sandy, cracked or spalled areas and any other areas, as directed by the Engineer. The Contractor shall remove faulty shotcrete and, carry out surface preparation as specified herein and re-spray over that area.

#### **(d) Curing**

For a certain period, depending on local conditions and as approved by the Engineer, the freshly placed shotcrete shall be protected against sunshine, cold, rain, running water, chemical attacks, and vibrations until it hardens.

#### **(4) Measurement and Payment**

Measurement of the item shall be in square meters based on the drawings on which field survey data for measurement purposes are plotted.

The “shotcrete for slope protection” shall be paid as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work in accordance with these Specifications which shall include the costs for furnishing and producing materials including wire mesh, nails, transporting, placing, etc. and for furnishing all labour, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specifications, and/or as directed by the Engineer.

Item No.	Description	Unit
<b>2412</b>	<b>Shotcrete for Slope Protection</b>	
2412-1	Shotcrete for Slope Protection (100 mm thick)	sq.m.

## **2413 DRY STONE PACKING AND SOLING**

### **(1) Description**

These works shall be carried out in accordance with the requirements of these specifications and to the lines, grades, dimensions and other particulars shown on the Drawings or as directed by the Engineer.

This work shall consist of the construction of the foundations for protection works installed in areas adjacent to culverts, piers and/or abutments, at outfalls of drainage, existing structures to be affected, along the road side and elsewhere, where protection is required as shown in the Drawing and as directed by the Engineer.

### **(2) Materials and Construction Method**

#### **(a) Stones and Boulders**

Stones or boulders from road cutting excavation, or river stones and/or boulder from approved borrow pits, can be used and shall be stockpiled safely at locations previously approved by the Employer. The Contractor shall investigate borrow area to obtain suitable materials for filling and shall submit the Construction Plan showing location, excavation area and demolishing plan to the Engineer for review and approval.

The stones, boulders or gravel shall satisfy the requirements for material specified in Sub-Clause 2401(2)(a): “Stones”, and Section 613: “Stone, Aggregate, Sand and Fillers”, as approved by the Engineer.

The material may be placed and spread out without compaction.

#### **(b) Excavation**

The excavation shall be done in a way that any public utilities or properties are not damaged. Any damage to a Third Party outside of the construction area caused under this work shall be compensated by Contractor at his own expenses.

### **(3) Measurement**

Measurement of the item for the “Dry Stone Packing and Soling” shall be in cubic metres of foundations actually constructed as shown in the Drawings, in accordance to these Specifications, and approved by the Engineer at Site.

The excavation for these works shall not be measured nor paid separately but deemed included in the rates and unit price established for the main item.

### **(4) Payment**

The works, measured as described above, shall be paid as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work in accordance with these Specifications which shall include the costs for furnishing materials, transporting, placing, boulders, stones,

excavation, etc. and for furnishing all labour, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings, as required by these Specifications, and/or as directed by the Engineer.

Item No.	Description	Unit
2413	Dry Stone Packing and Soling	
2413-1	Dry Stone Packing and Soling	cu.m.

## SECTION 2600: MASONRY FOR STRUCTURES

### 2611 MEASUREMENT

- (1) *Delete the full text of Sub-Section 2611: “Measurement” and replace with the following:*

Stone masonry for breast wall (Concrete Class D, M20/20) shall be measured in square metres, and Stone masonry for gravity wall (Concrete Class D, M20/20) and Stone masonry (MM7.5) shall be measured in cubic metres.

The works pointing shall not be measured nor paid separately; but shall be deemed included in the measurement of the masonry.

### 2612 PAYMENT

- (2) *Delete the first paragraph of Sub-Section 2612: “Payment” and replace with the following:*

The Stone Masonry shall be paid at its respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work as per these Specifications including the works for pointing, scaffolding (if needed), curing, preparation of mortar, and the costs for providing and laying random rubble stone masonry in cement sand mortar MM7.5 (Mortar Mix with 7.5 Mpa compression strength at 28 days) for structure work, other materials, transporting, etc. and for furnishing all labour, tests, tools, equipment and any incidentals to complete the work as shown in the Drawings, and/or as directed by the Engineer.

Item No.	Description	Unit
<b>2600</b>	<b>Masonry for Structures</b>	
2600-1	Stone masonry for breast wall (Concrete Class D, M20/20)	sq.m
2600-2	Stone masonry for gravity wall (Concrete Class D, M20/20)	cu.m
2600-3	Stone masonry (MM7.5)	cu.m

## SECTION 2800: BIO ENGINEERING WORKS

### 2801 SCOPE

- (1) *Rename and delete the full text of Sub-Clause 2801 and replace with the following as follows:*

### 2801 GENERAL

#### (1) Scope

This Section covers all component of bio-engineering works such as provision of seed and plant cutting, nursery construction and operation, slope preparation for planning, site planting and sowing, jute netting, gabion wire bolsters and wire bolsters and wire netting, site protection and aftercare/maintenance.

#### (2) Contractor's Personnel

The Contractor shall provide, in a full time assignment, an expert in Bio-Engineering who shall take responsibility of management of execution of works related to Bio-Engineering during the whole project execution period, including periodical assignment during the Defects Notification Period.

The expert shall have similar experience for five (5) years or at least in two roads projects.

### 2806 FINAL SLOPE PREPARATION FOR BIO-ENGINEERING

#### (1) Cut Slope Preparation for Grass Planting

- (2) *Rename this Clause as follows:*

#### (1) Cut Slope Preparation for Grass Planting – Slope Trimming

- (3) *Delete the full text of Sub-Clause 2806(1)(c) and replace with the following:*

#### (c) Trimming Works:

This work shall consist of the trimming of slopes, site protection and site aftercare in accordance with these specifications. The area to be trimmed shall be part of cut slopes or embankments of the road as shown in the Drawings and as directed by the Engineer. The classification of soil shall be made by the Engineer based on the results of test performed by the Contractor.

Trimming shall be as follows:

- ♦ new sites: trimming to straight plan section;  
retaining wall to be filled behind.
- ♦ old sites: minor trimming only required on part of site;  
keeping rill or gully pattern in plan section.

- (4) *Delete the full text of Sub-Clause 2806(1)(f): "Measurement and Payment:" and replace with the following:*



(f) Measurement and Payment:

The works for trimming shall not be measured and nor paid separately. All costs related to this requirements shall be deemed included in the Contractor's Unit Prices for the applicable works (earthworks, slope protection, etc.) and shall be the full and final compensation to the Contractor as per Clause 112 to complete the work as herein specified including the arrangements for traffic control, removal of loose materials, all labour, tools equipment, safety harness and incidentals to complete the work as per these Specifications.

## 2807 SITE PLANTING AND SOWING

- (5) *Delete the full text of Sub-Clauses 2807(2)(b), 2807(3)(b), 2807(4)(b), 2807(5)(b), 2807(6)(b) and replace with the following:*

The Contractor shall prepare the surface for planting in accordance with the Drawings, or as instructed by the Engineer. Areas to be planted shall be given a layer of topsoil at least 75 mm thick unless, due to the presence of suitable sub-soil, the Engineer orders that the topsoil can be omitted.

### (2) Direct Seed Sowing of Shrubs and Trees on Site

- (6) *Delete the full text of Sub-Clause 2807(2)(h): "Measurement and Payment", and replace with the following:*

- (h) Measurement and Payment: The works for this item shall be measured in number of seedlings planted in accordance to these Specifications, counted and accepted by the Engineer at Site.

The payment shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work as herein specified including making arrangements for traffic control, supplying and storage of seeds, collection and application of mulch, all labour, tools, equipment, safety harness and incidentals to complete the work as specified herein.

Item No.	Description	Unit
<b>2807</b>	<b>Site Planting and Sowing</b>	
2807-1	Orange trumpet creeper ( <i>Pyrostegia venusta</i> )	No.
2807-2	Wall creeper ( <i>Ficus pumila</i> )	No.

### (3) Site Planting of Grass Slips and Cuttings

- (7) *Delete the full text of Sub-Clause 2807(3)(j): "Measurement and Payment", and replace with the following:*

- (j) Measurement and Payment: The measurement shall be the actual area of grass planted and covered surface in square meters for the actual completed works in accordance with the Drawings and as directed by the Engineer.

The payment shall be the full and final compensation to the Contractor as per

Clause 112 to complete the work as herein specified including making arrangements for traffic control, providing grass slips or rhizome, collection of mulch, all labour, tools, equipment, safety harness and incidentals to complete the work as per these Specifications. If the grass slips and mulch are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the supply slips and mulch, no separate payment shall be made for these items.

Item No.	Description	Unit
2807	Site Planting and Sowing	
2807-3	Site Planting of Grass Slips	sq.m.

**(4) Site Planting of Shrubs and Trees raised in Polythene Pots**

(8) *Rename the Sub-Clause 2807(4)(a) as follows:*

**(4) Tree Planting**

(9) *Delete the full text of Sub-Clause 2807(4)(a) and replace with the following:*

- (a) The planting of trees and shrubs is intended to replace or restore something of the natural vegetation on the slope to be treated.

The Contractor shall perform the works as herein Specified and in accordance with approved Program.

The work shall be carried out as designated in the drawings and as directed by the Engineer.

(10) *Delete the full text of Sub-Clause 2807(4)(i): “measurement and payment...” and replace with the following:*

- (i) For at least six months after completion of planting, the work will be inspected and evaluated by the Engineer. The area, where planting and straw mats are damaged and/or the covering rate of the grass is less than the average result, shall be repaired and/or re-seeded by the Contractor at his own expenses, and as directed by the Engineer.

- (j) Measurement: The measurement shall be made in number of seedlings planted in accordance to these Specifications, counted and accepted by the Engineer at Site.

Topsoil (75mm thick) shall be applied in accordance with the requirements of Sub-Section 2813: “Topsoil”, and as approved by the Engineer

- (k) Payment: The quantities measured shall be paid at the unit rates shown in the Bill of Quantities. This payment shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work as herein specified including supplying seedlings and mulch, and the works for making arrangements for traffic control, providing seedlings, collection and application of mulch, all labour, tools, equipment, safety harness and any other incidentals to complete the work as per these Specifications.

Item No.	Description	Unit
<b>2807</b>	<b>Site Planting and Sowing</b>	
2807-4	Lahre pipal tree	No.
2807-5	Jacaranda tree	No.
2807-6	Dhupi	No.
2807-7	Kaphal (Mountain peach) tree	No.
2807-8	Induru kumal	No.
2807-9	Beli chameli	No.

## 2811 SITE AFTERCARE AND MAINTENANCE

(11) *Delete the first paragraph of Clause 2811(12): “measurement and payment” and replace with the following:*

(12) **Measurement and Payment:** The works for Sub-Section 2811: “Site Aftercare and Maintenance” shall be carried out as specified herein; however, these shall not be measured nor paid separately. All costs related to these requirements shall be deemed included in the Contractor’s Unit Prices for the applicable works for Bio-Engineering and shall be the full and final compensation to the Contractor as per Clause 112 to complete the work as herein specified including the arrangements for traffic control, removal of loose materials, all labour, tools equipment, safety harness and incidentals to complete the work as per these Specifications.

(12) *Add the following new Sub-Sections at the end of Sub-Section 2811: “Site Aftercare and Maintenance” and before Section 2900: “Maintenance Works”:*

New Sub-Sections:

- ♦ 2812 “Turfig with Sods”
- ♦ 2813 “Topsoil”

## 2812 TURFING WITH SODS

### (1) General

This work shall consist of furnishing and laying of the live sod of perennial turf forming grass on embankment slopes, verges (earthen shoulders) or other locations shown on the drawings or as directed by the Engineer. Unless otherwise specified, the work shall be taken up as soon as possible following construction of the embankment, provided the season is favourable for establishment of the sod.

### (2) Materials

The sod shall consist of dense, well-rooted growth of permanent and desirable grasses, indigenous to the locality where it is to be used, and shall be practically free from weeds or other undesirable material. At the time the sod is cut, the grass on the sod shall have a length of approximately 50 mm and the sod shall have been freed of debris.

Thickness of the sod shall be as uniform as possible, with some 50 - 80 mm or so of soil covering the grass roots depending on the nature of the sod, so that practically all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width, not less than about 250 mm x 300 mm in size but not so large that it is inconvenient to handle and transport these without damage. During wet weather, the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

### **(3) Construction Operations**

#### **(a) Preparation of the earth bed**

The area to be sodded shall have been previously constructed to the required slope and cross section. Soil on the area shall be loosened, freed of all stones larger than 50 mm size, sticks, stumps and any undesirable foreign matter, and brought to a reasonably fine granular texture to a depth of not less than 25 mm for receiving the sod. Where required, topsoil shall be spread over the slopes. Prior to placing the topsoil, the slopes shall be scarified to a depth which, after settlement, will provide the required nominal depth shown on the plans. Spreading shall not be done when the ground is excessively wet. Following soil preparation and top soiling, where required, fertilizer and ground limestone when specified shall be spread uniformly at the rate indicated on the plans. After spreading, the materials are incorporated in the soil by digging or other means to the depths shown on the Drawings.

#### **(b) Placing the sods**

The prepared sod bed shall be moistened to the loosened depth, if not already sufficiently moist, and the sod shall be placed thereon within approximately 24 hours after the same had been cut. Each sod strip shall be laid edge to edge and such that the joints caused by abutting ends are staggered. Every strip, after it is snugly placed against the strips already in position, shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil. On side slopes steeper than 2 (horizontal) to 1 (vertical), the laying of sods shall be started from bottom upwards. At points where water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over them followed by its thorough compaction.

#### **(c) Staking the sods**

Where the side slope is 2 (horizontal) to 1 (vertical) or steeper and the distance along the slope is more than 2m, the sods shall be staked with pegs or nails spaced approximately 500mm to 1000mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

#### **(d) Top dressing**

After the sods have been laid in position, the surface shall be cleaned of loose sod, excess soil and other foreign material. Thereafter, a thin layer of topsoil shall be

scattered over the surface of top dressing and the area thoroughly moistened by sprinkling with water:

**(e) Watering and maintenance**

The sods shall be watered by the Contractor for a period of at least four weeks after laying. Watering shall be so done as to avoid erosion and prevent damage to sodded areas by wheels of water tanks. The Contractor shall erect necessary warning signs and barriers, repair or replace sodded areas failing to show uniform growth of grass or damaged by his operations and shall otherwise maintain the sod at his cost until final acceptance,

**(4) Measurement**

The measurement of Turfing with Sods shall be made square metres of the actual areas performed in accordance to these Specifications and accepted by the Engineer at Site, in accordance with the following requirement:

- ♦ Turfing with Sods (50%): Sods for turfing are placed on the prepared surface on strips of 50cm spaced 50cm each other covering approximately 50% of the total area subject for payment under this item.

Topsoil applied in accordance with these specifications and approved by the Engineer shall satisfy the requirements of Sub-Section 2813: “Topsoil”. However, the measurement of Filling for Topsoil for turfing works shall not be measured nor paid separately but deemed included in the rates established for turfing works.

**(5) Payment**

The quantities, as measured above, shall be paid at the unit rates shown in the Bill of Quantities. This payment shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work as herein specified including supplying sods, topsoil-filling, and the works for making arrangements for traffic control, all labour, tools, equipment, safety harness and any other incidentals to complete the work as per these Specifications.

Item No.	Description	Unit
<b>2812</b>	<b>Turfing with Sods</b>	
2812-1	Turfing with Sods (50%)	sq.m.

**2813 TOPSOIL**

**(1) General**

This work consists of the preparation of the ground surface for topsoil application, hauling the topsoil material stockpiled for reuse as stipulated in Sub-Section 201: “Clearing and Grubbing”, Clause (4): “Measurement” and placing and spreading in accordance with these Specifications..

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**(2) Materials**

- (a) Topsoil shall be the surface layer of soil with no admixture of refuse or any material toxic to plant growth, and it shall be reasonably free from subsoil and stumps, roots, brush, stones (50 mm or more in diameter), clay lumps or similar objects.
- (b) Brush and other vegetation that will not be mixed into the soil during handling operations shall be cut and removed.
- (c) Ordinary sods and herbaceous growth such as grass and weeds are not to be removed but shall be thoroughly broken up and intermixed with the soil during handling operations.
- (d) Topsoil or soil mixture, unless otherwise specified or approved, shall have a pH range of approximately 5.5 to 7.6.
- (e) The organic content shall not be less than 3% but not higher than 20%.
- (f) The material passing the 0.075mm sieve, as determined by the wash test in accordance with ASTM C117, shall not be less than 20% and not higher than 80%.
- (g) Upon the request by the Contractor, approval on the materials for topsoil may be issued by the Engineer upon inspection and evaluation of the existing conditions of topsoil material stockpiled in accordance to Clause (4) of Sub-Section 201: "Clearing and Grubbing".

Obtaining Topsoil:

- (a) The material for topsoil shall be exclusively such material stockpiled as result of the works performed for Clearing and Grubbing in the Project.
- (b) Heavy sod or other cover, which cannot be added into the topsoil by disking or other means, shall not be transported to the Site where topsoil will be applied, and shall be spoiled accordingly with respective specifications.
- (c) The sites of all stockpiles and areas adjacent thereto which the Contractor has disturbed, shall be graded as required by these Specifications.
- (d) Topsoil shall be hauled to the site of the work and placed for spreading, or spread as required. Any topsoil hauled to the site of the work and stockpiled shall be re-handled and placed without additional compensation.

Filling Material for Topsoil:

The filling material, when required for those areas to be covered with topsoil but requiring some filling materials to be in accordance with the designed levels, shall be, as described for embankment construction, reasonably compacted as instructed by the Engineer.

**(3) Construction Operations**

**(a) Preparing Ground Surface**

- Immediately prior to dumping and spreading the topsoil on any area (except directly on a rock surface), the surface shall be loosened by discs or spike tooth

- harrows, or by other approved means, to a minimum depth of 50 mm to facilitate bonding of the topsoil to the covered subgrade soil.
- The surface of the area to be covered with topsoil shall be cleared of all stones larger than 50 mm in any diameter and all litter or other materials which may be detrimental to proper bonding, the rise of capillary moisture, or the proper growth of the desired planting.
- Limited areas as shown in the Drawings, which are too compact to respond to these operations, shall receive special scarification.
- Grades on the area to be covered with topsoil, as shown in the Drawings, shall be maintained in a true and even condition. Where grades have not been established, the areas shall be smooth graded and the surface left at the prescribed grades in an even and properly compacted condition to prevent, insofar as practical, the formation of low places or pockets where water will stand.
- Areas to be covered with topsoil that require filling material to reach the lines and levels described in the Drawings, shall be filled up to a level that topsoil can be applied properly as specified in this Specification Section.

**(b) Placing Topsoil**

- Topsoil shall be evenly spread on the prepared areas to a uniform depth of 150 mm after compaction, unless otherwise shown in the Drawings. Spreading shall not be done when the ground or topsoil is excessively wet, or otherwise in a condition detrimental to the work. Spreading shall be carried out so that seeding operations can proceed with a minimum of soil preparation or tilling.
- After spreading, any large, stiff clods and hard lumps shall be broken with a pulverizer or by other effective means, and all stones or rocks (50 mm or more in diameter), roots, litter, or any foreign matter shall be raked up and disposed of by the Contractor. After spreading is completed, topsoil shall be satisfactorily compacted by rolling or by other approved means. The compacted topsoil surface shall conform to the required lines, grades, and cross sections. Any topsoil or other dirt falling upon pavements as a result of hauling or handling of topsoil shall be promptly removed.

**(4) Measurement**

The measurement of Topsoil shall be made square metres of the actual areas performed in accordance to these Specifications and accepted by the Engineer at Site.

The Topsoil-filling used for the item of Turfing shall not be measured nor paid under this Section.

**(5) Payment**

The quantities, as measured above, shall be paid at the unit rates shown in the Bill of Quantities. This payment shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work as herein specified including hauling Topsoil from Project' stockpiles, conservation, pre-preparation to meet specification requirements,



ground surface preparation, placing, spreading and preparing final topsoil surface and all necessary clean-up and remedial work and the works for making arrangements for traffic control, and providing all labour, tools, equipment, safety harness and any other incidentals to complete the work as per these Specifications.

Item No.	Description	Unit
2813	Topsoil	
2813-1	Topsoil (150mm thick)	sq.m.



## SECTION 3100: MISCELLANEOUS WORKS

### 3105 RAILINGS

(1) *Insert the following additional requirement at the end of Sub-Clause 3105(1)(f):*

(g) Galvanizing Repair:

- ♦ In the event that minor damage to the galvanized coating of the guardrail occurs during handling before or during installation, the Engineer may, after evaluation of the situation, require removal and replacement, or allow the Contractor to make repairs, at his own cost, by three applications of zinc anticorrosive paint as approved by the Engineer. The Contractor shall provide to the Engineer, for review and approval, all details and information, including the manufacturer's application and surface preparation requirements for the repair application coating that he is proposing.
- ♦ Repair of the coating application shall not proceed until such information and data have been approved by the Engineer.

#### (7) Payment

(2) *Insert the following additional requirement at the end of Clause 3105(7): "Payment":*

Item No.	Description	Unit
<b>3100</b>	<b>Miscellaneous Works</b>	
<b>3105</b>	<b>Railings</b>	
3105-1	Steel railings Type A (H=1.10m for pedestrians)	lin.m.

(3) *Add the following new Sub-Sections at the end of Sub-Section 3110: "Filter Materials":*

New Sub-Sections:

- ♦ 3111 "Bridge Drainage"
- ♦ 3112 "PVC Water-Stops"

### 3111 RC BRIDGE DRAINAGE

#### (1) Description

This work consists of the construction of bridge drainage including drainage pipes, catch pit with grating and strainer.

#### (2) Material Requirements

##### (a) Catchpit with Grating and Strainers

Catch Pit with gratings, strainers and chains shall be as shown in the Drawings, complying with the requirements for types, shape, sizes, galvanizing and connections.

**(b) Drain Pipes**

Pipes and pipe fittings for drains shall be as shown in the Drawings, complying with the requirements for types and sizes, and conforming to the standards of JIS K 6741, ASTM D1785 - 15 or equivalent for Polyvinyl Chloride (PVC) pipes (VP pipes).

**(c) Delivery, Storage and Handling**

- ♦ Delivery and Storage: Materials delivered to site shall be inspected for detecting damages, and shall be unloaded and stored with minimum handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Plastic pipes shall be installed within six (6) months from the date of manufacture unless otherwise approved.
- ♦ Handling: Materials shall be handled in such a manner as to ensure delivery to the point of installation in sound, undamaged condition. Pipes shall be carried and not dragged along the ground to the installation location.

**(d) Submittals**

The Contractor shall submit for the approval of the Engineer method statements, schedule, materials, all certifications from the manufacturers, attesting that materials meet the specification requirements. Certificates are required for all drain pipes, fittings, catch pit and slab drain.

**(3) Construction Requirements**

**(a) Installation of Catch Pit**

Catchpit shall be installed completing with gratings, strainers, chains and connections at the locations indicated in the Drawings. The catchpit shall be firmly fixed with deck slab reinforcement before concreting, so as not to be moved during the concreting operation.

**(b) Pipe Placement**

Each pipe shall be carefully inspected before it is placed. Any defective or damaged items shall be rejected and replaced immediately. The pipes shall be jointed fully with leak-resistant seals using gasket, bell and spigot joints. The adhesive for securing piping and fittings shall be suitable for the application and approved by the Engineer.

The pipes shall be firmly fixed with the bridge structures using metal accessories and appropriate gradient. After completion of the catch pit and the drain pipe installation, water leak test shall be carried out and any defects shall be corrected and repaired.

**(4) Measurement**

**(a) Catch Pit**

Catch Pit shall include all the materials described in the Drawings. Catch Pit shall be measured for payment by the actual quantity of drainage devices constructed and

installed in accordance with the requirements of the Drawings, these Specifications and instructions by the Engineer.

(b) Drainage Pipe

Drainage piping shall be measured for payment by the actual length (in linear meters) of the straight PVC drain piping in the diameter and type required in the Drawings.

No separate measurement shall be made for the bolts, nuts, washers, accessories, protective coatings and metal supports for PVC Pipes.

(c) Drainage Pipe for Elbows and Branch Connections

Elbows and Branch connections shall not be measured and nor paid separately but shall be deemed included in the price rates for Drainage Pipes. These include pipes processed for connection, flexible joints, protective coatings, constructed and installed in accordance with the requirements of the Drawings, these Specifications and instructions by the Engineer.

(5) Payment

Payment shall be made in accordance with the applicable unit prices of the pay items of the Bill of Quantities listed below, and shall be the full and final compensation to the Contractor as per Clause 112 to complete the work as herein specified including all materials, fabrication, installation, all labors, equipment, tools and incidentals necessary to install catch-pits, elbows and branch connections, and piping to complete the work as per these Specifications. and accepted by the Engineer at Site.

Item No.	Description	Unit
<b>3111</b>	<b>Bridge Drainage</b>	
3111-1	Casting Catch Pit	No.
3111-2	PVC Drain Pipe (VP) $\phi$ 150mm	lin.m.

## 3112 PVC WATER-STOPS

(1) Description

This work consists of the preparation, fabrication and placing of PVC Water Stops as shown on the Drawing to this Specification or as directed by the Engineer.

PVC Water Stops are defined as joints placed in construction joints between the continuous concrete floor slab or the deck and the wall. The purpose of the PVC Water Stops is to permit free movement of the structure due to thermal effect, vibration and rotational articulation, to prevent cracking in the surface layer by effectively supporting the surfacing and to prevent water and water-borne contaminants from invading the superstructure, substructure and foundation.

(2) Material

The water-stop shall be fabricated from a plastic compound, the basic resin of which shall be polyvinyl chloride. The compound shall contain additional resins, plasticizers, inhibitors or other materials such that when the material is compounded, it shall meet the requirements given in these Specifications.

### (3) Test Requirements

PVC water-stops shall meet the requirements specified in Table 31-1. The procedure for sampling and the criteria for conformity shall meet the requirements of the of IS 15058: 2002 (Annex-D).

**Table 31-1 Requirement for PVC Water-Stops**

Sl. No.	Characteristic	Requirement	Test Method (Note 1)
i)	Tensile Strength, Min	13.8 Mpa	IS 8543 (part 4/sec I)
ii)	Elongation, Min	285%	IS 8543 (part 4/sec I)
iii)	Hardness (Shore A), Min	65	IS 8543 (part 5/sec II)
iv)	Water absorption, percent by mass, Max	0.6	Annex A of IS 15058: 2002
v)	Cold bend temperature at which samples does not crack, Min	-25° C	Annex G of IS 9766
vi)	Accelerated extraction test:		Annex B of IS 15058: 2002
a)	Tensile strength, Min	10.3Mpa	
b)	Elongation, Min	280%	
vii)	Stability in effect of alkalis test		Annex C of IS 15058: 2002
a)	Weight increase at 7 days, percent by mass, Max	0.25	
b)	Weight decrease at 7 days, percent by mass, Max	0.10	
c)	Change in hardness at 7 days, (Shore A)	±5	
d)	Weight increase at 28 days, Max	0.40%	
e)	Weight decrease at 28 days, Max	0.30%	
f)	Dimension change	±1%	

Note-1: Equivalent test methods applied by standards of ASTM, JIS or AASHTO may be applied upon the approval by the Engineer.

The surface of water-stop shall be ribbed. The outside edges shall be at the level of the central bulb.

The water-stops shall be free from blisters, pinholes, cracks and embedded foreign matters.

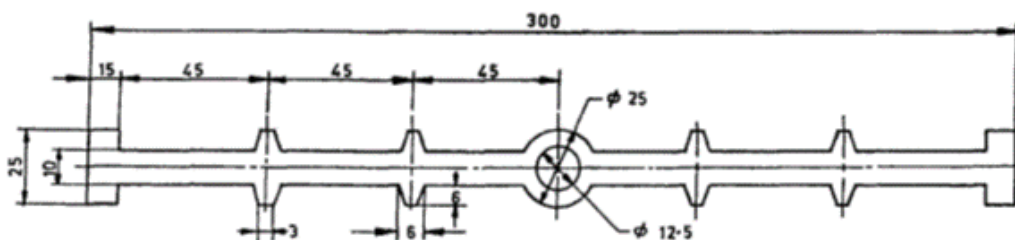
### (4) Shape and Dimensions

The cross-section of PVC water-stops may vary depending upon the water head and site conditions. A typical cross section of PVC water-stops is shown in Figure 31.1 as per reference.

Water stops shall be furnished full length for each straight portion of the joint, without field splices. Water stops shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion. All field splices shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations to form continuous watertight joints.

The water-stop shall be packed in coil form, the inside diameter of which shall not be

less than 300 mm.



Note: All dimensions are in millimeters.

**Figure 31.1 Typical Cross Section of PVC Water-Stops (for reference)**

**(5) Tolerances on Dimensions**

The permissible tolerance on width and thickness shall be as follows:

- ♦ Width: .....± 10mm
- ♦ Thickness .....+2mm

**(6) Marking**

The water-stops shall be marked with the following information:

- ♦ Size of the water-stops;
- ♦ Name of manufacturer or trade-mark, if any; and
- ♦ Month and year of manufacture

**(7) BIS Certification Marking**

The PVC water-stops may also be marked with the Standard Mark. The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the Rules and Regulations made there under. The details of conditions under which the license for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

**(8) Installation**

The PVC Water Stops shall be held firmly in place to prevent displacement during concreting. If after placing concrete water stops are materially out of position or shape, the surrounding concrete shall be removed, the water stop reset, and the concrete replaced, all at the Contractor's expense.

The following procedure may be applied for the installation:

- ♦ The PVC Water Stop shall be carefully and accurately fixed in position with the bulkhead of the forms slotted and shaped to hold the PVC Water Stop in alignment, and to prevent leakage of mortar or damage to the PVC Water Stop. Provision shall also be made to hold that portion of the PVC Water Stop being built accurately in position during concrete pouring and compaction.
- ♦ After removing forms and before placing the second part of the concrete joint, PVC Water Stop shall be cleaned of mortar or other debris.

- ♦ Where required, joint filler or removable inserts for joint filler shall be placed and fixed as shown on the Drawings.
- ♦ The second part of the joint concrete shall then be placed. Provision shall again be made to hold that portion of PVC Water Stop being built in accurately in position during placing and compaction of concrete.
- ♦ Particular care shall be taken to ensure that no air is trapped between the concrete and PVC Water Stop. In locations where the PVC Water Stop is installed horizontally or near horizontally and the top face is not formed, the PVC Water Stop shall be bent upwards while concrete is placed in the lower part of the joint to within 10 mm of the underside of the PVC Water Stop and compacted. An excess of 1:2 cement:fine aggregate mortar shall then be placed under the turned up PVC Water Stop and the PVC Water Stop then straightened into position on full bedding of mortar. No further concrete shall be poured on top of the PVC Water Stop until the bedding of the PVC Water Stop has been inspected and passed as satisfactory by the Supervising Engineer. Excess mortar squeezed out when straightening the PVC Water Stop shall be spread on top of the PVC Water Stop and the balance of the concrete for the joint placed and compacted.

**(9) Jointing**

- ♦ Use of its specialized welding equipment for on-site welding.
- ♦ This consists of thermostatically controlled welding blades and welding jigs.
- ♦ On-site joining is a critical application and must be completed correctly to guarantee to quality of the system.
- ♦ The ends of the PVC Water Stop are cut square and placed into the adjustable jig.
- ♦ The ends of the PVC Water Stop then slide up against the welding iron and bring the two ends together until the molten ends of the PVC fuse.
- ♦ Splices, directional changes and intersections are achieved with premolded unions, fittings and a rubber adhesive kit.
- ♦ Welding requirements shall in all respects conform to the standards of AWS D1.1-98.

**(10) Measurement**

PVC Water - Stop shall be measured in nominal linear meter measured by the Drawings. Measurement shall be made along the center line of the concrete joint where the water-stop has actually been installed.

**(11) Payment**

PVC Water - Stop measured as provided above shall be paid at the contract unit rate which shall be the full and final compensation to the Contractor as per Clause 112 to complete the work as herein specified including all materials, supplying, installation, all labors, equipment, tools and incidentals necessary to install the PVC Water Stops to complete the work as per these Specifications. and accepted by the Engineer at Site.

Item No.	Description	Unit
3112	PVC Water Stops	
3112-1	PVC Water Stops (W=300mm)	lin.m.

(4) Add the following new Sub-Sections at the end of Sub-Section 3112: “PVC Water-Stops”:

New Sub-Sections:

- ♦ 3120 “Street Lighting System (SLS)”
- ♦ 3130 “Traffic Information Boards (TIB)”

### 3120 STREET LIGHTING SYSTEM (SLS)

#### (1) Description

This work shall include the following:

- ♦ Supplying, construction and installation of the Street Lighting System (SLS)
- ♦ Ancillary Works and Testing

The street light system consists of the specified electrical hardware, mast arm poles, and footing which includes excavation, breaking of concrete or any other hard surface such as road pavement, concreting, erecting poles to lines and levels and curing the concrete and re-instatement of the surface to its original condition and disposal of excess spoil materials: on an all complete net basis.

The works shall include furnishing all materials, construction or installation of the above referred items, and all ancillary works and any other incidental necessary to complete the Works in conformity with the Drawings and these Specifications, or as directed by the Engineer.

This work shall also include the Design Review and Updating of the Street Lighting System (SLS) by the Contractor based on the Conceptual Design provided by the Employer. The report shall include also all detailed drawings, applicable technical specifications and requirements for construction and materials.

The Contractor shall be responsible for providing all design, fabrication and installation details necessary to provide work and operations as intended under and required by the Drawings and Specifications.

#### (2) Compliance with Authorities and Standards

All works under this Contract shall comply with the applicable regulations and requirements of Statutory Authorities.

All equipment and materials shall conform to the requirements of the codes and standards specified herein and the Drawings, or certified by other internationally recognized standard institutions or testing laboratories that maintains periodic inspection of production of listed



equipment and materials meet nationally recognized standards or has been tested and found suitable for use in the specified manner.

All cabling work shall be carried out by licensed sub-contractors and certified installers for the cabling system being installed.

Certification of the system shall be provided by the Contractor.

Codes and Standards: Unless otherwise indicated in the Drawings or in the Specifications, the design, materials, manufacture, testing, inspection and performance of all electrical and electromechanical equipment shall comply with the latest revisions of relevant standards listed in Section 113: “National Specifications” and the following standards:

- ♦ JIS: Japanese Industrial Standard
- ♦ JEC: Japanese Electro-technical Committee
- ♦ JEM: The Standards of the Japan Electrical Manufacturer’s Association
- ♦ IEC: International Electro-technical Commission (authorized standards)

When local regulatory bodies, have jurisdiction over installation, the following Nepalese standards shall be applied:

- ♦ Nepal Electricity Authority
- ♦ Nepal National Building Code NBC207: 2003 – Electrical Design Requirements

### **(3) Construction Method and Design Review and Updating Report**

Before commencement of the works, the Contractor shall prepare and submit to the Engineer, for review and approval, a statement method for construction and installation of the Street Lighting System (SLS) describing the labour, materials and equipment to be used and the method of work execution. The Statement shall also describe the safety precautions to be adopted and all measures for compliance with environmental requirements of these specifications. In addition to the statement, the Contractor shall submit a detailed report of the Design Review and Updating. These documents shall be attached to the Program which requirements are described in Section 116: “Programme”.

The Street Lighting System (SLS) shall be installed with the height as shown on the Drawings or as directed by the Engineer.

### **(4) Submittals**

Prior to commencement of the Electrical Works, the Contractor shall prepare and submit the following for the Engineer’s review and approval:

- (a) Details of the manufacturer and subcontractor(s), including description of work experience, major equipment, labour, methods of quality control and safety control, etc.
- (b) Manufacturer’s detailed technical data, specifications and installation instructions for all materials, equipment, components and accessories required for this Section.
- (c) Manufacturer’s Certification for all materials, equipment and/or systems shall be provided by the Contractor (prior to installation) and indicating compliance



with the requirements of the Specification. Where so instructed by the Engineer, the Contractor shall obtain independent certification for materials, equipment and/or systems from independent and approved testing agencies, all at the expense of the Contractor.

(d) Guarantee:

- ◆ The guarantee for the Electrical Works shall be at least for a full two (2) year period and shall cover the Employer for the complete responsibility of the Contractor for design, suitability and performance of the Electrical Works.
- ◆ The Guarantee shall cover replacement by the Contractor or manufacturer, free of charge, of any components which fail to perform (intentional damage, fair wear and tear excepted) for the guarantee period stated above.
- ◆ The Engineer may request that the Guarantees are provided in writing and in a form approved by the Engineer and by the Employer, for the due and faithful observance and performance of this obligation. In this case the guarantee shall be delivered to the Engineer for approval at the same time as the “Request For Approval” (RFA) of the relevant System, equipment, materials or manufacturer.

Materials and equipment shall not be ordered or fabricated until the above submittals have been approved by the Engineer.

Moreover, in addition to the above, the following submittals are required:

- (a) Schedule of equipment, cables and other materials.
- (b) Shop-Drawings for all work required under this Section. The Shop Drawings shall clearly indicate the particular manufacturer’s document number and fitting details used as reference in the development of the shop drawings.  
Shop drawings shall include scale plans, and details of the equipment, structures, piping, cable and wiring and shall show the method of installation with all conduits, trays and other cable and pipe support and conveying systems and all foundations supports and accessories.  
All Field dimensions shall be verified and included showing exact locations and dimensions.
- (c) Samples and test certificates of materials and equipment as specified or as requested by the Engineer. Any materials delivered thereafter that the Engineer considers not equal to the approved samples, shall be rejected and removed from the Site.  
Samples should be the same as the permanent items to test the performance and show the workmanship, colour and finishes.  
Samples are not returnable, nor included in quantities listed for payment of the Works.  
Approved samples shall be kept on Site, under the Engineer’ supervision, for reference.
- (d) Listing of all signs and nameplates required, giving full text for each item.
- (e) Certification of materials and equipment shall be provided for each system of

the Electrical Works (after installation) by the Manufacturer of the System indicating that the complete System as installed complies fully with the requirements of the Contract. Certification shall be complete with all necessary test reports, and data sheets.

- (f) **Maintenance Instructions:** The Contractor shall be responsible for obtaining from the manufacturer, for each type of fitting, control and accessory, the recommended operation and maintenance manual including tools required and types of cleaners to be used.

The Contractor shall incorporate the manufacturer's information within the Operation and Maintenance Manuals prepared by the Contractor and submitted to the Engineer for review and approval.

#### (5) **Materials, Equipment and Systems**

- (a) Unless otherwise specified in the Drawings or the contract, products shall be Manufacturer's first quality line of standard and/or series of factory fabricated items.
- (b) Materials and equipment specified shall conform standards herein established or equivalent if approved by the Engineer and tested satisfactorily. The approved material shall be certified by an approved independent agency.
- (c) Comparable materials, assemblies and systems of manufacturers other than those specified may be proposed subject to prior approval by the Engineer.
- (d) Electrical Works shall be designed, fabricated and supplied by a single manufacturer for all work under this Contract.

#### (6) **Requirements for the Street Lighting System**

The following basic requirements shall be satisfied for the Street Lighting System (non-solar system):

- ◆ Type of the Street Lighting is High-Pressure Sodium Lamp. Power of the lamp is 250W. Luminous flux of the road lighting shall be 28,000 lumen minimum, and shall be the product of Phillips or equivalent as approved by the Engineer
- ◆ The lighting poles shall be made from octagonal steel plate with the thickness of 3.2mm minimum and also protected by hot dip galvanize.
- ◆ Lamp Power: ..... 250W
- ◆ Reliability / MTBF: ..... 5 years (product life cycle)
- ◆ Gear ..... SGR (SON gear)
- ◆ Ingress Protection ..... IP 65
- ◆ Housing material ..... Aluminum
- ◆ Voltage/Hz ..... 220V / 50 Hz
- ◆ Dimension ..... 755 x 380 x 275 mm

#### (7) **Requirements for the Solar Street Lighting System**

##### (a) **Definition**

A standalone Solar Photo-Voltaic (SPV) Street Lighting System (SLS) is an outdoor

lighting unit used for illuminating a street or an open area. It consists of Photo-Voltaic (PV) module(s), Compact Fluorescent Lamp (CFL), lead acid battery, control electronics, inter-connecting wires/cables, module mounting Pole including hardware and battery box. The CFL is fixed inside a luminaire which is mounted on the pole. The PV module is placed at the top of the pole at an angle to maximize incident solar radiation, and a battery is placed in a box attached to the pole. The module is mounted facing south, so that it receives solar radiation throughout the day, without any shadow falling on it. Electricity generated by the PV module will charge the battery during the day time. This system operates from dusk to dawn.

**(b) Requirements**

◆ Duty Cycle:

The system should automatically switch ON at dusk, operate throughout the night and automatically switch OFF at dawn.

◆ PV Modules (s):

- ✓ Both crystalline and thin film technology modules are allowed in the system. The PV module should have a certificate of testing conforming to IEC 61215 Edition II / BIS 14286 or IEC 61646 for crystalline and thin film PV modules respectively. The certificate should be from an NABL or IECQ accredited Laboratory.
- ✓ The power output of the module(s) under STC should be a minimum of 74 Wp. Either two modules of minimum 37 Wp output each or one module of 74 Wp output should be used. In case of thin film technology PV modules, the specified values refer to the stabilized power output after the initial degradation. The module efficiency should not be less than 12%.
- ✓ The operating voltage corresponding to the power output mentioned above should be  $16.4 \pm 0.2$  V.
- ✓ The open circuit voltage of the PV modules under STC should be at least 21.0 Volts.
- ✓ The terminal box on the module should have a provision for opening for replacing the cable, if required.
- ✓ Each PV module must use a RF identification tag (RFID), which must contain the following information:
  - ✧ Name of the manufacturer of PV Module.
  - ✧ Model or Type Number
  - ✧ Serial Number
  - ✧ Month and year of the manufacture
  - ✧ I-V curve for the module
  - ✧ Peak Wattage of the module at 16.4 volts

- ✧ Im, Vm and FF for the module
- ✧ Unique Serial No and Model No of the module Until March 2013, the RFID can be inside or outside the module laminate, but must be able to withstand harsh environmental conditions.
- ✓ A distinctive serial number starting with NSM will be engraved on the frame of the module. The distinctive number starting NSM will also be screen printed on the tedlar sheet of the module.
- ◆ Battery:
  - ✓ Lead Acid, tubular positive plate flooded electrolyte or Gel or VRLA Type.
  - ✓ The battery will have a minimum rating of 12V, 75 Ah (at C/10 discharge rate).
  - ✓ 75 % of the rated capacity of the battery should be between fully charged and load cut off conditions.
- ◆ Lamp:
  - ✓ The lamp should be 11 Watt compact fluorescent lamp (CFL) with 4 pins along with proper pre- heating circuit.
  - ✓ The light output from the lamps should be around  $900 \pm 5$  % lumens (for 11 W CFL).
  - ✓ The lamp should be housed in an assembly suitable for outdoor use, with a reflector on its back.
  - ✓ No blackening or reduction in the lumen output by more than 10%, should be observed after 1000 ON/OFF cycles (two minutes ON followed by four minutes OFF is one cycle).
- ◆ Electronics:
  - ✓ The inverter should be of quasi sine wave/ sine wave type, with frequency in the range of 20 - 30 KHz. Half-wave operation is not acceptable.
  - ✓ The total electronic efficiency should be not less than 85 %.
  - ✓ The idle current consumption should not be more than 10 mA.
  - ✓ The PV module itself should be used to sense the ambient light level for switching ON and OFF the lamp.
- ◆ Electronic Protections:
  - ✓ Adequate protection is to be incorporated under no load conditions e.g. when the lamp is removed and the system is switched ON.

- ✓ The system should have protection against battery overcharge and deep discharge conditions.
- ✓ Fuses should be provided to protect against short circuit conditions.
- ✓ Protection for reverse flow of current through the PV module(s) should be provided.
- ✓ Electronics should have temperature compensation for proper charging of the battery throughout the year.
- ◆ Mechanical Hardware:
  - ✓ A metallic frame structure (with corrosion resistance paint) is to be fixed on the pole to hold the SPV module(s). The frame structure should have provision to adjust its angle of inclination to the horizontal between 0 and 45, so that the module(s) can be oriented at the specified tilt angle.
  - ✓ The pole should be made of mild steel pipe with a height 6 m above the ground level, after grouting and final installation. The pole should have the provision to hold the weather proof lamp housing. It should be painted with a corrosion resistant paint.
  - ✓ All poles will be of slip base type. This type of special purpose Street Lighting Pole addresses the universal problem of high-speed road accidents (over 60km/h) involving roadside collisions with light poles. These poles shall comply with Australian Standards 1158.1.3 or equivalent Indian Standards. Slip Base Poles differ in design which features the two base plates bolted together with the facility of freely coming apart if a crash occurs. This separation lessens resistance and mitigates the overall effects of the impact (and subsequent damage to the vehicle or injury to its occupants).
  - ✓ All poles shall be tapered round of specified diameter and consist of standard base-plate mounted with either in-ground section or connection spool on rag bolts, bolts, slip washer and rectangular washers. All poles shall be hot dip galvanized to Australian Standards 4680:2006 or equivalent Indian Standards and shall be either powder coated or painted as approved by the Engineer. The slip base poles shall be in a single and double outreach arm arrangement, curved or straight as approved by the Engineer. Poles shall have security or tamper proof screws for access door covers.
  - ✓ A vented, acid proof and corrosion resistant painted metallic box for outdoor use should be provided for housing the battery with a provision of lock and key.
- ◆ Other Features
  - ✓ The system should be provided with 2 LED indicators: a green light to

indicate charging in progress and a red LED to indicate deep discharge condition of the battery.

- ✓ There will be a Name Plate on the system, which will give: (a) Name of the Manufacturer or Distinctive Logo. (b) Serial Number.
- ✓ Components and parts used in the solar street lighting systems should conform to the latest BIS specifications, wherever such specifications are available and applicable.
- ✓ The PV module(s) will be warranted for a minimum period of 25 years from the date of supply and the street lighting system (including the battery) will be warranted for a period of two years from the date of supply. PV modules used in Solar Street Lighting System must be warranted for their output peak watt capacity, which should not be less than 90% at the end of Twelve (12) years and 80% at the end of Twenty five (25) years. The Warranty Card to be supplied with the system must contain the details of the system.
- ✓ Necessary lengths of wires/cables and fuses should be provided.
- ✓ An Operation, Instruction and Maintenance Manual, in English should be provided with the Solar Street Lighting System. The following minimum details must be provided in the Manual: basic principles of photovoltaics; a small write-up (with a block diagram) on the Solar Street Lighting System - describing its components (PV module, battery, electronics and luminaire) and their expected performance; a section on charging and significance of indicators; together with clear instructions about erection of poles and mounting of PV module (s) and lamp housing assembly on the pole.

#### **(7) Testing and Commissioning**

Testing and Commissioning of the completed installation of Street Lighting System (SLS) shall be made in accordance with the requirements of Clause 509(3): “Testing and Commissioning”.

#### **(8) Measurement**

The measurement for these works shall be made by the Number of Lights actually installed, satisfactorily tested according to Clause 509(3): “Testing and Commissioning” and conforming the requirements of Clause 9: “Test on Completion” of the Conditions of Contract, confirmation of proper function of the established system, satisfying all requirements of these specifications, and approved by Engineer. All materials, equipment and ancillary works or incidentals shall not be measured separately but shall be deemed included in the rates of the main items for lighting system.

#### **(9) Payment**

The works for the Street Lighting System (SLS) measured as described above shall be paid

at the unit rates shown in the Bill of Quantities. This payment shall be the full and the final compensation to the Contractor as per Clause 112 including the cost for Design Review and Updating, provision of all materials, transportation, all operations required for construction and installation as shown in the Drawings and described in this Item including drawings, tests and all other ancillary works, and any incidental work needed to complete the work as per these Specifications and/or directed by the Engineer.

Item No.	Description	Unit
<b>3120</b>	<b>Street Lighting System (SLS)</b>	
3120-1	Street Lighting System for West Portal and West Toll-Gate Area	No.
3120-2	Street Lighting System for East Portal and East Toll-Gate Area	No.
3120-3	Solar Street Lighting System for Balambu Intersection	No.

### 3130 TRAFFIC INFORMATION BOARDS (TIB)

#### (1) Description

This works shall include the following:

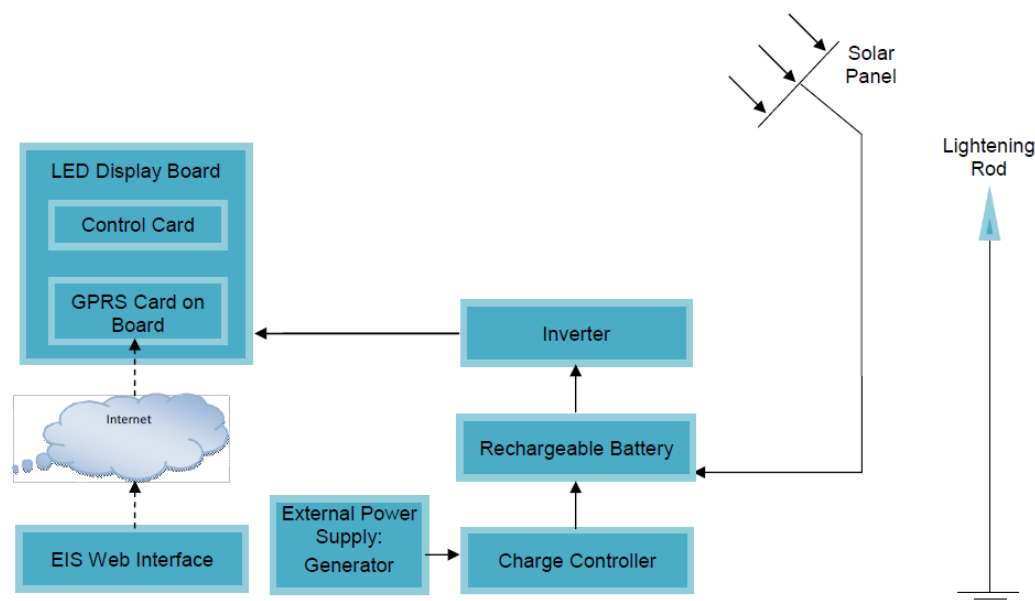
- ♦ Supplying, construction and installation of the Traffic Information Boards (TIB) including, but not limited to, the following:
  - ✓ Complete system for information display with data connection to the data center
  - ✓ Solar power system
  - ✓ Display board and a control system
  - ✓ Design for the provision of off-grid solar power system for operation of the TIB
  - ✓ Design of Data Communication system with data center
  - ✓ Preventions measures against rain or water and anti-theft
- ♦ Ancillary Works and Testing

Figure 35.1 shows as per reference the system for installation of the Traffic Information Boards (TIB) that shall be implemented for the Project.

The works shall include furnishing all materials, construction or installation of the above referred items, and all ancillary works and any other incidental necessary to complete the Works in conformity with the Drawings and these Specifications, or as directed by the Engineer.

This work shall also include the Design Review and Updating of the Traffic Information Boards (TIB) by the Contractor based on the Conceptual Design provided by the Employer. The report shall include also all detailed drawings, applicable technical specifications and requirements for construction and materials.





**Figure 35.1: System Structure of the System for Traffic Information Boards (TIB)**

The Contractor shall be responsible for providing all design, fabrication and installation details necessary to provide work and operations as intended under and required by the Drawings and Specifications.

## (2) Compliance with Authorities and Standards

All works under this Contract shall comply with the applicable regulations and requirements of Statutory Authorities.

All equipment and materials shall conform to the requirements of the codes and standards specified herein and the Drawings, or certified by other internationally recognized standard institutions or testing laboratories that maintains periodic inspection of production of listed equipment and materials meet nationally recognized standards or has been tested and found suitable for use in the specified manner.

All cabling work shall be carried out by licensed sub-contractors and certified installers for the cabling system being installed.

Certification of the system shall be provided by the Contractor.

Codes and Standards: Unless otherwise indicated in the Drawings, the design, materials, manufacture, testing, inspection and performance of all equipment shall, unless otherwise specified in the Specifications, comply with the latest revisions of relevant standards listed in Section 113: “National Specifications” and the following standards:

- ♦ JIS: Japanese Industrial Standard
- ♦ JEC: Japanese Electro-technical Committee
- ♦ JEM: The Standards of the Japan Electrical Manufacturer’s Association
- ♦ IEC: International Electro-technical Commission (authorized standards)



When local regulatory bodies, have jurisdiction over installation, the following Nepalese standards shall be applied:

- ♦ Nepal Electricity Authority
- ♦ Nepal National Building Code NBC207: 2003 – Electrical Design Requirements

### **(3) Construction Method and Design Review and Updating Report**

Before commencement of the works, the Contractor shall prepare and submit to the Engineer, for review and approval, a statement method for construction and installation of the Traffic Information Boards (TIB) describing the labour, materials and equipment to be used and the method of work execution. The Statement shall also describe the safety precautions to be adopted and all measures for compliance with environmental requirements of these specifications. These documents shall be attached to the Program which requirements are described in Section 116: “Programme”.

The Traffic Information Boards(TIB) shall be installed with the height and dimensions as shown on the Drawings or as directed by the Engineer.

The TIB shall be installed along the roadside of Tribhuvan Highway Intersection as shown in the Drawings. The battery and inverter shall be installed inside each control house (Control House of Eastern and Western portals). Similarly, the solar panels shall be installed above each control house.

### **(4) Submittals**

Prior to commencement of the Electrical Works, the Contractor shall prepare and submit the following for the Engineer’s review and approval:

- (a) Details of the manufacturer and subcontractor(s), including description of work experience, major equipment, labour, methods of quality control and safety control, etc.
- (b) Manufacturer’s detailed technical data, specifications and installation instructions for all materials, equipment, components and accessories required for this Section.
- (c) Manufacturer’s Certification for all materials, equipment and/or systems shall be provided by the Contractor (prior to installation) and indicating compliance with the requirements of the Specification. Where so instructed by the Engineer, the Contractor shall obtain independent certification for materials, equipment and/or systems from independent and approved testing agencies, all at the expense of the Contractor.
- (d) Guarantee:
  - ♦ The guarantee for the Electrical Works shall be at least for a full two (2) year period and shall cover the Employer for the complete responsibility of the Contractor for design, suitability and performance of the Electrical Works.
  - ♦ The Guarantee shall cover replacement by the Contractor or manufacturer, free of charge, of any components which fail to perform (intentional damage, fair wear and tear excepted) for the guarantee period stated above.

- ♦ The Engineer may request that the Guarantees are provided in writing and in a form approved by the Engineer and by the Employer, for the due and faithful observance and performance of this obligation. In this case the guarantee shall be delivered to the Engineer for approval at the same time as the “Request for Approval” (RFA) of the relevant System, equipment, materials or manufacturer.

Materials and equipment shall not be ordered or fabricated until the above submittals have been approved by the Engineer.

Moreover, in addition to the above, the following submittals are required:

- (a) Schedule of equipment, cables and other materials.
- (b) Shop-Drawings for all work required under this Section. The Shop Drawings shall clearly indicate the particular manufacturer’s document number and fitting details used as reference in the development of the shop drawings.  
Shop drawings shall include scale plans, and details of the equipment, structures, piping, cable and wiring, installation with all conduits, trays and other cable and pipe supports and conveying systems and all civil works and steel works for construction of the supports and accessories.  
All Field dimensions shall be verified and included showing exact locations and dimensions.
- (c) Samples and test certificates of materials and equipment as specified or as requested by the Engineer. Any materials delivered thereafter that the Engineer considers not equal to the approved samples, shall be rejected and removed from the Site.  
Samples should be the same as the permanent items to test the performance and show the workmanship, colour and finishes.  
Samples are not returnable, nor included in quantities listed for payment of the Works.  
Approved samples shall be kept on Site, under the Engineer’ supervision, for reference.
- (d) Listing of all signs and nameplates required, giving full text for each item.
- (e) Certification of materials and equipment shall be provided for each system of the Electrical Works (after installation) by the Manufacturer of the System indicating that the complete System as installed complies fully with the requirements of the Contract. Certification shall be complete with all necessary test reports, and data sheets.
- (f) Maintenance Instructions: The Contractor shall be responsible for obtaining from the manufacturer, for each type of fitting, control and accessory, the recommended operation and maintenance manual including tools required and types of cleaners to be used.  
The Contractor shall incorporate the manufacturer’s information within the Operation and Maintenance Manuals prepared by the Contractor and submitted to the Engineer for review and approval.

## **(5) Materials, Equipment and Systems**

- (a) Unless otherwise specified in the Drawings or the contract, products shall be Manufacturer's first quality line of standard and/or series of factory fabricated items.
- (b) Materials and equipment specified shall conform standards herein established or equivalent if approved by the Engineer and tested satisfactorily. The approved material shall be certified by an approved independent agency.
- (c) Comparable materials, assemblies and systems of manufacturers other than those specified may be proposed subject to prior approval by the Engineer.
- (d) Electrical Works shall be designed, fabricated and supplied by a single manufacturer for all work under this Contract.
- (e) Substantial increase in size(s) of items of equipment or major components shall not be permitted, unless approved in advance by the Engineer.
- (f) The following basic requirements shall be satisfied:
  - ♦ LED board size of approximately 192 cm x 96 cm with steel frame, Module 32x16, with pitch size P10 capable to display messages in both Nepali and English
  - ♦ Proposed Solar Power System: 3610 watt.hr considering maximum three rows of text with font size of 16 cm.
  - ♦ Solar Plant with 3 days autonomy: 600A/48V Battery System, 6 solar panels (Senersun SSP72-285-C) and 3KVA Inverter (Axpert MKS-2K-48) with built-in MPPT charger of 50 amps
  - ♦ Reliability / MTBF:..... 5 years (product life cycle)
  - ♦ Voltage/Hz ..... 220V / 50 Hz
- (g) The materials for construction of the supports shall conform the requirements of the following sections:
  - ✓ Section 400: ..... "Fencing"
  - ✓ Section 2000: ..... "Concrete for Structures"
  - ✓ Section 2014: ..... "Reinforcement"
  - ✓ Section 2200: ..... "Structural Steel Work"

## **(6) Testing and Commissioning**

Testing and Commissioning of the completed installation of Street Lighting System (SLS) shall be made in accordance with the requirements of Clause 509(3): "Testing and Commissioning".

## **(7) Measurement**

The measurement for this Section 3130 shall be made by the Number of TIB actually installed, satisfactorily tested according to Clause 509(3): "Testing and Commissioning" and conforming the requirements of Clause 9: "Test on Completion" of the Conditions of Contract, confirmation of proper function of the established system, satisfying all requirements of these specifications, and approved by Engineer. All materials, equipment and ancillary works or incidentals shall not be measured separately but shall be deemed

included in the rates of the main item of TIB.

**(8) Payment**

The works for the Traffic Information Board (TIB) system measured as described above shall be paid at the unit rates shown in the Bill of Quantities. This payment shall be the full and the final compensation to the Contractor as per Clause 112 including the cost for Design Review and Updating, provision of all materials, transportation, all operations required for construction and installation as shown in the Drawings and described in this Item including drawings, tests and all other ancillary works, and any incidental work needed to complete the work as per these Specifications and/or directed by the Engineer.

Item No.	Description	Unit
<b>3130</b>	<b>Traffic Information Board (TIB)</b>	
3130-1	Traffic Information Board (TIB) for West Portal	No.
3130-2	Traffic Information Board (TIB) for East Portal	No.

Add the following new Sections at the end of Sub-Section 3130: “Traffic Information Boards”:

New Sections:

- ◆ 6000 “Supply of O&M Equipment”
- ◆ 6100 “O&M Facilities and Buildings”
- ◆ 6300 “Toll Gate Facilities”
- ◆ 6500 “Transmission Line”
- ◆ 7000 “Roadside Service Station”
- ◆ 7500 “Steel Bridge for Flyover”

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## **SECTION 6000: SUPPLYING OF O&M EQUIPMENT**

### **6001 DESCRIPTION**

#### **(1) Scopes**

Without detriment to requirements of the Conditions of Contract, Clause 4.1: “Contractor’s General Obligations”, or other relevant conditions or specifications of the contractual documents, this item shall include the following:

- ◆ Supplying of the following O&M equipment:
  - ✓ Pickup truck
  - ✓ Lift truck
  - ✓ Movable sign-board truck
  - ✓ Light towing vehicle
  - ✓ Heavy towing vehicle
  - ✓ Small size fire fighting
  - ✓ Ambulance car
  - ✓ Weight scale (Mat type)
  - ✓ Height restriction device (Gate type)
  - ✓ Rescue machinery and tools
  - ✓ Inspection machinery and tools
- ◆ Each item of equipment that is delivered by the Contractor shall be furnished with its manufacturer’s Operation & Maintenance Manual Book. And for the overall system operation manuals, the Contractor shall provide the whole system operation manual to be submitted to the Engineer as per the As-Built Documents, for onward transmission to the Employer.
- ◆ The Contractor shall prepare and submit the Instruction Manuals for operating and maintenance to the Engineer, including all modifications that should be required. The manuals shall be resubmitted before the date of issue of the Taking-Over Certificate.
- ◆ The schedule for procurement and mobilization of the O&M plant shall be submitted to the Engineer for review and approval. This approval shall be the basic condition for respective measurement and payment.

The works shall include furnishing all materials, and all ancillary works and any other

incidental necessary to complete scopes of this Item in conformity with these Specifications, and as directed by the Engineer.

## (2) Workmanship and Standards

The works comprehended on supplying of the O&M equipment shall conform in all respects to highest standards of engineering, design, workmanship, this specifications and the latest revisions of relevant standards applicable in Nepal.

## (3) Submittals

The Contractor shall submit all information regarding to the equipment to be supplied including fabrication drawings, catalogues and manufacturer's specifications, fabricator, installation manuals, including details of procurement, and details at fabrication shop, etc. for the Engineer's consent.

The Contractor shall allow the Engineer four (4) weeks from receipt of any submittal or re-submittal, for his review and acceptance prior to commencing the procurement for supplying the O&M equipment to which this submittal refers.

## (4) Basic Requirements

The equipment supplied for O&M works shall conform with the following basic requirements (all items shall be of the latest model as approved by the Engineer):

Item No.	Description	Requirement
1	Pickup truck	<ul style="list-style-type: none"> <li>♦ 4WD Type</li> <li>♦ Turbo-diesel engine</li> <li>♦ Capacity: 3000 cc</li> <li>♦ Gearbox//No. of Gears: 5 Forward, 1 Reverse</li> <li>♦ Fuel Tank//Capacity: 65 liters</li> <li>♦ Performance Speed: 120 km/h</li> <li>♦ Gross Vehicle Weight (kg): 3000</li> <li>♦ Seating Capacity: 4+1</li> </ul>
2	Lift-mounted truck	<ul style="list-style-type: none"> <li>♦ Product Details: Operating Height = 10m</li> <li>♦ Material: Strength Steel</li> <li>♦ Other details: platform capacity = 225kg - 450 kg; and height ranges up to 8.76m, (working height 10.76m)</li> <li>♦ Mounted on a chassis of 7.5 ton</li> </ul>
3	Movable sign board-mounted truck	<ul style="list-style-type: none"> <li>♦ Turbo-diesel engine</li> <li>♦ Capacity: 3783 cc</li> <li>♦ Gearbox//No. of Gears: 5 Forward, 1 Reverse</li> <li>♦ Fuel Tank//Capacity: 160 liters</li> <li>♦ Max Speed (km/h): 110</li> <li>♦ GVW / GCW (Kgs): 7490</li> <li>♦ Kerb Weight (Kgs): 3690</li> <li>♦ Payload (Kgs): 3800</li> <li>♦ Moving Message Displays: 3.0m x 1.8m</li> <li>♦ Color: Amber</li> </ul>
4	Light towing vehicle	<ul style="list-style-type: none"> <li>♦ 2017 Tow Truck Wrecker, 8 Ton</li> <li>♦ Fuel Type: Diesel, Emission Standard: Euro 4</li> <li>♦ Transmission Type: Manual</li> <li>♦ Foton 4*2 180HP</li> <li>♦ 8Ton road recovery wreck truck with 2 winch 8ton</li> <li>♦ Unload weight: 3600kg, Engine: foton cummins</li> </ul>
5	Heavy towing	<ul style="list-style-type: none"> <li>♦ 2017 Tow Truck Wrecker, 30 Ton</li> </ul>

Item No.	Description	Requirement
	vehicle	<ul style="list-style-type: none"> <li>Fuel Type: Diesel, Emission Standard: Euro 3</li> <li>Transmission Type: Manual</li> <li>Horse Power: 270HP</li> <li>Maximum under-pulling, capacity: 30000kg</li> <li>Maximum hoisting-pulling capacity: 24000kg</li> </ul>
6	Small size fire fighting	<ul style="list-style-type: none"> <li>4WD Type</li> <li>Provided with Hydraulic Lift Equipment for Pump</li> <li>Gross Vehicle Weight (kg): 1220kg</li> <li>Pump Capacity: 0.6 m3/min</li> <li>Seating Capacity: 2</li> </ul>
7	Ambulance car	<ul style="list-style-type: none"> <li>Engine: inline 4-cylinder, DOHC</li> <li>Cylinder capacity: 2.694 cc</li> <li>Fuel: Gasoline</li> <li>Fuel tank capacity: 70 liters</li> </ul>
8	Weight scale (portable weigh-pad: Mat type)	<ul style="list-style-type: none"> <li>The weigh pads shall be of a complete portable weighing solution for load control</li> <li>Weigh pads shall not be used as weighbridge to invoice weights</li> <li>Each pad shall have a capacity of 15Ton. Calibrated as 30ton x 10kg.</li> <li>These pads don't work on abnormal sized vehicles.</li> </ul>
9	Rescue machinery and tools	(as approved by the Engineer)
10	Inspection machinery and tools	(as approved by the Engineer)

## 6002 MEASUREMENT

The works for this item shall be measured respectively in accordance with the specified units established here below of the specific units (each) provided and tested in place as indicated in the Bill of Quantities and the Drawings.

## 6003 PAYMENT

The works for supplying the O&M equipment shall be paid under this Section at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 including the related cost of all materials, all operations required for supplying the equipment as described in this Item and incidentals needed to complete the work as per these Specifications and/or directed by the Engineer.

Item No.	Description	Unit
<b>6000</b>	<b>Supplying of O&amp;M Equipment</b>	
6000-1	Pickup truck	No.
6000-2	Lift-mounted truck	No.
6000-3	Movable sign board-mounted truck	No.
6000-4	Light towing vehicle	No.
6000-5	Heavy towing vehicle	No.
6000-6	Small size fire fighting	No.
6000-7	Ambulance car	No.
6000-8	Weight scale (portable weigh-pad: Mat type)	No.

<b>Item No.</b>	<b>Description</b>	<b>Unit</b>
6000-9	Rescue machinery and tools	PS
6000-10	Inspection machinery and tools	PS



## SECTION 6100: O&M FACILITIES AND BUILDINGS

### 6101 DESCRIPTION

This work shall include the Design Review and Updating by the Contractor based on the Conceptual Design provided by the Employer. The report of the Design Review shall include also all detailed drawings, applicable technical specifications and requirements for construction and materials.

This works shall include all the necessary civil works, water supply and sanitation works, and electrification works as per the specification, the Drawings and instruction by the Engineer.

The works shall consist of the following:

West Portal: Block-1, Block-2 and Block-3

- ◆ O&M office building
- ◆ Garage
- ◆ Power house building
- ◆ Water tank
- ◆ Security guard office building

East Portal: Block-1, Block-2 and Block-3

- ◆ O&M office and power house building
- ◆ Warehouse and staff canteen building
- ◆ Police, toll and emergency staff office building
- ◆ Water tank and pump house
- ◆ Fuel tank
- ◆ Security guard office building No.1
- ◆ Security guard office building No.2

The works shall include furnishing all materials including all required for flooring, doors, windows, roofing, waterproofing, etc., all for construction of the above referred buildings and systems, and all ancillary works and any other incidental necessary to complete the Works in conformity with the Drawings and these Specifications, or as directed by the Engineer.

### 6102 STANDARDS

The works for design's verification and construction of O&M Facilities and Buildings shall conform in all respects to highest standards of engineering, design, workmanship, this specifications and the latest revisions of relevant standards applicable in Nepal (Specifications of Building Construction Works and Nepal National Building Code NBC206: 2003 - Architectural Design Requirements)

### 6103 CONSTRUCTION METHOD, DESIGN REVIEW AND UPDATING

Before commencement of the works, the Contractor shall prepare and submit to the Engineer, for review and approval, a construction method statement and the detailed report

of the Design Review and Updating for O&M Facilities and Buildings. These documents shall be attached to the Program which requirements are described in Section 116: “Programme”.

#### 6104 MEASUREMENT

The works for this item shall be measured in “lump sum” but summarized by respective Item No. in accordance with the specified works completed in place as indicated in the Bill of Quantities and the Drawings including all subsidiary items related to relevant sections of these specifications.

#### 6105 PAYMENT

The works for the construction of O&M Facilities and Buildings, as measured above, shall be paid under this Section at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 including the cost for Design Review and Updating, provision of all materials, all operations required for construction as shown in the Drawings and described in this Item including drawings, tests and all other ancillary works and any incidental work needed to complete the work as per these Specifications and/or directed by the Engineer.

Item No.	Description	Unit
<b>6100</b>	<b>O&amp;M Facilities and Buildings</b>	
6100-1	West portal side O&M office building	sq.m
6100-2	West portal side garage	sq.m
6100-3	West portal side power house building	sq.m
6100-4	West portal side water tank	lump sum
6100-5	West portal security guard office building No.1	sq.m
6100-6	West portal security guard office building No.2	sq.m
6100-7	East portal side O&M office and power house building	sq.m
6100-8	East portal side warehouse and staff canteen building	sq.m
6100-9	East portal police, toll and emergency staff office building	sq.m
6100-10	East portal side water tank and pump house	lump sum
6100-11	East portal side fuel tank	lump sum
6100-12	East portal security guard office building No.1	sq.m
6100-13	East portal security guard office building No.2	sq.m
6100-14	O&M office facility, furniture and tools	PS

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## SECTION 6300: TOLL GATE AND FACILITIES

### 6301 DESCRIPTION

#### (1) General

- (a) This work consists of the Design Review & Updating, supply, construct and install of toll gate islands, booths, roof, lighting, name board, lane IP incident cameras, traffic lights, automatic lane barriers and toll gate equipment including civil works and works for electricity installation conforming to the Specification, the Drawings and instruction by the Engineer.
- (b) This shall include all works needed for furnishing and installing all materials and equipment, manufacturer's manual/instructions, latest accepted standards of the industry and the Drawings, or as directed by the Engineer.
- (c) The locations of toll gate facilities shown in the Drawings are approximate, and the exact locations may be modified to fit in with surrounding structures. Any such modifications shall be made in accordance with the Engineer's instructions.

#### (2) Scope of Work

The scope of this work consists of supply and delivery to the site, installation, testing and commissioning as required of all materials, equipment and labor for the works of the following:

- ♦ **Toll Gate Facilities**

Roof, Toll Island, Toll Booth, Related Equipment

#### (3) Quality Assurance

- (a) For the actual fabrication, installation, and testing of the work described in this Specification Section, the Contractor shall use only thoroughly trained and experienced personnel who are completely familiar with the requirements for this work and with the installation recommendations of the manufacturers of the specified items. In acceptance or rejection of the installed electrical system, no allowance will be made for lack of skill on the part of the installers.
- (b) Installers shall hold the relevant valid certificates complying with the regulations of the concerned Nepal's authorities.

#### (4) Drawings and Documents

The Contractor shall refer to all relevant Drawings and ascertain for himself the location and routes of all other utility services so as to maintain adequate clearance between the services. The Drawings issued for construction indicate the general arrangement of the works, and the Contractor shall provide working drawings (in accordance with Sub-Section 117: "Contractor's Drawings") showing the exact routes of all pipes, overhead and underground installations, the exact run of conduits and trunk-connection, the location of manholes or control holes, draw-in and junction units, the number and size of cables in each conduit, etc.

The Contractor shall submit a schedule showing lists of intended events and times such as the date on which concreting in different sections will take place, together with the submission of the working drawings.

Upon completion of the work, and as a condition of its acceptance, the Contractor shall provide to the Employer copy of instructions/manuals for the operation and maintenance of all equipment and a parts list sufficient for the ordering of parts.

## **6302 MATERIAL**

### **(1) Standards and Regulations**

- (a) The work covered by this Contract shall be carried out in accordance with the regulations issued by the local authority and with the following applicable standards and codes:
  - ◆ IEC (International Electrotechnical Commission)
  - ◆ JIS (Japanese Industrial Standards Committee)
  - ◆ JEAC (Japan Electric Association Code)
  - ◆ JEM (Standards of the Japan Electrical Manufacturers' Association)
- (b) The Contractor shall carefully examine at his own expense all the regulations issued by the local power company, and ensure that selected materials and method of installation are in accordance with such regulations.

The Contractor shall include in his unit price for any reasonable minor changes, modification, or supplementation of engineering drawings and specifications to ensure conformance with local regulations.

### **(2) General Requirements**

All works shall be done under the supervision of the Engineer and in accordance with the Drawings and the requirements herein described. Any changes made thereof shall only be made upon obtaining previous consent from the Engineer.

All electrical installations shall be done in accordance with the applicable ordinances, rules and regulations or standards of the local power company and with requirements of the relevant authority. The construction works shall be carried out under the supervision of a licensed engineer of the Contractor.

The materials shall comply with the following general requirements:

- (a) All the materials used in the works must be brand-new which satisfies the requirements of quality and performance denoted in the drawings. However, this does not apply to the case of temporal construction.
- (b) The Contractor must submit the documents certifying the quality and performance of the materials to the Engineer. However, in case of using materials which has been specified to use JIS in the drawings and approved by the Engineer in advance to use the materials marked "JIS", submission of this documents can be omitted.

- (c) The Contractor must report to the Engineer in each time of carrying materials into the site. However, this does not apply to the case where the Contractor obtains approval from the Engineer.
- (d) Material Inspection
  - ◆ Material inspection shall be carried out by each type of materials when these materials are carried into the Site.
  - ◆ As the result of above inspection, the same types of material which passed the inspection can generally change to sampling inspection. However, this does not apply to the case where the Engineer gives instructions.
  - ◆ Carrying material into the site which is designated as an inappropriate material due to the deterioration, etc. by the Engineer must be conveyed out from the site immediately.
- (e) Testing Associated with Material Inspection

Without detriment to the requirements of Sub-Clause 7.4 “Testing” of the Conditions of Contract, or other relevant requirements of these Specifications, the Contractor shall perform the following:

  - ◆ In case of conducting material testing to certificate its quality or performance, test shall be performed based on the designated method in the Drawings. In the event that there is no designation in the Drawings, the test shall be performed based on the method which is approved by the Engineer.
  - ◆ The Contractor shall submit the testing plan to the Engineer before the testing.
  - ◆ The test shall be performed at the appropriate site such as Examination Institution, construction site, etc. For the selection of testing site, approval by the Engineer shall be required.
  - ◆ Generally, the test shall be performed in the presence of the Engineer. However, this does not apply to the case where the Contractor obtains approval from the Engineer.
- (f) Material Storing
  - ◆ Material which is carried into the site shall be stored not to be deteriorated till the time to use in the construction work.

## 6303 CONSTRUCTION

### (1) Construction Works

- (a) Construction works shall be conducted according to the Drawings, work plan, method statement, working/shop drawings.
- (b) In case of the work which shall make a hided area such as Concrete placing work, the Contractor must not conduct the work till required inspection is completed. However, this does not apply to the case where the Contractor obtains previous approval from the Engineer.

### (2) Inspection of Construction Works

- (a) When the instruction from the Engineer received, the inspection of the construction work shall be conducted.
- (b) As the results of the above inspection, the same types of material and work

method which passed the inspection of construction work can generally change to sampling inspection. However, this does not apply to the case where the Engineer gives instructions.

**(3) Equipment Installation Works**

- (a) Equipment installation work must be carefully performed in terms of horizontal and vertical position so as not to interfere with its performance after the installation of the equipment due to strain, etc.
- (b) Used ironmongery shall be manufactured after the adequate site survey.

**(4) Management of Construction Site**

- (a) Appropriate curing shall be performed not to deface existing facilities, already completed or installed facilities, etc.
- (b) When construction works are completed, the Contractor shall conduct clean up the site both inside and outside of the architecture.

**6304 WORKS' REQUIREMENTS FOR TOLL FACILITIES**

Construction and installation of the Toll Facilities shall comply with the following requirements of the relevant sections of these Specifications:

Works	Material / Description	Specification and Requirements
Concrete and Reinforcement for main structure	<ul style="list-style-type: none"> <li>Concrete Class B</li> <li>Concrete Class D</li> </ul>	<ul style="list-style-type: none"> <li>Section 2000: "Concrete for Structures" main structure: Concrete Class-B; other ancillary works: Concrete Class-D.</li> </ul>
	<ul style="list-style-type: none"> <li>Reinforcement Bar</li> </ul>	<ul style="list-style-type: none"> <li>Section 600: "Materials and Testing of Materials"</li> <li>Section 2014: "Reinforcement"</li> </ul>
Asphalt Concrete Pavement	<ul style="list-style-type: none"> <li>Asphalt Concrete Wearing Course (50 mm)</li> </ul>	<ul style="list-style-type: none"> <li>Section 1300: "Bituminous Surface and Base Course"</li> </ul>
	<ul style="list-style-type: none"> <li>Asphalt Concrete Binder Course (50 mm)</li> </ul>	
	<ul style="list-style-type: none"> <li>Asphalt Treated Base (ATB) Course (100 mm)</li> </ul>	
Concrete Pavement	<ul style="list-style-type: none"> <li>Jointed Reinforced Concrete Pavement (JRCP) [t300mm] (Concrete Class P)</li> </ul>	<ul style="list-style-type: none"> <li>Section 2050: "Concrete Pavements"</li> </ul>
Steel Roofing and columns	<ul style="list-style-type: none"> <li>Structural steel for Frame structure for roof and columns</li> </ul>	<ul style="list-style-type: none"> <li>Section 600: "Materials and Testing of Materials"</li> <li>Section 2200: "Structural Steel Work"</li> <li>Steel SM90YA (or equivalent); SM400A (or equivalent);</li> </ul>
	<ul style="list-style-type: none"> <li>High Tension Bolts (HTB)</li> </ul>	<ul style="list-style-type: none"> <li>Section 2200, IS: 961 (HTB) with minimum tensile strength of 58 kg/mm<sup>2</sup></li> </ul>
	<ul style="list-style-type: none"> <li>MS Purlins and MS Pipes</li> <li>Corrugated metal sheet</li> </ul>	<ul style="list-style-type: none"> <li>SS400, SN400B, SN400C, STKR400: JIS or equivalents</li> <li>SSC400: JIS or equivalents</li> </ul>
	<ul style="list-style-type: none"> <li>Painting</li> </ul>	<ul style="list-style-type: none"> <li>Sub-Section 2205: "Painting"</li> </ul>
	<ul style="list-style-type: none"> <li>Others</li> </ul>	<ul style="list-style-type: none"> <li>Design Review shall be made by Contractor to confirm the capacity of steel frame before starting factory production.</li> <li>Testing of Welding Section: UT (Ultrasonic Test) AOQL:</li> </ul>

Works	Material / Description	Specification and Requirements
		Shop Welding 4.0% Field Welding 4.0%
Guard Rail	<ul style="list-style-type: none"> <li>♦ <math>\phi</math> 100 GI pipe Guard Rail</li> <li>♦ Other Steel Guard Rail</li> </ul>	♦ Sub-Section 3105: "Railing"
Lighting Facility	<ul style="list-style-type: none"> <li>♦ Illuminance: (a) Under Roof = 150(Lx) at road surface level (b) Inside Toll Booth = 500(Lx) at 85cm from floor</li> </ul>	<ul style="list-style-type: none"> <li>♦ JIS: Japanese Industrial Standard</li> <li>♦ JEC: Japanese Electro-technical Committee</li> <li>♦ JEM: The Standards of the Japan Electrical Manufacturer's Association</li> <li>♦ IEC: International Electro-technical Commission (authorized standards)</li> <li>♦ Nepal Electricity Authority</li> <li>♦ Nepal National Building Code NBC207: 2003 - Electrical Design Requirements</li> </ul>
Conduit and Wiring Works	<ul style="list-style-type: none"> <li>♦ Material for Conduit and Wiring, including the <math>\phi</math> 150mm PVC pipes, etc., as approved by the Engineer</li> </ul>	<ul style="list-style-type: none"> <li>♦ Specifications: same than above</li> <li>♦ Terminal processing to the cable termination and jointed perfectly.</li> <li>♦ All cables must be marked manufacture's name, year and month of manufacture and testing laboratory on outer surface of the cable or wire. Name plate, which indicates connected place from/to, must be attached on the cable.</li> <li>♦ Prior to the construction work, the Contractor shall conduct the calculation of conduit and wiring and obtain the approval by the Engineer.</li> <li>♦ Cable in handhole must secure the extra length.</li> </ul>
Distribution Panel	<ul style="list-style-type: none"> <li>♦ Material for Panels as approved by the Engineer</li> </ul>	<ul style="list-style-type: none"> <li>♦ Specifications: As approved by the Engineer</li> <li>♦ Work space for repairing and maintenance must be secured sufficiently.</li> <li>♦ The wiring diagram must be provided on the inside of panel door.</li> <li>♦ Prior to the construction work, the Contractor shall conduct the calculation of piping and wiring and obtain the approval by the Engineer.</li> </ul>
Truck Scale Facility	<ul style="list-style-type: none"> <li>♦ Weight scale (portable weigh-pad: Mat type) (to be used on some particular cases only)</li> </ul>	♦ As described in Section 6000: "Supplying of O&M Equipment"
Single Toll Booth	<ul style="list-style-type: none"> <li>♦ W=1400mm x L=3300mm x H=2400mm</li> </ul>	♦ Specifications of Building Construction Works and Nepal National Building Code NBC206: 2003 - Architectural Design Requirements
Lane IP incident Camera, Traffic Lights, Automatic Lane Barrier, new Jersey barriers	<ul style="list-style-type: none"> <li>♦ As approved by the Engineer</li> </ul>	♦ The Contractor shall submit complete details of the material from the suppliers including catalogs and specifications

The works for providing and installation of the Polyethylene tank crash barriers shall be in accordance with the requirements of Section 1509: Polyethylene Tank Crash Barrier.

## 6305 MEASUREMENT

The quantity of Toll Gate Facilities described in this item shall be measured in Lump Sum of each Toll Gates Facilities provided for each portal (Eastern and Western side) furnished



and installed in accordance with this Specification Section, as shown in the Drawings, and in accordance with the instructions of the Engineer.

The works for providing and installation of the Polyethylene tank crash barriers shall be measured and paid under the items of Section 1509: Polyethylene Tank Crash Barrier.

## 6306 PAYMENT

The Toll Gates Facilities measured as above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 including cost for all materials labour, equipment, tools, and all incidentals to complete the work in accordance with the Drawings and Specifications, and as directed by the Engineer.

The unit rates shall deemed include, inter alia and in addition to other items previously stated (e.g. concrete, reinforcement steel, structural steel works, etc.), the following:

- ◆ Construction of Toll islands
- ◆ Providing and installation of lane IP incident camera, traffic lights, automatic lane barrier
- ◆ Construction and installation of booths
- ◆ Handholes and respective connections with other handholes and with the main “Operation Center” of the Toll-Gate Office
- ◆ Drainages
- ◆ Equipment, materials, labor, transportation, installation, and testing
- ◆ Related works, which are not specifically described in this section, such as excavation and backfilling, markers for underground cables, buried cable protectors, etc. shall be deemed included in the rates of pay items specified hereunder.

Item No.	Description	Unit
<b>6300</b>	<b>Toll Gate and Facilities</b>	
6300-1	West portal side toll gate	lump sum
6300-2	East portal side toll gate	lump sum



## SECTION 6500: TRANSMISSION LINE

### 6501 DESCRIPTION

These works shall include the following:

- ◆ Supplying and Installation of Transmission Line (11kV), XLPE Power Cable.
- ◆ Cable Termination Kit and Joint Kit for XLPE
- ◆ Supplying and Installation of HDPE Pipe and PPR Pipes
- ◆ Sub-station and Transmission Line:
  - ✓ Vacuum Circuit Breaker (VCB) Switch Gear - 2sets - 11kV
  - ✓ Adaptation Panel - 2sets
  - ✓ Power Cable (11kV) for underground cabling - 1.95 km length
  - ✓ Civil Works for Cable Laying : RCC Channel Box (Pre-cast)
- ◆ For East Portal Switch Yard:
  - ✓ Transformer (11kV/400V), Dry, Indoor Type, Capacity 750kVA x 2 nos.
  - ✓ Bus coupler - 2 nos.
  - ✓ Air Circuit Breaker (ACB) Switch Gear
- ◆ Supplying and Installation of Ground Rods and Clamps, and Grounding Conductor.
- ◆ Ancillary Works and Testing

The works shall include furnishing all materials, construction or installation of the above referred items, and all ancillary works and any other incidental necessary to complete the Works in conformity with the Drawings and these Specifications, or as directed by the Engineer.

This work shall also include the Site' Survey for confirmation and preparation of drawings, and a full Design Review and Updating by the Contractor based on the Conceptual Design provided by the Employer. The report shall include also all detailed drawings, applicable technical specifications and requirements for construction and materials.

### 6502 STANDARDS

All works under this Contract shall comply with the applicable regulations and requirements of Statutory Authorities.

All equipment and materials shall conform to the requirements of the codes and standards specified herein and the Drawings, or certified by other internationally recognized standard institutions or testing laboratories that maintains periodic inspection of production of listed equipment and materials meet nationally recognized standards or has been tested and found suitable for use in the specified manner.

Certification of the system shall be provided by the Contractor.

**Codes and Standards:** Unless otherwise indicated in the Drawings or in the Specifications, the design, materials, manufacture, testing, inspection and performance of all electrical and electromechanical equipment shall comply with the latest revisions of relevant standards listed in Section 113: “National Specifications” and the following standards:

- ♦ JIS: Japanese Industrial Standard
- ♦ JEC: Japanese Electro-technical Committee
- ♦ JEM: The Standards of the Japan Electrical Manufacturer’s Association
- ♦ IEC: International Electro-technical Commission (authorized standards)

When local regulatory bodies, have jurisdiction over installation, the following Nepalese standards shall be applied:

- ♦ Nepal Electricity Authority
- ♦ Nepal National Building Code NBC207: 2003 – Electrical Design Requirements

### **6503 CONSTRUCTION METHOD AND DESIGN REVIEW AND UPDATING REPORT**

Before commencement of the works, the Contractor shall prepare and submit to the Engineer, for review and approval, a construction method statement and the detailed report of the Design Review and Updating. These documents shall be attached to the Program which requirements are described in Section 116: “Programme”.

### **6504 GENERAL OPERATING CONDITIONS**

The following are the general operating conditions for the system:

- ♦ Ambient temperature: ..... -5°C to 45°C
- ♦ Altitude: ..... Approximately 1420 m above MSL
- ♦ Humidity: ..... 100% (max.)
- ♦ Main voltage: ..... 11 kV for Distribution HT and 400/230 V for LT
- ♦ System frequency ..... 50 Hz

Note: The variation of frequency and voltage for design and operation is as per actual system operation i.e.  $\pm 5\%$ .

### **6505 MATERIALS AND CONSTRUCTION REQUIREMENTS**

#### **(A) XLPE CABLE & ACCESSORIES**

##### **(A1) 11 kV XLPE Power Cable**

##### **(1) Cable Construction Details**

- (a) The XLPE insulated cables shall conform to the requirements of IEC 60502-2 (applicable clauses only) for construction and IEC 60840 and other relevant standards for testing. The terminating accessories shall conform to IEC 60840/IEC 62067 (as applicable). The offered cables and its terminating accessories shall be compatible with each other.
- (b) The 11kV XLPE cable shall be three core, armoured, stranded, compacted Aluminum conductor of 300 sq.mm size, core screening by a layer of

semiconducting XLPE, treeing resistant XLPE insulation, insulation screening by a layer of semiconducting XLPE. The core screening, insulation and insulation screening to be triple extruded and dry cured. Helically wound copper wire screening with equalizing tape, shall be provided on each conductor. Each core shall have a Polyethelene sheath. The over-sheath shall be black HDPE. Bidder may offer necessary layers such as water blocking, separation tape, binder tapes etc. additionally as per their manufacturing practices for meeting required performance of the offered cable.

- (c) The cable shall be suitable for installing in the climate conditions (as specified in this chapter)
- (d) Cable shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.
- (e) Cable sheath shall be embossed "ELECTRIC CABLE 11000V". The size of the lettering shall not less than 15% of the approximate cable diameter and shall not be larger than 13mm. The gap between the end of one set of embossed characters and the beginning of the next set shall be not greater than 250mm. In addition the manufacturer and year of manufacture shall be embossed on the cable at regular intervals and shall not affect the spacing of the other characters.
- (f) Each core shall be identifiable throughout the cable either by colour or numbering.
- (g) Repaired cables shall not be accepted.
- (h) Allowable tolerance on the overall diameter of the cables shall be + 2 mm.
- (i) Conductor: The conductor shall be of Aluminium as specified in the Bid Price Schedule (BPS). The shape of conductor shall be compacted having high compactness and smooth surface finish.
- (j) Conductor Screen: The conductor screen shall consist of extruded semi-conducting XLPE. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor XLPE. The conductor screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids. The aluminum conductor shall comply with requirements specified in relevant IEC with latest amendments.
- (k) Insulation: The conductor screen shall consist of extruded semi-conducting tape or insulation. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor insulation. The conductor screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.
- (l) Insulation Screen: The insulation screen shall consist of extruded semi-conducting XLPE. Suitable bedding tapes shall be applied over the extruded semi-conducting XLPE in combination with 1 non-magnetic metallic shield.
- (m) Insulation: and Semi Conducting SCREENs The XLPE insulation and semi conducting screens shall be triple extruded and dry cured.
- (n) Moisture Barrier: Longitudinal water barrier:  
The longitudinal water barrier shall be applied over insulation screen by a layer of non-woven synthetic tape with suitable water swellable absorbent.

- (o) *Metallic Screen:* The metallic screen shall be of plain copper wires, helically applied over the radial moisture barrier. A binder tape of annealed plain copper shall be applied in the form of an open helix over the copper wire screen. The combination of the metallic sheath (lead sheath) in combination with wire screen shall be designed to meet the requirement of the system short circuit rating as specified in the bidding documents. The copper wire screens shall be applied to each core.
- (p) *Outer Sheath:* The outer sheath shall consist of extruded black colored HDPE. The outer sheath shall be suitably designed by the addition of chemicals in the outer sheath for protection against termite and rodent attack.

*Armouring:*

The armour of cables shall consist of aluminum wires or strips. The armoring shall be applied such that the minimum area of coverage shall be 90% and the gap between any two armour strips/ wire shall not be more than the width of strip/ diameter of armour wire. The galvanized steel strips/wire shall comply with the requirements of IEC with latest amendments.

In case of Single core cable armouring shall be of Non-magnetic material with dimensions as per relevant IEC with latest amendments. No tolerance on the negative side shall be acceptable.

- (q) *Rating:* The contractor/ manufacturer shall declare current rating of cable for maximum conductor temperature of 90°C under continuous operation and 250°C during short-circuit condition. The contractor/ manufacturer shall also declare over load curve with duration for conductor temperature of 105°C. A complete set of calculation made in arriving at the current rating shall be furnished, for laying condition envisaged under the project, during detailed engineering for Employer/Employer's reference.

- (r) *Cable Jointing Accessories:*

- ♦ The cable jointing accessories shall include all the straight through joints. Bidder shall arrange all special tools and tackles required for making these joints at his own cost. Unless specified separately in BPS, cable end terminating kits shall be deemed included as part of cable jointing accessories.
- ♦ The joints shall be suitable for tropical conditions as specified in this chapter. Straight joints shall be heat shrink type with compression ferrules. Each joint shall include all necessary material and components for effecting a reliable and durable joint. Particularly importance is attached to the proper provision of stress relieving materials and tubing.
- ♦ The straight through joints and cable end terminations shall be of proven design and should have been type tested as per relevant IEC standard. A list shall be furnished indicating supply of such cable jointing accessories which are successfully operating in other projects.
- ♦ The detailed description on jointing procedure shall be furnished during detailed engineering.
- ♦ The cable end terminations shall be of anti-fog type and shall be of

Polymeric type suitable for withstanding the climatic conditions with required Creepage distance as specified in bidding documents. The cable end terminals for terminating the cables shall be complete with accessories & fully compatible with the cables to be supplied. The terminations shall also be capable to withstand mechanical forces during normal and short circuit operations.

**(2) Cable Drums**

- (a) Cables shall be supplied in wooden/steel drums of heavy construction of suitable size and packed conforming to applicable standards. Maximum drum length shall be 500m.
- (b) Standard drum lengths for manufacturing shall be finalised during detailed engineering. Each drum shall carry the manufacturer's name, the employer's name, address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.
- (c) Packing shall be sturdy and adequate to protect the cables from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with heat shrink caps so as to eliminate ingress of water during transportation and erection.

**(3) Tests on Cables**

All XLPE insulated cables shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC & shall submit the type test reports for Employer's approval. If specified in Section-Project, Type tests shall be carried out on the EHV cable as per relevant standard.

**(4) Tests on Accessories**

Contractor shall submit type test reports for accessories, as per IEC 60840:1999/ IEC 62067 for Employer's acceptance. Contractor shall submit type test reports as per respective Technical Specification, GTR for Employer's acceptance.

**(5) Tests After Installation**

All tests on cable system as prescribed in IEC 60840:1999/IEC 62067 (as applicable) shall be performed after installation in the presence of Employer. The result of the tests shall be well documented and submitted with the as built drawings.

**(6) Laying and Installation**

- (a) The bidder is advised to visit the site and acquaint themselves with the topography, infrastructure etc. The contractor shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the erection and successful commissioning of XLPE cables in all respects. In general the cable laying operation shall be in

accordance with best internationally accepted practices and procedures and in accordance to manufacturers recommendation.

- (b) Cable drum shall be positioned in such a way that the axle of the drum is perpendicular to the cable trench. The cable shall come off the drum always at the lower part in order to minimize stress. If the laying is done by the winch it has to be equipped with a tension release in order to avoid any excess stresses on the cable. The cable tension as well as the continuity of the laying operation shall be monitored by instruments and shall not exceed limits given by the manufacture's recommendation. Winching equipment which doesn't fulfil above requirements will be rejected.
- (c) Cable rollers shall be used to roll off the cables from the drums. The rollers shall ensure that the cable does not scuff on the ground during pulling operation. The rollers must be cleaned and lubricated properly.
- (d) Cables shall be laid in the cable duct throughout the route. Further, as per requirement of the field, the cables shall also have to be laid in the followings (with prior approval of employer):
  - ◆ In ducts
  - ◆ In HDPE ducts (wherever necessary)
  - ◆ In air at terminations
  - ◆ At varying depths due to obstructions
  - ◆ As per approved drawings
- (e) At places where the cables cross roads, the cables can be laid in HDPE pipes of adequate strength.
- (f) Concrete trenches with precast covers may be used in exceptional cases in smaller portions, wherever bending of cables are involved and HDPE pipes can't be laid.
- (g) The arrangement of laying the cable en-route shall be submitted by contractor during detailed engineering for Employer's acceptance. The Bidder shall also submit inception report indicating detail description of procedure (Method Statement for Construction) to be deployed for laying of underground and fibre optic cable. The contractor shall propose optimum cable sizing based on load current, voltage drop, short circuit current and protective device requirement and also to maintain reliable ring main 11 kV supply.
- (h) Any damage occurred to existing utility services during cable laying shall be brought into notice of relevant authorities and rectified immediately.

**(7) Trenching**

- (a) Trenches shall in general, unless impeded, be in accordance with the dimensions indicated in the cable installation specification included with this document.
- (b) The cable trench work involves earth excavation for cable trench, back filling and removal of excess earth from site. The work site shall be left as clean as possible.
- (c) Wherever possible sidewalks shall be used for the installation of cable. The trench shall be excavated using manual /mechanical modes as per field conditions. Most main roads are of asphalt surface and some of the roads with



cement concrete surface. The sides of the excavated trenches shall wherever required, be well shored up.

- (d) Where paved footpaths, black topped roads or concrete slabs are encountered, the pavement slabs, roads shall be properly reinstated in original condition or better. Identification markers of other services shall be properly stored and reinstated. The excavated material shall be properly stored and filled back within 24 hours of excavation to avoid obstruction to public and traffic movement.
- (e) Suitable barriers should be erected between the cable trench and pedestrian/motorway to prevent accidents. The barriers shall be painted with yellow and black or red and white coloured cross stripes. Warning and caution boards should be consciously displayed. Red lights as warning signal should be placed along the trench during the nights.
- (f) The bottom of the excavated trench should be levelled flat and free from any object which would damage the cables. Any gradient encountered shall be gradual. All cables shall only be laid directly onto the bottom of the trench, if the surface is unlikely to cause damage to the outer sheath. Where a sand bedding material needs to be used for the base of a trench, the depth of the trench shall be increased by the appropriate amount to ensure that the required minimum depth of cover is achieved.
- (g) Following installation, cables shall be blinded to a compacted depth of 100mm above the cable or cable joint with soil taken from the excavated material or imported material. The blinding shall be free from materials that may damage the cable. Imported material for blinding (sand) shall only be used if all the excavated material is unsuitable.
- (h) The Contractor shall remove from site all rubbish and salvaged materials. The whole area shall be left in a neat and tidy condition to the satisfaction of Employer.

**(8) Trefoil/Flat Formation**

Cables shall be laid in flat formation for entire route. The Contractor shall submit drawings and arrangements for Employer's approval. If a single three core/triplex cable is installed, then the cable shall just be laid direct. If two or more 3 core cables are laid in the same trench then each cable needs to be horizontally separated by a minimum of 400mm.

**(9) Cable Handling**

The inspection of cable on receipt, handling of cables, paying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surfaces, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully planned and in accordance with acceptable standard practices/statutory requirements.

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**(10) Damage to Property**

The Contractor shall take all precautions while excavation of trench, trial pits etc., to protect the public and private properties and to avoid accidental damage. Any damage so caused shall be immediately repaired and brought to the notice of the concerned and to the Employer. The contractor shall bear all responsibilities and liabilities and shall bear all costs of the damages so caused by him or by his workman or agents.

**(11) Cable Route Markers/Cable Joint Markers**

Permanent means of indicating the position of joints and cable route shall be fabricated supplied and erected as per approved drawings.

Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible and above ground surface.

The marker should incorporate the relevant information such that the name of the Employer, voltage, circuit and distance of cable from the marker.

**(12) Depth of Laying of Cables**

Depth of laying shall be as per drawing enclosed with Specification. Laying at varying depths due to obstructions/site conditions may be accepted in extreme cases with prior approval of Employer during detailed engineering.

**(13) Paying Out the Cable**

The excavated cable trench shall be drained of all water and the bed surface shall be smooth, uniform and fairly hard before paying out the cable. The cable shall be rolled in the trench on cable rollers, spaced out at uniform intervals. The paying out process must be smooth and steady without subjecting the cable to abnormal tension. The cable on being paid out shall be smoothly and evenly transferred to the ground after providing the cushion. The cables shall never be dropped. All snake bends shall be straightened. Suitable size cable stocking pulling eye shall be used for pulling the cable. While pulling the cable by winches or machines, the tension/ loading shall be monitored by tension indicator and shall not exceed the permissible value for the cable. The cable laying shall be performed continuously at a speed as recommended by manufacturer.

The cable end seals shall be checked after laying and if found damaged shall immediately be resealed. Sufficient number of heat shrinkable cable end sealing caps shall be stocked at site stores for testing and jointing work. The integrity of the outer sheath shall be checked after the cable is laid in position.

**(14) Sand Bedding**

The cable shall be completely surrounded by well-compacted cable sand to such a thickness and of such size that the cable is protected against damage (applicable where cables are not to be laid in pipes).



**(15) Snaking**

Snaking shall be done at necessary places recommended by manufacturer with prior approval of Employer.

**(16) Thermal Backfill**

If specifically mentioned in Section-Project, Thermal Backfilling shall be carried out based on the evaluation of soil thermal resistivity along the cable route and after approval from the Employer the contractor shall design, specify, supply, lay and monitor the installation of thermal backfill surrounding the cables. Thermal back fill shall be of thermal resistivity of 1.20 K.m/W or better.

**(17) Immediate Envelope to Cable**

The option on the use of the material that immediately envelopes the cable viz., thermal backfill or sand or sieved native soil rests with the Employer/Employer. The contractor shall seek prior approval on the use of the envelop material from the Employer before execution of the works.

**(18) Back Filling**

Normally back filling shall consist of the material earlier excavated. However, bigger stones or pieces of rock shall be removed.

**(19) Warning Tape**

A pre-warning, Red colour plastic/ PVC tape, of at least 250 mm wide 100 microns thick, shall be laid at approx. 0.4 m above the cable specified depth, throughout the cable route. The tape shall carry the legend printed in black continuously as under Caution; Employer, Voltage Class Of Cables. Protection concrete tiles shall also be used all along the route of the cable to protect the cables.

**(20) Prevention of Damage due to Sharp Edges**

After the cables have been laid in the trench and until the cables are covered with protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench. Straight and curved rollers used shall have no sharp projecting parts liable to damage the cable. While pulling through pipes and ducts, the cable shall be protected to avoid damage due to sharp edges. The cables shall never be bent, beyond the specified bending radius recommended by the manufacture.

**(21) Road, Rail & Canal Crossings**

(a) The road cutting, whether cement concrete asphalt or macadam road surface; canal crossing shall be taken after obtaining approval for cutting/crossing from the concerned authorities i.e. office of the municipality, traffic police, telephone authorities, roads and water supply department etc., and work should be planned to be completed in the shortest possible time. Where necessary the work shall be planned during night or light traffic periods. HDPE pipes shall be used for

crossing. HDPE pipes diameter shall be as specified in BPS.

- (b) Trenchless Digging: It is envisaged that trenchless digging shall be used for crossing the National highways, and Canals etc. and the same shall be in the scope of bidder. Trenchless digging shall also be used where the concerned authorities do not permit open cut method and it is essentially required to carry out for installation of underground cables. The trenchless digging methods shall generally conform to ITU-T L.38. The various methods of trenchless digging such as hand/ manual auguring (up to 15m), impact moling (from 16m to about 40-50m), HDD (above 40-50m) shall be adopted based on the soil/site conditions and the requirement. The exact method for trenchless digging shall be finalised during detail engineering as per actual site/soil condition. The equipment used for HDD shall be capable of drilling at least 100m at one go. The contractor shall propose the exact methods and procedures for implementation of trenchless digging at various crossings taking into consideration the following guidelines, for approval by the Employer.

- ◆ Excavation and backfilling of trial pits and verification of soil condition
- ◆ Excavation of entry and Exit pits
- ◆ Erection of drill machine for Drilling of pilot hole
- ◆ Placement and driving hand augur
- ◆ Placement and carrying out impact moling
- ◆ Reaming and widening of bore holes in steps (if required)
- ◆ Pulling of product pipe

## **(22) Footpath Cutting**

The slabs, kerbstones, on the roads shall be removed and reinstated without damage. The Contractor shall ensure that all surfaces make smooth junction with existing works. In case of damages they have to be replaced by new ones.

## **(23) Reinstatement**

After the cables and pipes have been laid and before the trench is backfilled all joints and cable positions should be carefully plotted and preserved till such time the cable is energized and taken over by the Engineer in charge. The protective covers shall then be provided, the excavated soil riddled, sieved and replaced. It is advisable to leave a crown of earth not less than 50 mm and not more than 100 mm in the centre and tapering towards the sides of the trench.

The temporary reinstatement of roadways should be inspected at regular intervals, more frequently in rainy season and immediately after overnight rain for checking settlement and if required the temporary reinstatement should be done.

After the subsidence has ceased the trench may be permanently reinstated and the surface restored to the best possible condition.

## **(24) Manholes**

Manholes shall be provided at every proposed joint location for jointing bays and as

directed by the Employer. The bidder shall identify the location of the joint bays after carrying out detailed survey of the cable route and excavation of the trial pits. The delivery lengths of the cables shall match the location.

The Contractor shall get inspected, by a representative of the Employer, all manholes before carrying out the backfilling. Pipe & cable sealing, installation of joint box and cable service loops as per approved drawings shall be visually inspected and checked for tightness.

The contractor shall submit design and drawing of joint bay including manholes for withstanding a live load of 20 ton vehicle plus 30% for impact from moving vehicle. The Contractor shall propose a suitable procedure for testing the manhole for approval by the Employer. Manholes type approved by the Employer only shall be acceptable. The manhole shall include sufficient number of suitable entries. I seriously caution against using joint pits with manholes. They become a major source of maintenance headaches with no benefit to the utility. With XLPE cables and heat shrink jointing there is no reason to have permanent access to a joint position. Joint holes can be backfilled with sand and given extra mechanical protection above the sand and then completely buried. The important aspect is to make sure joint positions are recorded and if considered necessary to place a marker somewhere near the joint position. Clearly it is best to avoid making joints in roadway, should this be unavoidable then extra depth and mechanical protection will prevent possible damage from traffic. In the event of cable faults, modern fault location techniques will enable accurate location of faults, therefore there will be no necessity to have access to any joints during fault finding. Should the fault location be in a joint, excavation will be a simple matter.

**(25) Tools and Plants**

The successful bidder shall arrange, at his own cost, all necessary tools, plant and equipment to carry out the survey and cable installation work. The bidders are instructed to give all the details of equipment at their disposal, to carry out the work successfully and speedily.

**(26) Bending Radius**

The cables shall be treated with according to manufacturer's recommendation. Any overstress due to over-bending, excess pulling must be avoided. The minimum bending radius of XLPE insulated cables shall be  $20XD$  where "D" means the Outer diameter of the cable.

**(27) Jointing and Termination of Cables**

The cable jointing personnel and his crew shall have good experience in the type of joints and terminations that are used. The jointing work shall commence as soon as two or three lengths of cables have been laid. All care should be taken to protect the factory-plumbed caps/ seals on the cable ends. The cable ends shall be protected all the times with heat shrink end caps.

Jointing of cables in carriage ways, drive ways under costly pavings, under concrete

or asphalt surfaces and in proximity to telephone cables and water mains should be avoided whenever possible.

Cable overlap of at least 1.5 m shall be allowed for making the joints.

The joint bay should be of sufficient dimensions to allow the jointers to work with as much freedom of movement and comfort as possible. Sufficient space should be kept below the cable to be jointed.

The joints of different phases shall be staggered in the jointing bay.

**(a) Sump-holes**

When jointing cables in water logged ground or under unforeseen rainy conditions, a sumphole should be made at one end of the joint bay, in such a position so that the accumulated water can be pumped or taken out by buckets, without causing interference to the jointing operation.

**(b) Tents/Covers**

An enclosure or suitable protection cover shall be used in all circumstances wherever jointing work is carried out in the open, irrespective of the weather conditions. Joints shall be made in as clean an environment as practicable.

**(c) Precautions Before Making a Joint**

The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/ inclement weather conditions, which might become uncontrollable.

If the cable end seals or cable ends are found to have suffered damage the cables should not be jointed, without tests and rectification.

**(d) Measurement of Insulation Resistance**

Before jointing, the insulation resistance of both sections of cables shall be checked.

**(e) Identification**

The identification of each phase, shall be clearly and properly noted. The cables shall be jointed as per the approved design. Each cable shall have identification for phase at joint bays.

**(f) Making a Joint**

Comprehensive jointing instructions should be obtained from the manufacture of jointing kits and meticulously followed.

The materials used in the joints like ferrules, screen/sheath continuity bonds, lugs etc., shall be of good quality and conform to standards.

The jointing tools shall be appropriate and as per the requirement of jointing XLPE cables.

All cable joints and terminations must be carried out by qualified personnel. The cable

jointers must be in possession of a valid trade certificate for jointing works from a recognized institution. CVs of cable jointers shall be approved by Employer prior to commencement of works.

**(28) Cable Laying & Terminations**

The preparation of the cable end for installing the terminations and the precautions to be taken before fixing the terminations shall be followed as in the case of the cable jointing procedures. The instructions furnished by the termination manufacturer shall be strictly followed. Cables shall be terminated at RMU, Distribution Transformers, Switches or LT distribution boxes.

At cable terminating end, the following provisions for supply and erections are to be included:

- (a) A sufficient length of spare cable shall be left in the ground, for future needs.
- (b) The rise of the cable immediately from the ground shall be enclosed in PVC/PE pipe of suitable diameter to protect against direct exposure to the sun.
- (c) The cable shall be properly fastened using non-metallic clamps.
- (d) Appropriate labels shall be fixed identifying the phase circuit, voltage and date of commissioning etc., on the cable supporting structure.

**(29) Bonding of Screen**

The cable earth screens shall be bonded to earth at the termination positions.

As indicated previously, cross bonding is not necessary on 11kV systems.

**(30) Connection of Radial Water Barrier and Cable Screen**

If the metallic radial water barrier is insulated from the metallic wire screen, a connection suitable to carry the currents occurring during operation must be installed between metallic radial water barrier of the cable and metallic wire screen in joints and sealing ends.

**(31) Measurement (for Civil Works)**

The buried cable trench shall be measured in the running meters including excavation, back filling, thermal back filling (if applicable), compaction, laying of concrete/reinforcement, placing of warning tape markers, dewatering as required as per the drawing & specification & any other job required for successful completion of work.

**(32) Optical Fibre Cable (For Communication Equipment)**

Optical fibre cable required for Communication Equipment shall also be laid in the same cable trench in separate HDPE pipe.

**(33) Miscellaneous**

All the civil works associated with laying of underground cable are described in Civil Works

### **(34) Inspection and Tests**

Through the work execution, various inspections and tests on the progressing works will be ordered to the Contractor by the Employer.

Following inspections and tests will be carried out after completion of the works section by section. The Contractor shall perform all the inspections and tests in accordance with IEC Standard.

#### Underground Power Cables:

- ♦ Visual inspection of the underground cable lines
  - Back filling and grade
  - Cable and joint marks
  - Cable termination and connection
- ♦ Measurement insulation resistance of the lines
- ♦ H. V. test

#### **(a) Tests for 11 Kv Power Cables, Straight Joints and Accessories**

##### Test at works

The following tests shall be carried out at the manufacturer's plant before shipment as far as applicable for type of conductors and cables:

- ♦ 11 kV XLPE power cable
  - i) Appearance check
  - ii) Conductor resistance measurement
  - iii) Capacitance measurement
  - iv) Insulation resistance measurement
  - v) A.C. withstand voltage
  - vi) A.C. long duration withstand voltage
  - vii) Impulse withstand voltage
  - viii) A.C. long duration breakdown voltage
  - ix) Impulse break-down voltage
  - x) Dielectric loss tangent
  - xi) Temperature-voltage characteristic
  - xii) Dimension
    - Conductor outermost diameter
    - Insulation thickness
    - Sheath thickness
    - Over-sheath thickness
    - Thickness of each tape
    - Interval of tape lapping
    - Total diameter
  - xiii) Bending withstand characteristic
  - xiv) Over-sheath, tensile strength
  - xv) - do - , thermal aging
  - xvi) - do - , oil-proof

- xvii) - do - , non-inflammability
- xviii) - do - , thermal deformation
- xix) - do - , hardness
- ♦ Sealing/termination ends or straight joints
  - i) Construction
  - ii) A.C. long duration withstand voltage
  - iii) Impulse withstand voltage
  - iv) A.C. long duration breakdown voltage
  - v) Impulse breakdown voltage
  - vi) Porcelain or epoxy insulator, construction
  - vii) - do - , power frequency flash-over voltage (dry)
  - viii) - do - , power frequency flash-over voltage (wet)
  - ix) - do - , 50% impulse flash-over voltage
  - x) - do - , cantilever strength
  - xi) - do - , thermal mechanical performance

Test on Completion:

After completely installing the 11 kV XLPE power cables, sealing ends and other conductors at site, the following test shall be carried out by the Contractor:

- ♦ D.C. High voltage test

**(b) Special Requirement**

Small cut piece lengths of cables will not be accepted. Cables up to 500 meters in length or as approved by Employer/Employer's Representative shall be of one length shipped in a drum of adequate size. For higher quantities, multiple lengths/drums may be shipped subject to the approval of Employer/Employer's Representative.

**(c) Drawings, Data & Manuals**

The following information shall be furnished along with the Tender.

- ♦ Manufacturer's leaflets giving constructional details, dimensions and characteristics of different cables.
- ♦ Current rating of cables including de-rating factor due to grouping, ambient temperature and type of various installation.
- ♦ Write-up with sketches illustrating the manufacturer's recommendation for splicing, jointing and termination of different types of cables.
- ♦ Type test report of power cables. The Bidder shall clearly describe the type and routine tests to be performed on cables.
- ♦ Drum length for each of cable.

**(d) Performance Guarantee**

The performance figures quoted on schedule of Technical Data shall be guaranteed within the tolerance permitted by relevant standards and shall become part of the Contract. In case of failure of the cables to meet the guarantees, the Employer reserves the right to reject the item. The Contractor shall have to rectify/replace the



defect/defective part at no extra cost to the Employer and without delaying the commissioning schedule.

**(e) Spare Parts, Tools & Instruments**

The bidder shall also furnish Manufacturers recommended spare parts, tools & Instruments with price. The Contractor shall submit an itemized list of such equipment.

**(A2) Cable Termination Kit and Joint Kit for XLPE**

**(1) Scope**

This specification covers the design, manufacture, factory test, supply and delivery of heat shrinkable, push on type termination and joint kits for 11 kV, 3 core screened, armoured, with aluminium conductor XLPE cables suitable for earthed system and confirming to relevant standard with latest amendment, if any.

The termination kits for the use on 50 Hz, 3 phase system with earthed neutral for working voltage of 11 KV.

**(2) Description**

- (a) All high voltage terminations and jointing kits shall be standard quality type. They shall be factory engineered kits containing all the necessary components to reinstate the cable insulation, metallic shielding of each core, together with the reinstatement of the sheath, of the cable being terminated.
- (b) The heat shrinkable termination and joint kit shall be manufactured and tested in accordance latest version of IEC, or any other national or international standard that ensures at least a substantially equal quality to the standard mentioned above will also be acceptable.
- (c) The manufacturer of the termination and joint kit (Indoor, outdoor and straight-through) must have been accredited with ISO 9001 quality certification. The heat shrinkable/push on type terminations offered shall be of proven design and make, which have already been extensively used and fully type tested.
- (d) The entire termination and joint kit shall be environmentally sealed and capable of preventing the ingress of external moisture and contamination.
- (e) Kits shall contain sufficient cleaning solvents and cleaning clothes for the proper making of the joint or termination.
- (f) Voltage stress relief shall be provided and this may be inherent in the heat recoverable polymeric material.
- (g) The terminating or jointing materials shall not be subjected to storage limitations such as controlled temperature or humidity restrictions, nor have self-life limitations.

**(3) Other Requirements**

- (a) The outdoor termination kits shall be suitable for terminating the cable at steel cross arm complete with brackets, terminals, saddles and all necessary materials for fixing the termination. The heat shrinkable termination kit to be supplied and



installed under this scope of work shall be capable enough to cope with all the weather change. Terminations that do not require manually built stress relief cones or field pouring compound are preferred.

The term heat shrinkable refers to extruded or molded polymeric materials which are cross-linked to develop elastic memory and supplied in expanded or otherwise deformed size/shape, subsequently heating in a non-constrained state to a temperature above the shrink temperature resulting in the material recovering or shrinking to its original shape

- (b) Since the sealant or adhesives (to be used for environment sealing) between the heat shrinkable materials and XLPE cables shall be exposed to high electrical stresses, they must be track resistant.
- (c) The heat shrinkable polymer materials being used for external leakage insulation between the high voltage of conductors and grounds should be weather resistant.
- (d) All cuts/nicks inadvertently occurred to XLPE insulation must be rendered discharge free by using suitable discharge suppression compound.
- (e) The heat shrinkable tubing may be either extruded or moulded type.
- (f) Higher thickness of heat shrinkable sleeves shall be preferable to counter erosion due to pollution.
- (g) Push on type (Terminations only):
- (h) Rubber components should be made from proven quality of tuber with tested curing properties.
- (i) The semi conducting portion of the stress cone should be vulcanized with insulation so that both semi conducting and insulation portion becomes an integrated part.
- (j) The stress cone must be of proven design of stress control.
- (k) The moulding of rubber components should be aimed to achieve a smooth finish on interior and exterior of the components.
- (l) The stress cone should probably be reusable type.
- (m) In case of outdoor terminations, the suitable provision for covering the cable cores with re-useable protective system from the crotch seal to the bottom of stress cone should be made.

Accessories shall match the cable test ratings in all respects. The material and components not specifically stated in the specification, but which are essential for satisfactory operation of the equipment shall be included without any extra cost.

The termination and joint kits shall be of suitable for following cables:

- ♦ Indoor use for 11 kV, 3-cores Aluminium XLPE insulated Power cables.

#### **(4) Testing**

The routine tests of the kits shall be done at manufacturer's plant in accordance with IEC or other equivalent national or international standards including following tests.

- ♦ Appearance Test
- ♦ Construction Test

- ♦ High Voltage Test

**(5) Bid Documentation**

- (a) The Bidder shall provide with the Bid two (2) clear copies of the manufacturer governing Standard of the termination and joints and kits two (2) clear copies of all other relevant standards referenced herein.
- (b) The Bidder shall provide certified type test results of the termination and joint kits as required by governing standards.
- (c) The Bidder shall provide complete description, catalogue and drawings of the termination and joint kits.
- (d) A clause-by-clause commentary on specification, specifying compliance and deviation, if any.
- (e) All data, drawing, catalogue and other technical documents supplied shall be bound separately from the Bid Document.

**(B) HDPE PIPE AND PPR PIPES**

**(1) Scope**

This Specification covers the fabrication and supply of 160 mm (outer diameter with inner dia 152mm) Flexible HDPE Pipe and PPR Pipes used for XLPE power cable in underground 11kV distribution system.

**(2) Description**

The HDPE pipes are black and should suitable for inserting cable. The flexible conduit pipe shall be corrugated hard polyethylene pipe shall be used for installation of XLPE power cable. The flexible pipe shall be buried before the cable installation and, then the cables shall be pulled in. The HDPE pipe material should be Fire Retardant or non-Flammable.

The HDPE pipes shall be fabricated and tested in accordance with BS: 3412, Class N HDPE or any revision thereof or other equivalent national or international standard provided that ensure at least equal or better quality to the standard mentioned above will also be acceptable. The minimum tensile strength of the pipe shall be 240 kg/cm<sup>2</sup>.

The HDPE pipe should be suitable for 4kg/cm<sup>2</sup> pressures with thickness not less than 6.5mm and weight of the HDPE pipe should not be less than 2.5kg per meter. The HDPE pipe shall have a minimum tensile strength of 3200 kg/mm<sup>2</sup>. The HDPE pipes should have design at 27°C for a stress of over 50kg/cm<sup>2</sup> with safety factor of 1.3.

The flexible conduit pipe shall be strong enough to withstand the compression force from heavy trucks or lorries when it is buried more than 80cm below the ground level and temperature rise up to 80°C.

The PPR pipes shall be fabricated and tested in accordance with EN ISO 15874, Class PN20 and PN25 or any revision thereof or other equivalent national or international standard provided that ensure at least equal or better quality to the standard mentioned above will also be acceptable. The specific chemical structure of green PPR should be

present to provide the well balanced mechanical properties and superior long term heat resistance.

**(a) For HDPE Pipe 160mm diameter**

Sl. No.	Description	Unit	Requirement
1	M.F.R. ( 190°C, 5kg load)	gm/10 mins	0.20 to 1.10
2	Specified base densiity		940 to 958
3	Material Grade	kg/m <sup>3</sup>	PE-63
4	Wall Thickness	mm	7.7 - 8.7
5	Carbon Black	%	2.5 ± 0.5
6	Antlox Idant	% by mass	<0.3% by mass
7	Overall Migration	mg/dm <sup>2</sup>	10 Max
8	Reversion	%	<=3%
9	Hydraulic Characteristics		No sign of localized swelling, leakage or weeping (at 80°C for 48 & 165 hrs.)
10	Continuous Temperature withstand capacity		120°C

**b) Accessories**

The flexible conduit pipe shall be provided with necessary accessories, such as joints and sealing material etc. The straight joint sleeve shall be made of high density polyethylene black coloured and to be so designed as to be screwed on to flexible pipe.

Bell mouth shall be fixed to the end of corrugated pipe to facilitate cable pulling in. The bell mouth shall be so designed as to screw into the pipe. It shall be made of hard density polyethylene and colored black.

Water proof materials for pipes in manhole shall be mounted to an outlet of duct to keep the water tightness. The waterproof materials shall be comprised the components such as sand-proof seal, sealing tape, neo seal compound, VUL-CO tape, PVC tape and other necessary materials to complete the specified scope of works.

**(3) Tests**

The type test and routine tests shall be carried out for the materials to be supplied according to the above mention technical specification in accordance with the governing standard.

**(4) Packaging**

The packing should be done for the materials to be supplied accordingly.

**(5) Bid Documentation**

- The Bidder shall provide a complete description, and catalogue of materials.
- The Bidder shall provide certified test report as required by governing standards for materials.
- A clause-by-clause commentary on specification, specifying compliance and deviations, if any.

- (d) All data, drawings, catalogues and other technical documents shall be bound separately from the Bid documents.

## **(C) MISCELLANEOUS**

### **(C1) Ground Rods and Clamps**

#### **(1) Scope**

This Specification covers the fabrication and supply of galvanized steel ground rods and clamps for use in overhead power line construction.

#### **(2) Description**

##### Ground Rod:

- (a) The ground rod shall be made of high carbon, open-hearth steel so as to achieve maximum strength. It shall be hot dip galvanized.
- (b) The ground rod shall be 19mm in diameter and 34,000 mm in overall length.
- (c) The driven end of the ground rod shall have a truncated cone point. The cone point shall be approximately 13mm long, measured along the axis of the ground rod. The driving head of the ground rod shall have an approximate 3 mm, 45 degrees chamfer.
- (d) The manufacturing process shall assure that ground rod does not bend when driven into hard soils.

##### Ground Rod Clamp:

- (a) The ground rod clamp shall be heavy duty forged steel clamp provided with a hex head cup point set screw of high strength steel with machine cut threads. It shall be so manufactured that it gives low resistance connection. The ground rod clamp shall be galvanized.
- (b) The clamp shall suitably accommodate and clamp a 19 mm. ground rod and a stranded grounding conductor of 7/12 SWG size (SPECIFICATION: SP 4.5.2).

#### **(3) Galvanizing**

The galvanization of ground rod and clamp shall be in accordance with IS: 2629-1985 or any revision thereof or other equivalent national or international standard provided that ensure at least equal or better quality to the standard mentioned above will also be acceptable.

#### **(4) Tests**

Grounds rods and clamps shall undergo type and routine tests in accordance with the relevant governing standard.

### **(C2) Grounding Conductor**

#### **(1) Scope**

This specification covers the fabrication and supply of galvanized stranded steel

grounding conductor for use in the neutral grounding of distribution transformers and body grounding of electrical equipment.

**(2) Description**

- (a) The conductor shall be 7 wire stranded conductor and shall conform to the characteristics as specified in Table 1 contained herein. Stranded conductor shall be galvanized.
- (b) The manufacturer of ground Conductor must have been accredited with ISO 9001:2000 with design and manufacturing quality certification.

**(3) Galvanizing**

The grounding conductor shall be galvanized after fabrication in accordance with IS: 2629-1985 or any revision thereof or any other national or international standards that ensure at least equal or better quality to the standard mentioned above will also be acceptable.

**(4) Tests**

The grounding conductor shall undergo type and routine tests in accordance with the relevant governing standard.

Grounding Conductor Minimum Requirements:

7 No. 12 SWG:

- ♦ Diameter of single strand..... 2.67 mm
- ♦ Weight ..... 299 kg/km
- ♦ Short time fusing current ..... 12 kA
- ♦ Resistivity ..... 15 Micro-Ohm-cm

**(D) CIVIL WORKS**

**(1) Site Works**

**(a) Work Included**

Furnishing all materials equipment and labor and performing all operations required for constructing access roads so indicated on the drawings, specified herein and as evidently necessary to complete to work as given in the price schedule.

**(b) Laying of underground cable**

Contractor shall furnish all construction work for under grounding of 12 kV cables. This work shall include excavation, sand filling from the top.

**(2) Foundations**

**(a) Work Included**

Furnishing all materials, equipment and labor and perform all operations required for the design and construction of all the concrete foundations for equipment and other

structures, oil containment and cable trenches, as specified herein and as evidently necessary to complete the work.

**(b) Foundation Design**

♦ General

The Contractor shall design all foundations as shown in the Drawings. The design shall be based on assumed soil parameters. Upon completion of the detail soil test, actual soil conditions shall be investigated and shown to be in compliance with the assumed condition.

♦ Submittals

Before commencement of the works, the Contractor shall submit design calculations, detailed drawings and reinforcement steel schedules to the Engineer for review and approval. Review of the foundation design by the Engineer shall not relieve the Contractor of his responsibility for an adequate foundation design. Upon receiving the Engineer observations (if any), the Contractor shall submit the full set of final drawings of all foundation details, including reinforcement steel schedules as established in Sub-Section 117: "Contractor's Drawings".

♦ Design Load

The structure design loads are defined on the structure outline drawings and the loads used to design the foundation shall be actual working loads applied to the foundations by the equipment and structures. The foundations shall be designed to resist all vertical and lateral forces, uplift forces and overturning moments with a minimum factor of safety of 1.5.

♦ Bearing Loads

The Contractor shall use an allowable soil bearing pressure of 1.0kg/cm<sup>2</sup> for the design of the foundation for the purpose of bidding, but this is only reference value. After award of contract the Contractor shall carry out detail soil test and detail design of foundation based on the soil test result. There may be variation in the volume of work in final design compared to the bidding design, for which the Contractor will not get any extra payment.

♦ Uplift and Overturning Loads

The uplift and overturning resistance of concrete spread footing shall be assumed as the weight of a volume of earth in the form of an inverted frustum of cone or pyramid. The cone or pyramid height shall be 30cm less than the depth from finish grade to the top of the concrete mat, the base area shall be the top area of the mat and the top area shall be determined by the intersection of planes starting at the mat edges and sloping outward at a 20 degree cone angle from the vertical and the horizontal plane 30 cm below finish grade.

♦ Unit weight for overturning resistance

The following unit weight shall be used for design:

- 
- |                 |                         |
|-----------------|-------------------------|
| ✓ Soil.....     | 12,000kg/m <sup>3</sup> |
| ✓ Concrete..... | 16,00kg/m <sup>3</sup>  |
- 

**(c) Ground bearing tests**

The Contractor shall carry out the required tests in accordance with Section 3000: “Sub-Surface Geotechnical Investigations” of these Specifications to determine the ground bearing capacity by means of a Standard Penetrations Test and Auger Boring or a method approved by the Engineer.

Soil sampling shall be made in accordance with ASTM D-1587-63T and the Standard Penetration Tests in accordance with ASTM-D-1586-64T.

Every undisturbed sample collected from thin-walled tube shall be subject to the following series of test:

- ♦ Natural moisture content
- ♦ Atterberg limits
- ♦ Sieve analysis
- ♦ Unit weight
- ♦ Specific gravity determination
- ♦ Unconfined compression tests

Accurate log of all soil strata penetration resistance test unconfined compressive strength, soil classification, ground water table and other tests result shall be recorded in the reports submitted.

**(b) Excavation and Backfill**

Excavation and Backfilling works shall be made in accordance with the requirements of Section 900: “Earthworks” and other pertinent and relevant sections of these Specifications as applicable, and as approved by the Engineer.

**(c) Concrete**

The concrete for these works shall met the requirements of Concrete Class C described in Section 2000: “Concrete for Structures” of these Specifications.

When placing concrete in hot weather, the recommendations of the American Concrete Institute’s publication “Recommended, Practice for Hot Weather Concreting”(ACI 605) shall be followed as directed by the Engineer. Concrete with a temperature higher than 30°C before placement shall be rejected and shall be wasted at the Contractor’s expense.

**(d) Steel reinforcing bar**

Steel reinforcing bar shall conform to the requirements of Sub-Section 2014: “Reinforcement” and other relevant sections of these Specifications.

**(e) Grouting**

Grouting for seating structural steel members and equipment on foundations shall be

made conforming the requirements of relevant sections of these Specifications.

#### **6506 MEASUREMENT**

The works for this item shall be measured in lump sum but summarized in each linear metre of the Transmission Line actually constructed/installed, satisfactorily tested according to Clause 509(3): “Testing and Commissioning” and conforming the requirements of Clause 9: “Test on Completion” of the Conditions of Contract, confirmation of proper function of the established system, satisfying all requirements of these Specifications, in accordance with the Drawings, and approved by Engineer.

#### **6507 PAYMENT**

The works for the Transmission Line shall be paid under this Section in lump sum which shall be the full and the final compensation to the Contractor as per Clause 112 including the cost for Design Review and Updating, provision of all materials, all operations required for construction as shown in the Drawings and described in this Item including drawings, tests, cabling, civil works and all other ancillary works and any incidental work needed to complete the work as per these Specifications and/or directed by the Engineer.

Item No.	Description	Unit
<b>6500</b>	<b>Transmission Line</b>	
6500-1	Transmission Line	lin.m.



## **SECTION 7000: ROADSIDE SERVICE STATION**

### **7001 DESCRIPTION**

This work shall include the Design Review and Updating by the Contractor based on the Conceptual Design provided by the Employer. The report of the Design Review shall include also all detailed drawings, applicable technical specifications and requirements for construction and materials.

This works shall include all the necessary civil works, water supply and sanitation works, and electrification works as per the specification, the Drawings and instruction by the Engineer.

The works shall consist of the following:

- ◆ Water Supplying System
- ◆ Parking Area Lighting System
- ◆ Restaurant Building
- ◆ Shopping Building
- ◆ Toilets Building
- ◆ Sewage System
- ◆ Security Guard Office Building

The works shall include furnishing all materials, construction of the above referred buildings and systems, and all ancillary works and any other incidental necessary to complete the Works in conformity with the Drawings and these Specifications, or as directed by the Engineer.

### **7002 STANDARDS**

The works for design's verification and construction of the Roadside Service Station shall conform in all respects to highest standards of engineering, design, workmanship, this specifications and the latest revisions of relevant standards applicable in Nepal (Specifications of Building Construction Works and Nepal National Building Code NBC206: 2003 - Architectural Design Requirements)

### **7003 CONSTRUCTION METHOD AND DESIGN REVIEW AND UPDATING REPORT**

Before commencement of the works, the Contractor shall prepare and submit to the Engineer, for review and approval, a construction method statement and the detailed report of the Design Review and Updating for the Roadside Service Station. These documents shall be attached to the Program which requirements are described in Section 116: "Programme".

### **7004 MEASUREMENT**

The works for this item shall be measured respectively in accordance with the specified units and method established in the relevant sections of these Specifications.



## 7005 PAYMENT

The works for the construction of the Roadside Service Station shall be paid under this Section at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 including the cost for Design Review and Updating, provision of all materials, all operations required for construction as shown in the Drawings and described in this Item including drawings, tests and all other ancillary works and any incidental work needed to complete the work as per these Specifications and/or directed by the Engineer.

Item No.	Description	Unit
<b>7000</b>	<b>Roadside Service Station</b>	
7000-1	Park area lighting system	nos.
7000-2	Restaurant building	sq.m
7000-3	Shopping building	sq.m
7000-4	Toilet building	sq.m
7000-5	Security guard office building	sq.m
7000-6	Water supply system including pipeline from western portal water tank to water supply tank	lump sum
7000-7	Sewage system including sewage pipeline, manhole with casting cover (Heavy duty) and treatment system	lump sum
7000-8	Roadside Service Station restaurant tables and chairs	PS

## SECTION 7500: STEEL BRIDGE FOR FLYOVER

### 7501 DESCRIPTION

This work shall include the following:

- ◆ Superstructure
- ◆ Reinforced Concrete Substructure
- ◆ Shinso Piles (Cast-in-Situ Pile by Manual Excavation) Foundation
- ◆ Boring (100mm Dia.) with SPT (@1m) and Corresponding Laboratory Tests and Reporting

The works shall include furnishing all materials, fabricating, transporting, erection, painting structural steel, rivet steel, cast steel, steel forgings, cast iron, providing all materials and construction of reinforced concrete substructure and Shinso Piles (Cast-in-Situ pile by manual excavation) for foundation, and all ancillary works and any other incidental necessary to complete the Works in conformity with the Drawings and these Specifications, or as directed by the Engineer.

This work shall also include the Design Review and Updating by the Contractor based on the Conceptual Design provided by the Employer. The report shall include also all detailed drawings, applicable technical specifications and requirements for construction and materials.

### 7502 MATERIALS

#### (1) Superstructure

The materials for construction of the steel superstructure shall meet with the following requirements:

Superstructure Component	Material	Specification and Requirements
Main Girder	Structural Steel	<ul style="list-style-type: none"> <li>◆ Section 600: "Materials and Testing of Materials"</li> <li>◆ Section 2014: "Reinforcement"</li> <li>◆ Steel SM90YA (or equivalent); SM400A (or equivalent)</li> </ul>
	High Tension Bolts	◆ Section 2200, IS: 961 with minimum tensile strength of 58 kg/mm <sup>2</sup>
	Erection of Girder	◆ Sub-Section 2204: "Erection"
	Painting of Girder	◆ Sub-Section 2205: "Painting"
RC-Slab	Concrete Class A	◆ Section 2000: "Concrete for Structures"
	Reinforcement Bar	<ul style="list-style-type: none"> <li>◆ Section 600: "Materials and Testing of Materials"</li> <li>◆ Section 2014: "Reinforcement"</li> </ul>
Railing and Guard Wall	Concrete Class A	◆ Section 2000: "Concrete for Structures"
	Reinforcement Bar	<ul style="list-style-type: none"> <li>◆ Section 600: "Materials and Testing of Materials"</li> <li>◆ Section 2000: "Concrete for Structures"</li> </ul>
	Railing; Fencing Type-F	<ul style="list-style-type: none"> <li>◆ Sub-Section 3105: "Railing"</li> <li>◆ Section 400: "Fencing"</li> </ul>
Wearing Surface	Waterproof sheets	◆ Section 1300: "Bituminous Surface and Base Course"
	Asphalt Concrete (50mm thick)	◆ Section 2000: "Concrete for Structures"

Superstructure Component	Material	Specification and Requirements
	Kerbs (Concrete Class-C)	
Elastomeric Bearing	Maximum reaction from superstructure: A1 (1,500kN to 3,500kN) P1 (3,500kN to 4,000kN) P2 (3,500kN to 4,000kN) P3 (3,500kN to 4,000kN) A2 (1,500kN to 3,500kN)	<ul style="list-style-type: none"> <li>♦ Section 600: "Materials and Testing of Materials"</li> <li>♦ Section 1900: "Bearings and Expansion Joints"</li> <li>♦ Sub-Section 1902: "Bearings", (4) Elastomeric Bearing</li> </ul>
Expansion Joint	Expansion Joint Type-B	<ul style="list-style-type: none"> <li>♦ Section 600: "Materials and Testing of Materials"</li> <li>♦ Section 1900: "Bearings and Expansion Joints" Sub-Section 1901: "Bearings"</li> </ul>
Drainage	Catch-Pit	<ul style="list-style-type: none"> <li>♦ Section 600: "Materials and Testing of Materials"</li> <li>♦ Section 3111: "Bridge Drainage"</li> </ul>
	PVC Drain Pipe (VP) φ200mm	

## (2) Reinforced Concrete Substructure

The materials for construction of the reinforced concrete substructure shall meet with the following requirements:

Substructure Component	Material	Specification and Requirements
RC-Pier and Abutments	Concrete Class B	♦ Section 2000: "Concrete for Structures"
	Reinforcement Bar	<ul style="list-style-type: none"> <li>♦ Section 600: "Materials and Testing of Materials"</li> <li>♦ Section 2014: "Reinforcement"</li> </ul>

## (3) Shinso Piles (Cast-in-Situ Pile by Manual Excavation) Foundation

The materials for construction of the cast-in-situ shinso piles foundations shall meet with the requirements of Sub-Section 1618: "Shinso Piles (Cast-in-Situ Pile by Manual Excavation)".

### 7503 CONSTRUCTION METHOD AND DESIGN REVIEW AND UPDATING REPORT

Before commencement of the works, the Contractor shall prepare and submit to the Engineer, for review and approval, a construction method statement and the detailed report of the Design Review and Updating. These documents shall be attached to the Program which requirements are described in Section 116: "Programme".

### 7504 MEASUREMENT

The works for this item shall be measured respectively in accordance with the specified units and method established in the following relevant sections of these Specifications:

- ♦ Section 400: "Fencing"
- ♦ Section 1300: "Bituminous Surface and Base Course"
- ♦ Section 1618: "Shinso Piles (Cast-in-Situ Pile by Manual Excavation)"
- ♦ Section 1900: "Bearings and Expansion Joints"
- ♦ Section 2000: "Concrete for Structures"
- ♦ Section 2200: "Structural Steel Work";
- ♦ Sub-Section 2018(1): "Concrete" (Measurement)
- ♦ Sub-Section 2018(4): "Reinforcement" (Measurement)

- ◆ Sub-Section 2204: “Erection”;
- ◆ Sub-Section 2205: “Painting”
- ◆ Sub-Section 2413: “Dry Stone Packing and Soling”
- ◆ Section 3000: “Sub-Surface Geotechnical Investigation”
- ◆ Sub-Section 3105: "Railing"
- ◆ Section 3111: “Bridge Drainage”

## 7505 PAYMENT

The works for the Steel Bridge For Flyover as measured above shall be paid under this Section at the respective contract unit rates, for the items shown here below, which shall be the full and the final compensation to the Contractor as per Clause 112 including the cost for Design Review and Updating, provision of all materials, all operations required for construction as designed, as shown in the Drawings and as described in this Item including drawings, tests and all other ancillary works and any incidental work needed to complete the work as per these Specifications and/or directed by the Engineer.

The payment method for “Shinso Piles (Cast-in-Situ Pile by Manual Excavation)” described in Section 1618 shall be applied.

Item No.	Description	Unit
<b>7500</b>	<b>Steel Bridge for Flyover</b>	
7500-1	Design review and update of the flyover bridge as per the specification, the Drawings and instruction by the Engineer	lump sum
<b>(1)</b>	<b><i>Superstructure</i></b>	
7500-2	Structural Steel Works for the Main Girder	ton
7500-3	Concrete Class A (M35/20, C30/20) for Superstructure	cu.m
7500-4	Concrete Class B (M30/20, C25/20) for Superstructure	cu.m
7500-5	Reinforcement for Superstructure	ton
7500-6	Fencing Type-F	lin.m
7500-7	Asphalt Concrete Wearing Course for Bridge (50mm Thick)	sq.m
7500-8	Bitumen Tar Felt	sq.m
7500-9	Elastomeric Bearing (Abutment) Type 1,500 kN to 3,500 kN	nos.
7500-10	Elastomeric Bearing (Pier) Type 3,500 kN to 4,000 kN	nos.
7500-11	Expansion Joint Type-B	lin.m
7500-12	Bridge Collapse Prevention Device for Steel Girders	set
7500-13	Casting Catch-Pit	nos.
7500-14	PVC Drain Pipe (VP) Φ200mm for Bridge Drainage	lin.m
7500-15	Kerb Type-C	lin.m
<b>(2)</b>	<b><i>Reinforced Concrete Substructure</i></b>	
7500-16	Concrete Class B (M30/20, C25/20) for Substructures	cu.m

Item No.	Description	Unit
7500-17	Concrete Class E (Lean Concrete) for Substructures	cu.m
7500-18	Reinforcement for Substructures	ton
7500-19	Dry Stone Packing and Soling	cu.m
(3)	<b><i>Shinso Piles (Cast-in-Situ Pile by Manual Excavation) Foundation</i></b>	
7500-20	Excavation above Shinso Piles Heads	cu.m
7500-21	Excavation of Shinso with Steel Lining (D=2.50m ~ 5.00m)	cu.m
7500-22	Excavation of Shinso with Shotcrete (D=2.50m ~ 5.00m, 100mm thick with steel net)	cu.m
7500-23	Excavation of Shinso with Shotcrete (D=2.50m ~ 5.00m, 200mm thick with steel H rib)	cu.m
7500-24	Excavation of Shinso without Protection (D=2.50m ~ 5.00m)	cu.m
7500-25	Concrete class-B (M30/20, C25/20) for Shinso Piles (D=2.50m ~ 5.00m)	cu.m
7500-26	Reinforcement for Shinso Piles	ton
7500-27	Boring (100mm dia.) with SPT (@1m) and corresponding laboratory tests and reporting	lin.m

Ministry of Physical Infrastructure  
and Transport, Department of  
Roads



Government of Nepal



# **NAGDHUNGA TUNNEL CONSTRUCTION PROJECT**

**LOAN AGREEMENT No. (NE-P10)**

**CONTRACT No. DOR - NTCP -W-ICB-01**

## **BIDDING DOCUMENTS**

### **PART 2: WORKS REQUIREMENTS (SECTION VI)**

#### **VI-C: Special Provisions to Standard Specifications (SPSS)**

#### **VOLUME- II : TUNNEL WORKS AND FACILITIES**



## **SECTION VI-C: SPECIAL PROVISIONS TO THE STANDARD SPECIFICATIONS (SPSS) FOR ROAD AND BRIDGE WORKS, ASAD, 2058 / JULY 2001**

### **PREFACE**

The Standard Specifications for Road and Bridge Works, ASAD, 2058 / July 2001 has not hitherto referred to tunnelling work.

In order to cope with various underground geotechnical behaviours likely to be encountered during construction, the Sections in the series of 4000s systematise the requirements of the civil elements of roadway tunnel construction, inter alia, underground excavation, ground support systems, waterproofing/drainage systems and final tunnel lining.

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## **SECTION 4000 – GENERAL REQUIREMENTS**

### **4001. Objectives and Application**

These specifications for Tunnel works - Civil Elements are prepared on a project specific basis for the use in Nagdhunga Tunnel Construction Project in the Kingdom of Nepal in mountain terrains using the New Austrian Tunnelling Method (NATM).

Tunnel features (dimensions, cross sections, shapes, orientations, support types, lining types, required construction sequences) have been determined in conformity to the following Japanese Standards taking into account of the ground conditions assumed from the findings of the ground investigations;

- 1) Standard Specifications for Tunnelling – 2006 [Mountain Tunnels] published by Japan Society of Civil Engineers (JSCE),**
- 2) Design Standard Section 3 [Tunnel] published by Nippon Expressway Company Limited (NEXCO), and**
- 3) Technical Standard for Road Tunnel [Structure Division] published by Japan Road Association (JRA).**

Notwithstanding the foregoing, other standards, where specified in these Specification Sections, shall be regarded as equally applicable under the Contract.

### **4002. Acronyms**

Whenever these abbreviations are used in these Specification Sections, they represent the following:

**AASHTO** - American Association of State Highway and Transportation Officials  
**ACI** - American Concrete Institute  
**ACGAI** - American Conference of Governmental Industrial Hygienists  
**ASTM**- American Society for Testing and Materials  
**AWS** - American Welding Society  
**JHS** – Japan Highway Standards  
**JIS** – Japan Industrial Standards  
**JCOSHA** – Japan Construction Occupational Safety and Health Association  
**JRA** – Japan Road Association  
**JSCE** – Japan Society of Civil Engineers  
**LSM** – Linier Schedule Method  
**NATM** – New Austrian Tunnelling Method  
**NEXCO** – Nippon Expressway Company Limited  
**SEM** – Sequential Excavation Method (aka New Austrian Tunnelling Method)

### **4003. Contractor's General Obligations**

Tunnel construction is inherently a dangerous undertaking. Excavation, mucking, support installation, shotcrete application, concrete placing and all other activities are carried out in a sequential way in close quarters often with moving heavy machinery.

The Contractor is required to fulfil the obligations described in more detail below. Payment for fulfilling these obligations is deemed included under other pay items.

Approval or consent given by the Engineer for the use of materials proposed by the Contractor shall not relieve the Contractor from any duties, obligations or responsibilities he has under the Contract.

#### **4003.1 Safety of Personnel**

Safety of personnel on the Site is the first priority above all in all construction activities. The Contractor shall vigilantly observe the requirements described hereunder. Rules and regulations currently effective under the laws of Nepal or bylaws imposed by the local authorities shall prevail in the event of disagreement.

Suitable Personal Protective Equipment (PPE) shall be provided to all persons permitted to be on site. PPE including head protection, respiratory protection, eye protection, reflective vest, etc. shall be of the type approved by the local authorities.

The Contractor shall prepare a written statement (a booklet) of safe systems of working which shall be issued to all persons at site.

##### **4003.1.1 Safety Training**

Persons when first employed on the Site shall be instructed in the hazards inherent in the Site, precautions to be taken, the form of construction, and emergency procedures and firefighting. The Contractor shall maintain a record of all persons on assignments and each person shall be required to sign such record confirming that instruction has been received.

In addition, the Contractor is required to hold a daily toolbox talk before entering into tunnels with the aim of promulgating the inherent risks related to the activities scheduled on the day. The toolbox talk shall be conducted by each ganger in charge of particular activities. The record of assignment mentioned above can be logged at the end of such toolbox meeting before starting the given assignments.

##### **4003.1.2 Fire Prevention and firefighting Arrangements**

Fire protection and proper firefighting arrangements such as fire extinguishers shall be provided on the tunnelling machines, other than machines which are too small to allow personal entry. Similar arrangement shall be provided when operations may emit potentially noxious gases or fumes in addition to ventilation arrangements stated hereinafter.

#### **4003.2 Temporary Electrical Installations**

Unless specified in the Contract, the Contractor shall be responsible for obtaining an adequate electrical supply for all his Site operations.

Installations shall comply with the current edition of the rules and regulations of the local authorities. If required by the Engineer, the Contractor shall make available a copy of all certificates prepared upon completion of electrical installations.

The Contractor shall appoint a competent person to be solely responsible for ensuring the safety of all temporary electrical installations,

### 4003.2.1 Ventilation during Construction

Constant supply of high quality breathable air is one of the more challenging safety aspects for tunnel workers. The Contractor shall provide a suitable ventilation system to remove dust caused by drill/blast and shotcrete as well as exhaust gases emitted from diesel engines during construction to comply with the requirements specified in Articles 86 [Ventilation] and 89 [Safety and Health] of Standard Specification for Tunnelling – 2006: Mountain Tunnels or as specified in these specifications. The ventilation rate that is required to dilute the gas emissions from diesel engines of construction machines and dust produced during drill/blast and shotcrete application should be calculated taking account of type and numbers of equipment used inside tunnels.

For safe working of persons in the tunnels, the Contractor shall use the following limit values in calculating the total fresh air requirement at the face area;

- (a) The minimum fresh air supply shall not be less than 3 m<sup>3</sup>/minute/person measured at the face,
- (b) The target dust (respiratory dust) concentration should be not more than 3 mg/m<sup>3</sup> measured at 50 m from the face,
- (c) The minimum air velocity throughout the tunnels shall not be less than 0.3 m/second, and
- (d) The maximum ambient temperature inside the tunnels shall be maintained below 30 degrees centigrade.

The Contractor shall, as a means of achieving the above values, determine the diameter of air piping and the capacity of fans, considering ventilation efficiency, machine efficiency and dimensions of profiles.

As drill/blast and shotcrete application take place at the face area, the Contractor will be required to provide a mobile dust collector attached extensible air duct at each tunnel face in order to achieve the limit value of the dust concentration.

For monitoring of the ventilation requirements, the Contractor shall provide necessary measuring devices to the satisfaction of the Engineer.

The Contractor shall submit a layout plan of his ventilation systems including dust collection systems along with a calculation of required fresh air supply for agreement with the Engineer before commencing tunnel excavation.

### 4003.2.1 Lighting during Construction

Suitable and sufficient lighting shall be provided in working places and pathways, so as to secure safe working environments. Working places such as the face need sufficient light that should exceed seventy (70) lux (1 lux = 1 lumen per square meter) in order that the work can be performed safely and efficiently.

It is also necessary to light walkway areas for the safe passage of workers and the safe operation of vehicles. It may be difficult to secure uniform light in the whole walkway areas, but the light of a minimum of ten (10) lux is necessary at the darkest site and twenty (20) lux in average is desired as recommended in Article 85 [Lighting] of Standard Specifications for Tunnelling – 2006: Mountain Tunnels.

### **4003.3 Security and Access Restriction**

The Contractor shall be responsible for the security and tunnel entry in and around all tunnels work areas. Tunnel security and exit/entry procedures and controls shall be detailed in the Contractor's safety plan (or health and safety plan) for the Works. The Contractor shall coordinate and plan tunnel security and entry with others having access to the tunnels, including all interfacing contractors, so as not to disrupt or interfere with their operations.

The Contractor shall provide and maintain fences and barricades in good conditions. Notice signs shall be displayed at intervals (as consented by the Engineer) around the Site and portal areas to warn the public of the dangers of entrance.

During the progress of the Works the Contractor shall maintain security patrols over the portal areas of the Works as may be necessary to protect the work and prevent trespassing.

### **4003.4 Entry/Exit Procedures**

The Contractor shall establish a procedure for recording all tunnel entry and exits, preventing unauthorized tunnel entry. This procedure, as a minimum, shall incorporate name cards and entry/exit records at all tunnel portals to record the entrance and exit of all personnel.

The Contractor shall set up and operate a system whereby only those persons entitled to be on the Site and/or in the tunnels can enter the Site and/or tunnel. The Contractor shall provide specific points of entry through a security fence or barricade. The Contractor shall provide gates and barriers at such points of entry and maintain a twenty-four-hour security guard or other security personnel as necessary to maintain security and prevent unauthorized entry

### **4003.5 Temporary Communication Systems**

The Contractor shall provide both a complete wired and a wireless telephone communication system capable of providing clear and concise communication between all tunnel works and the tunnel portals. The communication systems shall also provide for communication between the tunnel works, Contractor's site office, and Employer's and Engineer's site offices.

The Contractor shall maintain at all times both wired and wireless communication systems in full working order during construction. The communication systems and equipment shall be suitable for use in all area, providing clear and dependable communication. This shall be subject to approval by relevant authority prior to use as the case may be.

The communication systems shall incorporate underground communication stations (telephone receptacle with bell and Indication lamp) within 50-metre of any work and at 100-meter intervals along the driven tunnel. The Contractor shall provide and maintain communication systems until the completion and acceptance of all tunnel works or as otherwise required by the Engineer.

### **4003.6 Daily Records/Reports**

(a) Notwithstanding reports on other work activities, the Contractor shall prepare daily records and reports of all tunnel works that shall include the following information and data, or as directed by the Engineer.

- ◆ duration of sequential excavation,
- ◆ all personnel working in tunnel areas,

- ◆ work stoppage, with reason for stopping work,
  - ◆ all instrument recordings with appropriate graphs,
  - ◆ weather conditions,
  - ◆ tunnel work equipment,
  - ◆ tunnel water inflows,
  - ◆ size of excavated sections,
  - ◆ length of advance,
  - ◆ station numbers,
  - ◆ photographs (not less than 12 Megapixels) of all tunnel faces after excavation, before support system installation,
  - ◆ the location and number of supports system members etc. for each round, and
  - ◆ reports and records required under specific specification requirements.
- (b) Unless agreed with the Engineer, the Contractors daily records/report shall be submitted to the Engineer before 10 AM on the following working day, and
- (c) The Contractor shall, as witnessed in the presence of the Engineer, record in detail geological conditions and prepare geological maps with necessary photographs attached to evaluate the suitability of excavation methods and supports. These details and maps shall serve as the basis for anticipating geological conditions ahead of the excavated tunnel face.
- (d) The Contractor shall immediately notify the Engineer in case of substantial difference between actual geological conditions and anticipated ones, or when severe changes in geological conditions are observed.
- (e) For the recording of geological data by the Engineer, the Contractor shall give all necessary assistance, and provide all workforce, facilities and equipment as may be required by the Engineer.

#### **4004 Measurement and Payment**

Measurement is not performed for the Works described in this Section. The Works required under this section is a subsidiary obligation of the Contractor. Payment for such Works is indirectly included under the pay items listed in the Schedule (reference Sub-Clause 1.1.1.7 of the Conditions of Contract).

As a general rule, the rates in the Bill of Quantities shall be deemed to include all the cost, without limiting to the following, in respect of:

- (a) Provision of all labour, equipment and materials required for the execution and completion of the Works and remedying of any defects;
- (b) Provision for loading, hauling and stockpiling the excavated material on approved areas or points of incorporation into Permanent Works up to a lead of 5.0 km and all lifts from the tunnel face, re-handling of materials including segregating, grading, draining and drying of materials suitable for use in the embankment construction or as backfill;
- (c) All delays resulting from unfavourable weather conditions;

- (d) Complying with all requirements of statutory laws and regulations relating to the works and any restrictions resulting therefrom, obtaining all necessary permits and licenses for use and transport of explosives and other materials; and
- (e) Surveying, setting out, checking and monitoring of excavated profile, layouts and any subsequent rectification works.

## SECTION 4100 – TUNNEL PROFILE AND SUPPORT SYSTEMS

### 4101. General

Physical properties for a ground, typically expressed as a class of ground or rock/ground classification, shall be formulated in accordance with Standard Specifications for Tunnelling – 2006 [Mountain Tunnels] published by Japan Society of Civil Engineers based on the samples taken from upper half (above the spring line) tunnel section.

Support members are selected based on the ground classification, and the support pattern shall be determined in combination with selected support members. It will be necessary to properly modify the design by reviewing from time to time the class of ground and support pattern/combination during construction.

### 4102. Ground Classification

Rock/ground classification and the corresponding support types are determined generally on the basis of the parameters prescribed in the Standard Specifications for Tunnelling – 2006 [Mountain Tunnels]. These terms of ground classifications are also applicable to the tunnel profiles and the support patterns used thereto.

Notwithstanding the above classifications, a special support pattern, Type DIII, is required particularly at the portal zones as prescribed by the Standard Specifications for Tunnelling. Physical properties of ground are described below to provide helpful guidelines for determining support patterns.

- **Type CI**

Rock Classification: Relatively solid, fair discontinuity orientation and stable.

The rock strength is greater than the tangential and radial stresses induced by the tunnel opening. The condition of discontinuity is fair and the yielding by the tunnelling occurs partly.

The partial rock falls along discontinuity which is easy to slide relatively occur rarely, and the displacement induced by tunnel opening would remain in the range of roughly 15 to 20 mm or may be less due to elastic deformation. The face can be self-supported.

- **Type CII**

Ground Classification: Relatively solid but poor discontinuity and unstable.

The rock strength is not greater than the tangential and radial stresses induced by the tunnel opening. In other words, the displacement created by the tunnel opening will tend to remain within the limit of elastic deformation.

Despite the intrinsic strength of the rock in the tunnel relatively high, rock blocks are prone to fall off along the discontinuity planes resulting in further ground slackening. The displacement induced by the tunnel opening, in case the tunnel width is less than 10m along the spring line, may verge on the elasto-plastic boundary of 30 mm when intrinsic rock strength of rock is lower than the tangential and radial stresses. However, the ground movement will normally cease when the tunnel face is advanced by a distance approximately 2 times of the tunnel width measured along the spring line. The face can be self-supported



- **Type DI**

Ground Classification: Weathered, not solid, very poor discontinuity and unstable.

The rock strength is comparably as low as the tangential and radial stresses induced by the underground opening; elastic deformation and plastic deformation may occur spontaneously and concurrently.

Since the discontinuity orientation is very poor, even the rock strength may be sufficient to hold the elastic deformation, loosening may continue along the discontinuities. When strength of rock is lower than the tangential and radial stresses, the deformation or settlement may verge on the range of 30 to 60 mm unless the invert ring is closed by temporary or permanent means. Given the invert is closed in such a manner as agreed with the Engineer, deformation will normally cease, as with Types CII and CII-L, when the tunnel face is advanced by a distance approximately 2 times of the tunnel width measured along the spring line. The stand-up time of the cut face is so short that breast boards (face shotcrete) and ring cuts may be necessary following consultation with the Engineer.

- **Type DIII**

There is no ground classification according to the Standard Specifications for Tunnelling – 2006 [Mountain Tunnels]. Type DIII is specifically designated for application of support systems at portal areas irrespective of physical properties of the ground, such as degree of weathering, rock properties, material composition, planes of weakness (discontinuity) and etc.

Portals are frequently located in a generally weak geologic zone, where erosion develops and a complicated topography is created. Thus, tunnelling or construction of the portal is likely to cause landslides or slope failures.

Type DIII applies from the portal to the distance at which the depth of cover exceeds 2 times the diameter of the tunnel at the spring line. Actual application shall be determined with consultation with the Engineer.

#### **4103. Tunnel Profile and Support System**

Tunnel profiles and the corresponding combination of support types will be determined generally on the basis of the parameters prescribed in the aforesaid Standard Specifications for Tunnelling. The initial support system in a mountain tunnel can be one or a combination of a number of options: rock reinforcement (rock bolts), steel ribs, shotcrete, wire mesh, pre-supports, etc. The combination of these support options including final concrete lining are shown on the Drawings although these options depend largely on the ground conditions encountered during tunnel driving.

The Engineer shall at all times have the authority to instruct the Contractor to revise the support systems based on his observations and instrumental data.

#### **4104. Measurement and Payment**

Measurement is not performed exclusively for the Works described in this Section. Works required under this section are subsidiary obligations of the Contractor.

Payment for such Works is indirectly included under other pay items of the Bill of Quantities.

## **SECTION 4200 - INSTRUMENTATION AND MONITORING**

### **4201. Objectives and Application**

Instrumentation and monitoring are considered as an integral part of the NATM tunnelling for verification of the design assumptions on the interactions between the surrounding ground and the initial tunnel support systems induced during excavation process.

Works described herein are subsidiary obligations of the Contractor. Payment for such work is deemed included under other pay items. Compensation provided by the pay items included in the Schedules, defined in Sub-Clause 1.1.1.7 of the Conditions of Contract, is full payment for performing the obligations in a complete and acceptable manner. No separate payment shall be made.

### **4202. Method of Monitoring**

Monitoring of ground movement is the mandatory activities for which direct payment is not provided and is a subsidiary obligation of the Contractor to assure that the tunnel centre remains in the alignment.

The monitoring of the ground movement aims to detect the displacement and settlement of the initial tunnel support systems -- particularly the shotcrete lining -- and the ground surface while they are still small and to enable early support system modifications.

These monitoring are categorized under indirect payment items and shall consists of the following observations/surveys.

#### **(a) Visual Examination of the Tunnel Opening and Ground Surface**

##### **(i) Geologic mapping of the face after each round.**

Geologic mapping of the tunnel face and the round periphery is an important element for determining initial support systems.

Information typically included in these face maps include:

- The station location for the cross-section; the date and time the face mapping was prepared;
- The name of the individual who prepared the face map;
- Classification of each type of material observed; the location of interface boundaries between these materials;
- Rock jointing including orientation of principal joints and joint descriptions;
- Shear zones;
- Observed seepage conditions and their approximate locations on the face, walls, or roof;
- Observed ground behaviour noting particularly the location of any instability or squeezing material at the face;
- The location of any boulders or other obstructions; and
- Any other significant observations.

In rock tunnels where the perimeter rock is left exposed, sketches presenting similar information can be prepared for the tunnel walls and roof. All mapping shall be prepared by an experienced geologist or geological engineer of the Contractor knowledgeable of tunnelling and with soil and rock classification.

Mapping of the face, walls and roof shall occur for every excavation round and formally documented and signed off by both the Contractor and the Engineer in the format acceptable to the Engineer.

- (ii) Groundwater inflow, if observed.

The quantity of observed seepage shall be recorded and monitored on a daily basis for all groundwater inflow including seepages in the previous rounds as well. The method of measuring inflow quantity shall be subject to the Engineer's approval.

- (iii) Deformation of initial support systems after each round.

Ground movement along the tunnel alignment will be the primary cause of displacement or buckling of initial support systems. Amongst others, displacement, buckling and subsidence (settlement) of steel ribs, integrity of shotcrete with wire mesh/steel ribs and rock face, and potential damage to or loosening of rock bolt components, shall be visually checked by the Contractor's geologist or the geological engineer before using the survey instruments. Information thus obtained shall be recorded and presented to the Engineer for review before next excavation.

- (iv) Ground surface settlement along the tunnel centre

The Contractor is required to make close observation on potential anomalies such as surface cracking, tilting of trees, changes in stream water flow direction, displacement of the existing boulders, and other unusual phenomena. The Contractor shall record any such anomalies with each excavation cycle, and submit such records as soon as possible but well before next excavation takes place.

The Engineer may instruct the Contractor to lay surface settlement markers and/or benchmarks for observation of ground movement.

(b) Lateral and Vertical Displacement

As for the lateral movement of the tunnel opening, distance between the shotcrete surfaces shall be measured at the points illustrated in Fig-1 for full-face excavation profile and Fig-2 for top-heading and bench excavation shown below.

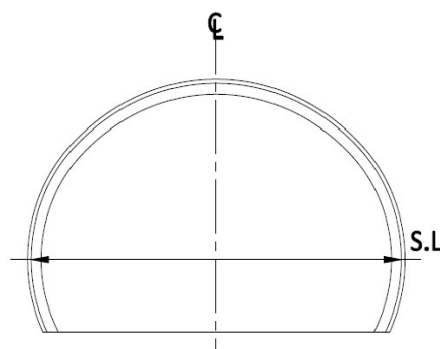


Fig-1: Full-face excavation

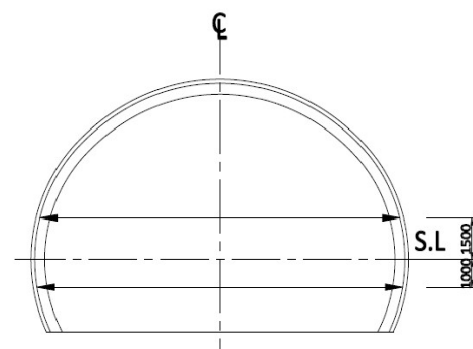


Fig-2: Top-heading and bench excavation

Vertical displacement of the tunnel cross-section shall also be monitored by surveying level of the crown.

Lateral displacement shall be measured at the spring lines for full-face excavation sections (Fig-1), and if tunnel is excavated sequentially, i.e. top heading ahead of bench, measurement shall be taken first at 1.5 meters above the spring line (Fig-2) for every top heading round.

Once bench excavation starts after the top heading excavation, the Contractor shall measure the displacement again at 1.5 meters above the spring line (Fig-2) and at 1.0 meter below the spring line (Fig-2) after each bench excavation round.

In unstable ground, which is vulnerable to excavation-induced stress relief such as DIII Rock Classification or tunnel sections near the portals under shallow overburden -- say less than about twice the tunnel width measured along the spring line -- additional measurements shall be taken along a pair of symmetrical lines between the points connecting the crown and points at 1.5 meters above the spring line (Fig-3).

In tunnel domains where any of or a combination of (i) excavation-induced sharp unsymmetrical pressure, (ii) settlement of steel rib, or (iii) ground heaving is likely to occur, the Engineer may instruct the Contractor to take further measurements along a pair of the symmetrical lines (indicated in dashed lines in Fig.-3) that connect the point at the crown and points at 1.0 meters below the spring line.

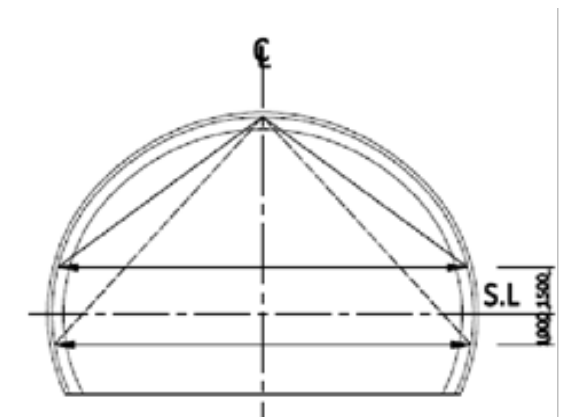


Fig-3: Lateral Displacement Survey Points  
for Top Heading & Bench Excavation

In case where the magnitude of the unsymmetrical pressure, settlement of steel ribs, or the ground heaving is considerable in the Engineer's judgement, the Engineer may instruct the Contractor to take readings of the vertical displacement at two off-set points from the crown in addition to the settlement reading of the crown level.

The number of survey points will be determined at the Engineer's discretion and the Contractor shall provide such survey points according to the Engineer's instructions given orally or in writing.

(c) Surface settlement above the centreline near the tunnel portal

Geological anomalies observed on the ground surface above tunnels, such as surface cracking, tilting of trees, changes in stream water turbidity and its flow direction, displacement of the existing boulders, and other unusual phenomena, shall be monitored and recorded in a format acceptable to the Engineer.

The Engineer may determine shorter intervals of survey points which are normally selected along the tunnel centre despite the normal intervals given in Table-1 below. Survey points may be increased on the ground surface at the Engineer's discretion in case readily noticeable movement is detected.

**Table-1: Depth of Overburden and Intervals of Survey Points**

Depth of Overburden	Intervals
Not exceeding D	5 m
Exceeding D and less than 2D	10 m

*D: Tunnel diameter at spring line.*

#### 4203. Monitoring Frequency and Interval of Distance

Lateral and vertical displacement of the tunnel opening shall be monitored at the frequencies indicated in Table-2, and at the intervals shown in Table-3.

**Table-2: Parameters of Monitoring Frequencies**

Monitoring Frequency <sup>(*)</sup>	Factors Controlling Monitoring Frequency <sup>(*)</sup>	
	Distance from Face	Rate of Lateral/Vertical Movement
2 times / 1day	0 – 0.5 D	Exceeding 10 mm / day
1 time / 1day	0.5 – 2.0 D	5 – 10 mm / day
1 time / 2 days	2.0 – 5.0 D	1 – 5 mm / day
1 time / 1 week	5.0 D or more	Not exceeding 1 mm / day

<sup>(\*)</sup>: Monitoring frequency will be determined by either the distance from face or rate of movement whichever effectuate higher frequency.

**Table-3: Intervals of Survey points**

Excavation Profiles	Interval of Survey points <sup>(*)</sup>			
	Within 50 m from Portal	50 – 200 m from Portal	Over 200 m from Portal	Overburden not exceeding 2D
CI & CII	10 m	20 m	30 m	10 m
DI	10 m	20 m	20 m	10 m
DIII	10 m	--	--	10 m

<sup>(\*)</sup>: The intervals will be determined by the Engineer based on the ground conditions encountered.

#### 4203.1 Surveying Requirements

- The Contractor shall use a total station for all surveys for accurate data collection. Thus, the Contractor shall submit to the Engineer for his approval details of the total station he proposes to use.
- All survey shall be conducted and controlled by a qualified professional surveyor having a minimum 3 years tunnel survey experiences using a modern total station.
- The required surveying accuracy is  $\pm 2$  mm for both lateral and vertical directions in any survey unless otherwise instructed by the Engineer. The surveying instruments shall be packaged with the minimum reading function not more than  $\pm 0.1$  mm.
- The lateral and vertical movement of the tunnel supports (and ground surface as well) shall be surveyed immediately after mucking is completed. It is recommended that the survey is conducted within 3 hours after completion of mucking. For synchronicity of the survey data between ground surface movement and the tunnel supports movement, the Contractor shall simultaneously carry out tunnel survey and ground survey unless otherwise the Engineer agrees.
- No excavation will be permitted unless all required survey data is collected.
- The data processing software shall be subject to the Engineer's approval.

### **4203.2 Survey Reference Points**

- (g) Permanent reference points shall be continuously located and installed along the tunnel route, no later than one day after installation of the tunnel support system.
- (h) The maximum spacing of the reference points shall be not more than 100 meters along straight sections of the tunnel, and no more than 50 meters along curved sections.
- (i) The installation of the reference points shall be to the satisfaction of and/or as required by the Engineer. The location of the reference points shall not conflict with other parts of the work, and
- (j) Reference points shall be rechecked and verified at one-kilometre intervals in conjunction with the completion of the tunnel support systems.

### **4203.3 Longitudinal Profile Survey**

The Contractor shall perform (and provide to the Engineer) longitudinal profile survey of the tunnel lining, by means of closed traverse, upon completion of the tunnel works.

### **4203.4 Submittal**

- (a) The Contractor shall submit for the Engineer's approval the following information within 28 days after the date of commencement of the Works.
  - Format of geologic mapping, and method of measuring quantity of groundwater inflow,
  - Details of the total station, and
  - Data processing software.
- (b) Other documents (reporting formats) which should be submitted before next excavation are as follows.
  - A report notifying geological anomalies observed during visual inspection of tunnel supports and ground surface above the tunnel alignment.

### **4204 Measurement and Payment**

Measurement is not performed exclusively for the Works described in this Section. The Works required under this section is a subsidiary obligation of the Contractor.

Payment for such Works is indirectly included under other pay items of the Bill of Quantities.

## **SECTION 4300 - EXCAVATION**

### **4301 Description**

The work consists of the excavation of tunnels to the cross-sectional dimensions along the neat line (pay line) prescribed in this Section.

Excavation shall be performed using the conventional “New Austrian Tunnelling Method (NATM)”, also referred to as the “Sequential Excavation Method (SEM)”.

### **4302 Material Requirements**

There are no specific permanent materials required for excavating the tunnels.

### **4303 Construction Requirements**

#### **4303.1 Equipment**

Equipment used inside tunnel shall be electric or diesel fuel powered. No gasoline engine is permitted inside the tunnel.

#### **4303.2 Experienced Personnel**

NATM tunnel construction requires solid and credible past tunnel construction experience and personnel skills. The skills should relate to the use of equipment and handling materials for excavation, installation of the initial tunnel supports including the steel ribs, shotcrete, pre-support measures, and rock reinforcing measures.

The Contractor shall provide experienced personnel including senior NATM superintendents with the minimum experience in NATM tunnelling as specified in the Bidding Documents. All general tunnel superintendents and tunnel gangers, except senior NATM superintendents, should also have the minimum in the NATM tunnelling experience as specified in the Bidding Documents.

To verify the individual experience, the Contractor shall submit, separate from the method statement mentioned below, curriculum vitae of all key personnel to be engaged in the tunnel construction activities.

The senior NATM superintendents shall be responsible for guiding excavation and support installation meeting the key requirements of NATM tunnelling:

- Observation of the ground
- Evaluation of ground behaviour as it responds to the excavation progress
- Implementation of the right initial support.

The senior NATM engineer is required to supervise the excavation and installation of the initial tunnel supports, installation of any local or additional support measures and pre-support measures to suite the ground conditions.

#### **4303.3 Excavation Procedures**

##### **4303.3.1 Probing**

Prior to drilling for blasting, the Contractor shall perform at least one probe drilling ahead of the face of the tunnels, using the drilling machine that the Contractor uses for drilling and blasting operations. Probing is intended to reduce risks and hazards associated with



tunnelling ahead of the face. The length, diameter and the direction of probe hole shall be determined by the Contractor at his discretion.

Cost associated with the probing is deemed included in the unit of measurement for tunnel excavation and no additional payment shall be made.

### **4303.3.2 Drilling and Blasting**

- (a) The Contractor shall obtain all necessary licenses and shall provide and, where appropriate, maintain a secure explosives store in accordance with statutory requirements to the approval of the Police and the Engineer.
- (b) Explosives shall be handled and used only by the Contractor's duly authorised personnel. The name and qualifications of such personnel shall be submitted to the Engineer in writing in advance of any possible use of explosives.
- (c) Blasting operations shall be carried out only under the direction of an experienced operator and explosives shall be handled only by shotfirers. The Contractor shall appoint one competent person to be responsible for the security of explosives.
- (d) The Contractor shall adhere to the round length specified on the Drawings. Deviations from the specified round length are not allowed unless agreed with the Engineer.
- (e) At an early stage, in advance of the proposed use of explosives, the Contractor shall notify the Engineer, third parties, statutory authorities and services which have an interest in or are likely to be affected by blasting operations, of the general nature of the operation. The Contractor shall subsequently give a minimum of 14 days' notice to the Engineer and others described above of the proposed use of explosives. With this notification the Contractor shall submit to the Engineer a detailed method statement on all aspects of the proposed use of explosives, including treatment of misfires
- (f) Based on the specified round lengths, the Contractor shall prepare blasting plans, including drilling patterns, type of explosives, detonators with delay sequencing and amount of explosive charge, which shall be compatible with the ground conditions, size and shape of tunnel cross-section, etc., and shall minimise the loosened zone and obtain a smooth excavation face.
- (g) Blasting shall be carried out carefully so as to avoid loosening or shattering rock beyond the required line of excavation, and all loose or shattered rock shall be removed by scaling down or other means before personnel will be permitted to restart operations after blasting.
- (h) Notices of blasting operations shall be posted on site. Before each firing, the Contractor shall give audible warning, clear the area, and shall take positive measures to prevent personnel from entering the danger area.
- (i) The Contractor shall monitor the results of blasting closely and where it is proper to do so, shall propose changes to his blasting operation for the agreement of the Engineer
- (j) Under no circumstances shall any holes be charged until completion of all drilling operations at the face.
- (k) No person shall be allowed to approach the face and no face operation shall commence until the Contractor's authorised person in charge of the operation has given permission
- (l) As soon as practicable after blasting and without undue delay the Contractor shall erect such support as may be necessary to safeguard the excavation and personnel.



- (m) The shot-firer must keep a record of the number of shots fired, their time of firing, type and weights of explosives used and the type and number of detonators used, together with a record of the post blast situation for each and every location. A copy of the record shall be available to the Engineer at the end of every shift on which shots are fired.
- (n) The Contractor shall comply with the Explosives Act, 2018 (1961) along with its amendments and other prevalent laws and ordinances as stipulated in Clause 904 of the Standard Specification for Road and Bridge Works ASAD, 2058 / July 2001.
- (o) The Employer shall provide reasonable assistance to the Contractor at the request of the Contractor for the Contractor's application for any permits, licences or approvals required for import, delivery, storage and use of explosives and accessories.

#### **4303.4 Mucking and Disposal**

- (a) The Contractor is required to carefully select and arrange muck haulage operations (including muck loader) taking account of material conditions. Size and dimensions of the haulage equipment shall be such that they would not damage the installed steel ribs, shotcrete lining, and other key temporary facilities, such as ventilation, lighting, drainage, etc. Muck from the tunnels shall be removed from the tunnels and transported to the disposal areas shown on the Drawings or as directed by the Engineer. Materials encountered in tunnel excavation and determined by the Engineer as suitable for incorporating in the roadway construction shall be conserved and utilized as directed by the Engineer
- (b) The portal areas shall not be used as a temporary storage for muck from the tunnel excavation. Muck shall be directly transported to the designated disposal areas (except for materials suitable for incorporation in the roadway construction as mentioned above) and sorted out according to composition of the material, i.e. hard rock, mixture of rock and soil, muddy soil, etc.
- (c) The Contractor shall maintain the record of the number of trips that haulage car travelled so that the volume of muck removed from the tunnels is registered. No materials shall be removed from the disposal areas without prior consent of the Employer. The Contractor is held responsible for the control of the excavated materials in the disposal areas.
- (d) Excavation may encounter contaminated soils or groundwater. Such soils may require special treatment such as capping after disposal. Separate disposal area or separate lot within the disposal area will be determined by the Engineer. If such contaminated soils are found to be toxic, the Contractor shall dispose of such soils as directed by the Engineer.

#### **4303.5 Safety, Hygiene and Environment Protection**

- (a) The Contractor shall comply with the relevant laws and regulations including laws in relation to health and safety of all persons entitled to be on the Site, particularly in confined working areas such as the tunnels.
- (b) The Contractor shall provide temporary facilities to reduce blasting noise to the threshold value imposed by the local authorities.
- (c) The Contractor shall minimise physical harm caused by construction vibration that impairs the value, usefulness, or normal function of properties of the nearby residents.

- (d) It is strongly recommended that the Contractor performs inventory surveys of the properties and maintain photo records before any blasting takes place.
- (e) The Contractor shall establish a regular air monitoring scheme through which content of oxygen and noxious gases, in particular carbon dioxide, in tunnels.
- (f) The Contractor shall assign a competent person to perform air monitoring required to determine proper ventilation and quantitative measurement of potentially hazardous gasses.
- (g) The objective of monitoring the atmosphere in a tunnel is to ensure that it is free from levels of toxicants and that it contains sufficient oxygen for persons to breath.
- (h) Routine checking/monitoring of oxygen and other noxious gases at every place where persons normally work or travel is a primary requirement in underground operations.

**Entering into tunnels shall be prohibited if the oxygen level in the air is below 18%(\*a) and the carbon dioxide level exceeds 0.5% (5000ppm) (\*b).**

**The oxygen level in the tunnel air body should be monitored at each shift before other gas samples are taken**

(\*a), (\*b): TLV-TWA (Threshold Limit Value - Time weighted Average) recommended by American Conference of Governmental Industrial Hygienists (ACGIH)

- (i) Unless the local authorities provide regulations related to entry to the tunnel, the following threshold points should be strictly observed until safe working condition is confirmed by the person in charge of monitoring. Checking of these gas concentrations shall be performed at every working shifts. If required under the local regulations, the Contractor shall obtain proper approvals in writing from the local authorities for the gas detectors that the Contractor intends to use. Otherwise, the Contractor shall obtain the Engineer's agreement for the use of such gas detectors before commencing tunnel excavation.

Gas (Symbol)	Density (kg/m <sup>3</sup> )	Physical Properties	Harmful Effects	Primary Source	TLV-TWA* <sup>1</sup> (ppm)
Carbon Dioxide (CO <sub>2</sub> )	1.53	colourless, odourless, slight acid taste	asphyxiant, increased respiration	strata, breathing, oxidation processes	5,000
Carbon Monoxide (CO)	0.97	colourless, odourless, tasteless	toxic, explosive	fire, explosion, IC engines	25
Hydrogene Sulfide (H <sub>2</sub> S)	1.54	colourless, rotten egg odour, acid taste	toxic, explosive	strata, stagnant water	10
Sulphur Dioxide (SO <sub>2</sub> )	2.26	colourless, irritating, acid taste	toxic	oxidation of sulphide ore IC engines	2
Nitrogen Dioxide (NO <sub>2</sub> )	1.59	irritating odour, red- brown colour bitter	toxic	blasting, IC engines	3
Nitrogen Monoxide (NO)	1.04	irritating odour, red- brown colour bitter	toxic	blasting, IC engines	25

\*<sup>1</sup> : TLV-TWA (Threshold Limit Value - Time Weighted Average); it is the time weighted average concentration for a normal 8-hour workday without adverse effect [Source - American Conference of Governmental Industrial Hygienists (ACGIH) ]

- (j) The Contractor is responsible to disseminate the tunnel safety procedures among all persons entitled to be on the Site, including the Employer's Personnel.

- (k) The Contractor shall construct, operate and maintain sedimentation systems complying to the environmental codes and regulations of the local authorities. The Contractor shall also observe the following requirements.
- i) The sedimentation system shall be provided as close to the portal area as possible with at least four settlement ponds divided by the biological filters or as recommended/instructed by the local authorities.
  - ii) All ground water emanating from tunnel excavation shall be discharged into these settlement ponds, to remove oil, sand, silt and other suspended matter.
  - iii) A neutralizing agent and a sedimentation accelerating agent, either in liquid form or in powder form, shall be added to the contaminated water before discharging into the settlement ponds. The chemicals to be used shall conform to the laws and regulation of the relevant local authorities.
  - iv) The inlet to the ponds shall be designed so that water discharged into the pond will not stir up sediment previously deposited in that pond. Provision shall be made for the ability to repair or clean the pond during the progress of the Works.
  - v) The outflow from each settlement pond shall be so arranged as to prevent any floating oil from leaving the pond, irrespective of the volume of water entering the pond. The settlement pond shall be constructed using suitable watertight materials, and lined with PVC membrane or similar material to prevent leakage. Wire mesh fencing of 2 meters minimum height shall be installed around the perimeter of the ponds to prevent unauthorized access.
  - vi) The outflow channel from the pond shall be designed and constructed to the satisfaction of the Engineer and in such a manner that soil erosion is prevented.
  - vii) To ensure the continuing satisfactory operation of the system, the Contractor shall remove accumulations of sand, silt, oil and sludge must be removed and disposed of at the locations approved by the Engineer.
  - viii) Natural ground water and storm water from areas outside the immediate area of the Contractor's activities must be prevented from flowing into the pond. The Contractor shall ensure that any diversion berms or drain protecting ponds constructed below ground are adequately maintained.
  - ix) Temporary drains or pipelines leading from the tunnel portal to the sedimentation ponds shall be designed to adequately handle the expected maximum initial flow of tunnel. In no case shall be less than 2.5 cubic meter per minute.
  - x) The Contractor may, upon approval by the Engineer, employ mechanical facilities to treat water, in lieu of settlement ponds at no additional cost to the Employer.

#### **4303.7 Changes to Excavation Method**

The Contractor may alter his excavation methods or procedures with a prior notice to the Engineer. If the method used by the Contractor renders the scheduled progress unviable, in the opinion of the Engineer, the Contractor shall submit upon the Engineer's instruction a revised method statement noting corrective actions to be taken.

#### **4303. Submittals**

### 4303.1 Method Statement

A method statement, which he intends to adopt in the tunnel construction, shall be prepared by the Contractor and submitted to the Engineer, not later than twenty-eight (28) days before commencing the first round of excavation, for his review and comments. The method statement shall include, inter alia, the following:

- (a) Linear Scheduling Method (LSM), in other terms “Time-Distance Diagram” or “Time-Location Diagram”; a time schedule with “Time” on vertical axis and “Distance” in the horizontal axis. All tunnel activities from the portal preparation till completion of road pavement and markings including incidentals shall be shown by individual lines. The LSM shall be prepared separately from the Programme prepared in accordance with Sub-Clause 8.3 of the Conditions of Contract,

***The LSM shall be established based on the round length specified on the Drawings.***

- (b) Organization Chart; it should show individual names and the line of responsibility amongst the different working shifts.
- (c) Equipment; type and capacity of excavation equipment, loading equipment, hauling equipment, drilling equipment, shotcrete machine, steel rib erector, ventilation facilities supported by calculations and other equipment as directed by the Engineer,
- (d) Temporary Facilities; ventilation, lighting, blasting noise/vibration control, water supply, drainage systems and other temporary facilities necessary for safe underground operations. Capacities of the temporary facilities shall be supported by proper calculations for the Engineer’s review and comments/agreement,
- (e) Evacuation and resuming procedures in blasting operations, including warning siren code and signal lights,
- (f) Emergency evacuation and resuming procedures to be followed in case of accidents or abnormal situations and the essential information shall be summarised in a booklet which should be distributed to all persons entitled to be on the Site,
- (g) Emergency Network; it shall show names and telephone numbers of all key personnel of the Contractor, the Engineer and public/private medical institutions in case of emergency,

The Contractor shall not make significant alteration to the method or arrangement without having such alteration previously been notified to the Engineer.

The Contractor shall also submit to the Engineer all deformation monitoring survey data on a daily basis, and other survey data including geological mapping and geological investigation surveys as soon as possible as requested by the Engineer.

### 4304 Method of Measurement

#### 4304.1 Excavation Profile and Measurement

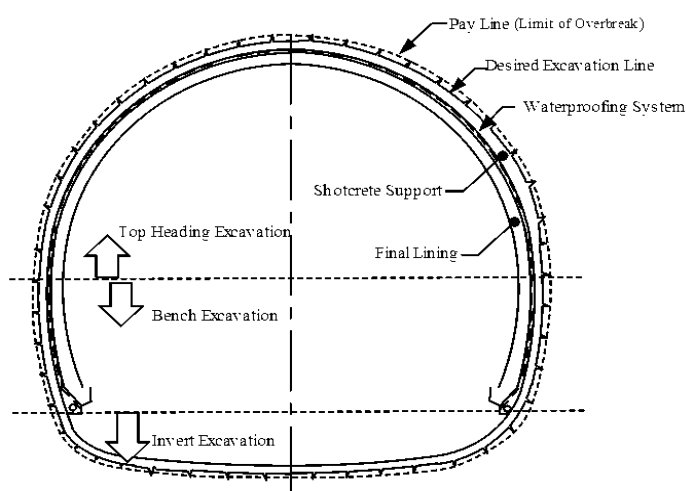
The quantities of tunnel excavation shall be measured in the unit of measurement specified in the Bill of Quantities along the centreline between the portal crowns for the main tunnel and the evacuation tunnel. Excavation below the portal crown shall be measured in the unit of measurement specified in the Bill of Quantities for payment under Section 900 - Earthworks of the Standard Specifications for Road and Bridge Works ASAD, 2058/July 2001.

Measurement of the excavation for cross passages and working adit shall be performed along the centreline at the height of the spring line. No separate remuneration shall be made for excavation above and below the spring line of the cross passages and the working adit where it inter. The cost of excavation above and below the spring line shall be included in the unit rates for excavation.

The Contractor shall submit survey data showing the coordinates of the start points on the portal crowns for agreement with the Engineer. The Contractor shall not commence tunnel excavation unless the Engineer agrees with the survey data.

Typical tunnel excavation profile is illustrated in **Figure 4300-1** as a reference only.

**Figure 4300-1**



In tunnel excavation using high explosives through rock, the effects of explosive action may well extend more than the tunnel diameter outside the designed finished surface; a good deal of overbreak is likely unavoidable. Overbreak will result in increased thickness of shotcrete lining and final concrete lining larger than design thickness.

Since overbreak is almost an inevitable result in rock tunnelling, the effects of overbreak in respect of payment shall be deemed taken into the rates and prices entered into the Bill of Quantities; thus, no payment will be made for overbreak beyond the pay line. Accordingly, the Contractor will be required to employ experienced, skilled and qualified blasting technicians so that overbreak can be controlled.

The costs contingent to such overbreak is deemed to have been included in the rates and prices in the Bill of Quantities based on the average thickness of overbreak shown on the Drawings

Note that removal and reinstallation/replacement of pre-supports (forepoles; length being 3.0 m or less, and fore-piles; length exceeding 3 m), steel ribs, wire mesh, rock bolts, shotcrete, and other incidental parts of these supports, as required necessarily in the course of excavation are not subject to separate payment; all of these activities are combined into the direct cost as incidentals necessary to complete a round of excavation irrespective of rock classifications encountered.

#### **4304.2 Recesses (Niches)**

Quantity of recess excavation shall not be measured for payment. Such quantity is deemed included in the measurement of linear metre of excavation in each profile.

### 4304.3 Partial Cut off

Steel ribs installed at the junctions with cross passages and niches shall be partially cut off and modified as indicated on the relevant Drawings.

The Contractor shall remove the steel ribs, the reinforced shotcrete protection and rock bolts to the dimensions necessary to accommodate the openings in the lining concrete.

### 4305 Basis of Payment

Payment for the excavation is deemed to include the payments for the Works performed under the following Sections which comprise initial support systems;

- Section 4400 – Tunnel Pre-Support,
- Section 4450 – Tunnel Steel Rib,
- Section 4500 – Wire Mesh
- Section 4550 – Shotcrete
- Section 4600 – Rock Bolt

Payment shall be made on condition that all initial support systems are installed according to the Drawings. Especially in the case of early-closer as an auxiliary construction method (see Fig-1.), the works, invert excavation, shotcrete, and backfilling, shall not be measured and paid separately, but shall be deemed included into the rates for unit prices of respective main items. However, the work contents, re-excavation, invert concrete, and backfilling, for final lining shall be deemed included into rates for unit prices of pay-items in the Section 4700 Concrete Lining (see Fig-2.).

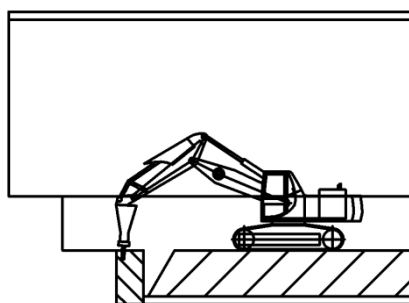


Figure-1 Early closure (With invert shotcrete)

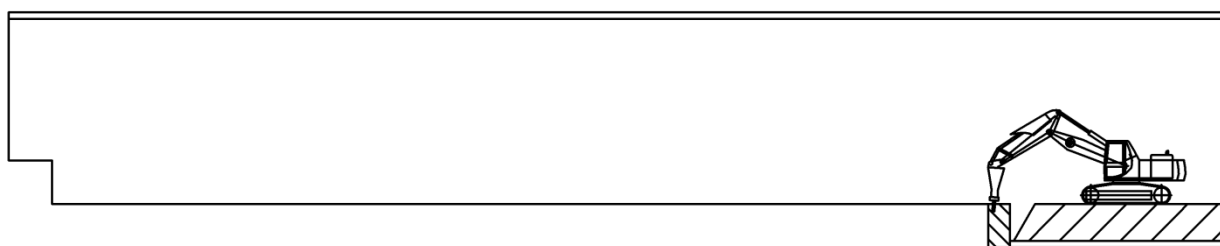


Figure-2 Invert lining



Related temporary facility works and operation (concrete batching plant, power supply, water supply, drainage, lighting etc.) shall not be measured and paid separately, but shall be deemed included into the rates for unit prices of respective main excavation items. In addition, all necessary works for controlling the dust, emission of gas and ventilating air flow inside tunnel shall be deemed included into this Section pay items.

Payment will be inclusive of difficulties in dealing with groundwater inflow being less than 10 litres per second at the face, and other potential difficulties attributable to the ground conditions that are obviously anticipated from the parameters indicated in the Contract Documents.

<u>Pay Item</u>	<u>Excavation Profile Type</u>	<u>Unit of Measurement</u>
<b>Main Tunnel</b>		
4300-01	Main Tunnel CI -- (Full-face Heading)	m
4300-02	Main Tunnel CI-L -- (Full-face Heading)	m
4300-03	Main Tunnel CII-B -- (Full-face Heading)	m
4300-04	Main Tunnel CII-L -- (Full-face Heading)	m
4300-05	Main Tunnel DI-B -- (Top Heading/Bench)	m
4300-06	Main Tunnel DI-FB -- (Top Heading/Bench)	m
4300-07	Main Tunnel DIII-A -- (Top Heading/Bench)	m
4300-08	Main Tunnel DIII-UA -- (Top Heading/Bench)	m
4300-09	Main Tunnel DIII-AF -- (Top Heading/Bench/Invert)	m
4300-10	Main Tunnel DIII-UAF -- (Top Heading/Bench/Invert)	m
<b>Evacuation Tunnel</b>		
4300-11	Evacuation Tunnel CI-P -- (Full-face Heading)	m
4300-12	Evacuation Tunnel CI-PL -- (Full-face Heading)	m
4300-13	Evacuation Tunnel CII-P -- (Full-face Heading)	m
4300-14	Evacuation Tunnel CII-PL -- (Full-face Heading)	m
4300-15	Evacuation Tunnel DIP -- (Full-face Heading)	m
4300-16	Evacuation Tunnel DIIP-A -- (Full-face Heading)	m
4300-17	Evacuation Tunnel DIIP-UA -- (Full-face Heading)	m
<b>Cross Passage</b>		
4300-18	Cross Passage CI-VP -- (Full-face Heading)	m
4300-19	Cross passage CI-VPL -- (Full-face Heading)	m
4300-20	Cross Passage CII-VP -- (Full-face Heading)	m
4300-21	Cross passage CII-VPL -- (Full-face Heading)	m
<b>Working Adit</b>		
4300-22	Working Adit DIW -- (Full-face Heading / Invert)	m
4300-23	Working Adit DIW-F -- (Full-face Heading / Invert)	m
4300-24	Working Adit DIIIW-AF -- (Full-face Heading / Invert)	m
4300-25	Working Adit DIIIW-UAF -- (Full-face Heading / Invert)	m

*Note: Letters hyphenated with the profile types have no distinction between the capital letters and the small letters. Capital letters are used in the above list for convenience.*

## **SECTION 4400 - PRE-SUPPORT**

### **4401 Description**

The work consists of tunnel pre-supports, also referred as the auxiliary method, by means of stabilizing techniques installed through and ahead of the tunnel face where and when tunnel encounters zones of badly weathered and/or broken rock.

The pre-supports involve installation of perforated steel pipes which shall be grouted with polyurethane resin as specified herein.

In these specifications, pre-supports are classified into the following types.

- (1) Forepoles;  $\phi 21.7$  mm, pipe length 3.0 m,
- (2) Forepiles;  $\phi 76.3$  mm or  $\phi 114$  mm, pipe length 12.5 m, and
- (3) Forepiles:  $\phi 76.3$  mm or  $\phi 114$  mm, pipe length 18.5 m.

### **4402 Material Requirements**

#### **4402.1 Pipes (Perforated)**

- (a) Pipes shall be round structural seamless tubing, conforming to the standards JIS G3444, STK490 or internationally recognised equivalent standards as approved by the Engineer.
- (b) Pipes may be assembled with a closed pointed end to prevent inflow of earth. Pipe lengths shall be measured from the pointed end of pipes.
- (c) In case the pipes for pre-supports are imported from outside the country, the Contractor shall submit manufactures data and/or certified mill test reports certifying the properties of the pipes to the Engineer for review and approval at least 6 months prior to intended use.

#### **4402.2 Polyurethane Resin**

- (a) Grouting material shall be of non-toxic polyurethane resin type, which provide a forming effect in relatively shorter hardening period following mixing and injection. The polyurethane grouting resin type shall exhibit an expansion rate (forming factor) of 4 at least and the unilateral compressive strength of 5N/mm<sup>2</sup> as the minimum requirements.
- (b) Since physical and mechanical properties of polyurethane grouting materials differ amongst the products, the Contractor shall propose the type of the polyurethane grouting material it plans to use in the project for approval of the Engineer.
- (c) The Contractor shall include in its proposal the manufactures application manual for review by the Engineer.

#### **4402.3 Grouting Equipment**

Injection of grouting material into pipes of the pre-support shall be performed by grouting pumps as recommended by the manufacturer of the polyurethane grouting material. The



Contractor shall include in his proposal the operation manual of the grouting pump he intend to use.

#### **4403 Construction Requirements**

- (a) Method of driving perforated steel pipes shall be selected by the Contractor and all costs thereof are deemed included in the rate per unit measurement.
- (b) After the initial injection pressure reaches a certain constant pressure, injection shall continue until the pressure increase by 2.5 MPa or more, unless otherwise specifically recommended by the manufacture of the grouting material.
- (c) The Contractor shall remain vigilant during injection and report to the Engineer any anomalies he observes on the tunnel face and the surrounding ground until the scheduled quantity has been injected. The Engineer may instruct the Contractor to cease the injection before the scheduled quantity has been injected in the event of anomalies. The Contractor will be required to take countermeasures against such anomalies to the satisfaction of the Engineer.
- (d) Grouting shall be deemed complete when the scheduled quantity has been injected.
- (e) Care shall be taken to prevent contamination of environment. Preventive measures shall be taken as recommended by the manufacturer of the polyurethane grouting material.

#### **4404 Method of Measurement**

Pre-supports installed as shown on the Drawings will not be measured separately for individual payment. Payment for pre-supports is deemed included in the unit of measurement for each excavation profile described in Section 4300 [Tunnel Excavation].

In the event that supplemental pre-support is instructed by the Engineer, measurement for payment for the individual installation will be performed according to the unit of measurement derived from the breakdown of the contract rates included in Section 4300 [Tunnel Excavation].

#### **4405 Basis of Payment**

In the event that the Engineer instructs the Contractor to install supplemental pre-support, payment for accepted quantity will be made separately at the unit rates per unit of measurement derived from the cost breakdown of work items in Section 4300 [Tunnel Excavation]. Payment will be full compensation for the incidental fixing work including materials

In any case that, according to the Engineer's evaluation, the provided and installed forepoling and/or forepiling are defective, risky or not conforming the requirements herein specified, the material and performed works shall be rejected and respective payment shall be suspended until the defects are solved by the Contractor, and duly approved by the Engineer. In any case that the defect continues, the Contractor shall submit to the Engineer, for review and approval, a method statement to solve the situation.

<u>Pay Item</u>	<u>Description</u>	<u>Unit of Measurement</u>
4400-01	Grouted Forepoling, L= 3 m	No.
4400-02	Grouted Fore-piling, L = 12.5 m	No.

## **SECTION 4450 - STEEL RIB**

### **4450.1 Description**

The work consists of fabrication and installation of structural steel ribs that form part of the tunnel support system. The structural steel ribs system shall provide an effective protection immediately after tunnel excavation.

Payment for the steel rib supports is deemed included in the payment of tunnel excavation by profile types.

### **4450.2 Material Requirements**

Shaped steels used for the fabrication of tunnel ribs shall be new and shall conform to JIS G 3101, SS400 [Rolled Steel for General Structure] or equivalent international standards approved by the Engineer.

### **4450.3 Construction Requirements**

#### **4450.3.1 Shaping, Fabrication and Assembly of Steel Rib Components**

- (a) H-beam steel ribs, tie rods and other steel components of the ribs shall be cut and shaped to the dimensions shown on the Drawings. Shaping shall be accomplished by means of full length cold bending. The application of heat for bending or shaping is not permitted. Steel ribs that are shaped by heating shall not be incorporated in the shotcrete lining.
- (b) The Contractor shall provide all necessary equipment, tools and facilities for the proper controlled bending and fabrication of steel components. Improperly fabricated steel components, including those with wrinkled or twisted steel ribs shall not be incorporated in the Works.
- (c) The Contractor shall submit to the Engineer for review and approval, at least 28 days prior to intended fabrication operations, shop drawings. Shop drawings shall take design intent and specifications prepared by the Employer and develop them to show in detail how the components will actually be manufactured, fabricated, assembled or installed. The Contractor shall not precede with steel fabrication operations until the Engineer gives approval. The Contractor shall not deviate from approved procedures without the written approval of the Engineer.
- (d) Allowable tolerances for the fabrication of steel ribs are as follows:
  - ◆ 2 mm for cutting and assembling
  - ◆ 10 mm for radius after cold bending
- (e) Bolts and accessories, in accordance with specified requirements, shall be used for all steel rib connections. Bolt tightening shall be done with properly calibrated wrenches, by turn-of-nut method or by use of direct tension indicators.
- (f) Welding shall not be permitted for any fabrication or assembly of steel rib components. Welding, in accordance with drawing requirements, shall only be used for securing tie rods and steel plates to H-beams. Welding, inspection, and corrective welding, shall be in accordance with the American Welding Society's Standard Structural Welding Code AWS D1.1 (Structural Welding Guide).

- (g) The sizes, shapes and quantity of steel components shall be installed in accordance with the requirements of the Drawings, based on rock classification and support systems as determined in accordance with Section 4100. The Engineer may, based on tunnel conditions, require the Contractor to make modifications to support system by adding additional supports and/or changing support member sizes.
- (h) The Contractor shall take this into consideration when ordering and pricing his support system components so as to prevent delays due to lack of the stocked materials. Stocked, but unused materials shall not be measured for payment.

### **4450.3.2 Installation of Steel Ribs**

- (a) Steel ribs shall be erected to accommodate the theoretical profile, and assembled at elevations and in positions shown on the Drawings, and/or as required by the Engineer. Hard wood blocks, wood wedges or other acceptable devices may be used as temporary supports for adjustment of steel ribs so as to provide proper placement and positioning prior to and or during the instalment of tie rods. Temporary support materials shall be removed prior to the placement of shotcrete.
- (b) All steel-ribs shall be completely embedded in shotcrete with a minimum coverage as indicated on the Drawings. Shotcrete shall fill all voids in and around steel ribs so as to provide a composite steel and shotcrete mass that is appropriately secured to the tunnel face.
- (c) Allowable tolerances for steel rib installations are as follows:
  - ◆ Deviation at centre of crown from the theoretical centreline of the tunnel: 2 cm
  - ◆ Deviation at invert: 10 cm toward outside, and 0 cm towards inside
  - ◆ Longitudinal spacing: + 5 cm

### **4450.4 Method of Measurement**

Steel ribs installed and modified as shown on the Drawings will not be measured separately for individual payment. Payment for steel ribs is deemed included in the unit of measurement for each excavation profile described in Section 4300 [Tunnel Excavation].

No deduction will be made for sections removed for construction of cross passages/niches and the like.

In the event that supplemental steel rib is instructed by the Engineer, measurement for payment for the individual installation will be performed according to the unit of measurement derived from the breakdown of the contract rates included in Section 4300 [Tunnel Excavation].

### **4450.5 Basis of Payment**

In the event that the Engineer instructs the Contractor to install supplemental steel rib, payment for accepted quantity will be made separately at the unit rates per unit of measurement derived from the cost breakdown of work items in Section 4300 [Tunnel Excavation]. Payment will be full compensation for the incidental fixing work including materials

In any case that, according to the Engineer's evaluation, the provided and installed steel ribs are defective, risky or not conforming the requirements herein specified, the material and performed works shall be rejected and respective payment shall be suspended until the defects are solved by the Contractor, and duly approved by the Engineer. In any case that the defect continues, the Contractor shall submit to the Engineer, for review and approval, a method statement to solve the situation.

<u>Pay Item</u>	<u>Description</u>	<u>Unit of Measurement</u>
4450-1	Steel Rib Support, H-125 mm	m

## **SECTION 4500 - WIRE MESH**

### **4500.1 Description**

The work consists of furnishing and installing wire mesh (Welded Wire Fabric) as indicated on the Drawings, and/or as directed by the Engineer.

Payment for the wire mesh is deemed included in the payment for the tunnel excavation by profile type.

### **4500.2 Material Requirements**

Wire mesh shall conform to the requirements of JIS G3551.

Wire mesh shall be of a fagot type with a square spacing of 150-mm in each direction. The diameter of the wire shall be 5-mm in accordance with JIS G3551.

### **4500.3 Construction Requirements**

Wire mesh shall be installed with the minimum clearance of 50-mm from the excavated surface as shown on the Drawings, accommodating the actual excavation profile, never to exceed more than 20-cm away from any part of the excavated rock face. A minimum overlap length of 20-cm shall be maintained. To prevent loosening during shotcrete application, wire mesh shall be firmly fixed to rock or other surfaces on which it is applied. The spacing of fixing points shall be not more than 50-cm in all directions unless approved or directed by the Engineer otherwise.

### **4500.4 Method of Measurement**

Wire mesh installed and removed as shown on the Drawings will not be measured separately for individual payment. Payment for wire mesh is deemed included in the unit of measurement for each excavation profile described in Section 4300 [Tunnel Excavation].

No deduction will be made for sections removed for construction of cross passages/niches and the like.

In the event that supplemental wire mesh is instructed by the Engineer, measurement for payment for the individual installation will be performed according to the unit of measurement derived from the breakdown of the contract rates included in Section 4300 [Tunnel Excavation].

### **4500.5 Basis of Payment**

In the event that the Engineer instructs the Contractor to install supplemental wire mesh, payment for accepted quantity will be made separately at the unit rates per unit of measurement derived from the cost breakdown of work items in Section 4300 [Tunnel Excavation]. Payment will be full compensation for the incidental fixing work including materials

In any case that, according to the Engineer's evaluation, the provided wire mesh is defective or not conforming the requirements herein specified, the wire mesh shall be rejected and respective payment shall be suspended until the defects are solved by the Contractor, and duly

approved by the Engineer. In any case that the defect continues, the Contractor shall submit to the Engineer, for review and approval, a method statement to solve the situation.

<u>Pay Item</u>	<u>Description</u>	<u>Unit of Measurement</u>
4500-1	Wire Mesh, $\phi$ 5-mm x 150-mm x 150-mm	m <sup>2</sup>

## **SECTION 4550 – SHOTCRETE**

### **4550.1 Description**

The work consists of furnishing, mixing and applying wet shotcrete. Reinforced shotcrete is mostly applied onto the excavated tunnel surfaces to act as initial tunnel support and primary lining.

Payment for shotcrete is deemed included in the payment for tunnel excavation according to the excavation profiles.

### **4550.2 Material Requirements**

The Contractor shall obtain prior approval of the Engineer on the materials to be used in producing shotcrete. Key materials are discussed hereinbelow.

#### **4550.2.1 Cement**

Portland cement shall meet the requirements of Clause 614, Standard Specifications for Road and Bridge Works ASAD, 2058 / July 2001. Certificates attesting that the cement meets specification requirements shall be submitted to the Engineer for review and approval at least 28 days prior to the commencement of shotcrete operations. Portland Cement will be accepted on the basis of a manufacturer's certificate of compliance, accompanied by mill test reports that the material meets the requirements of these specifications. At the expense of the Contractor, when/if directed by the Engineer, the Contractor shall perform tests to verify the cement certification. Cement will be rejected if test results are not satisfactory

#### **4550.2.2 Aggregates**

Aggregates shall conform to Clause 2710, Standard Specifications for Road and Bridge Works ASAD, 2058 / July 2001.

The maximum aggregate size shall be 15-mm in consideration of thickness of application. The Contractor shall provide test results and necessary data, including sieve analyses, to the Engineer for review and approval at least 28 days prior to the commencement of shotcrete application.

Aggregates will be accepted on the basis of certificates of compliance and test reports that show the material meet the quality and grading requirements of these specifications

#### **4550.2.3 Water**

Water used in mixing or curing concrete shall be fresh, clean, potable, and free from injurious amounts of oil, salt, acid, alkali, organic matter, or other deleterious substances. Water used for curing shall not contain excessive impurities to discolour the shotcrete surface.

#### **4550.2.4 Admixtures**

Admixtures to be used, when required or approved, shall comply with the sections of JIS A 6204 – Chemical Admixture for Concrete, or equivalent international standards as approved by the Engineer. Except as otherwise accepted by the Engineer, soluble admixtures shall be dissolved in water before introduction into the shotcrete mixture.



## 4550.2.5 Accelerators

If accelerating admixtures complying with ASTM C 1141, Standard Specification for Admixture for Shotcrete, Type II, Grade 1, are to be used, the Contractor shall establish the accelerator compatibility of the job cement and the proposed accelerators using ASTM C 266, Standard Test Method for Time of Setting of Hydraulic-cement Paste by Gilmore Needles, except as modified herein.

The powdered accelerator shall be blended with 50 grams of cement until uniform and 15 millilitres of water shall then be added. The liquid accelerator shall first be mixed with 15 millilitres of water and then added to 50 grams of cement. Three percent (3%) of the proposed accelerator by mass of cement shall be used as a starting point. Mixing shall be accomplished within 15 seconds. The specimen shall be moulded within 1 minute of adding the mixing water. If initial set is 2 minutes or less and a final set is 10 minutes or less, the accelerator is considered compatible. If these values are not achieved in the first test, additional tests shall be run using 2 percent and 4 percent of accelerator. The quality and quantity of accelerating admixture used shall not decrease the Shotcrete 28-day strength.

Chemical admixtures that have been in storage at the project site for longer than 6 months shall be subject to retesting at the expense of the Contractor when/if directed by the Engineer and shall be rejected if test results are not satisfactory. Certificates attesting that the admixtures meet specification requirements shall be submitted to the Engineer for review and approval at least 28 days prior to the commencement of Shotcrete operations.

## 4550.2.6 Reinforcement

Welded wire fabric reinforcement (wire mesh) shall comply with the requirements of Section 4500 [Wire Mesh].

## 4550.3 Construction Requirements

### 4550.3.1 Shotcrete mix Design Approval

The standard mix design for wet type shotcrete is as follows.

Compressive Strength at 28days $\sigma_{28}$	Slump	W/C	Max. Aggregate	Unit Cement Content	Volume of Sand	Volume of Aggregates	Accelerator by Weight of Cement
18 N/mm <sup>2</sup>	10 $\pm$ 2cm	56%	15mm	360kg/m <sup>3</sup>	0.80m <sup>3</sup> (675kg)	0.47m <sup>3</sup>	5.5%

Contractor shall submit the proposed shotcrete mix designs to the Engineer for initial evaluation and comment. No sooner than 14 days after mix design submittal, the Contractor shall (after giving the Engineer at least 48 hours prior notice) prepare test panels using the proposed shotcrete mix design in the presence of the Engineer.

### 4550.3.2 Shotcrete Criteria for Mix Design

Mixture proportions (Mix Designs) for shotcrete shall be selected and approved on the basis of compressive strength tests of cores obtained from test panels fabricated in accordance with ASTM C 1140, Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels, and the initial and final set properties of the mix as determined in accordance with

ASTM C 403/ C 403M, Standard Test Methods for Time of Setting of Concrete Mixtures by Penetration Resistance.

### **4550.3.3 Test Panels for Mix Design**

Test panels shall be at least 762 mm by 762 mm. Test panels shall be made using equipment, water pressure, air pressure and nozzle operator the Contractor proposes to use for the work. Four separate test panels shall be made, two shall be vertical placements (representing side placement of Shotcrete) and two shall be overhead placements. From each panel, six (6) cores shall be taken; two (2) from each panel for testing at 24 hours after placement, two (2) for each panel for testing at 7 days, and two (2) from each panel for testing at 28 days after placement in light of Article 46 [Mechanical Characteristics of Shotcrete] of the Standard Specifications for Tunnelling – 2006 [Mountain Tunnels] published by Japan Society of Civil Engineers (JSCE). Cores shall be taken perpendicular to the test panel and cured in accordance with the requirements of ASTM C 1140, until testing.

### **4550.3.4 Mix Design Acceptance Criteria**

The compressive strength of the mix design for 24 hours shall attain 5 N/mm<sup>2</sup> as a target strength and 18N/mm<sup>2</sup> as the requirement at the age of 28 days as required by the Design Standard Section 3 [Tunnel] published by Nippon Expressway Company Limited (NEXCO) and Article 45 of the Standard Specifications for Tunnelling – 2006 [Mountain Tunnels] published by Japan Society of Civil Engineers (JSCE).

### **4550.3.5 Revision to Approved Mix Design**

Shotcrete mix designs, as approved by the Engineer, shall be based on the approvals for cement, admixtures, accelerator, water and aggregates used with an approved mix. If the Contractor, for any reason, changes any of these materials or gradation, the Contractor shall submit and obtain approval for new mix constituents and provide a new mix design for approval by the Engineer.

### **4550.3.6 Batching and Mixing of Shotcrete**

Batching and mixing shall be accomplished in accordance with the applicable provisions of ASTM C 94/ C 94M, Standard Specification for Ready-Mixed Concrete and ACI 506-R, Guide to Shotcrete. The mixing equipment shall be capable of thoroughly mixing the specified materials in sufficient quantity to maintain continuous placing. Ready-mix shotcrete complying with ASTM C 94 may be used.

### **4550.3.7 Delivery Equipment**

The equipment shall be capable of delivering the premixed materials accurately, uniformly, and continuously through the delivery hose. Recommendations of the equipment manufacturer shall be followed on the type and size of nozzle to be used and on cleaning, inspection, and maintenance of the equipment.

### **4550.3.8 Air Supply**

The Contractor shall provide a supply of clean, dry air adequate for maintaining sufficient nozzle velocity for all parts of the work and, if required, for simultaneous operation of a suitable blowpipe for clearing away rebound.

#### **4550.3.9 Application of Shotcrete**

- (a) Shotcrete shall be produced through wet-mix process using Portland cement, coarse and fine aggregates, water, and admixture mixed to provide a proper consistency to allow spraying using compressed air.
- (b) The cement, admixtures except accelerator, and water shall be thoroughly mixed in the mixing facility to obtain sufficient consistency so that freshly mixed shotcrete can be conveyed through a delivery hose to a nozzle whereby shotcrete is accelerated by means of compressed oil-free dry air. The accelerator for the wet-mix process shall be added to the shotcrete mixture in such a way that the quantity can be properly regulated and the material uniformly dispersed throughout the shotcrete when it is applied.
- (c) Shotcrete will be applied on the tunnel crown and walls in combination of rock bolts, steel ribs, and wire mesh.
- (d) Time is of the essence for work associated with shotcrete application. Therefore, laboratory and field-testing shall commence as soon as possible after the Commencement Date in order to obtain an approved shotcrete mix before it is necessary to apply shotcrete to the permanent work.

#### **4550.3.10 Shotcrete Nozzle Operators**

The Contractor shall submit a resume for each nozzle operator certifying that each has not less than 2 years of experience for the particular type of shotcrete to be applied. The resume shall include company name, address, and telephone number, name of supervisor, and detailed description of work performed.

Qualifications of additional nozzle operator throughout the job shall be similarly submitted for approval.

Each shotcrete crew shall demonstrate to the satisfaction of the Engineer, acceptable proficiency in the application of shotcrete of field trial quality to vertical and overhead test panels before beginning production work.

The nozzle operator and shotcrete crews shall also produce the shotcrete test panels for mix design evaluations.

- **Placement Control**

Thickness, method of support, air pressure, and water content of shotcrete shall be controlled to preclude sagging or sloughing off. Shotcrete placement shall be discontinued or suitable means shall be provided to screen the nozzle stream if wind or air currents cause separation of the nozzle stream during placement.

- **Placement around Corners**

Horizontal and vertical corners and any area where rebound cannot escape or be blown free shall be filled first.

- **Placement around Reinforcement**

The nozzle shall be held at such distance and angle to place material behind reinforcement before any material is allowed to accumulate on the face of the reinforcement. Shotcrete shall not be placed through more than one layer of reinforcing steel rods or mesh in one application unless demonstrated by preconstruction tests that steel is properly encased.

- **Placement Precautions**

The following precautions shall be taken during placement.

- (a) Placement shall be stopped if drying or stiffening of the mixture takes place at any time prior to delivery to the nozzle. and
- (b) Rebound or previously expended material shall not be used in the shotcrete mixture.

- **Repair of Defects and Core Holes**

- (c) Defects

Defective areas larger than 150 cm<sup>2</sup> or as otherwise identified by the Engineer shall be removed and replaced with fresh shotcrete at the cost of the Contractor. These defects include honeycombing, lamination, dry patches, voids, or sand pockets.

- (d) Repair

All repairs shall be made as soon as practicable after the deficiency is discovered. All unacceptable materials shall be removed and repaired by the Contractor at its cost in accordance with the method approved by the Engineer.

- (e) Core Hole

Core holes shall not be repaired with shotcrete. Instead, they shall be filled solid with a dry-pack mixture, approved by the Engineer, after being cleaned and thoroughly dampened.

#### **4550.3.11 Acceptance Criteria**

Final acceptance of the Shotcrete will be based on compressive strength results obtained from cores of test panels and shotcrete placements.

- **Compressive Strength**

The average compressive strength of cores taken from the structure and test panels, representing a shift or not more than 38 m<sup>3</sup> of shotcrete (tested at 28 days) shall be 18 N/mm<sup>2</sup> or more, with no individual core less than 85 percent of the required minimum compressive strength.

- **Test Panels taken during Actual Applications**

For every shift or every 38 m<sup>3</sup> of shotcrete placement, at least one sample panel fabricated in accordance with ASTM C 1140 shall be made. Three (3) cores at the age of 24 hours and three (3) cores at the age of 28 days.

Core testing shall be made in accordance with ASTM C42, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete AASHUTO No. T24, core samples shall be taken perpendicular to test panels in accordance with requirements of ASTM C 1140.

- **Rejection**

Shotcrete placement found not to be in accordance with compressive strength acceptance criteria 18 N/nm<sup>2</sup> at 28 days, or otherwise unacceptable due to cracking, lack of water-tightness, the presence of voids (emitting voided sound when knocked by hammer), or improper placement, shall not be accepted. Payment shall not be made for any unaccepted shotcrete placement.

The Engineer may direct the Contractor to remove and replace rejected shotcrete or make necessary corrections. Corrections deemed necessary (in the opinion of the Engineer) may include installation of additional shotcrete (with or without reinforcement), the placement of additional rock bolts, partial removal and replacement of shotcrete or other measures.

All corrective work and associated costs incurred by the Contractor for accomplishing corrective work or removing and replacing unaccepted shotcrete shall be made good at the cost of the Contractor.

#### **4550.4 Method of Measurement**

Shotcrete applied and removed as shown on the Drawings will not be measured separately for individual payment. Payment for accepted shotcrete is deemed included in the unit of measurement for each excavation profile described in Section 4300 [Tunnel Excavation].

No deduction will be made for sections removed for construction of cross passages/niches and the like.

## SECTION 4600 - ROCK BOLT

### 4601 Descriptions

This work consists of furnishing and installation of grouted rock bolts as rock reinforcement in the tunnel opening.

Rock bolts referred to in this Specification Section are fully grouted over the whole length and principally installed untensioned at the arch section, sides or face of a tunnel, locally or systematically, during excavation. Together with shotcrete they provide a bearing force by the formation of a rock-arch and become a part of tunnel support system.

### 4602 Material Requirements

#### 4602.1 Grouted Rock Bolts

- (f) Rock bolts shall be fabricated from steel bars for concrete reinforcement as specified on the Drawings. The rock bolts shall be marked with the ultimate (fracture) load. The outer end of anchor rod shall be threaded counter-clockwise along a length of at least a 150-mm. Threaded end of rock bolts shall be coated with grease and packed with PVC cloth or other materials for protection from damage.
- (g) The Contractor shall submit manufactures data certifying the properties and strength of rock bolts to the Engineer for review and approval at least 28 days prior to intended use.
- (h) The projected end of anchor and sharp edges of the washers and bearing plates shall be covered with cement mortar or other materials acceptable to the Engineer. The main purpose of covering is to protect the waterproofing sheet from potential damage.
- (i) The physical properties of the rock bolt shall satisfy the minimum requirements of Standard Specifications for Tunnelling – 2006 Mountain Tunnels published by Japan Society of Civil Engineers as listed below.

Classification	CODE	Nominal Diameter (mm)	Physical property (threaded part)			Physical property (raw material)		
			Cross area (mm <sup>2</sup> )	Yield load (kN)	Fracture load (kN)	Cross area (mm <sup>2</sup> )	Yield load (kN)	Fracture load (kN)
>117.7kN	SD345	D25	353.0	121.8	173.0	507.0	174.9	248.4
>176.5kN	STD510 (FE500)	TD24 (D32)	353	180.0	243.6	446.0	227.5	307.7

#### 4602.2 Bearing Plates, Washer, and Nuts

All nuts and washers shall conform to rolled steel for general structure, Grade D SS400 manufactured according to JIS 3101, and be of the sizes and dimensions shown on the Drawings or as indicated in the Bills of Quantities.

The Contractor shall submit manufactures data certifying the properties and strength of all nuts, washers and bearing plates to the Engineer for review and approval at least 28 days prior to intended use.

#### 4602.3 Cement Mortar

- (j) Cement mortar for grouting of rock bolts shall be approximately one-part cement and one-part sand mixed with sufficient water to provide a consistency that shall enable grouting upward into

vertical holes. The water cement ratio of the mortar shall be between 0.35 and 0.45. The compressive strength for 5-cm cube specimens at 1-day shall be not less than 10-N/mm<sup>2</sup> when tested in accordance with ASTM C579 Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grout, and Monolithic Surfacing and Polymer Concrete. The 28-day compressive strength of the cement mortar shall be at least 24N/mm<sup>2</sup>.

- (k) The Contractor may use commercially produced and packaged cement mortars, provided they meet the compressive strength requirements of these specifications. Mixing and application of commercially produced cement mortars shall be in accordance with manufacturer's instructions and recommendations. The Contractor shall provide manufactures information and data (with mixing and application information) to the Engineer for review and approval at least 28 days prior to the intended use.
- (l) Prior to the use of any cement mortar mix and/or a commercially produced mortar product, the Contractor shall provide a sample mix in the presence of a representative of the Engineer. After obtaining the approval of the Engineer, the Contractor shall not deviate from his mix design without the consent of the Engineer. The Engineer may at any time direct the Contractor to provide and test any number of cement mortar cubes. The Contractor, at no additional cost, shall accomplish such testing.
- (m) Sand used with cement mortar mixes shall be natural or manufactured sand conforming to the requirements of ASTM C 144 Standard Specification for Aggregate for Masonry Mortar, and having the following gradation;

Sieve Size	Finer – % by weight (Natural Sand)	Finer – % by weight (Manufactured Sand)
No.4 (4.75 mm)	100	100
No.8 (2.36 mm)	95 to 100	95 to 100
No.16 (1.18 mm)	70 to 100	70 to 100
No. 30 (600 µm)	40 to 75	40 to 75
No. 50 (300 µm)	10 to 35	20 to 40
No.100 (150 µm)	2 to 15	10 to 25
No. 200 (75 µm)	-	0 to 10

- (n) The Contractor shall provide test results and necessary data, including sieve analyses, to the Engineer for review and approval at least 28 days prior to the commencement of bolt grouting operations. Aggregates will be accepted on the basis of certificates of compliance and test reports that show the material meets the quality and grading requirements of these specifications.
- (o) Cement used for cement mortar mixtures shall be Type I, II, or V Portland Cement conforming to the requirements of ASTM C 150 Standard Specification for Portland Cement. Certificates attesting that the cement meets specification requirements shall be submitted to the Engineer for review and approval at least 28 days prior to the commencement of bolt grouting operations. Portland Cement will be accepted on the basis of a manufacturer's certificate of compliance, accompanied by mill test reports that the material meets the requirements of these specifications. At the expense of the Contractor, when/if directed by the Engineer, the Contractor shall perform tests to verify the cement certification. Cement shall be rejected if test results are not satisfactory.
- (p) Water used for cement mortar mixtures shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali.
- (q) The Contractor may at his discretion, use a set-accelerating admixture which shall have a chloride content not exceeding 1% by weight and meet the requirements of ASTM C 494 Standard



Specification for Chemical Admixture for Concrete, Type C or E. Chemical admixtures that have been in storage at the project site for longer than 6 months shall be subject to retesting at the expense of the Contractor when/if directed by the Engineer and shall be rejected if test results are not satisfactory. Certificates attesting that the admixtures meet specification requirements shall be submitted to the Engineer for review and approval at least 28 days prior to the commencement of bolt grouting operations.

#### **4603 Construction Requirements**

##### **4603.1 Installation of Rock Bolts**

- (a) Cement mortar grouting of drill holes shall proceed continuously from the end of the drill hole to the mouth, until the whole length of hole is completely filled.
- (b) Soon after filling the drill hole with grout, rock bolt shall be inserted.
- (c) The diameter of drill holes shall be at least 1.5 time of the rock bolt diameter, but not more than 2 times.
- (d) All drill holes shall be completely cleaned of dust, sludge and debris before installation of grout.

##### **4603.2 Improper Advancement of Rock Bolts**

In cases where a rock bolt cannot be advanced to the required depth, due to a collapse of the borehole wall, failure of the rock bolt or other physical difficulties that may, in the opinion of the Engineer, cause the bolt to be unable to provide the necessary strength, installation shall be discontinued and the Contractor shall either enlarge the hole, re-grout and reinstall, or provide an alternative anchor bolt by drilling a new hole nearby the failed rock bolt as directed by the Engineer.

The failed rock bolt shall be retracted and the hole shall be re-grouted to fill the gap. If the failed rock bolt cannot be retracted, the failed rock bolt shall be cut flush with the borehole mouth and covered the cut edge with cement mortar. No additional payment will be made for unsuccessful rock bolt installation.

##### **4603.3 Drilling for Rock Bolts**

Bore holes shall be drilled to a depth of 300mm beyond the specified length of rock bolts and normal to the rock surface or within the maximum crossed axes angle of 15 degrees formed by the washer plate and the tendon.

Deviation from these requirements will not be acceptable unless the Engineer has agreed to such deviations otherwise.

##### **4603.4 Cutting off and Final Rock Bolt Preparation**

After it has been confirmed, that no additional tunnel deformations are recorded and the Contractor has been advised by the Engineer to proceed, the Contractor shall provide final rock bolt preparation. Final rock bolt preparation shall consist of cutting off the excessive rock bolt length flush with tightening nuts and covering the rock bolt, nut and washer and rock bolt plate with cement mortar the mix proportion of which is acceptable to the Engineer.



## **4603.5 Pullout Test and Quality Control**

### **(e) Testing Procedures**

The tunnels have been designed partly based on Standard Specifications for Tunnelling - 2006 Mountain Tunnels published by Japan Society of Civil Engineers.

The frequency of the pullout tests shall be conducted every 20 m in the initial stage of the excavation, then every 50 m: about 3 bolts per section respectively (one in the crown, arch and side wall). Rock bolts will be judged to be adequate, if it exhibits about 80% of the required pullout strength; required pullout strength is set to 117.7kN(SD345),176.5kN(STD510) thus, rock bolts will be tested to confirm the design pullout strength of 95k(SD345),145kN(STD510) at the age of 3 days. In general, the pullout strength is set to the yield strength of the threaded portion of rock bolts.

The Engineer may designate bolts for testing and witness all tests. The Contractor shall record all tests in a format acceptable to the Engineer. Test records shall provide for signature by the Engineer and the Contractor of all witnessed tests and clearly indicates all bolts that are accepted by the Engineer based on tests conducted. The Contractor shall provide copies of all signed test records to the Engineer daily.

The Engineer may adjust the frequency and number of rock bolt pullout tests, to assure the quality of rock bolt installation. The Contractor at no additional cost shall accomplish verification testing as required by the Engineer.

### **(f) Rock Bolt Testing Equipment**

All equipment for testing of rock bolts shall be provided by the Contractor and be available so that testing can be accomplished at any time at the discretion of the Engineer.

The rock bolts can be pulled using a torque wrench or a hydraulic jack, as approved by the Engineer, capable of applying load up to the pullout load (95kN,145kN) of the tested bolt (threaded portion). The testing equipment shall be calibrated every three months unless otherwise approved by the Engineer. The Contractor shall provide the operating manuals of the torque wrench and/or the hydraulic jack, as the case may be, including the most recent calibration results to the Engineer for information and approval prior to the commencement of any rock bolt installation.

### **(g) Evaluation Criteria**

Efficiency of grouted rock bolts will be evaluated by pullout testing as described herein before. Tested bolts will be deemed acceptable if they withstand the pulling load of 50% of the accepted yield strength of 95kN(145kN). Thus, a rock bolt is considered adequate if it exhibits 50kN(70kN) of the yield strength.

## **4603.5 Submittals**

In accordance with requirements of this Specification Section, the Contractor shall provide the following information to the Engineer for his approval not later than 28 days before the intended commencement.

(a) Certificates of rock bolts, bearing Plates, washers, and anchor nuts.

### **(b) Detail description of stressing methods, equipment to be used and its calibrations**

- (c) Cement mortar
  - (i) Mix design including water cement ratio, compressive strength and sand gradation and data.
  - (ii) Corporate information if the Contractor proposes to use a commercially produced mortar grout, including product technical brochure and test certificates.
  - (iii) Certificates of cement such as mill certificates.
  - (iv) Certificates attesting that the admixtures meet specification requirements.
- (d) A complete list of equipment he intends to use for rock bolt installation and testing, noting intended applications of all equipment, for review and comment by the Engineer.
- (e) Cement mortar test results,

#### **4604 Method of Measurement**

Rock bolts installed and removed as shown on the Drawings will not be measured separately for individual payment. Payment for rock bolts is deemed included in the unit of measurement for each excavation profile described in Section 4300 [Tunnel Excavation].

No deduction will be made for sections removed for construction of cross passages/niches and the like.

In the event that supplemental rock bolt is instructed by the Engineer, measurement for payment for the individual installation will be performed according to the unit of measurement derived from the breakdown of the contract rates included in Section 4300 [Tunnel Excavation].

#### **4605 Basis of Payment**

In the event that the Engineer instructs the Contractor to install supplemental rock bolt, payment for accepted quantity will be made separately at the unit rates per unit of measurement derived from the cost breakdown of work items in Section 4300 [Tunnel Excavation]. Payment will be full compensation for the incidental fixing work including materials

The required strength of the rock bolts at the thread portion is approximately 95kN and 145kN. If testing of a group of rock bolts (with a representative number of tests) indicates bolts to be below the required strength, the works shall be rejected and respective payment shall be suspended until the failed bolts are replaced and re-installed, and results of re-testing are approved by the Engineer. In any case that the defect continues, the Contractor shall submit to the Engineer, for approval, a method statement to solve the situation.

- (i) Bolt tests showing less than 50kN(or70kN)– no payment shall be made for the number of bolts in the group equivalent to the percentage represented by the number of bolts tested in the grouping.
- ( ii ) Bolt tests showing more than 50kN(or70kN) but less than 95kN(or145kN) – payment shall be made at 50% of the unit rate for the number of bolts in the group equivalent to the percentage represented by the number of tests in this grouping.

<u>Pay Items</u>	<u>Descriptions</u>	<u>Units</u>
4600-01	Rock Bolts 2.0 m long	Nos.
4600-02	Rock Bolts 3.0m long	Nos.
4600-03	Rock Bolts 4.0m long	Nos.

## SECTION 4650 - WATERPROOFING

### 4650.1 Description

The work consists of installation of drained waterproofing system prior to placing the lining concrete. The tunnel waterproofing system is required to prevent groundwater inflow into tunnels.

The waterproofing system, installed between the shotcrete and concrete lining, is comprised of two layers; the non-woven geotextile outer layer and the waterproofing membrane inner layer.

### 4650.2 Material Requirements

The material of the waterproofing membrane shall be Ethylene Vinyl Acetate (EVA) conforming to the requirements noted in Table 4650-1. Alternative international equivalent standards to the standards listed in Table 4650-1 may be acceptable with the approval of the Engineer.

The non-woven geotextile is a backup material for the waterproofing membrane and it shall be made of polyester and conform to the requirements of Table 4650-2. Alternative international equivalent standards to the standards listed in Table 4650-2 may be acceptable with the approval of the Engineer.

#### 4650.2.1 Requirements for Waterproofing Membrane

- (a) The membrane length in each roll of material shall be supplied to coincide with placement along the peripheral length of the tunnel without longitudinal joints. Longitudinal joint shall only be permitted as indicated on the Drawings.
- (b) Material Requirements and test standards as shown on Table 4650-1.

**Table 4650-1 – Requirements and Test Standards for EVA Waterproofing Membrane**

Properties	Specified Value	Standards (See Note 2)
Specific gravity	0.95±0.05	JIS K 6773
(2) Hardness (scale: Shore A)	98 max.	JIS K 6773
(3) Variance of Thickness	Average thickness at 5 points in traverse direction shall be more than the designated thickness, and minimum thickness is more than 95% of the designated thickness.	JIS A 6008
(4) Min. Thickness	0.8 mm	JIS A 6008
(5) Min. Tensile Strength	16 N/mm <sup>2</sup> at 20°C	JIS K 6773
(6) Elongation	600% at 20°C	JIS K 6773
(7) Min. Tear Strength	500 N/cm	JIS K 6252
(8) Flexibility	Viable at -30°C	JIS K 6773
(9) Weight Change (Alkali Resistance)	Within ± 1%	JIS K 6773
(10) Min. Seam Strength	20%	<b>JHS 706</b> or ASTM D6392

**Notes:**

1. Seam Strength is defined as the strength at welded seam to the tensile strength.
2. For JIS standards, approved equivalent ASTM can be adopted. **JHS 706** is a test method for strength of welded seams established by Nippon Expressway Company Limited (NEXCO).

#### 4650.2.2 Requirements for Non-Woven Geotextile

The non-woven geotextile is a backup material for the waterproofing membrane and it shall be made of polyester and conform to the requirements of Table 4650-2.

**Table 4650-2**

**Requirement and Test Standards for Non-Woven Geotextile Protective Fleece for EVA Waterproofing Membrane**

Properties		Unit	Specified Value	Test Standards (See Note)
(1) Unit Weight		g/m <sup>2</sup>	300 min	JIS L 1096
(2) Thickness at 19.6 x 10 <sup>-4</sup> N/mm <sup>2</sup> load (20 g/cm <sup>2</sup> )		mm	3.0 min	JIS L 1096
(3) Tensile Strength	Vertical	N/50 mm (kgf/5cm)	196 min (20 min)	JIS L 1096
	Horizontal		49 min (5 min)	
(4) Elongation	Vertical	%	20 min	JIS L 1096
	Horizontal		50 min	
(5) Tear Propagation Strength	Vertical	N (kgf)	49 min (5 min)	JIS L 1096
	Horizontal		49 min (5 min)	

Notes: 1. For JIS standards, approved equivalent ASTM can be adopted

### 4650.2.3 Transportation, Storage and Testing of Materials

#### (a) Transportation

- (i) All materials shall be of originally packaged at the manufacturing plant. Packaging shall be sufficient to protect materials from damage, deterioration and exposure during shipping and storage. To prevent ultra-violet exposure during transportation and storage all non-woven geotextile materials shall be packaged with a black covering.
- (ii) The outer face of all material packing shall clearly describe material and note the size or quantity of material, the manufacturer's name, material type number, lot number and manufacturing date.

#### (b) Storage

- (i) All material shall be stored in the dry and well-ventilated warehouse in accordance with manufacture requirements.
- (ii) Material temporarily stored outdoors shall be properly covered for protection against exposure and deterioration. No damaged material shall be used. All damaged materials shall be removed from the site at the expense the Contractor.

#### (c) Testing of Materials

Materials shall be supplied with certified test results for each lot from the manufacturer. Testing of material lots shall be accomplished and certified by an independent laboratory. All materials transported to the site shall be verified to be applicable to a certified and tested lot. Only materials from lots with acceptable test results shall be used. Copies of all certified tests for each lot of material shall be submitted to the Engineer prior to use of material.

## 4650.3 Construction Requirements

### 4650.3.1 General Requirements

- (a) The surface to receive the Waterproofing membrane shall be clean and free of loose and foreign material. All protruding objects such as nails, rock bolts, pipes, fittings and reinforcing steel shall be ground smooth, so as not to penetrate any layer of the membrane system. Shotcrete surfaces shall be checked and approved prior to membrane placement. The Contractor shall employ a manufacturer's representative to inspect and approve the preparation of shotcrete surface for waterproofing membrane placement.
- (b) All membrane layers shall be installed and constructed in conformity to approved shop drawings and manufacturer's requirements and recommendations.
- (c) The Contractor shall employ a manufacturer's representative to supervise the placement of the membrane system. All work shall be executed by skilled labour under the guidance and supervision of a manufacturer's representative.
- (d) The waterproofing shall be installed as specified and shown on the Drawings, or as appropriate, to accurately fit within the dimensions shown on the Drawings, or as approved by the Engineer. Additionally, the waterproofing membrane together with geotextile, applied uniformly and continuously from the shotcrete wall, shall be extended to cover the entire Mole Drainage pipe and surrounding filter material, as detailed on the Drawings, and shall be subject to approval by the Engineer. If necessitated, any joining between the membrane covering the shotcrete wall and the membrane extended over and under the mole drainage pipe, shall be heat welded watertight in accordance with methods and specification described herein. Such welding connection shall be subject to all relevant bonding tests herein, and shall be subject to approval by the Engineer.

#### **4650.3.2 Installation of Non-Woven Geotextile**

- (a) Non-woven geotextile shall be fastened onto the shotcrete face using "waterproofing disks" supplied by the membrane manufacturer. The spacing between disks shall not be more than 60 cm, and not be less than 4 disks per square meters.
- (b) The overlapping length of non-woven geotextile shall be not less than 10 cm. Longitudinal joints shall be installed with no more than two loops.
- (c) To avoid damage to the material, the non-woven geotextile shall be installed as close to shotcrete surface as possible, without an excessive pulling force.

#### **4650.3.3 Installation of Waterproofing Membrane**

- (a) The waterproofing membrane shall be fixed on tunnel waterproofing disks installed with the geotextile by means of heat welding.
- (b) Joints shall be installed by means of heat welding in accordance with the manufacturer's requirements and recommendations. Overlapping lengths of the waterproofing membrane shall be at least 8 cm. They shall be joined with double seams using an approved heat welding method.
- (c) The waterproofing membrane shall be installed with no longitudinal joints along its peripheral length.
- (d) In locations where heat welded double seams cannot be made, such as at intersection points, where pipes or other objects are required to pass through the membrane, at niches and inverts, the Contractor shall submit applicable details and requirements with his shop drawings for approval of the Engineer. Jointing using melted connection procedures other than double seam procedures

shall also be in accordance with manufacturer's recommendations and requirements and be approved by the Engineer.

- (e) All double seam waterproofing membrane joints shall be air pressures tested to assure proper bonding. Air pressure test and requirements shall be in accordance with the manufacturer's requirements. All non-double seam waterproofing membrane joints shall be subject to vacuum bell testing in accordance with the manufacturer's requirements. At least 28 days prior to commencing with the installation of waterproofing membrane, the Contractor shall submit testing procedures to the Engineer for approval. The Contractor shall be responsible for providing all equipment and materials necessary for proper joint testing as recommended by the manufacturer. The Contractor shall advise the Engineer prior to testing of joints. A manufacturer's representative shall supervise all joint testing. All joints that fail to meet the requirements of the joint test shall be resealed and tested.
- (f) During the installation of the membrane lining, sample joint test specimens shall be made for every 1000 linear meters of double seam joint installed and for every 500 linear meters of non-double seam joints installed. An independent laboratory, approved by the Engineer, shall test all specimens. Testing and sample preparation shall be in accordance with the requirements of JIS, ASTM or internationally recognised standards approved by the Engineer for the EVA membrane as shown in the above Tables 4650-1. The Contractor shall be responsible for testing and test reporting costs including sample preparation, and transportation.
- (g) Damages to the membrane, including penetrations, rips and/or tears, shall be properly repaired. Repairs shall include proper placement (in accordance with recommended manufacture procedures) of a membrane section overlapping at least 15 cm around the circumference of the section to be repaired. All repair areas shall be vacuum bell tested in accordance with requirements and procedures recommended by the manufacturer. The Contractor shall submit repair-testing procedures to the Engineer for approval. The Contractor shall be responsible for providing all equipment and materials necessary for proper repair testing as recommended by the manufacturer. The Contractor shall advise the Engineer prior to testing of repairs. A manufacturer's representative shall supervise all repair testing. All repairs that fail to meet the requirements of repair test shall be reinstalled and retested.
- (h) During construction, except for its own weight, the membrane shall not be subject to external forces.

#### **4650.3.4 Field Tests for Hermeticity of Joints and Repairs**

##### **(a) Air pressure test**

Using equipment and procedures, as required by the manufacturer, compressed air to a pre-determined pressure (1.0 to 2.0 kg/cm<sup>2</sup> or as recommended by the manufacturer) is applied to joints. The pressure is maintained for a period of time (approximately 5 minutes – as recommended by the manufacturer). Acceptance of the joint is based on an allowable excepted pressure drop (as recommended by the manufacturer) over the period of time the pressure is maintained on the joint.

##### **(b) Vacuum Bell Test**

Using equipment and procedures recommended by the manufacturer, a vacuum test cup is used to draw air out of the test section with a pre-determined pressure (0.2 - 0.5 kg/cm<sup>2</sup> or as recommended by the manufacturer). Observance of a pressure needle indicator on the testing device indicates acceptance or rejection of the joint.



Note: The above field testing procedures are incorporated in the manufacture's specifications to provide the Contractor with a general understanding of the field-testing required. Testing equipment, testing procedures and acceptance criteria for all field testing shall be verified with the waterproofing manufacturer and accomplished in accordance with the manufacturer's recommendations and requirements, as approved by the Engineer.

#### **4650.3.5 Submittals**

The Contractor shall submit Three (3) copies of following documentation and data to the Engineer for approval at least Six (6) months before scheduled commencement of the installation, considering the time required for manufacturing and delivery to the Site.

- **Shop Drawings**

The Contractor shall submit shop drawings for non-woven geotextile and waterproofing membrane showing the procedures how they should be fabricated, assembled and installed at the Site. The following information shall be included in the submission, but they may be presented as installation manual/procedures.

- (a) General installation procedures and requirements,
- (b) Overlapping requirements and treatment,
- (c) Portal installations,
- (d) Repair methods and procedures,
- (e) Anchoring systems, devices and procedures,
- (f) Treatment for membrane penetrations including construction requirements and procedures for steel bar supports, rock bolts, projecting articles, and pipes penetrations, and any other drawings and information necessary for and to fully describe the complete installation of the waterproofing system.

- **Manufacturer's Data**

The Contractor shall submit manufacturer's data and information which shall include, but not limited to:

- (a) Original product catalogues noting material type and related technical data and information,
- (b) Test reports of material properties and seam strength shall be issued and signed by an independent testing laboratory. Reports shall be certified by the testing agency with notice that tests were conducted on representative samples of the manufacturer's product,
- (c) Construction and installation procedures and requirements including procedures for installation of membrane joints and membrane repairs,
- (d) Testing requirements and procedures for material joints and repairs,
- (e) A copy of the agreement (excluding financial terms) between the Contractor and supplier detailing material supplies, shipping agreement, technical support and assistance, warranties and validity of



agreement (the valid period thereof shall not be shorter than the construction period of the work), and

- (f) Manufacturer's performance certification with past performance records on highway tunnels with placement area greater than 30,000 square meters.

- **Specimen/Samples**

The Contractor shall submit samples of the following:

- (a) Non-woven geotextile: (one-piece) 1m x 1m,
- (b) Water-proofing membrane: (one-piece) 1m x 1m,
- (c) Anchors and fixing blocks: one set,
- (d) Sample of welded joint: one-piece 1 meter long, and
- (e) Assembled sample: one whole set.

#### **4650.4 Method of Measurement**

Waterproofing system, geotextile and membrane combined, will be not measured separately for individual payment. The waterproofing system will be considered as integral part of concrete lining. Payment for waterproofing installed as shown on the Drawings is deemed included in the unit of measurement for concrete lining described in Section 4700 [Concrete Lining].

#### **4650.5 Basis of Payment**

Payment for waterproofing is included as an integral part of the concrete lining. Costs of labour, materials, loss from overlapping, equipment, scaffolding, testing, inspection, technical guidance, power, storage, transportation, treatment of placing face anchor and fixing blocks and any other costs related for the Works described in this section shall be included in the concrete lining work.

Unaccepted waterproofing sections shall be entirely removed and replaced, including all required testing. Replacements shall not be measured for payment.

## SECTION 4700 – CONCRETE LINING

### 4700.1 Description

The work consists of cast-in-place concrete lining which is cast against the waterproofing systems installed on top of shotcrete lining. Cast-in-place concrete lining will be used as final lining and therefore the undecorated surface (mainly arch section) shall be finished with the required accuracies as specified herein.

For payment purposes, the concrete lining and the waterproofing systems are combined as a single pay item for which payment is made after completion of concrete lining.

### 4700.2 Material Requirements

Materials used in cast-in-place concrete shall conform to the requirements specified under Section 2000 of the Standard Specifications for Road and Bridge Works ASAD, 2058 / July 2001 or equivalent international standards approved by the Engineer.

Steel reinforcing bars shall conform to the requirement specified in Clause 620 of the Standard Specifications for Road and Bridge Works ASAD, 2058 / July 2001 or equivalent international standards approved by the Engineer.

### 4700.3 Construction Requirements

#### 4700.3.1 Concrete mix Design Approval

The standard mix design for wet type concrete is as follows.

Compressive Strength at 28days $\sigma_{28}$	Slump	W/C	Max. Aggregate	Unit Cement Content	fiber-mixing ratio	application
18 N/mm <sup>2</sup>	15 ± 2.5cm	60%	40mm	270kg/m <sup>3</sup>	-	C I 、 C II 、 D I
18 N/mm <sup>2</sup>	15 ± 2.5cm	60%	40mm	340kg/m <sup>3</sup>	0.3(vol%)	D III

Contractor shall submit the proposed concrete mix designs to the Engineer for initial evaluation and comment. No sooner than 14 days after mix design submittal, the Contractor shall (after giving the Engineer at least 48 hours prior notice) prepare test panels using the proposed concrete mix design in the presence of the Engineer.

#### 4700.3.2 Formwork

- (a) Formwork shall be of a mobile carriage type equipped with external form vibrators and windows on the shell for inspection and for ensuring sufficient consolidation of concrete. The Contractor shall submit design calculations and shop drawings of formwork to the Engineer for his approval.
- (b) Design calculations and shop drawings shall clearly indicate materials and their grades according to the accepted standards, and they be delivered to the Engineer at least 28 days before starting fabrication.

- (c) The external vibrators shall be electrically driven type with sufficient vibration effect to achieve sufficient consolidation of fresh concrete. No fuel combustible vibrator will be permitted inside tunnel.
- (d) The travelling devices, hydraulic jacks, external vibrators, and other outfitting shall be easily replaceable and must also be available for replacement. The Contractor shall have sufficient spares in hand for emergency replacement.
- (e) Before erecting formwork, damages to the waterproofing membrane shall be repaired in a manner acceptable to the Engineer.
- (f) The Contractor shall notify the Engineer before batching begins for placement of concrete. Placement shall not begin until all preparations are complete.
- (g) The Engineer will have the authority to stop or delay concrete placement if (in the opinion of the Engineer) formwork arrangement and concrete production are not adequate or are not properly prepared. The Contractor shall be responsible for all costs and time necessary to make good as required by the Engineer.
- (h) Forms shall be constantly monitored and their position adjusted as necessary during concrete placements.

#### **4700.3.2 Concrete Placing**

- (a) Concrete shall be placed with concrete pumps or other acceptable means approved by the Engineer. The concrete shall be supplied to the concrete pump continuously. Stand-by-concrete placing equipment, including concrete pumps shall be provided for each pour to ensure smooth and uninterrupted placement in case of equipment breakdown.
- (b) When pumping is completed, concrete remaining in the pipeline shall be ejected without contamination of concrete in place. After each operation, equipment shall be thoroughly cleaned, and flushing water shall be wasted outside of the forms. Grout used to lubricate the pumping equipment at the beginning of the placement shall not be incorporated into the placement.
- (c) Depositing of the concrete shall be so regulated that it may be effectively consolidated in horizontal layers 500 mm or less in thickness with a minimum of lateral movement. The amount deposited in each location shall be that which can be readily and thoroughly consolidated. Sufficient placing capacity shall be provided so that concrete placement can be kept plastic and free of cold joints while concrete is being placed. Concrete shall be placed by methods that will prevent segregation and/or loss of ingredients.
- (d) The maximum fall height shall not exceed 1.5 meter. If the free-falling height of the concrete exceeds 1.5 meters, flumes, tremies or the like acceptable to the Engineer shall be used to avoid the segregation of concrete constituents
- (e) The maximum rising speed of the concrete shall not exceed 2.0 m/h. Concrete shall be placed alternately between the sidewalls to maintain balance of the pressure.
- (f) The maximum thickness of a concrete layer shall not exceed 0.5 meter per lift.

#### **4700.3.3 Compaction of Freshly Place Concrete**

- (a) Freshly placed concrete shall be consolidated by external formwork vibrators supplemented by poker vibrators approved by the Engineer. The vibration shall be sufficient to remove all undesirable air voids from the concrete, including the air voids trapped against forms and construction joints.
- (b) The Contractor shall avoid excessive use of vibrators. Excessive vibration will cause segregation and excessive bleeding.
- (c) Poker vibrators should be used to penetrate into the previous layer to uniformly blend the previous concrete layer with the freshly poured concrete.

#### **4700.3.4 Finishing Tolerances**

- (a) Unless the Engineer instructs otherwise, formwork shall be provided to achieve the tolerance prescribed in this Section, which is a surface finish category with smooth and of uniform texture and appearance. For this class, the formwork lining shall leave no stain on the concrete and shall be so joined and fixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only one source throughout any one structure. The Contractor shall make good any imperfections in the finish. Internal ties and embedded metal parts shall not be used. Materials used shall be subject to the Engineer's approval.
- (b) In all cases the Contractor shall maintain the tunnel centre line within a tolerance of 5-mm throughout the tunnel length. This target tolerance is achievable since the inner dimensions of the tunnel is designed with a maximum 50-mm of allowance to the minimum clearance limit of the tunnel.
- (c) Notwithstanding the maximum allowance of 50-mm to the minimum clearance limit, the maximum deviation of finished concrete surface shall not exceed 20-mm inward at any point. In general, outward deviation will not be acceptable as outward deviations reduces the thickness of concrete lining.
- (d) The gap between the previous concrete lining and the freshly placed concrete shall not exceed 5-mm. Gaps thus formed shall be scabbled and smoothed as approved by the Engineer. The Contractor shall submit to the Engineer for approval a proposed method for making such gaps smooth.

#### **4700.3.5 Formwork Removal**

- (a) It is recommended from the empirical knowledge that tunnel formwork may be removed about 12 hours after concrete placing with the Engineer's approval. Approval of the Engineer to remove forms does not in any way relieve the Contractor of its obligation to delay the removal of forms and shoring until the concrete has attained sufficient strength to support its own weight. The Contractor shall demonstrate that the concrete at 12-hour age has attained sufficient compressive strength.
- (b) The formwork shall be removed slowly with due care, as the sudden removal of the formwork gives an uneven shock load on partly hardened concrete.

#### **4700.3.6 Curing and Protection of Concrete**

- (a) Cast-in-place concrete shall be continuously cured immediately after stripping by keeping the concrete moist or by applying an approved curing compound (membrane). Curing compound, if approved by the Engineer, can only be applied if the concrete is the finished exposed surface.
- (b) All materials and equipment needed for adequate curing and protection shall be available and at the placement site prior to the start of concrete placement. Concrete shall be continuously cured for at least 7 days for concrete mixed with ordinary Portland cement. If high-early-strength Portland cement is used, the curing period may be reduced to about 3 to 4 days with prior approval of the Engineer.
- (c) No fire or excessive heat including welding shall be permitted near or in direct contact with concrete or concrete embedment at any time.
- (d) Where wooden form sheathing is left in place during curing, the sheathing shall be kept wet at all times.
- (e) Where steel forms are left in place during curing, the forms shall be carefully broken loose from the hardened concrete and curing water continuously applied into the void so as to continuously saturate the entire concrete surface.
- (f) Horizontal surfaces may be moist cured by ponding, by covering with a minimum uniform thickness of 50 mm of continuously saturated sand, or by covering with saturated non-staining burlap or cotton mats.
- (g) Horizontal construction joints may be allowed to dry for 12 hours immediately prior to placing the next lift.

#### **4700.3.7 Shop Drawings**

Apart from the shop drawings prepared prior to formwork fabrication mentioned under Clause 4700.3.1 hereof, the Contractor shall submit tunnel lining shop drawings for review and approval by the Engineer no later than fifty-eight (58) days prior to the start of tunnel lining work. Shop drawings shall note the Contractor's proposed sequence of lining construction, joint details, all imbedded items and incorporate details and requirements for reinforcing.

#### **4700.4 Method of Measurement**

Concrete lining shall be measured in linear meter of completed sections including the secondary lining of the portal canopy sections. Measurement shall be taken along the centre line of the tunnels, based on neat lines and thickness as shown on the Drawings.

No deduction will be made for sections removed for construction of cross passages/niches and the like.

#### **4700.5 Basis of Payment**

The accepted quantities will be paid at the contract price per unit of measurement.

Payment shall be full compensation for the work prescribed in this Specification Section. Unaccepted concrete-lining sections shall be entirely removed and replaced at the cost of the Contractor.

The works, excavation, invert concrete, and backfilling, for final lining shall not be measured and paid separately, but shall be deemed included into rates for unit prices of pay-items in this Section.

<u>Pay Item</u>	<u>Concrete Lining Profile Type</u>	<u>Unit of Measurement</u>
<b>Main Tunnel</b>		
4700-01	Main Tunnel CI	m
4700-02	Main Tunnel CI-L	m
4700-03	Main Tunnel CII-B	m
4700-04	Main Tunnel CII-L	m
4700-05	Main Tunnel DI-B & BF	m
4700-06	Main Tunnel DIII-A & UA	m
4700-07	Main Tunnel DIII-AF & UAH	m
<b>Evacuation Tunnel</b>		
4700-08	Evacuation Tunnel DIIP-A & UA	m
<b>Cross Passage</b>		
4700-09	Cross Passage CI-VP	m
4700-10	Cross Passage CII-VP	m
<b>Working Adit</b>		
4700-11	Working Adit DIIIW-AF & UAF	m

## SECTION 4750 – INTERIOR FINISH

### 4750.1 Description

The work consists of interior finish by intumescent paint coating on the walls of the main tunnel throughout the entire length as shown on the Drawings.

Painting of concrete tunnel require better visibility and higher reflective values, enabling the vehicle drivers to travel inside the tunnel with less stress. Furthermore, painting work of higher quality will allow the tunnel monitoring system (Closed Circuit Television; CCTV) to capture undistorted images.

### 4750.2 Material Requirements

#### 4750.2.1 Paint

##### (a) Colour Elements

“x” value and “y” value of the colour element shall be 0.3345 and 0.3478 respectively based on the CIE 1931 x-y chromaticity diagram, or compatible colour elements as approved by the Engineer.

The Contractor shall submit the colour samples to the Engineer for his approval before placing order.

##### (b) Fire Resistivity

The Contractor is required to propose water-based or solvent-based intumescent paint(s) together with the compatible primers he intend to use for the interior finish of the main tunnel. His proposal shall accompany third party verifications of the test results of ISO 5660-1.

When testing a product according to the current version of ISO 5660, average values of 3 samples shall be taken and the results should satisfy the following requirements;

- Total Heat Release is less than 8MJ/m<sup>2</sup>,
- Heat Release Rate does not exceed 200kW/m<sup>2</sup> in 10 second, and
- No penetration either in the form of cracks or holes.

The proposed intumescent paint shall obtain approval of the Engineer before placing order.

##### (c) Adhesion Strength

Adhesion strength of intumescent paints shall be tested in accordance with JIS 5600-566 (cross cut method) which is similar to ISO 4624 (pull-off test for adhesion). The minimum adhesion strength shall be not less than 1 N/mm<sup>2</sup>. If the recommended dry film thickness exceeds 250 µm, the adhesion strength shall be tested in accordance with JIS 5400-8-5.

The Contractor shall submit third party verifications of test results for evaluation and approval by the Engineer.

##### (d) Scratch Hardness

The proposed intumescent paint shall have the minimum scratch hardness (pencil method) of H3 according to JIS 5600-5-4 Testing Methods for Paint – Part 5 Mechanical Property of film – Section 4: Scratch Hardness (Pencil Method).

The Contractor shall submit third party verifications of test results for evaluation and approval by the Engineer.

(e) Reflection Rate

Initial reflection rate of finished paint surface shall be not less than 60% as tested in accordance with JIS 5600-7-7.

The Contractor shall submit third party verifications of test results for evaluation and approval by the Engineer.

### **4750.3 Construction Requirements**

#### **4750.3.1 Surface Preparation**

The surfaces of concrete lining shall be prepared in accordance with the coating manufacture requirements and as follows.

- (a) The concrete surface shall be free from cement laitance, oil grease and loose particles,
- (b) If a curing compound was previously applied to the concrete surface it shall be completely removed prior to the coating application, and
- (c) Surface irregularities such as air pockets and other surface depressions exceeding 5-mm from surrounding area shall be filled using two components of coating mixed with ordinary Portland cement in a ratio of 1:1, or in accordance with the paint manufactures recommendation or as directed by the Engineer.

#### **4750.3.2 Coating Application**

Unless otherwise recommended by the paint manufacturer, two coats of paint shall be applied following recommended primer application. Prior to application in the tunnel, the Contractor shall demonstrate in an open field the painting procedures.

Following permission of the Engineer, painting work may be proceeded in the manner recommended by the paint manufacture using recommended tools (rollers, brushes or other method).

Stains beyond the scheduled paint area or drips on the concrete floor shall be removed in accordance with the manufacturer's recommendations and to the satisfaction of the Engineer.

#### **4750.3.3 Thickness of Coating**

Thickness of dry film shall be not less than the minimum thickness recommended by the paint manufacturer.

- (a) Dry film thickness shall be measured in accordance with ASTM D 1005 – Method A or other internationally recognised standards approved by the Engineer.
- (b) The Contractor's laboratory shall be equipped with necessary equipment which, as required and witnessed by the Engineer shall be checked for calibration.
- (c) Additional coatings shall be applied to surfaces where testing indicates there is less than the minimum specified dry-film thickness.



#### **4750.3.4 Protection and Safety Precautions**

The Contractor shall vigilantly observe the following safety precautions, failing which the Engineer may suspend the operation until the situations are improved as required.

- (a) Adjacent materials and equipment shall be protected against damage from spillage, dripping, and spatter of coating materials. Building materials and equipment shall be left clean and with all damaged surfaces corrected.
- (b) Forced ventilation for interior spaces shall be provided during application and drying of coatings to prevent the buildup of toxic or explosive concentrations of solvent vapors.
- (c) Fire extinguishers of the required quantity and correct type shall be provided to combat flammable liquid fires.
- (d) Rags used to wipe up coating materials, solvents, and thinners shall be disposed of by drenching them with water and putting them in a covered metal container.

#### **4750.3.5 Clean-up**

- (a) At the end of each working day, discarded paint materials, rubbish, dirty rags, and other similar trash shall be removed from the project.
- (b) At the completion of the work, paint spots shall be removed from finish surfaces and the project left in a clean condition.

#### **4750.3.6 Submittals**

Manufacturer's Catalogue Data product information shall be submitted to the Engineer for review and approval at least 58 days prior to the Contractor's intended start of coating work.

Data and information shall include but not be limited to the following:

- (a) detailed analysis of the coating material, with constituents measured as percentages of the total weight of coating and verification of compliance with specification requirements,
- (a) safety data sheets detailing safety precautions, and procedures for handling, applying and storing the coating materials,
- (b) instructions including details of thinning, mixing, handling, and application
- (c) manufacturer's standard color charts and color chips showing manufacturer's recommended finish color in accordance with specification requirements,
- (d) detailed mixing, thinning and application instructions,
- (e) minimum and maximum application temperature,
- (f) curing and drying times between coats,
- (g) detailed application instructions and
- (h) surface preparation requirements.

#### 4750.4 Method of Measurement

The accepted quantity of interior finish shall be measured in the unit of measurement specified in the Bill of Quantities. Defects of the paint shall be removed in a manner recommended by the paint manufacturer and made good for payment to the satisfaction of the Engineer.

#### 4750.5 Basis of Payment

The accepted quantities will be paid at the contract price per unit of measurement. Payment will be full compensation for the work prescribed in this section.

<u>Pay Item</u>	<u>Description</u>	<u>Unit</u>
4750-01	Tunnel Interior Finish (Painting)	m <sup>2</sup>

## **SECTION 4800 - DRAINAGE SYSTEM, WALKWAY & PATH**

### **4800.1 Description**

The work consists of tunnel Drainage System, Emergency Walkway and Inspection Path. The drainage system is part of the drained waterproofing system to receive inflow of groundwater sealed and collected by the waterproofing systems.

### **4800.2 Material Requirements**

#### **4800.2.1 Drain Pipes**

- (a) Unless otherwise specifically indicated in the Drawings, tunnel drain pipes, joints and fittings shall be polyethylene pipes conforming to the requirements of JIS K 6761 or equivalent international standards.
- (b) All drain pipes, except short piece of transverse drain to be embedded in the concrete lining, shall be perforated as shown on the Drawings. The perforation shall be approximately 150-mm centre-to-centre along rows, and each row shall be arranged in a staggered pattern so that all perforations lie at the midpoint between perforations in adjacent rows.
- (c) Hole size of perforation shall be: 10-mm for centre drain ( $\phi$ 350-mm) and 5-mm for transverse drain ( $\phi$ 150-mm). unless indicated on the Drawings. Deviation in hole size may be permitted with the Engineer's approval. These requirements do not apply if permeable drainage pipes are used as approved by the Engineer.
- (d) The spigot or tongue end of the pipe shall not be perforated for a length equal to the depth of the socket, and perforations shall continue at uniform spacing over the entire length of the pipe.
- (e) Detail of sidewall drain outlet connection to the transverse drain varies from one manufacturer to the others. The Contractor shall submit to the Engineer for his approval catalogue or shop drawings and installation manual for the connection he proposes to adopt. Proposal shall be delivered to the Engineer not later than 28 days before the intended date of commencement of relevant work.

#### **4800.2.2 Filter Aggregate/Backfilling Sand**

Filter aggregate to be used in the drainage system or shall be single-sized aggregate consisting of 20/40-mm coarse aggregate unless other sizes are shown on the Drawings or as approved by the Engineer.

#### **4800.2.3 Lean Concrete Bedding**

Lean concrete bedding provided for drain pipes, side ditches and structures shall conform to the classes or grades as indicated on the Drawings.

#### **4800.2.4 Concrete for Ancillary Structures**

Materials used for concrete shall conform to the requirements heretofore specified under Clause 4700.2 of Section 4700. Concrete for ancillary structures such as, Side Ditch, Kerb, Emergency Walkway and Inspection Path shall conform to the size, dimensions and classes or grades as specified on the Drawings.

## **4800.2.5 Handrails for Emergency Walkway**

Handrails (beams, brackets and sockets) shown on the Drawings shall conform to JIS G 3444 (STK 41) or equivalent standards as approved by the Engineer.

Handrails including brackets, sockets, posts and base plates shall be hot dip galvanized to JIS H8641 [Hot Dip Galvanized Coating] according to the thickness of steel, unless approved by the Engineer otherwise. Coating thickness will be tested according to JIS H 0401 [Testing Method for Hot Dip Galvanized Coating].

## **4800.3 Construction Requirements**

### **4800.3.1 Delivery and Storage of Materials**

Materials delivered to site shall be inspected for damage, unloaded, and stored with minimum handling. Materials shall not be stored directly on the ground.

Plastic pipes for drainage shall be stored to avoid exposure to direct rays of the sun and weather effects. They shall be installed within 6 months from the date of manufacture unless otherwise approved by the Engineer.

Handrails shall be delivered to the Site in crates and stored under shade to avoid direct weather effects. Defective handrails shall be replaced at no additional cost to the Employer.

### **4800.3.2 Installation**

- **Pipe Laying**

Each pipe shall be carefully inspected before it is laid. Any defective or damaged pipe shall be rejected. Plain section of pipe shall be laid on the bedding so that water collected will run on smooth surface of the pipes. No pipe shall be laid when the trench conditions are unsuitable for such work. Water shall be removed from trenches by sump pumping or other approved methods. The pipe shall be laid to the grades and alignment as indicated. The pipe shall be bedded to the established grade line. Pipes of either the bell-and-spigot type or the tongue-and-groove type shall be laid with the bell or groove ends upstream. All pipes in place shall be approved before covering up with the filter aggregates.

- **Placing Filter Aggregate and Lean Concrete Bedding**

(a) Centre Drain Pipe: The lean concrete bedding shall be placed to the thickness indicated on the Drawings. Centre drain pipe may be laid 24 hours after the lean concrete bedding is placed. Filter aggregate may be placed after the piping has been properly placed on the bedding and been inspected and approved by the Engineer. Filter aggregate shall be loosely deposited first up to top of the pipe and moderately compact both side of the pipe. Fill the rest of the trench with the filter aggregate and compact steadily to the satisfaction of the Engineer.

(b) Transverse Drain Pipe: Filter aggregate shall be placed and compacted to the bottom level of transverse drain pipe. Lay the transverse pipe and connect to the junction socket provided at the sidewall drain pipes. Thereafter follow the procedure set out for the centre drain pipe.

- **Tests of Drainage Pipes**

Strength tests for pipes shall conform to field service test requirements of the ASTM F 1248 el Standard Test Method for Determination of Environmental Stress Crack Resistance (ESCR) of Polyethylene Pipe, if required in the opinion of the Engineer. Such tests shall be carried out at no additional cost to the Employer and the Engineer. The Contractor shall demonstrate that the pipes delivered to the Site meet the requirements of this Specification Section.

- **Handrails**

Handrails shall be installed along the edge of the Emergency Walkway as shown on the Drawings and within a tolerance of  $\pm 5$ -mm measured with a 3-m straight edge laid on the top of the handrail in vertical directions. For horizontal directions, the deviations shall be within a tolerance of  $\pm 10$ -mm measured with a 3-m straight edge. Method for adjusting excessive deviations shall be subject to the Engineer's approval.

### **4800.3.3 Submittals**

Certifications from the manufacturers attesting that material meet specification requirements shall be submitted to the Engineer for approval no later than 28 days prior to the intended commencement of each work. Certificates are required for all drain pipe, handrails, gratings and other materials as requested by the Engineer.

## **4800.4 Method of Measurement**

### **4800.4.1 Drainage Pipes**

Accepted quantity of the tunnel drainage system will be measured from one end to the other end along the centre drain of the main tunnel. The transverse drains, joints, all filter aggregates, foundation concrete and all other incidentals necessary to complete the drainage system are deemed included in the length of the centre drain, without any deduction for the dimensions of connecting structures. Connecting structures are deemed included in the unit of measurement. No separate measurement will be performed for the connecting structures.

### **4800.4.2 Side Ditch**

Accepted quantity of the side ditches will be measured along both side ditches in the unit of measurement listed in the Bill of Quantities. All connecting structures and incidental fittings of the connecting structures, which are reasonably estimated from the Drawings, are deemed included in the unit of measurement. No separate measurement will be performed for individual payment.

### **4800.4.3 Inspection Path, Emergency Walkway and Handrails**

Accepted quantity of the Inspection Path and the Emergency Walkway will be measured in the unit of measurement listed in the Bill of Quantities.

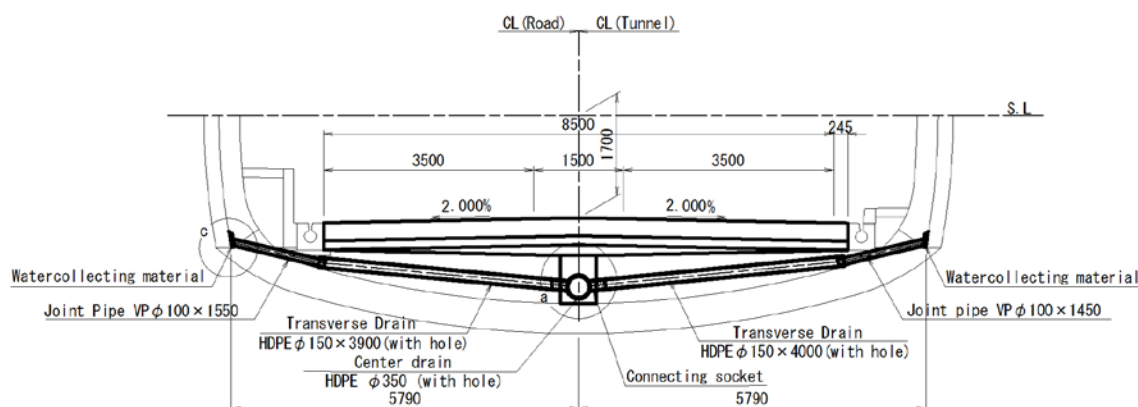
The Emergency Walkway including steps and the handrails shall be measured in linear meter as all-in-one complete element irrespective of opening for steps.

Kerbs (curbs) installed along the Inspection Path shall be deemed included in the unit of measurement for the Inspection Path.

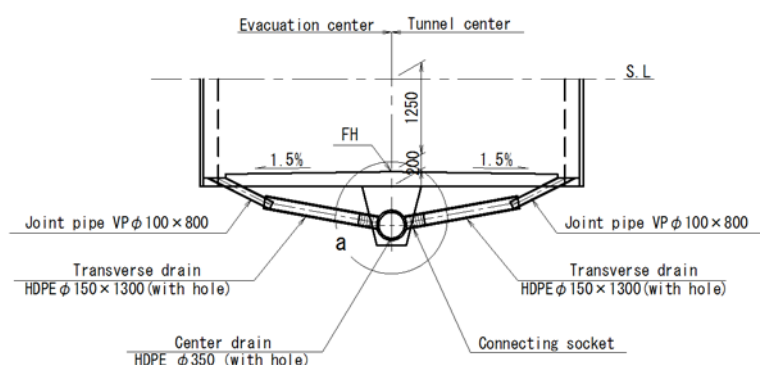
## 4800.5 Basis of Payment

The accepted quantity will be paid at the contract price per unit of measurements shown below and as indicated in the Bill of Quantities.

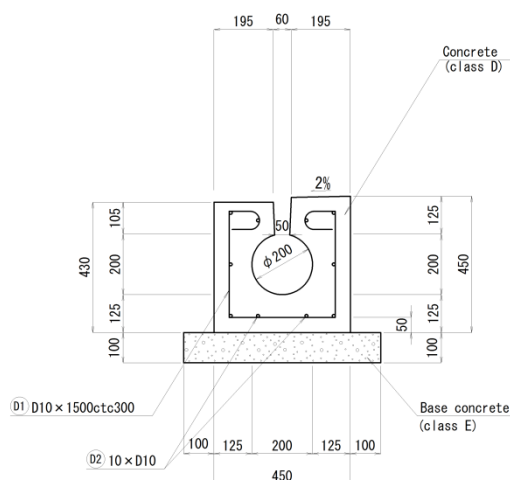
Payment will be full compensation for the materials and all work described in this section, such as excavation, lean concrete fittings, filter aggregates and other incidentals to complete the Works.



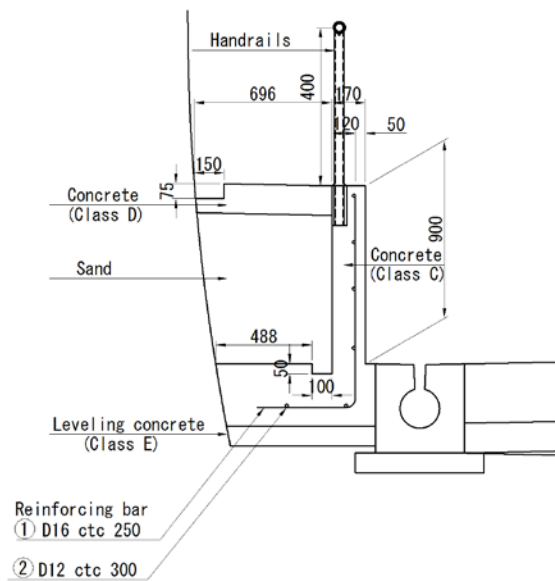
4800-01 Drainage system for Main tunnel



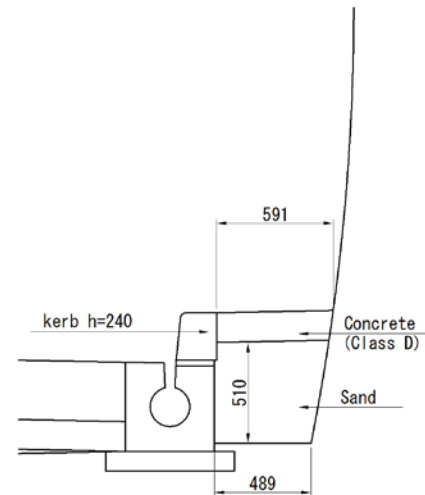
4800-02 Drainage system for Evacuation tunnel



4800-03 Side Ditches



4800-05 Emergency Walkway with  
Handrails and Steps



4800-04 Inspection Path with Kerbs

<u>Pay Items</u>	<u>Descriptions</u>	<u>Unit of Measurement</u>
4800-01	Drainage System for Main Tunnel as all-in-one complete element	m
4800-02	Drainage System for Evacuation Tunnel as all-in-one complete element	m
4800-03	Side Ditches with Connecting Structures	m
4800-04	Inspection Path with Kerbs	m
4800-05	Emergency Walkway with Handrails and Steps	m

## **SECTION 4850 – PORTAL WORKS**

### **4850.1 Description**

The work consists of tunnel portal preparation, which include, without limiting to, clearing, grubbing, excavation, slope protective measures, door of reducing a noise in blasting, pre-support at the portal face, erection of shotcrete canopies, concrete retaining walls, backfilling and drainage networks to the lines, levels, grades, dimensions and cross-sections shown on the Drawings or established by the Engineer.

Portal works will include both surface and subsurface activities. Requirements for surface activities, such as will be discussed in the respective Sections/Clauses of the Standard Specifications for Road and Bridge Works ASAD, 2058 / July 2001 or in the modifications introduced in the Special Provisions. Thus, payment for the Works performed in the subsurface activities are dealt with under those Sections/Clauses.

### **4850.2 Material Requirements**

Particulars of the materials used under this Section are identical to the requirements of materials discussed heretofore in these tunnel specifications.

The Contractor is required to refer to the respective Sections/Clauses of these tunnel specifications for detail requirements.

Corrugated metal sheet used as the outer shell of the steel rib (main frame of the shotcrete canopy) shall conform to JIS G 3352, having the metal thickness of 1.2mm. Alternative metal sheet, if the Contractor wishes to use, shall be of equivalent quality as approved by the Engineer.

### **4850.3 Construction Requirements**

#### **4850.3.1 General**

##### **(a) Operation Procedure**

- (i) Removal of topsoil and subsequent excavation shall commence from the upper surface and progress carefully in incremental steps, lest the stability of the existing slopes above the portal areas should be disturbed.
- (ii) Excavation shall cease when it reaches the formation level (subgrade surface level). If unsuitable material, rock fragments, or boulders are found at the formation level, they shall be removed as directed by the Engineer and cave-ins, holes, or depressions formed below the formation level after removal shall be backfilled with suitable material compacted in layer in accordance with the provisions of Clause 906 of the Standard Specifications for Road and Bridge Works or any modifications introduced in the special provisions.
- (iii) The Contractor shall not start the first round of tunnel excavation until the shotcrete canopy is provided in its full length.
- (v) Backfilling of the cut-and-cover section (shotcrete canopy section) may start after the canopy has gained the desired compressive strength which shall be agreed with the Engineer.
- (vi) Materials for backfilling may be taken from the stockpiles at the designated areas or material excavated from within the Site as proposed by the Contractor and



approved by the Engineer. Maximum size allowed shall not exceed 70 mm (1/3 of the compacted thickness of a layer).

- (vii) Backfill materials shall be cement treated soil with cement content of 4 to 8 % by weight. When cement is uniformly blended and mixed with soil within 2 % above the optimum moisture content and compacted to 95% of the maximum density, it shall yield the compressive strength of at least 1 N/mm<sup>2</sup> (10 kgf/cm<sup>2</sup>) at the age of 28 days. Compressive strength testing shall be performed in accordance with ASTM D 1633 Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders.
- (viii) Blending, mixing, spreading and compaction of soil cement will not be permitted in wet condition. If the time between blending and compaction exceed 2 hours, such materials shall not be incorporated into the Permanent Works. Unused materials shall be disposed of with no additional cost to the Employer.
- (ix) If the time compacting adjacent partial width exceed 30 minutes, or when trying into the previous work, the Contractor shall provide a construction joint according to the Engineer's direction.
- (x) The Contractor is required to determine and report to the Engineer the in-place density and moisture content according to AASHTO T 3310 or other test procedures approved by the Engineer.
- (xi) Where use of heavy rollers is not practical, the Contractor shall use approved light weight mechanical or vibratory compacting equipment. Soil cement layers within 1 m of the canopy shall be compacted using light weight compacting equipment approved by the Engineer.
- (xii) The thickness of each layer shall not exceed 20-cm before compaction, if a light weight compacting equipment is used. Notwithstanding, a thick layer may be acceptable to the Engineer, provided the Contractor can demonstrate that that a thicker layer can be compacted to 95% of the maximum density.
- (xiii) Backfill materials shall be placed evenly in layers on both sides of the arch so that the side pressure on the canopy walls will be balanced.
- (xiv) Movement or deformation of the canopy shall be made good by the Contractor with no additional cost to the Employer.

(b) Method of Operation

The Contractor shall submit to the Engineer for his review and comment a method statement for the construction, including type of equipment, procedures to achieve required quality, and sequence of operations which the Contractor intend to adopt, and other essential information.

Method of backfilling operations may be presented separately from that of excavation. As for backfilling, the Contractor shall demonstrate, either by mould specimen compressive testing or trial compaction tests as acceptable to the Engineer, at least 28 days before intended commencement of backfilling operation for different cement contents, e.g. 4%, 6%, and 8% by weight.

No placement of soil cement shall commence in the Permanent Works without the authorisation of the Engineer.

### **4850.3.2 Submittals**

No later than 28 days prior to the intended commencement of work for portal construction the Contractor shall submit to the Engineer for his approval the survey data, profile drawings, the method of construction. Failure to provide such detail information will be considered a default of the Contractor and thereby rendering the Engineer to instruct to suspend that part of the Works in accordance with Sub-Clause 8.8 of the Conditions of Contract.

### **4850.3.3 Slope Protection Measures**

The Contractor shall perform the excavation with full care, and ensure that the cut slope remains stable during and after the excavation until the portal canopies are backfilled to the lines, grades, and dimensions shown on the Drawings or as directed by the Engineer.

### **4850.2.4 Dewatering**

All excavation shall be maintained free of water and the Contractor shall provide all necessary materials, equipment and labour for de-watering (pumping), diverting water-ways and the construction of temporary drains, cut-off walls and cofferdams as occasion may demand. Standby pumps shall be maintained in the vicinity of the workplace in good working order at all times to ensure no interruption in the continuity of de-watering procedures.

## **4850.4 Method of Measurement**

### **4850.4.1 Surface Work**

Quantity of clearing, grubbing, felling of trees, slope excavation and protective measures, concrete headwalls and retaining walls (wing walls) and all incidental works will be measured according to the unit of measurement specified in the Bill of Quantities. and paid according to the relevant items under the Standard Specification for Road and Bridge Works, ASAD, 2058 / July 2001 or modifications introduced in the Special Provisions.

### **4850.4.2 Portal Face and Canopy Works**

- (a) Pre-supports installed at the portal faces as shown on the Drawings and shotcrete applied at the portal face will not be measured separately for individual payment. Payment for the pre-supports installation and application/removal of the shotcrete protection is deemed included as the integral part of the portal construction and is therefore deemed included in the unit of measurement of the portal canopy.
- (b) Shotcrete applied inside the portal canopies as shown on the Drawings will not be measured separately for individual payment. Payment for shotcrete applied inside the portal canopies is deemed included as the integral part of portal construction and is therefore deemed included in the unit of measurement of the portal canopy.
- (c) Steel rib and the corrugated metal sheet installed as the main frame of the portal canopies will not be measured separately for individual payment. Payment for the steel ribs and corrugated metal sheets is deemed included in the unit of measurement for construction of the portal canopies.
- (d) Backfilling performed in the periphery of the portal canopies as shown on the Drawings will not be measured separately for individual payment. Payment for backfilling is deemed included in the unit of measurement for construction of the portal canopies.

- (e) Payment for soundproof door against tunnel blasting is deemed included in the unit of measurement for construction of the portal canopies.

#### **4850.5 Basis of Payment**

Accepted quantities of clearing, grubbing, felling of trees, slope excavation and protective measures, concrete headwalls and retaining walls (wing walls) and all incidental works will be paid separately according to the relevant items under the Standard Specification for Road and Bridge Works, ASAD, 2058 / July 2001 or modifications introduced in the Special Provisions.

Accepted quantities of portal canopy will be paid according to the unit of measurement specified below and as listed in the Bill of Quantities.

No separate remuneration will be paid for demolition of shotcrete protection at the portal face. The cost is deemed included in the tunnel excavation.

Payment will be full compensation for the materials, labour, equipment and any other incidentals necessary to complete the portal canopies.

<u>Pay Items</u>	<u>Descriptions</u>	<u>Unit of Measurement</u>
4850-01	Erection of Portal Canopy – Main Tunnel	m
4850-02	Erection of Portal Canopy – Working Adit	m
4850-03	Erection of Portal Canopy – Evacuation Tunnel	m

## SECTION 4900 - GATES

### 4900.1 Description

The work consists of furnishing and installation of the entrance gate for the evacuation tunnel and the gate connecting the main tunnel with the evacuation tunnel as shown in the Drawings.

### 4900.2 Material Requirements

#### 4900.2.1 Type and Functional configuration

(a) The types of doors are as shown below:

Type	Description
Gate for cross passage	Consists of a door for person and emergency car (between Main Tunnel and Evacuation Tunnel)
Gate for entrance of evacuation tunnel	Consists of a door for person and roadway

(b) Functional configuration

The material shall be equivalent to SUS 304.

When the door opens, put the display signal to the management site such as the facility control room.

#### 4900.2.2 Structure

(a) Door for people

Make it easy for people to pass (W 1350 mm × H 2000 mm).

It shall be robust even when the static pressure difference between the front and back of the door is 760 Pa.

It shall have a mechanism that automatically starts closing even if it stops at any position within an arbitrary set time after opening.

(b) Door for emergency car

Make it easy for emergency car to pass (W 2900 mm × H 3200mm).

It shall be robust even when the static pressure difference between the front and back of the door is 760 Pa.

### 4900.3 Construction Requirements

#### 4900.3.1 Inspection contents

(a) Wind resistance test

Confirm that the door will not be damaged when a static pressure difference of 760 Pa door is generated. (Reference JIS A1515 Wind resistance test method of fittings 6 test)

(b) Door operation force inspection

With door for emergency car, the inspection is carried out with a push-pull gauge in a state of no static pressure difference between the front and back of the door. With door for people, in accordance with "JIS A 1519 Testing method of opening and closing force of fittings", at the time of pressurization of 290 Pa, from the fully closed state to the initial 10 cm which requires the most operation force is released with the push-pull gauge Measure the operating force of 98N or less.

#### 4900.4 Method of Measurement

The accepted quantity of gates shall be measured in the unit of measurement specified in the Bill of Quantities. Defects of the gates shall be repaired in a manner recommended by the manufacturer and made good for payment to the satisfaction of the Engineer.

#### 4900.5 Basis of Payment

The accepted quantities will be paid at the contract price per unit of measurement. Payment will be full compensation for the work prescribed in this section.

<u>Pay Item</u>	<u>Description</u>	<u>Unit</u>
4900-01	Gate for cross passage	nos
4900-02	Gate for west entrance of evacuation tunnel	nos
4900-03	Gate for east entrance of evacuation tunnel	nos

**SECTION VI-C: SPECIAL PROVISIONS TO THE STANDARD SPECIFICATIONS (SPSS)**

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## SECTION 5000. TUNNEL FACILITIES

### (1) GENERAL

#### (1.1) Description

This work consists of the provision and installation of the Tunnel Facilities, protection and maintenance during the construction period and the Defects Notification Period. This work also includes all testing for approval of material and equipment to be provided, test and commissioning for final reception, all ancillary and incidental works necessary to complete the following items as shown in the Drawings, and as approved by the Engineer:

- ♦ Tunnel Power Supply System
- ♦ Tunnel Lighting System
- ♦ Tunnel Emergency Facilities
- ♦ Remote Monitoring and Control System
- ♦ Tunnel Ventilation System
- ♦ Tunnel Fire Fighting System

#### (1.2) Design-Review and Updating

These requirements shall be read and applied accordingly, and without detriment, to the requirements and provisions of Clause 4.1 “Contractor’s General Obligations” of the Conditions of Contract and any other relevant requirements of the Special Provisions to the Standard Specifications.

- (a) These works consist of the Design Review and Updating by the Contractor based on the Conceptual Design provided by the Employer. The report of the Design Review/Updating shall include also all detailed drawings, applicable technical specifications and requirements for construction and materials.
- (b) The Contractor shall be responsible for surveying, designing, manufacturing, testing of equipment/ materials at the factory, packing, transporting, maintaining, installing, integrating the test system, misadjusting and commissioning the items, which are involved in the corresponding sections or paragraphs of this Specifications, at the site.
- (c) The Contractor shall be responsible for any incidental works generated on relevant items. Drawings or specifications shall be described as the Contractor’s design review and updating being in accordance with the requirements of the standards.
- (d) Specific work-items, which are consisting the design review to be performed by the Contractor, shall be in conformity with the specifications with dimensions, content, scales, forms and functions.

- (e) Unless otherwise stipulated in the Contract, the design review and updating performed by the Contractor, and the selected manufacturer/ supplier of equipment/ materials and components shall be ensured with the following design life in the actual environmental and operational conditions:
  - (i) Constructional facilities: .....min. 20 years
  - (ii) Work structure: .....min. 50 years
  - (iii) Components covering the buildings.....min. 20 years
  - (iv) Electrical system, lighting system: .....min. 20 years
  - (v) Indoor architectural items: .....min. 15 years
- (f) The Contractor shall review and update the design and construct or install the auxiliary or additional facilities which are assumed to be necessary for completing the works in accordance with the Drawings, specifications and functions requirements for the system as well as by the applicable condition by the Engineer.
- (g) The Contractor shall ensure entirely his designed systems, equipment, devices, materials and components are installed and integrated fully; besides, it should be sure that operation and maintain shall be easily and effectively conducted together with a high commercial efficiency as well as a small operational and maintaining cost.
- (h) The Contractor shall also implement the requirements to ensure that all systems, equipment, materials or components shall satisfy in terms of interference from any electrical and electronic appliances in the tunnel, though they are provided by the individual chapters of technical specifications, or the systems, equipment, materials or components of other items.
- (i) The design, dimension and material of entire structures, parts shall be reviewed to avoid any impacts of any harsh operating conditions which may create distortion, vibration that may cause unfavorable impacts to the structural integrity or operation of the equipment.
- (j) The Contractor shall do the design review/updating in conformity with the relevant environmental requirements and standards.
- (k) The Contractor is responsible to meet the requirements of the relevant authorities as well as obtain all necessary agreements and approvals from the relevant agencies, including firefighting and prevention agencies, power supply companies and others.
- (l) The Contractor is responsible for coordinating with the suppliers of equipment, devices (under this Project's scope) to clearly know the overall design, the required software and hardware; thus, it is ensured the appropriate interface as well as the interactive information among designed systems in accordance with the description in the specifications.

### **(1.3) Calculation by the Contractor**

- (a) The Contractor shall prepare all calculations to justify and substantiate the

- reviewed/updated design of all civil, structural, mechanical, electrical, process and control works and systems for which he is responsible for the design. The calculations shall contain sufficient explanation and diagrams to enable a complete understanding without any further verbal explanations. All assumption, loadings, alternates and revisions shall be clearly documented.
- (b) Computerized calculations shall include documentation which explains clearly the applied program, terminology, conventional symbols and signs.
  - (c) The Contractor shall prepare and submit a single-line diagram indicating the ratings such as capacity, etc. of every items of equipment and protection, metering or any ancillary devices in accordance with the requirements of proposed equipment. A detailed load computation shall be attached with a complete diagram and a manual accompany for each applied major item.
  - (d) The Contractor shall explain and submit all calculations, drawings, data of manufacturer as well as other supporting information requested by the Engineer for review and approval of the proposed or selected materials, equipment. The Engineer has right to request full or partial submissions at any time.
  - (e) Procurement and manufacturing shall not commence prior to such approval being received unless it is expressly agreed by the Engineer (so the Contractor shall remain his responsibility if the further changes are necessarily requested in such this case).
  - (f) The Contractor shall submit to the Engineer, for review and approval, the full detailed design review/updating documentation and drawings in order to demonstrate that the requirements of the Specifications have been completely incorporated.
  - (g) The Contractor shall submit to the Engineer, for review and approval, the necessary procedures, reports and certificates to certify that the Contractor is capable to promptly carry out the manufacture, installation and other related works.
  - (h) The Contractor shall undertake design-related interface meetings, in the Site, with all of the relevant sub-contractors and suppliers in the presence of the Engineer. The purpose of these design-related interface meetings is to ensure all interface requirements have been integrated.
  - (i) All submittals to be made by the Contractor shall be in accordance with the Conditions of Contract (Clause 4.1: “Contractor’s General Obligations”, Sub-Clause 1.1.6.1: “Contractor’s Documents”, and other relevant conditions) and Section 117: “Contractor’s Drawings” of these Special Provisions to the Standard Specifications.
  - (i) The Contractor shall submit, for review and approval by the Engineer, an schedule for the following items and shall include respective milestone-dates into the approved Programme in accordance to Section 116: “Programme”:

Submittal No.1 of the Design Review/Updating:

- ✓ Detailed Work Schedule for the systems, equipment and materials showing location, fabrication, and shipment and installation periods.
- ✓ List of drawings and documents to be submitted
- ✓ Preliminary Interface Information for all other Sections/Divisions.
- ✓ General information on proposed software including operating systems and programming language

Submittal No.2 of the Design Review/Updating:

- ✓ Detailed Interface Design among facilities in the Project
- ✓ System diagram
- ✓ Calculations and drawings
- ✓ Diagrams connecting to systems of control, electrical, mechanical, emergency equipment, etc.
- ✓ Preliminary layout of equipment rooms and the others
- ✓ Layout drawings showing the routing and sizes of piping routes and electrical cables and all accessory systems
- ✓ Arrangement of foundations, steel support structures, stairs and walkways.
- ✓ Anchor types
- ✓ Equipment colors
- ✓ Functional analysis, outline of software specification, tables and drawings of operators' screens and policy for development and construction of software.

Submittal No.2 of the Design Review/Updating:

The Contractor shall submit the final design review/updating with all supporting information and final drawings. The submittal shall contain all necessary information to permit final and efficient review by the Engineer and shall include (but is not limited to):

- ✓ Final detailed drawings
- ✓ Equipment lists
- ✓ Details (with all equipment/device lists and specifications) of all control systems and interfaces
- ✓ Detailed design calculation sheets (mechanical, structural, electrical calculations)
- ✓ Arrangement of electrical equipment and devices including computer

control system

- ✓ Final software including specification and user manuals
- ✓ Design evaluation report
- ✓ Details of assembly and installation and fixing of all system, equipment and materials
- ✓ Caution plates and exit signs including symbols for signage

## **(2) QUALITY CONTROL**

### **(2.1) Testing in Site**

This Sub-Clause shall be interpreted for the Tunnel Facilities, supplementary to, and without detriment to the stipulations of Section 500: “Quality Control” of these Specifications and Sub-Clause 4.9: “Quality Assurance” and Sub-Clause 7.4: “Testing” of the Conditions of Contract, and all relevant stipulations of the Contract.

- (a) All equipment, devices, units, components, and parts, which are delivered and installed under the Contract, shall be tested, inspected and certified prior to the acceptance in accordance with the requirements of the Standards, and as approved by the Engineer.

- (b) In accordance with the Specifications, the Contractor shall demonstrate that all requirements described in the Contract are satisfactorily complied.

Details of all complied documents and procedures shall be submitted to the Engineer for review and approval before each execution stage is commenced.

- (c) For the off-the-shelf or routinely manufactured equipment, the Contractor may submit a test result report or the manufacturer’s test and inspection certificate instead of an in-factory test (being exempted). In addition, the Contractor shall submit the factory's routine testing procedures to the Engineer for review and acceptance.

For the equipment or components requiring special order or specifically designed and manufactured for this project, the Contractor shall submit to the Employer proposed factory test items and test procedures for review and approval as soon as the System Design is accepted.

The Contractor shall notify in advance of each factory test to be undertaken.

After each test, upon the Engineer’s approval on the test results, the Contractor can start transporting equipment to the Site. The devices which are detected to have defects or been produced inconsistent with the standards, shall be rejected and replaced immediately on the Contractor’s expenses and responsibility.

### **(2.2) Factory Test**

The testing cost shall cover cost for providing all facilities, tools, labor, consumable parts, measuring apparatus and appliances required in connection for all inspection

and tests at factory or on the manufacturer's premises, and all other expenses. Separate payment of these cost will not be made,

The Contractor shall state the location of factory test for the test items in his Technical Proposal.

The locations where the factory test is conducted shall have the necessary facility, testing device, measuring apparatus, recording system, power supply and other arrangements to conduct the test items listed in the Test Procedure. The Contractor shall state specifically the in-situ facility and equipment tests as well as the required measurement tools or devices applied into these tests at the proposed locations in his technical proposal.

### **(2.3) Inspection**

All equipment shall be inspected before delivery and upon arrival at the site. The inspection shall be performed with the following items:

- ♦ Painted surfaces and color
- ♦ Assembling conditions
- ♦ Design and dimensions
- ♦ Part setting
- ♦ Wiring within the cabinet
- ♦ Damages during transportation

## **(3) COMMISSIONING**

This Sub-Clause shall be interpreted for the Tunnel Facilities, supplementary to, and without detriment to the stipulations of Subsection 509: "Acceptance Tests for Completed Works or Parts of the Works", Clause (3): "Testing and Commissioning" of these Specifications, and Clause 9: "Test on Completion" and Sub-Clause .4: "Testing" of the Conditions of Contract, and all other relevant stipulations of the Contract.

### **(3.1) Procedure**

- (a) Commissioning Test procedure shall be applied to the equipment, devices and software comprising the system including network equipment, fiber optic cable, communication and power cables, all electrical equipment installed at the required locations, adjusted and tested by the Contractor.
- (b) Commissioning Test shall be conducted at two levels; Commissioning Test for a portion of works, and Commissioning Test for the entire Works. The Commissioning Test for a portion of works shall be conducted for a group of equipment at the site that functions as a sub-system and achieves part of the system functions.
- (c) The Commissioning Test for the entire Works shall be conducted to confirm that the system supplied under the Contract complies with the Employer's requirements, the approved specifications, the prepared drawings which have

been submitted for all aspects of one system by the Contractor.

- (d) During the Commissioning the entire Works, all the functions of the equipment required under the Contract shall be tested. Data exchange between the terminal equipment and the Tunnel Control Center system will be tested including the case of the interruption and recovering the communication link between the terminal equipment in addition to the functions of respective systems. The test shall be conducted with the attendance of the Project Manager.
- (e) The Contractor shall keep a clear record of all tests conducted. The record shall include time, place, equipment, procedure, functions, persons attending, and faults or problems encountered. The test results, even if they are not satisfactory, shall be documented.
- (f) The Employer will provide electricity free of charge to the Contractor for the purpose of conducting Commissioning Test if permanent electrical supply is available. Otherwise, the Contractor shall arrange electricity, water and gas necessary for the Commissioning Test.
- (g) The Contractor shall prepare or arrange the test apparatus and equipment, temporary connection, testing software, test data, test vehicle, tools and other items necessary for conducting test. The cost of such items shall be included in the cost of test in the Pricing Document and no separate payment shall be made.

### **(3.2) Commissioning Test for the Whole System**

- (a) *Procedure*: The Contractor, in accordance with these Specifications and the Conditions of Contract, shall notify to the Engineer before the date of commissioning for the whole system with test items, procedure, criteria for judging the test results and test schedule.

The Contractor shall send to the Engineer the regular certified copies of the test results when the tests have been successfully completed. The Engineer, if the results satisfy the requirements, will notify the Contractor in written that the Works are ready for commissioning operations.

If any major defects are uncovered during the test, the Contractor shall prepare and submit to the Engineer, for reviewing and approval, a proposal to remedy the defects including a method statement and all necessary technical details. The Contractor shall not take corrective actions before the proposed solution have received the Engineer's approval. Minor faults and defects detected during the Commissioning procedure may be corrected during the trial operation period upon the Engineer's acceptance.

"Major defects" might cause, among others, the following results:

- ✓ Lose data, erroneous data or inconsistency in operation;
- ✓ Low quality of data acquisition such as missing observation or delay in



observation;

- ✓ Low quality of local/ remote control such as no response or delay of response;
- ✓ Unexpected shutdown or halt of operation;
- ✓ Failure to changeover to backup equipment; and
- ✓ Failure to restart and resume the operation after power recovery of the device that is designed to have such function.
- ✓ Worsen the situation of other defects which were initially classified as minor defect.

- (b) Test on Completion: Testing and Commissioning shall be in accordance with the Clause: “Test on Completion” of the Conditions of Contract and all related conditions of these specifications and the Contract. The Taking Over Certificate shall be issued in accordance with Clause 10: “Employer’s Taking Over” of the Conditions of Contract upon the duly compliance on the requirements for “Test Completion”.
- (c) Trial Operation Time: Trial operation shall be conducted for two (2) months after Taking-Over Certificate has been issued for the respective works. The operation of the system will be carried out by the Employer or his designated operator. Should any critical or major defect be found during the trial operation, the trial operations shall restart after rectification of the defects are approved by the Engineer.

In such case, the Employer based on the evaluation made by the Engineer, can apply the following:

- ♦ Repetition of the trial period, and consequent extension of the Defects Notification Period in accordance to Clause 11.3: “Extension of Defects Notification Period” of the Conditions of Contract; or
- ♦ Application of Clause 11.4: Failure to Remedy Defects” of the Conditions of Contract.

For minor defects, the Contractor shall rectify it to the satisfaction of the Engineer and the trial operation will continue without interruptions.

#### **(4) OPERATION/MAINTENANCE/REPARATION SERVICES**

- (a) The Contractor has be responsible of providing operation, maintenance and reparation services for all equipment, systems and work items during warranty period, as mentioned in related chapters of these Specifications.
- (b) Proposal of the Contractor for operation, maintenance and reparation services shall be updated and developed to comprehensive operation, maintenance and reparation program.
- (c) Operation, maintenance and reparation services provided by the Contractor including:



- (i) Assign skilled staffs to support the Employer in operation of machines, equipment and systems during warranty period.
- (ii) Periodical and annual testing and maintenance procedures in regulated time in approved Operation and Maintenance manuals, including checking of system, equipment and machines, calibration, cleaning and greasing for all couplings to avoid incidents by any reason .
- (iii) Immediate reparation service including capacity of reparation after receiving orders from the Employer or the Engineer.
- (iv) Supply spare-part equipment, grease, oil
- (d) In case the reparation, maintenance or other external services are necessary due to excessive use, misuse or other reasons out of control of the Contractor. The Contractor shall provide external service for maintenance, reparation and all cost shall be paid by the Employer.
- (e) The Contractor still have responsibility for the effectiveness and optimization of system operation
- (f) All maintenance and reparation services implemented by the Contractor or local agencies and established officially under the responsibility of the Contractor, certified or authorized to provide service of the Contractor and manufacturing factories of specified system, equipment or related woks. The reparation and maintenance implemented by such organization is legal.
- (g) All reparation, maintenance, operation services shall be implemented with the witness of the Employer representative for the operation and maintenance training.

## **5100. TUNNEL POWER SUPPLY SYSTEM**

### **(1) Application**

This list of specifications specifies electrical equipment to supply, and the equipment for each device for step-down conversion from the NEA 11kV power supply. An independent generator facility, DC power supply, and uninterruptible power supply are also included to secure safe operation of tunnel facilities during times of NEA power outages.

### **(2) Facility Structure**

The power distribution equipment comprises the following facilities.

- ♦ East-side high voltage electrical room, electrical room facilities (including DC power supply uninterruptible power supply), generator room
- ♦ East-side independent generator room (including underground fuel tank)
- ♦ West-side high voltage electrical room, electrical room facilities (including DC power supply, uninterruptible power supply)

### **(3) Applicable Standards**

These facilities abide by the laws and standards below.

- (a) Electricity Business Act
- (b) Japanese Industrial Standards (JIS)
- (c) Japan Electric Committee Standards (JEC)
- (d) Japan Electrical Manufacturers' Association (JEM)
- (e) Japan Land Engine Manufacturers' Association (LES)
- (f) Independent Generator Facility Earthquake Resistance Design Guidelines (NEGA)

In addition, the following laws and standards will be applied. However, these specifications should be given priority.

Applicable Standards
Seven Design Essentials Electrical Facilities Electrical Facilities Chapter 1, Power Distribution Equipment (NEXCO RI July 2017)
Seven Design Essentials Electrical Facilities Electrical Facilities Chapter 2, Independent Generator Facilities (NEXCO RI July 2017)
Seven Design Essentials Electrical Facilities Electrical Facilities Chapter 3, DC Power Supply and Uninterruptible Power Supply (NEXCO RI, July 2017)
Electronic Telecommunications Facility Design Guidelines/Explanation (Electric Facilities) 2017 version The Telecommunications Association
Electronic Telecommunications Facility Installation Standard Diagrams January 2015. The Telecommunications Association
Facility Equipment Specifications Manual Electricity Power Distribution Equipment Standard Specifications Manual. July 2017 (NEXCO-RI)
Facility Equipment Specifications Manual Electricity Independent Generator Facility Standard Specifications Manual July 2017 (NEXCO-RI)

These facilities must be manufactured, installed, tested, and commissioned under a quality guarantee and quality management system meeting ISO 9001 standards. The manufacturer must be an organization which possesses ISO 9001 certification from an independent public body.

#### (4) Basic Requirements

##### (a) Basic Design

The power distribution equipment will receive 11kV50Hz power from NEA via two lines near the east-side electrical room, and these lines will run into the east-side high voltage electrical room. The boundary of responsibility for NEA jurisdiction will be installed at the two switchgear panels near the east-side electrical room, and the interior sector switchgear (DS) will be the primary NEA cable bed. The high voltage electrical room will comprise 12kV switchgear and a transformer board for step-down conversion of 11kV to

400V. The 400V electricity will be supplied to the electrical room, where it will be converted to either 220V or 110V as needed to supply power for each piece of equipment. The status of each device can be monitored from the front of the switchgear and cubicle, and the necessary signals will connect to a control system device through the relay terminal board, to enable monitoring control.

Backup power for use during NEA power outages is provided according to facility importance level. Circuits are classified into general circuits (AC), independent generator circuits (GC) and important circuits (INV).

(Note):

- ✓ AC circuits go offline during NEA power outages.
- ✓ GC circuits supplied with power from the independent generator facility during NEA power outages
- ✓ INV circuits reverse-switch to DC power during the period required to switch from NEA power to independent generator facility power during NEA power outages. Prevents momentary blackouts to keep the power supply stable.

(b) Reliability

This system will run 24 hours a day, 365 days a year. Devices which can bear up to sustained use will be employed.

(c) Extensibility

Extensibility will be made possible, to promote ease of future expansions and repairs. It will be made easy to add basic facilities, etc.

**(5) Power Distribution Equipment**

This item will be applied to devices installed as part of power supply control facilities (hereinafter, “the facilities.”)

Equipment Outline:

(a) Use Locations

The equipment will be used in the east-side electrical room and west-side electrical room, and will be indoor devices.

However, the east-side sectional switchgear will be an outdoor device.

(b) Surrounding Conditions

- ✓ Temperature: Indoor 0°C to +40°C  
Outdoor -10°C to +40°C
- ✓ Humidity Indoor 10% to 85% RH.

However, this assumes no condensation.

(6) Facility Structure

(a) Device List:

Table 51-1 shows the list of devices included in the power distribution equipment for Eastern Side Electrical Room:

**Table 51-1: Power Distribution Equipment in Eastern Side Electrical Room**

Item	Details	Qty.	Unit	Comments
Sectional Switchgear (1)	DS LA	1	Panel	Outdoor type
Sectional Switchgear (2)	DS LA	1	Panel	
Draw-In Board (1) Circuit A	DS	1	Panel	
Power Receiving Panel (1): Circuit A	CB×1	1	Panel	
Draw-In Board (2) Circuit B	DS	1	Panel	
Power Receiving Panel (2): Circuit B	CB×1	1	Panel	
Ventilation Transformer (1): Primary Panel/ Ventilation Transformer (2): Primary Panel	CB×2	1	Panel	
Lighting Transformer Primary Panel/ West-Side Electrical Room Power Sending Panel (1) Circuit A	CB×1	1	Panel	
Bus Tie Panel (1)	CB×1	1	Panel	
Bus Tie Panel (2)	CB×1	1	Panel	
Independent Generator Tie Panel/ West-Side Electrical Room Power Sending Panel (2) : Circuit B	CB×2	1	Panel	
Independent Generator Power Transfer Panel	DT-DS	1	Panel	
West-Side Electrical Room , Power Sending Panel ; Independent Generator Circuit /Maintenance Power Panel	CB×2	1	Panel	
West-Side Electrical Room Power Sending Transfer Panel	DT-DS	1	Panel	
Ventilation Transformer Panel (1)	Tr 300kVA	1	Panel	
Ventilation Transformer Secondary Panel (1)	MCCB	1	Panel	
Ventilation Transformer Panel (2)	Tr 300kVA	1	Panel	
Ventilation Transformer Secondary Panel (2)	MCCB	1	Panel	
Lighting Transformer Panel	Tr 300kVA	1	Panel	
Lighting Transformer Secondary Panel	MCCB	1	Panel	

Item	Details	Qty.	Unit	Comments
Auxiliary Transformer Panel (1)	Tr 75kVA	1	Panel	
Auxiliary Transformer Panel (2)	Tr 50kVA	1	Panel	
Lighting Control Panel		1	Panel	Including light sensor and automatic light adjustment device
Tunnel Lightning Panel (1)	MCCB	1	Panel	
Tunnel Lightning Panel (2)	MCCB	1	Panel	
Uninterruptible Power Supply Device	30 kVA 100Ah/ 180 Cell	1	Set	
Controller DC Power Supply Device	50Ah/ 54 Cell	1	Set	
Maintenance Transfer Panel No.1 No.2		1	Panel	
Ground Terminal Board		1	Panel	
Telecommunications Equipment Room Distribution Panel		1	Panel	
Ventilation Control Center (1)	2 units installed	1	Panel	
Ventilation Control Center (2)	2 units installed	1	Panel	

Table 51-2 shows the list of devices included in the power distribution equipment for Western Side Electrical Room:

**Table 51-2: Power Distribution Equipment in Western Side Electrical Room**

Item	Details	Qty.	Unit	Comments
West-Side Electrical Room				
Draw-In Board (1) Circuit A	DS	1	Panel	
Power Receiving Panel (1) Circuit A	CB×1	1	Panel	
Draw-In Board (2) Circuit B	DT-DS	1	Panel	
Power Receiving Panel (2) Circuit B	CB×1	1	Panel	
Maintenance Power Supply Panel	CB×1	1	Panel	
Ventilation Transformer (1) Primary Panel/ Ventilation Transformer (2); Primary Panel	CB×2	1	Panel	
Lighting Transformer Primary Panel/ Road Station; Power Sending Panel	CB×2	1	Panel	
Bus Tie Panel	CB×1	1	Panel	

Item	Details	Qty.	Unit	Comments
Ventilation Transformer Panel (1)	Tr 300kVA	1	Panel	
Ventilation Transformer Secondary Panel (1)	MCCB	1	Panel	
Ventilation Transformer Panel (2)	Tr 300kVA	1	Panel	
Ventilation Transformer Secondary Panel (2)	MCCB	1	Panel	
Lighting Transformer Panel	Tr 300kVA	1	Panel	
Lighting Transformer Secondary Panel	MCCB	1	Panel	
Auxiliary Transformer Panel (1)	Tr 75kVA	1	Panel	
Auxiliary Transformer Panel (2)	Tr 75kVA	1	Panel	
Lighting Control Panel		1	Panel	Including light sensor and automatic light adjustment device
Tunnel Lightning Panel (1)	MCCB	1	Panel	
Tunnel Lightning Panel (2)	MCCB	1	Panel	
Uninterruptible Power Supply Device	20 kVA 100Ah/ 180 Cell	1	Set	
Controller DC Power Supply Device	50Ah/ 54 Cell	1	Set	
Maintenance Transfer Panel No.1 No.2		1	Panel	
Ground Terminal Board		1	Panel	
Ventilation Control Center (1)	2 units installed	1	Panel	
Ventilation Control Center (2)	2 units installed	1	Panel	

(b) Device Design

The designs for the devices and equipment are detailed below:

- (i) All devices are “indoor use” except when specified otherwise.
- (ii) The shape of the housing for high-voltage devices must be JEM1425 “High Voltage Metal Closed-Type Switchgear,” conforming to the standards in the table below.
- (iii) The shape of the housing for low-voltage devices must be JEM1265 “Low Voltage Metal Closed-Type Switchgear,” conforming to the standards in the table below.

Power Distribution Panel Type	Format ※1	Standard
-------------------------------	-----------	----------

Draw-In Panel	CY	JEM 1425
Power Receiving Panel	CX	JEM 1425
Transformer Primary Panel	CX	JEM 1425
Power Transfer (DS) Panel	CY	JEM 1425
Main Transformer Panels	CY	JEM 1425
Transformer Secondary Panel	CX	JEM 1425
Low Voltage Power Panel	CY CX	JEM 1425
Low Voltage Lighting Panel	CY CX	JEM 1425
Low Voltage Maintenance Transfer Panel	CX	JEM 1425

※1 The low-voltage maintenance transfer panel is assumed to be a free-standing panel.

✓ First format letter: M: Metal-Clad Type Switchgear

C: Cubicle-Type Switchgear

✓ Second format letter: W: Pull-Out-Type Device

X: Fixed-Type Device

Y: Carry-Out Type

- (iv) The control center for the jet fan must be a “JEM 1195 Control Center” series model, and all models of the same structure and rated values must be compatible.

In addition, all sides must have a door for each unit, and the back must have a hooking cover or door.

The phase-advancing condenser will be housed inside the panel.

- (v) All sides of the high voltage power distribution panel must have doors, and the back side must have a hooking cover or door.

- (vi) Materials for the high-voltage and low-voltage panels must have capacities exceeding those of a steel sheet (hot rolled steel sheet) or equivalent item.

- (c) Temperature Increase

Temperature increase inside the panels and within each device must meet the compliance standards mentioned in the previous item detailing ambient conditions, and must be within a range that does not interfere with any of the components.

## (7) Device Specifications

### (a) East-Side Electrical Room Switchgear

- (i) Section Switch Box (1)(2)

✓ Format Outdoor Closed Free-Standing Type

✓ Quantity 2 panels

✓ Equipment Stored in Main Panel (per 1 panel):

- 
- ① Surge Arrester.....14kV 5kA 3 pc.
  - ② Circuit Breaker .....3P DS 12kV 1200A 25kA 1 unit
  - ③ Voltage Detector.....11kV 1 Phase Detection  
1 set with detector, controller, voltmeter
  - ④ Other necessary items .....as required
- (ii) Draw-In Board (1) Circuit A Draw-In Board (2) Circuit B
- ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 2 panels
  - ✓ Equipment Stored in Main Panel (per 1 panel):
    - ① Single-Throw Circuit Breaker 3P DS 12kV 1200A 25kA 1 unit
    - ② Other necessary items .....as required
- (iii) Power Receiving Panel (1) Circuit A Power Receiving Panel (2) Circuit B
- ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 2 panels
  - ✓ Equipment Stored in Main Panel (per 1 panel):
    - ① High Voltage Vacuum Circuit Breaker 12kV 630A 25kA  
draw-out type..... 1 unit
    - ② Gauge Transformer.....11kV/110V molded type draw-out type  
..... 2 units
    - ③ Current Transformer .....200/5A molded type  
.....2 units
    - ④ Other necessary items .....as required
- (iv) Ventilation Transformer (1) Primary Panel / Ventilation Transformer (2) Primary Panel
- ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① High Voltage Vacuum Circuit Breaker 12kV 630A 25kA  
.....draw-out type 1 unit each
    - ② Current Transformer .....20/5A molded type 3 units each
    - ③ Other necessary items .....as required
- (v) Lighting Transformer Primary Panel / West-Side Electrical Room Power Sending Panel (1) Circuit A
- ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:



- 
- ① High Voltage Vacuum Circuit Breaker 12kV 630A 25kA  
draw-out type .....1 unit each
- ② Current Transformer .....20/5A molded type  
.....3 units each
- ③ Other necessary items .....as required
- (vi) Bus Tie Panel (1) Bus Tie Panel (2)
- ✓ Format Indoor Unit Closed Free-Standing Type
- ✓ Quantity 2 panels
- ✓ Equipment Stored in Main Panel (per 1 panel)
- ① High Voltage Vacuum Circuit Breaker 12kV 630A 25kA  
draw-out  
..... type 1 unit
- ② Gauge Transformer .....11kV/110V molded type draw-out type  
..... 2 units
- ③ Other necessary items .....as required
- (vii) Independent Generator Tie Panel / West-Side Electrical Room Power  
Sending Panel (2) Circuit B
- ✓ Format Indoor Unit Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel
- ① High Voltage Vacuum Circuit Breaker 12kV 630A 25kA  
draw-out type .....1 unit each
- ② Current Transformer .....100/5A molded type  
.....3 units
- ③ Other necessary items .....as required
- (viii) Intendent Generator Power Transfer Panel
- ✓ Format Indoor Unit Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
- ① Double-Throw Circuit Breaker: 3P DT-DS 12kV 1200A 25kA 1  
unit
- ② Other necessary items .....as required
- (ix) West-Side Electrical Room Power Sending Panel Independent Generator  
Circuit/Maintenance Power Panel
- ✓ Format Indoor Unit Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
-

- 
- ① High Voltage Vacuum Circuit Breaker 12kV 630A 25kA  
draw-out type ..... 1 unit each
  - ② Current Transformer ..... 100/5A 15/5A molded type  
..... 3 units each
  - ③ Other necessary items ..... as required
- (x) West-Side Electrical Room Power Sending Transfer Panel
- ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① Double-Throw Circuit Breaker: 3P DT-DS 12kV 1200A 25kA 1 unit
    - ② Other necessary items ..... as required
- (xi) Ventilation Transformer Panel (1)
- ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① Three-Phase Transformer .1 unit
      - Format: molded type (with short-proofing panel)
      - Capacity: 300kVA
      - Primary Voltage three-phase three-wire : 11000V 50Hz
      - Secondary Voltage : three-phase three-wire ; 460V 50Hz
      - Connection System: Star (Y) and Delta (Δ) Connection
      - Accessories: dial thermometer (with alarm contact), anti-vibration rubber, wheels
    - ② Other necessary items ..... as required
- (xii) Ventilation Transformer Secondary Panel (1)
- ✓ Format Indoor Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① Gauge Transformer ..... 440/110V molded type 2 units
    - ② Current Transformer ..... 600/5A molded type 2 units
    - ③ Surge Arrester ..... 480V 2.5kA 3 units
    - ④ Molded Case Circuit Breaker 1 set
    - ⑤ Knife Switch ..... 3P 100A 1 unit
    - ⑥ Other necessary items ..... as required

(xiii) Ventilation Transformer Panel (2)

- ✓ Format Indoor Unit Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel
  - ① Three-Phase Transformer ..... 1 unit
    - Format: molded type (with short -proofing panel)
    - Capacity: 300kVA
    - Primary Voltage: three-phase three-wire 11000V 50Hz
    - Secondary Voltage: three-phase three-wire 415V 50Hz
    - Connection System: Star (Y) and Delta (Δ) Connection
    - Accessories: dial thermometer (with alarm contact), anti-vibration rubber, wheels
  - ② Other necessary items ..... as required

(xiv) Ventilation Transformer Secondary Panel (2)

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Gauge Transformer ..... 440/110V molded type 2 units
  - ② Current Transformer ..... 500/5A molded type 2 units
  - ③ Surge Arrester ..... 480V 2.5kA 3 units
  - ④ Molded Case Circuit Breaker .... 1 set
  - ⑤ Knife Switch ..... 3P 100A 1 unit
  - ⑥ Other necessary items ..... as required

(xv) Lighting Transformer Panel

- ✓ Format Indoor Unit Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Three-Phase Transformer ..... 1 unit
    - Format: molded type (with short-proofing panel)
    - Capacity: 300kVA
    - Primary Voltage: three-phase three-wire 11000V 50Hz
    - Secondary Voltage: three-phase three-wire 415V 50Hz
    - Connection System: Star (Y) and Delta (Δ) Connection
    - Accessories: dial thermometer (with alarm contact), anti-vibration rubber wheels

- 
- ② Other necessary items ..... as required
- (xvi) Lighting Transformer Secondary Panel
- ✓ Format Indoor Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel
    - ① Gauge Transformer ..... 440/110V molded type 2 units
    - ② Current Transformer ..... 500/5A molded type 2 units
    - ③ Surge Arrester ..... 480V 2.5kA 3 units
    - ④ Molded Case Circuit Breaker.... 1 set
    - ⑤ Knife Switch ..... 3P 100A 1 unit
    - ⑥ Other necessary items ..... as required
- (xvii) Auxiliary Transformer Panel (1)
- ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① Three-Phase Transformer..... 1 unit
      - Format: molded type
      - Capacity: 75kVA
      - Primary Voltage: three-phase three-wire 415V 50Hz
      - Secondary Voltage: three-phase three-wire 220V 50Hz
      - Connection System: Star (Y) and Delta ( $\Delta$ ) Connection
      - Accessories: anti-vibration rubber, wheels
    - ② Other necessary item ..... 1 set
- (xviii) Auxiliary Transformer Panel (2)
- ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① Three-Phase Transformer ..... 1 unit
      - Format: molded type
      - Capacity: 50kVA
      - Primary Voltage: three-phase three-wire 415V 50Hz
      - Secondary Voltage: single-phase two-wire 220V 50Hz
      - Connection System: Scott connection
      - Accessories: anti-vibration rubber, wheels
    - ② Other necessary items ..... as required

(xix) Lighting Control Panel

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Automatic Light Modulation Device  
(with light senses) ..... 1 set
  - ② Light Modulation Transformer ..... 1 unit
  - ③ Other necessary items ..... as required

(xx) Tunnel Lightning Panel (1) (2)

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 2 panels
- ✓ Equipment Stored in Main Panel
  - ① Zero-Phase Current Transformer ..... 1 set
  - ② MCCB ..... 1 set
  - ③ Earth Fault Overcurrent Circuit Breaker..... 1 set
  - ④ Other necessary items ..... as required

(xxi) Maintenance Transfer Panel

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Molded Case Circuit Breaker ..... 1 set
  - ② Gauge Transformer ..... 440/110V molded type  
..... 1 unit
  - ③ Double-Throw Circuit Breaker ..... 1 set
  - ④ Other necessary items ..... as required

(xxii) Ventilation Control Center Panel (1)

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel (2 units installed)
- ✓ Equipment Stored in Main Panel:
  - ① Zero-Phase Current Transformer ..... 1 set
  - ② MCCB ..... 1 set
  - ③ Earth Fault Overcurrent Circuit Breaker..... 1 set
  - ④ Phase-Advancing Condenser ..... 1 set
  - ⑤ Other necessary items ..... as required

(xxiii) Ventilation Control Center Panel (2)

- ✓ Format Indoor Closed Free-Standing Type

- ✓ Quantity 1 panel (2 units installed)
- ✓ Equipment Stored in Main Panel:
  - ① Zero-Phase Current Transformer .....1 set
  - ② MCCB .....1 set
  - ③ Earth Fault Overcurrent Circuit Breaker .....1 set
  - ④ Phase-Advancing Condenser ..... 1 set
  - ⑤ Other necessary items .....as required

(xxiv) Telecommunications Equipment Room Distribution Panel

- ✓ Format Indoor Wall Mounted Type (with cable duct)
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Molded Case Circuit Breaker .....1 set
  - ② Other necessary items .....as required

**(b) East-Side Electrical Room DC Power Supply**

- ✓ Format Indoor Unit Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Three-Phase Rectifier .....1 unit
    - Format thyristor with automated constant-voltage device
    - Capacity 30A
  - ② Lead-Acid Battery .....1 set
    - Format .....control valve seal type (MSE Type)
    - Capacity.....50Ah
    - No. of Cells.....54 Cells
  - ③ Silicon Dropper .....20A 1 set
  - ④ Other necessary items .....as required

**(c) East-Side Electrical Room Uninterruptible Power Supply Device**

(i) Input/output Panel

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Three-Phase Transformer .....1 set
    - Format .....dry-type
    - . Capacity.....30KVA 10kVA
  - ② Molded Case Circuit Breaker .....1 set

- ③ Other necessary items .....as required

(ii) Battery Panel

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Lead-Acid Battery .....1 set
    - Format .....control valve seal type (MSE type)
    - Capacity.....100Ah
    - No. of Cells.....180 Cells
  - ② Other necessary items .....as required

(iii) Inverter Panel

- ✓ Format: Indoor Closed Free-Standing Type
- ✓ Quantity: 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Three-Phase Inverter.....1 unit
    - Format: continuous inverter power supply system
    - Capacity: 30kVA
    - Element: GPT Element High-Frequency PWM Inverter
  - ② Converter .....1 unit
    - Format: high-efficiency converter type
    - Capacity: 150(A)
    - Element: IGBT Element High-Frequency PWM Inverter:
  - ③ Molded Case Circuit Breaker ..... 1 set
  - ④ Electromagnetic Contactor ..... 1 set
  - ⑤ Current Transformer ..... /5A 1 set
  - ⑥ Other necessary items ..... 1 set

(d) West-Side Electrical Room Switchgear

(i) Draw-In Board (1) Circuit A

- ✓ Format: Indoor Unit Closed Free-Standing Type
- ✓ Quantity: panel
- ✓ Equipment Stored in Main Panel:
  - ① Single-Throw Circuit Breaker 3P DS 12kV 1200A 25kA  
.....1 unit
  - ② Other necessary items .....as required

- (ii) Draw-In Board (2) Circuit B
  - ✓ Format: Indoor Unit Closed Free-Standing Type
  - ✓ Quantity: 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① Single-Throw Circuit Breaker: 3P DT-DS 12kV 1200A 25kA  
.....1 unit
    - ② Other necessary items .....as required
    - ③ Main Panel Mounting Equipment:
- (iii) Power Receiving Panel (1) Circuit A Power Receiving Panel (2) Circuit B
  - ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 2 panels
  - ✓ Equipment Stored in Main Panel (per 1 panel)
    - ① High Voltage Vacuum Circuit Breaker 12kV 630A 25kA  
draw-out type .....1 unit
    - ② Gauge Transformer.....11kV/110V molded  
type  
draw-out type .....2 units
    - ③ Current Transformer .....100/5A molded type  
..... 2 units
    - ④ Other necessary items .....as required
- (iv) Maintenance Power Supply Panel
  - ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① High Voltage Vacuum Circuit Breaker: 12kV 630A 25kA draw-  
out type .....1 unit
    - ② Current Transformer: 15/5A molded type ... 3 units
    - ③ Other necessary items .....as required
- (v) Ventilation Transformer (1) Primary Panel / Ventilation Transformer (2) Primary Panel
  - ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① High Voltage Vacuum Circuit Breaker .....12kV 630A 25kA  
draw-out type .....1 unit each
    - ② Current Transformer: 20/5A molded type ..3 units each



- 
- ③ Other necessary items .....as required
- (vi) Lighting Transformer Primary Panel / Backup Panel
- ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① High Voltage Vacuum Circuit Breaker: 12kV 630A 25kA draw-out type .....1 unit each
    - ② Current Transformer: 20/5A molded type .....3 units each
    - ③ Other necessary items .....as required
- (vii) Bus Tie Panel
- ✓ Format Indoor Unit Closed Free-Standing Type
  - ✓ Quantity 1 panel
  - ✓ Equipment Stored in Main Panel:
    - ① High Voltage Vacuum Circuit Breaker: 12kV 630A 25kA draw-out type .....1 unit
    - ② Gauge Transformer: 11kV/110V molded type draw-out type ..... 2 units
    - ③ Other necessary items .....as required
- (viii) Ventilation Transformer Panel (1)
- ✓ Format: Indoor Unit Closed Free-Standing Type
  - ✓ Size: Quantity 1 panel
  - ✓ Equipment Stored in Main Panel
    - ① Three-Phase Transformer .....1 unit
      - Format .....molded type (with short-proofing panel)
      - Capacity.....300kVA
      - Primary Voltage .....three-phase three-wire 11000V 50Hz
      - Secondary Voltage.....three-phase three-wire 460V 50Hz
      - Connection System....Star (Y) and Delta (Δ) Connection
      - Accessories.....dial thermometer (with alarm contact), anti-vibration rubber, wheels
    - ② Other necessary items .....as required
- (ix) Ventilation Transformer Secondary Panel (1)
- ✓ Format: Indoor Closed Free-Standing Type
  - ✓ Quantity: 1 panel
  - ✓ Equipment Stored in Main Panel:

- ① Gauge Transformer: 440/110V molded type  
.....2 units
- ② Current Transformer: 600/5A molded type 2 units
- ③ Surge Arrester: 480V 2.5kA .....3 units
- ④ Molded Case Circuit Breaker ..... 1 set
- ⑤ Knife Switch.....3P 100A 1 unit
- ⑥ Other necessary items .....as required

(x) Ventilation Transformer Panel (2)

- ✓ Format: Indoor Unit Closed Free-Standing Type
- ✓ Quantity: 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Three-Phase Transformer .....1 unit
    - Format .....molded type (with short-proofing panel)
    - Capacity.....300kVA
    - Primary Voltage .....three-phase three-wire 11000V 50Hz
    - Secondary Voltage.....three-phase three-wire 415V 50Hz
    - Connection System.... Star (Y) and Delta (Δ) Connection
    - Accessories.....dial thermometer (with alarm contact),  
anti-vibration rubber, wheels
  - ② Other necessary items .....as required

(xi) Ventilation Transformer Secondary Panel (2)

- ✓ Format: Indoor Closed Free-Standing Type
- ✓ Quantity: 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Gauge Transformer: 440/110V molded type  
.....2 units
  - ② Current Transformer: 500/5A molded type  
.....2 units
  - ③ Surge Arrester: 480V 2.5kA .....3 units
  - ④ Molded Case Circuit Breaker ..... 1 set
  - ⑤ Knife Switch.....3P 100A 1 unit
  - ⑥ Other necessary items .....as required

(xii) Lighting Transformer Panel

- ✓ Format: Indoor Unit Closed Free-Standing Type
- ✓ Quantity: 1 panel
- ✓ Equipment Stored in Main Panel:

- ① Three-Phase Transformer ..... 1 unit
  - Format .....molded type (with short-proofing panel)
  - Capacity.....300kVA
  - Primary Voltage .....three-phase three-wire 11000V 50Hz
  - Secondary Voltage.....three-phase three-wire 415V 50Hz
  - Connection System....Star (Y) and Delta ( $\Delta$ ) Connection
  - Accessories.....dial thermometer (with alarm contact), anti-vibration rubber, wheels
- ② Other necessary items .....as required

(xiii) Lighting Transformer Secondary Panel

- ✓ Format: Indoor Closed Free-Standing Type
- ✓ Quantity: 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Gauge Transformer: 440/110V molded type  
.....2 units
  - ② Current Transformer: 500/5A molded type  
.....2 units
  - ③ Surge Arrester: 480V 2.5kA .....3 units
  - ④ Molded Case Circuit Breaker.....1 set
  - ⑤ Knife Switch: 3P 100A .....1 unit
  - ⑥ Other necessary items .....as required

(xiv) Auxiliary Transformer Panel (1)

- ✓ Format Indoor Unit Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Three-Phase Transformer ..... 1 unit
    - Format .....molded type
    - Capacity.....75kVA
    - Primary Voltage .....three-phase three-wire 415V 50Hz
    - Secondary Voltage.....three-phase three-wire 220V 50Hz
    - Connection System....Star (Y) and Delta ( $\Delta$ ) Connection
    - Accessories.....anti-vibration rubber, wheels
  - ② Current Transformer: 250/5A molded type  
.....2 units
  - ③ Zero-Phase Current Transformer.....1 set
  - ④ Earth Fault Overcurrent Circuit Breaker..... 1 set

- ⑤ Other necessary items .....as required

(xv) Auxiliary Transformer Panel (2)

- ✓ Format Indoor Unit Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Three-Phase Transformer .....1 unit
    - Format .....molded type
    - Capacity.....50kVA
    - Primary Voltage .....three-phase three-wire 415V 50Hz
    - Secondary Voltage.....single-phase two-wire 220V 50Hz
    - Connection System....Scott connection
    - Accessories .....anti-vibration rubber, wheels
  - ② Current Transformer: 150/5A molded type  
.....2 units each
  - ③ Zero-Phase Current Transformer .....1 set
  - ④ Earth Fault Overcurrent Circuit Breaker.....1 set
  - ⑤ Other necessary items .....as required

(xvi) Lighting Control Panel

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Automatic Light Modulation Device (with light sensor)  
.....1 set
  - ② Light Modulating Transformer .....1 unit
  - ③ Molded Case Circuit Breaker .....1 set
  - ④ Single-Throw Electromagnetic Contactor ..1 set
  - ⑤ Zero-Phase Current Transformer .....1 set
  - ⑥ Earth Fault Overcurrent Circuit Breaker.....1 set

(xvii) Tunnel Lightning Panel (1) (2)

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 2 panels
- ✓ Equipment Stored in Main Panel
  - ① Zero-Phase Current Transformer .....1 set
  - ② MCCB .....1 set
  - ③ Earth Fault Overcurrent Circuit Breaker.....1 set
  - ④ Other necessary items ..... 1 set

(xviii) Ventilation Control Center Panel (1)

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel (2 units installed)
- ✓ Equipment Stored in Main Panel
  - ① Zero-Phase Current Transformer ..... 1 set
  - ② MCCB ..... 1 set
  - ③ Earth Fault Overcurrent Circuit Breaker..... 1 set
  - ④ Phase-Advancing Condenser ..... 1 set
  - ⑤ Other necessary items ..... as required

(xix) Ventilation Control Center Panel (2)

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel (1 unit installed)
- ✓ Equipment Stored in Main Panel
  - ① Zero-Phase Current Transformer ..... 1 set
  - ② MCCB ..... 1 set
  - ③ Earth Fault Overcurrent Circuit Breaker .. 1 set
  - ④ Phase-Advancing Condenser ..... 1 set
  - ⑤ Other necessary items ..... 1 set

(xx) Maintenance Transfer Panel

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Molded Case Circuit Breaker ..... 1 set
  - ② Gauge Transformer: 440/110V molded type  
..... 1 unit
  - ③ Double-Throw Circuit Breaker..... 1 set
  - ④ Other necessary items ..... as required

(xxi) Ground Terminal Panel

- ✓ Format Indoor Wall-Mounted Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Ground Terminal Plate ..... 1 set
  - ② Auxiliary Electrode Terminal for Measurement 2 pc.
  - ③ Other necessary items ..... as required

**(e) West-Side Electrical Room DC Power Supply**

- ✓ Format Indoor Unit Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Three-Phase Rectifier .....1 unit
    - Format: thyristor with automated constant-voltage device
    - Capacity: 30A
  - ② Lead-Acid Battery .....1 set
    - Format .....control valve seal type (MSE type)
    - Capacity.....50Ah
    - No. of Cells.....54 Cells
  - ③ Silicon Dropper: 20A .....1 set
  - ④ Molded Case Circuit Breaker .....1 set
  - ⑤ Other necessary items .....as required

**(f) West-Side Electrical Room Uninterruptible Power Supply Device**

**(i) Input/output Panel**

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Size 900W×1000D×2350H
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Three-Phase Transformer .....1 set
    - Format .....dry-type
    - Capacity.....20KVA
  - ② Molded Case Circuit Breaker .....1 set
  - ③ Other necessary items .....as required

**(ii) Battery Panel**

- ✓ Format Indoor Closed Free-Standing Type
- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Lead-Acid Battery .....1 set
    - Format .....control valve seal type (MSE type)
    - Capacity.....100Ah
    - No. of Cells.....180 Cells
  - ② Other necessary items .....as required

**(iii) Inverter Panel**

- ✓ Format Indoor Closed Free-Standing Type

- ✓ Quantity 1 panel
- ✓ Equipment Stored in Main Panel:
  - ① Three-Phase Inverter.....1 unit
    - Format .....continuous inverter power supply system
    - Capacity.....20kVA
    - Element.....IGBT Element High-Frequency PWN Inverter
  - ② Converter .....1 unit
- ✓ Format High-Efficiency Converter Format
- ✓ Capacity 100(A)
- ✓ Element IGBT Element High-Frequency PWN Inverter
- ③ Molded Case Circuit Breaker ..... 1 set
- ④ Electromagnetic Contactor .....1 set
- ⑤ Current Transformer ...../5A 1 set
- ⑥ Other necessary items .....as required

## (8) Independent Generator Facility

### (a) Equipment Outline

#### (i) Location

The usage location shall be the east-side generator room, and an indoor model shall be used.

#### (ii) Ambient Conditions

- ✓ Temperature:
  - indoor 0°C -to +40°C
  - outdoor -10°C to +40°C
- ✓ Humidity:
  - indoor 10% to 85%RH

However, this assumes no condensation.

### (b) Facility Structure

The independent generator facility will consist of the following items:

Item	Unit	Qty	Comments
AC Generator	Unit	1	625kVA, 3ø 3W 11kV 50Hz, 4P 1500min <sup>-1</sup>
Diesel Engine	Unit	1	546kW, radiator cooling, light oil or electric start-up
Generator Panel	Panel	1	VCB, EVT, CT
Automatic Start-Up Panel	Panel	1	EXTR, AVR, auxiliary circuit
Start-Up DC Power	Set	1	DC 24V 200Ah

Supply			
Exhaust Muffler	Unit	1	85dB(A) attached to generator
Fuel Transfer Pump	Unit	1	0.75kW
Fuel Tank	Unit	1	900 liters
Fuel Supply Box	Panel	1	SUS-made outdoor, wall-mounted
Vent Fan	Unit	2	85dB(A), fan 5.5kW, damper, anti-insect net on hood
Exhaust Duct	Unit	1	With damper and hood

(c) **Device Structure**

Device designs are stipulated as follows:

- (i) All devices shall be “indoor type” unless specified otherwise.
- (ii) The shape of the housing for high-voltage devices must be JEM1425 “High Voltage Metal Closed-Type Switchgear,” conforming to the standards in the table below.

Panel Type	Format	Standard
Generator Panel	CW	JEM 1425

First format letter: C: Cubicle-Type Switchgear

Second format letter: W: Pull-Out-Type Device X: Fixed-Type Device

Y: Carry-Out Type

The panel material must have capacities exceeding steel sheet (hot rolled steel sheet) or the equivalent.

- (iii) Devices and power distribution wires must be heat-resistant so as not to be affected by heat generated by the motor, and must be firmly affixed. The motor and generator must include anti-vibration rubber or similar measures to absorb vibration.
- (iv) The engine must include a device exceeding the capacities of the lubricating oil pump, and the sliding portion and moving parts of the lubricating oil supply nozzle must not cause a breakage in the oil film when switched off.
- (v) The devices must be coated or painted to prevent rust. Pipes must be painted the same color as the generator. Once the pipes are painted, a color stripe shall be painted at the entrance/exit of the pipe, along with an arrow indicating the direction of the flow through the pipe. Furthermore, the surface of pipes to be buried in the outdoor pit must be painted to prevent rust.
- (vi) All components of devices, etc. must meet or exceed JIS standards, and effort should be made to increase reliability of all devices by using a standard for components that exceeds actual usage conditions by as much as possible.

In addition, anti-explosive designs must also be compatible with these standards.



- (vii) These devices must provide a stable supply of electricity to each type of load system.
- (viii) The earthquake resistance of the facilities must satisfy the “heavy machinery A” standard set forth in the Japanese Ministry of Land, Infrastructure, Transport, and Tourism “Electronic and Telecommunication Facilities Construction General Specification Manual, Chapter 3 – Earthquake Resistance Standards.”
- (ix) To prevent movement and falls during earthquakes, items equipped with anchor bolts and anti-shake devices selected based on earthquake engineering calculations must include anti-quake stoppers.
- (x) Radiator shutters must automatically open during diesel engine operation and close when operation is stopped.  
Dimensions must fit the radiator-equipped independent generator facility structure, and not impede exhaust.
- (xi) Meters must be included to measure the following operational conditions.
  - ✓ Rotation or frequency of the internal combustion engine.
  - ✓ Lubricating oil pressure on the internal combustion engine. (However, for items which supply lubricating oil through a forced circulation system, it must be possible to change to measuring lubricating oil amount or lubricating oil surface.)
  - ✓ Lubricating oil temperature in the internal combustion engine (however, for items which operate based on the temperature of the water used to cool the lubricating oil, it must be possible to change to measuring the temperature of the cooling water.)
  - ✓ Cooling water temperature in the internal combustion
- (xii) Silencers must satisfy area noise regulations, and must be designed so as not interfere with the performance of the motor.

**(d) Device Specifications**

**(i) Independent Generator Device (Package)**

The independent generator device must be a low-noise cubicle type (85dB(A)).

**(ii) AC Generator**

- ✓ Format                      three-phase projective type synchronous generator
- ✓ Rated Output            625kVA
- ✓ Rated Voltage and Frequency: three-phase three-wire type, 11kV, 50Hz
- ✓ No. of Poles and RPM: 4 poles, 1500 rpm (1/min)
- ✓ Power Factor            80% (delayed)
- ✓ Excitation System      brushless excitation system

- 
- ✓ Running Time continuous, more than 24 hours
  - (ii) Diesel Engine
    - ✓ 4-cycle water cooled vertical direct injection type
    - ✓ Output more than 546kW
    - ✓ Rotations 1500rpm
    - ✓ Start-Pp Mechanism: electric start-up
    - ✓ Start-Up Time within 10-40 seconds
    - ✓ Cooling Format radiator cooling (built-in type)
    - ✓ Fuel light oil
    - ✓ Run Time more than 72 hours
    - ✓ Accessories: common bed (with anti-vibration device), priming pump, no. of rotations, lubricating oil thermometer, lubricating oil pressure gauge, cooling water thermometer, exhaust thermometer, cooling water heater, oil pan heater, oil tank heater, canvas duct, other necessary items
  - (iv) Generator Panel
    - ✓ Format Indoor Unit Closed Free-Standing Type
    - ✓ Quantity 1 panel
    - ✓ Equipment Stored in Main Panel:
      - ① High Voltage Vacuum Circuit Breaker: 12kV 630A 25kA  
.....1 unit
      - ② Excitation Transformer.....1 unit
      - ③ Grounding Gauge Transformer: 11kV/110V/110/3V  
.....1 unit
      - ④ Current Transformer.....100/5A 3 units
      - ⑤ Current Limiting Resistor.....1 set
      - ⑥ Filter .....1 set
      - ⑦ Other necessary items.....as required
  - (v) Automatic Start-Up Panel
    - ✓ Format Indoor Unit Closed Free-Standing Type
    - ✓ Quantity 1 panel
    - ✓ Equipment Stored in Main Panel:
      - ① Automatic Voltage Regulator.....1 set
      - ② Molded Case Circuit Breaker .....1 set
      - ③ Electromagnetic Contactor .....1 set
      - ④ Other necessary items.....as required
  - (vi) Start-Up DC Power Supply
    - ✓ Format Indoor Unit Closed Free-Standing Type

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(xi) Vent Fan

- ✓ Format indoor wall-mounted type
- ✓ Quantity 2 units
- ✓ Sound Level less than 85 dB (A) 1 m from air intake vent
- ✓ Accessories damper, air supply hood (SUS-made, with anti-insect net SUS mesh), other necessary items

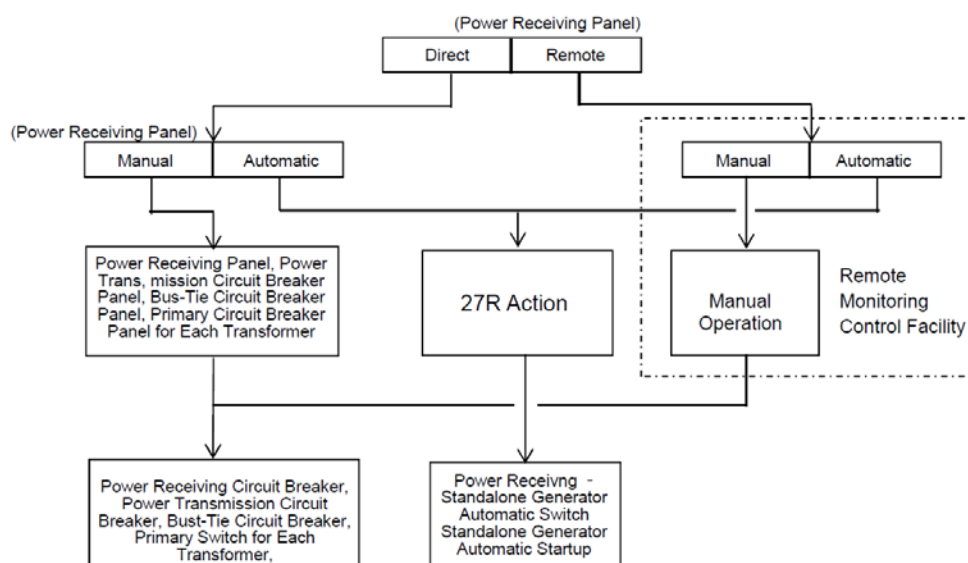
(xii) Exhaust Duct

- ✓ Format indoor floor type
- ✓ Quantity 1 unit
- ✓ Sound Level less than 85 dB (A) 1 m from air intake vent
- ✓ Accessories damper, vent hood (SUS-made, bird protection net SUS mesh), other necessary items

(9) Monitoring Control Format

(a) Power Reception Control

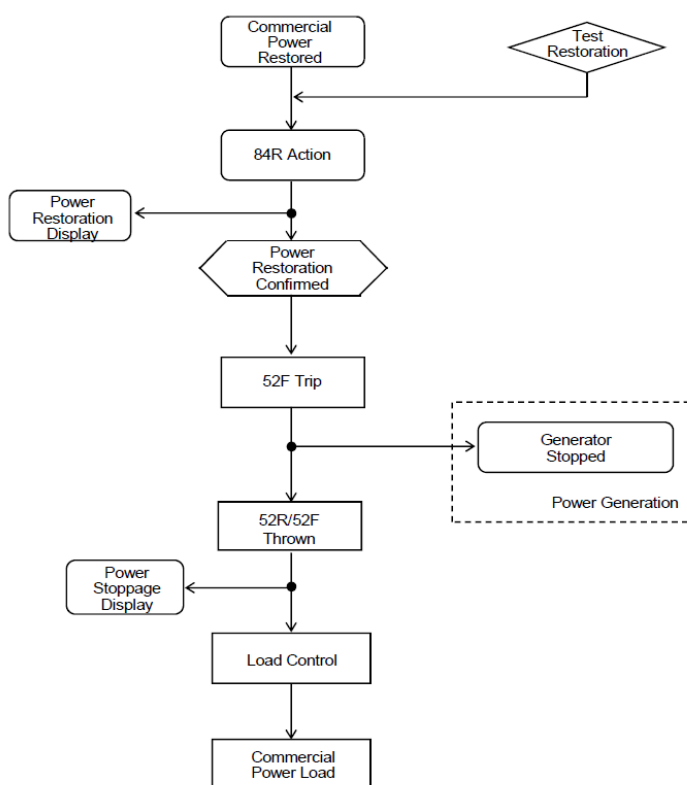
Control is achieved through the power receiving (automatic-manual) toggle switch mounted on the power receiving panel and the remote-direct toggle switch, according to the following scheme:



(b) Power Recovery Control

- (i) When power restoration is detected at the voltage relay (84) at the power receiving point, after being confirmed by the timer and tripping the bus-tie circuit breaker (52), the power receiving circuit breaker (52) is thrown.
- (ii) When the power receiving circuit breaker (52) is thrown, a stop order is sent to the generator simultaneously.

(c) Action flow-chart

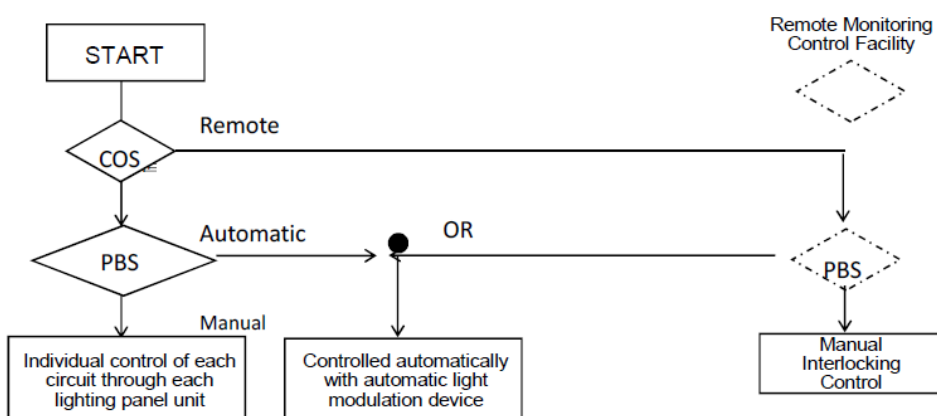


(d) Lighting Control:

(i) Control Format Switching

① Block Diagram

Lighting control is achieved based on the following scheme, using the remote-manual toggle switch mounted on the lighting control panel, and the power receiving remote-direct share toggle switch mounted on the power receiving panel.



(ii) Lighting Control Details

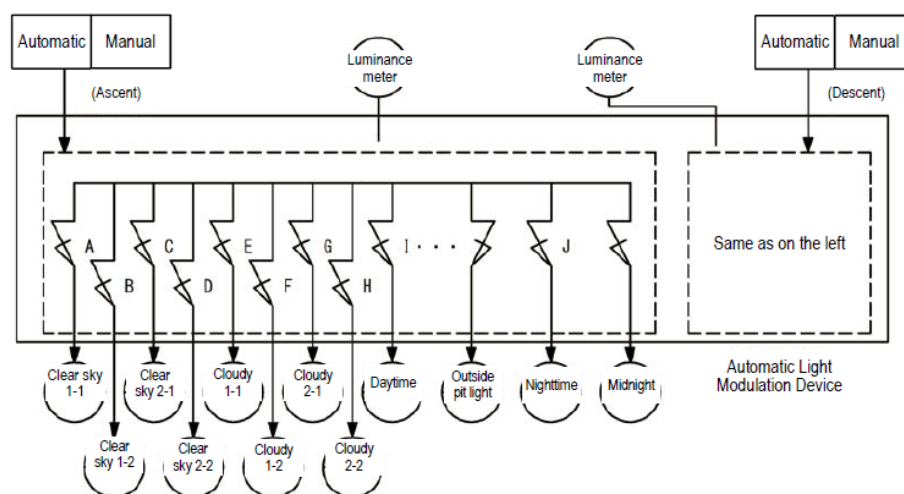
① Individual Control

- Switch the toggle switches to “manual” and “direct,” then press the push-button switch on the front of the control center unit to achieve individual control.
- If the switches are set to “manual” and “direct,” the interlocking display light on the front of the lighting control panel will go out, and display signals will be sent as-is to the remote monitoring control facility.

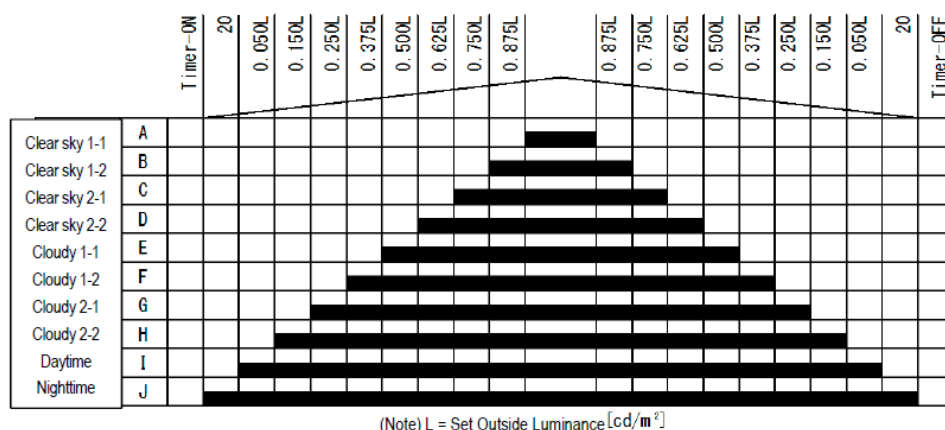
(Depending on the conditions of the electromagnetic contactor)

② Manual Interlocking Control

- Switch the toggle switches to “manual” and “remote” to achieve interlocking control, with each applicable circuit controlled by the remote monitoring control facility operations switches.
- The signal from the main electrical room lighting control panel automatic light modulation device automatically controls the entrance lights on the main electrical room side, while the signal from the auxiliary electrical room lighting control panel automatic light modulation device automatically controls the entrance lights on the auxiliary electrical room side.
- Basic lighting is controlled by interlocking control for the east-side electrical room and the west-side electrical room.



- Automatic light modulation device operation chart



## (9) Spare Items / Accessories

Spare items and accessories listed below are in addition to the spare items stipulated in the manufacturer standard set.

### (a) Spare Items

#### (i) Power Distribution Equipment

No.	Item	Quantity	Remarks
1	Fuses	100%	
2	Bulbs for Signal Lights	100%	LED
3	Globes for Signal Lights	20%	
4	In-Panel Fluorescent Lamp	100%	

#### (ii) DC Power Supply / Uninterruptible Power Supply

No.	Item	Quantity	Remarks
1	Fuses	100%	
2	Bulbs for Signal Lights	100%	LED
3	Globes for Signal Lights	20%	

(Note) No. of devices is the number of devices per electrical room.

#### (iii) Independent Generator Facility

No.	Item	Quantity	Remarks
1	Rubber Seals	1 set	
2	Fuses	100%	
3	Bulbs for Signal Lights	100% (note)	LFD
4	Globes for Signal Lights	20%	

### (b) Accessories

#### (i) Power Distribution Transforming Equipment

No.	Item	Quantity	Remarks
1	Breaker Lifter	1 unit	
2	Breaker Handle	1 pc.	

No.	Item	Quantity	Remarks
3	Transformer Draw Rail	1 unit	
4	Test Terminal Plug	1 set	For VT and CT
5	Protection Relay Plug	1 set	
6	Door Handle Key	3 pc.	
7	Breaker Operation Handle	1 pc.	

(Note) No. of devices is the number of devices per electrical room.

(ii) DC Power Supply / Uninterruptible Power Supply

No.	Item	Quantity	Remarks
1	Spanner	1 pc.	For storage battery terminal connection
2	Accessory Storage Box	1 pc.	

(Note) No. of devices is the number of devices per electrical room.

(iii) Independent Generator Facility

No.	Item	Quantity	Remarks
1	Standard Tools	1 set	With storage box
2	Test Terminal Plug	1 set	For VT and CT
3	Protection Relay Plug	1 set	
4	Door Handle Key	1 pc.	
5	Breaker Draw Rail	1 unit	
6	Breaker Handle	1 pc.	

**(10) Tests and Inspections**

**(a) Independent Inspection**

The devices used in the facilities must be subject to an independent inspection including all the tests below at the factories where they are manufactured, and the results of the inspections must be submitted for review.

(i) Power Distribution Equipment

- ✓ External Inspection
- ✓ Mechanism Operation Test
- ✓ Sequence Test
- ✓ Insulation Resistance Test (Voltage Resistance Test)
- ✓ Interface Test
- ✓ Phase Sequence

(ii) DC Power Supply / Uninterruptible Power Supply

- ✓ External Inspection
- ✓ Mechanism Operation Test
- ✓ Sequence Test
- ✓ Insulation Resistance Test (Voltage Resistance Test)
- ✓ Characteristics Test
- ✓ Interface Test



(iii) Independent Generator Facility

The devices used in the facilities must be subject to an independent inspection including all the tests below at the factories where they are manufactured, and the results of the inspections must be submitted for review.

- ✓ External Inspection
- ✓ Startup Test
- ✓ Load Test
  - ① 1/4 load .....20 minutes
  - ② 2/4 load .....20 minutes
  - ③ 3/4 load .....20 minutes
  - ④ 4/4 load .....2 hours
  - ⑤ 11/10 load .....30 minutes
- ✓ Generator Bearing Temperature Measurement
- ✓ Governor Test
- ✓ Overspeed Proof Test
- ✓ Sequence Test (including test of the protection devices)
- ✓ Mechanism Operation Test
- ✓ Insulation Resistance Test (Voltage Resistance Test)

(b) On-Site Inspection

Once construction on the site is complete, the following on-site inspections shall be performed, and the results shall be submitted for review.

(i) Transformers

- ✓ External Inspection
- ✓ Mechanism Operation Test
- ✓ Sequence Test
- ✓ Main Circuit Insulation Resistance Test
- ✓ High-Voltage Element Voltage Resistance Test
- ✓ Ground Resistance Measurement
- ✓ Phase Sequence

(ii) DC Power Supply / Uninterruptible Power Supply

The same inspections shall be performed as were performed as independent inspections, and the results of the inspections shall be submitted for review.

(iii) Independent Generator Facility

Once construction on site has finished, the following on-site inspections shall be performed, and the results of the inspections shall be submitted for review.

The inspections shall be performed on the same items as for the independent inspections.

If a request for a report is received from a concerned party institution, the following inspections shall be conducted and the results submitted for review.

- ✓ Underground fuel tank and fuel use tank leakage inspection
- ✓ Fuel pipe pressure inspection

**(c) General Operation Tests**

When on-site inspections are finished, all facilities must be subject to commissioning as a whole, and adjusted if necessary.

- ✓ Power Distribution Equipment Internal General Operation Tests
- ✓ Counter Test with Monitoring Control Facilities

## **5200. TUNNEL LIGHTING SYSTEM**

**(1) Description**

Tunnel lighting shall be mounted on tunnel walls, using the format detailed below to ensure that the interior of the tunnel is well-lit, thereby contributing to traffic safety.

Lighting will be installed in the connecting evacuation tunnels to ensure an evacuation route in case of emergency.

- ◆ Basic Lighting
- ◆ Entrance Lighting
- ◆ Special Structure Lighting (Emergency Parking Strip, Etc.)
- ◆ Backup Lighting for Power Outages

Lighting shall be installed outside the tunnel entrances and exits to illuminate the width of the road and changes in road path and surface, etc.

**(2) Tunnel Lighting**

**(a) Applicable Standards**

Each device must meet the standards below and conform to these specifications.

- ◆ Electrical Appliances and Materials Safety Act
- ◆ The Ministerial Ordinance on Technical Standards for Electrical Equipment
- ◆ Japanese Industrial Standards (JIS)

JIS C 8105-1:2013      Lighting Components – Part 1: General Safety Requirement Rules

JIS C 8105-2-3:2011      Lighting Components – Parts 2-3: Safety Requirements for

Road and Highway Lighting Components

JIS C 8105-3:2011 Lighting Components – Part 3: General Capacity Requirement Rules

JIS C 8105-5:2014 Lighting Components – Part 5: Luminous Intensity Measurement Methods JIS C 8153:2009

Applicable Standards
Seven Design Essentials Electrical Facilities Electrical Facilities Chapter 4, Road Lighting Facilities. (NEXCO RI July 2017)
Seven Design Essentials Electrical Facilities Electrical Facilities Chapter 5, Tunnel Lighting Facilities (NEXCO RI July 2017)
Electronic Telecommunications Facility Design Guidelines / Explanation (Electric Facilities) 2017 version. The Telecommunications Association
Electronic Telecommunications Facility Utility Standard Diagrams January 2015. The Telecommunications Association

**(b) Equipment Specifications**

LED lamps shall be used for tunnel lighting facilities. These lamps use LEDs as a light source and comprise the following components: LED tunnel light fixtures, LED modules, LED module controllers.

**(c) Tunnel Lighting Fixtures**

**(i) Fixture Design**

LED lamps used for tunnel lighting facilities use LEDs as a light source and comprise the following components: LED tunnel light fixtures, LED modules, LED module controllers.

**(d) Fixture Types**

Fixture types are shown in Table 52-1.

**Table 52-1: LED Tunnel Lighting Fixture Types**

Type	Fixture Format	Rated Luminosity	Mass
Side Wall Mounted Type For Basic Lighting	White LED (LED108)	> 13,550 lm	<15kg
	White LED (LED36)	> 4,500 lm	
Side Wall Mounted Type For Entrance Lighting	White LED (LED40)	> 6,100 lm	
	White LED (LED60)	> 9,050 lm	
	White LED (LED80)	> 12,050 lm	
	White LED (LED120)	> 18,100 lm	
	White LED (LED160)	> 24,150 lm	

Type	Fixture Format	Rated Luminosity	Mass
	White LED (LED200)	> 30,200 lm	
	White LED (LED240)	> 36,250 lm	
	White LED (LED280)	> 42,250 lm	

Note. The lowest rated luminosity value is more than 90% of the value shown in the table. All components shall be luminosity-adjustable.

(e) **General Structure**

(i) **Shared Characteristics**

Fixtures shall be enclosed, durable, waterproof, corrosion-resistant, and easy to inspect. Therefore, they should be able maintain their mechanical, electrical, and luminescent functions during normal operation.

Protection against the intrusion of solid, waterborne, or airborne dust and dirt shall abide by a standard of JIS C 8105-1:2013 IP55 at minimum. Damage from solid, waterborne, or airborne dust and dirt must be prevented.

Both the fixtures and the mounting brackets must have the highest corrosion resistance rating, and include prevention measures against interstitial rust and electrolytic corrosion caused by contact between different metals.

The front surfaces of fixtures shall be free of fasteners (screws, bolts, nuts) which could impede cleaning.

In principle, mounting brackets should be made of the same metal as the fixtures to be mounted, but if the metals are of different types, measures against electrolytic corrosion must be installed.

The housing for LED modules, reflecting plates, lenses, etc. must be designed to minimize the possibility of intrusion by solid dust and dirt particles which could decrease the luminescence of the components.

(ii) **Design, Materials, and Parts**

Fixture design and main materials and parts are listed as follows.

Main Body:

The main body of fixtures shall be made of aluminum or extruded aluminum alloy meeting the JIS H 4100 standard, or die-cast aluminum alloy meeting the JIS H5202 standard, or die-cast aluminum alloy meeting the JIS H 5302, and the main body of the fixtures should have a strength rating greater than or equal to stainless steel plate with a standard material thickness of 1.0mm (SUS304).

Mounting Brackets:

Mounting brackets shall be made of JIS G 4305 standard cold-rolled stainless-steel plate (SUS304) with a standard thickness of at least 4.0mm.

Translucent Covers:

Translucent covers shall have strength and translucency ratings compatible with JIS R 3206:2014 tempered glass with a standard thickness of at least 4.0 mm. The optical performance of components must be fully sustainable, and must be impervious to scratches, cracks, and clouding which could impede performance.

Reflecting Plates and Lenses:

Control of light distribution of LED modules shall be achieved with reflecting plates, lenses, or a combination of the two. If reflecting plates are used, they must be molded to JIS H 4000:2014 “aluminum and aluminum alloy plate and strip” standard, or molded from resin, and must be at least as durable as surface-treated material. If lenses are used, they must be molded from resin with maximum heat resistance and durability, or similar. The combined LED modules, reflecting plates or lenses, and translucent covers must fully maintain their optical performance.

Seals:

Seals must be highly elastic and heat-resistant, must not absorb moisture, and must be resistance to deterioration.

Internal Wiring:

All connections to internal wiring of fixtures shall use crimp terminals.

Cable Glands:

Cable glands shall be made of waterproof composite resin.

Nameplates:

Nameplates should not be easily removable.

(iii) Fall Prevention

Fixture bodies shall include support hardware at the left and right of the top side, so that stainless wires can be inserted as a fall-prevention measure.

(iv) Coating

Fixture bodies shall be preprocessed by degreasing, etc., then bake-coated with at least one layer of composite resin, with equivalent strength, rust and corrosion resistance.

**(f) Optical Performance**

Fixtures shall have sufficient optical performance to effectively illuminate the surface of the road and tunnel walls while mounted on the side walls of the tunnel. They shall be measured using the methods stipulated in JIS C 8105-5:2014, and must satisfy the capacity indices laid out in 5. Performance Requirements.

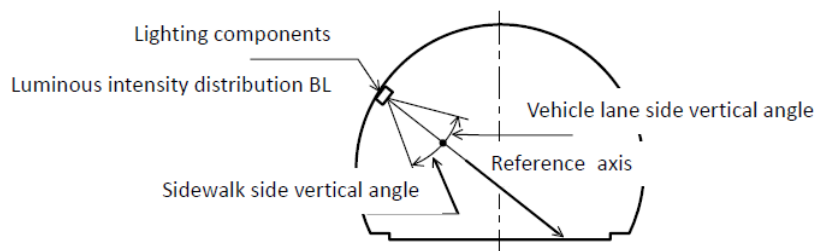
The lighting utilization factor shall be calculated based on the values measured according to the method stipulated in JIS C 8105-5:2014, and must be greater

than or equal to the values shown in Table 52-2.

Light output ratio must be at least 80% of the values for the conditions stipulated in JIS C 8105-5:2014 for ambient temperatures of -10 to 40° C.

**Table 52-2: Lighting Utilization factor**

Type	Fixture Format	Angle Direction	Lighting Utilization Factor at Vertical Angle from Reference Axis					
			10°	20°	30°	40°	50°	60°
Side Wall Mounted Type For Basic Lighting	White LED (LED108)	Vehicle Lane	0.12	0.29	0.47	0.57	0.59	0.60
	White LED (LED36)	Sidewalk	0.09	0.16	0.23	0.29	0.34	0.37
Side Wall Mounted Type For Entrance Lighting	White LED (LED40)	Vehicle Lane	0.19	0.36	0.46	0.48	0.49	0.50
	White LED (LED280)	Sidewalk	0.19	0.35	0.44	0.46	0.47	0.48



**Reference Axis, Vertical Angle, Direction (Vehicle Lane Side/Sidewalk Side)**

**(g) Insulation Resistance**

Must satisfy the capacities when measured according to the method standardized in JIS C 8105-1:2013.

- (i) When tested as detailed in (2), insulation resistance must be greater than or equal to 5 MΩ. Also, when tested in the cold, it must be greater than or equal to 30 MΩ.
- (ii) For the insulation resistance test, lamps must be lit continuously until all parts of the fixture have reached roughly the same temperature. Then, the insulation resistance of both terminals and the non-charging metal parts must be measured with a 500 V Insulation Resistance Meter or other instrument with greater precision, as standardized in JIS C 1302:2014 “Insulation Resistance Meter.”

**(h) Voltage Resistance**

Must satisfy the capacities in (1) when measured according to the method standardized in JIS C 8105-1:2013.

- (i) Voltage resistance must withstand the voltage delivered when tested as

detailed in (2).

- (ii) The voltage resistance test must be conducted directly after the insulation resistance test, sending a test voltage ( $2U+1000$  V) close to a sign wave of 50 Hz or 60 Hz in frequency between the charged parts and non-charged parts for about one minute, and checking that no abnormalities occur.

**(i) Thermal Shock Resistance**

The thermal shock resistance of fixtures must satisfy (1) at the time of testing using the JIS C 8105-2-3:2011 standard method.

- (i) When thermal shock resistance is tested according to (2), the fixture exterior and translucent cover must not crack, warp, or break.
- (ii) For the thermal shock resistance test, the fixture should be illuminated as it would be for normal use, until all parts of the fixture have reached roughly the same temperature. At this point, water  $10^{\circ}\text{C}$  colder than the surrounding temperature shall be poured on the translucent cover to simulate rain for the test. However, the simulated rainwater should be no colder than  $4^{\circ}\text{C}$ .

**(j) Spare Items**

Fuse 100%

**(3) Led Modules For Tunnel Lighting**

**(a) Types and Applicable Regulations**

The following standards shall be applied to LED modules for road lighting, along with these specifications.

JIS C 8152-2:2014 White Lighting Luminous Diode (LED) Measurement Methods, Part 2:

LED modules and LED light engines

JIS C 8154:2009      General Lighting LED Modules – Safety Specifications

JIS C 8155:2010      General Lighting LED Modules – Required Performance

**(b) LED Module Performance**

LED modules shall be contained within fixtures with a protection class rating of at least IP55, as standardized in JIS C 8105-1:2013 “Lighting Components – Lighting Components – Part 1: General Safety Requirement Rules,” and shall be designed for appropriate heat dissipation to maintain the standard luminous flux continuously over the long term.

The initial characteristics of the combined module and module control device must satisfy Table 52-3, and shall also conform the requirements of Clause 5.5 Connecting Road Lighting for lighting equipment.

**Table 52-3: LED Module Initial Characteristics (Total Luminous Flux)**

Type	Initial Characteristics (Rated Value)	
	Correlated Color Temperature (K)	Average Color Rendering Index Ra
White LED for Lighting	4500±2000	> 60

**(c) LED Module Lifespan**

**(i) Lifespan**

The total illumination time elapsed before the LED modules illuminated according to standard conditions cease to illuminate, or the total illumination time elapsed before their luminous flux falls below 80% of the value (LED module standard luminous flux) measured at initial illumination (regarded as non-lighting) shall be compared, and the shorter of the two-time spans shall be considered the lifespan of the LED modules.

**(2) Rated Lifespan**

The published average value for the time elapsed until the survival rate calculated based on the number of units which have ceased to function in a group of LED modules of the same type manufactured at the same time falls to 50% shall be considered the rated lifespan, and the value is shown in Table 52-4.

Alternatively, in addition to manufacturer testing, rated lifespan can be estimated logically based on the LED unit manufacturer's LED operation conditions specifications for temperature and current, the technical data showing the change over time of the optical performance maintenance rate, the LED element temperature depending on the condition of the fixture, etc.

**Table 52-4: Rated Lifespan of LED Modules**

Type	Rated Lifespan (h)
White LED for Lighting	> 90,000

Fixtures must be engineered for heat dissipation at greater than or equal to the value shown in Table 52-4, and LED modules must be selected accordingly.

**(iii) Method for Calculating Lifespan**

LED module lifespan testing must be conducted according to JIS C 8155:2010 Appendix C (Luminous Flux Maintenance Test and Lifespan Test Illumination Conditions).

The estimated lifespan of LED modules must be calculated using one of the methods below.

- ✓ Value estimated using Illuminating Engineering Society of North



America (IES) LM-80 (Luminous Flux Maintenance Rate Measurement Method) and TM-21 (Long-Term Luminous Flux Maintenance Rate Estimation Method)

- ✓ Lifespan value estimated from the Arrhenius plot of temperature acceleration test results based on the use temperature. Lifespan estimation conditions shall be set as a fixture ambient temperature of 30 °C, with normal rated current flowing to the LED modules mounted in the fixture.

#### **(4) Tunnel Lighting Led Module Controllers**

##### **(a) Types and Applicable Regulations**

The following standards shall be applied to LED module controllers for road lighting, along with these specifications.

JIS C 8147-1:2011 Lamp Controllers - Part 1: General Rules and Safety Requirements

JIS C 8147-2-13:2014 Lamp Controllers - Part 2-13:  
Individual Requirements for LED Module Controllers for DC or AC Power Supply

JIS C 8153:2009 LED Module Controllers – Performance Requirements

JIS C 61000-3-2:2011 Electromagnetic Compatibility – Part 3-2: Limit Value – Harmonic Current Generation Limit Value  
(Device with input current of less than 20A per phase)

JIS C 61000-4-5:2009 Electromagnetic Compatibility – Part 4-5: Testing and Measuring Technology – Surge Immunity Testing

##### **(b) LED Module Controller Performance**

###### **(i) Design and Materials**

Design and materials shall be in accordance with JIS C 8147-2-13:2014.

###### **(ii) Dimensions**

LED module controllers should be of the right dimensions to be housed within the fixture body, and should be mounted with consideration for fixture heat dissipation, etc.

###### **(iii) Lead Wires**

Lead wires must have capacities equivalent to JIS C 3317:2000 “Grade heat-resistant polyvinyl chloride insulated wires”, JIS C 3306:2000 “vinyl cord” or JIS C 3327:2000 “600V rubber cable” and must have a nominal cross-sectional area of at least 0.75 mm<sup>2</sup>.

###### **(iv) Performance**

LED Module controllers must have sufficient power supply capacity for the LED modules in their light fixture.

LED module controllers shall be contained within fixtures with a protection class rating high than IP55, as standardized in JIS C 8105-1:2013 “Lighting Components – Part 1: General Safety Requirement Rules,” so as to withstand long-term use.

LED Module controllers must have the capacity to stably supply electricity at the maximum level used by the LED modules, and must function to protect the LED modules by suppressing excess current, etc.

(v) Characteristics of LED Module Controllers for Basic Lighting

The circuit power factor for LED module controllers shall be at least 90% (for full illumination), and should be designed to minimize input power.

Rated input current for LED module controllers shall be AC415V.

The main characteristics of LED module controllers for basic lighting are shown in Table 52-5.

**Table 52-5: Characteristics of LED Module Controllers for Basic Lighting**

Component Format	Rated Input Voltage (V)	Rated Input Current (A)	Rated Electricity Consumption (W)	Power Factor (%)
White LED (LED108)	415	< 0.26	< 102	> 90
White LED (LED36)		< 0.10	< 36	
White LED (LED40)		< 0.12	< 45	
White LED (LED60)		< 0.17	< 65	
White LED (LED80)		< 0.21	< 85	
White LED (LED120)		< 0.33	< 129	
White LED (LED160)		< 0.41	< 169	
White LED (LED200)		< 0.53	< 213	
White LED (LED240)		< 0.62	< 254	
White LED (LED280)		< 0.74	< 299	

Note 1: Rated input current and rated electricity consumption values are for the end of lifespan (after 90,000 hours have elapsed).

(vi) Noise Characteristics

Noise terminal voltage from the light fixtures and noise power from the light fixtures must satisfy the performance listed below when measured by the method stipulated in the Electrical Appliances and Materials Safety Act.

✓ Terminal Voltage 526.5 kHz - 5 MHz: < 56 dB

5 MHz - 30 MHz: < 60 dB

✓ Noise Power 30 MHz - 300 MHz: < 55 dB

(vii) Harmonic Current

Relative limit values for fixtures whose active input power exceeds 25 W (Class C: lighting devices) shall be less than those standardized in JIS C 61000-3-2 :2011.

**Table 52-6: Relative Limit Values for Class C Devices**

Harmonic Degree n		Maximum Permissible Harmonic Currents as a Percentage of Light Fixture Fundamental Harmonic Input Current (%)
Even Harmonics	2	2
Odd Harmonics	3	$30 \times \lambda^{\text{Note}}$
	5	10
	7	7
	9	5
	$11 \leq n \leq 39$	3

Note:  $\lambda$  indicates circuit power factor

(viii) Surge Protection

Surge protection must be greater than or equal to that necessary for voltage loads of 4 kV for common mode (ground) and 2kV for normal mode (wire), as standardized for class 4 conditions in JIS C 61000-4-5:2009.

(ix) Initial Luminous Flux Correction

A function must be included which automatically adjusts excess brightness at the time of installation to a standard brightness level (at least 80% of the rated luminous flux value). The initial luminous flux correction method shall be automatic, using light sensors to measure the interior brightness of the light fixtures, or using program control.

(xi) Light Adjustment Function

The basic lighting level must be adjustable such that lighting is 1/2 during nighttime and 1/4 during daytime, and such that entrance lighting level is 3/4 in sunny weather, 1/2 in level I cloudy weather, and 1/4 in level 2 cloudy weather.

Light adjustment control shall be achieved via a timer or light adjustment signal from the lighting control panel.

**(c) LED Module Control Device Lifespan**

(i) Lifespan

The total illumination time elapsed before the LED module controllers operating under standard conditions either break, or their output falls below the rated value and they become unusable, shall be considered the lifespan of the LED module controllers.

(ii) Rated Lifespan

The average value for the time elapsed until the lifespan survival rate of a group of LED module controllers of the same type manufactured at the same time falls to 50% shall be considered the rated lifespan, and the value is shown in Table 52-7.

**Table 52-7: LED Module Control Device Rated Lifespan**

Type	Rated Lifespan (h)
White LED for Road Lighting	> 90,000

Circuits must be designed and parts selected such that components housed within fixtures for use may operate for longer than their rated lifespan.

(ii) Lifespan Calculation Method

The manufacturer shall report to the client on the basis for the engineered lifespan of the LED module controllers, achieved using one of the methods below.

Lifespan shall be estimated under conditions of a set fixture ambient temperature of 30 °C.

- ✓ Lifespan value estimated from the Arrhenius plot of temperature acceleration test results based on the use temperature
- ✓ Lifespan value estimated based on calculations using the maximum temperature derating factor, etc. for the main components used
- ✓ Value calculated using lifespan value estimated via a method standardized by the LED module control device manufacturer and ambient temperature conditions during actual installation

**(5) Connecting Road Lighting (Entrance Lighting)**

The LED road illumination light fixtures use LEDs as a light source, and are composed of LED road light fixtures, LED modules, and LED module controllers.

**(a) Applicable Standards**

The following standards shall be applied to LED module controllers for road lighting, along with these specifications.

- JIS C 8147-1:2011 Lamp Controllers - Part 1: General Rules and Safety Requirements
- JIS C 8147-2-13:2014 Lamp Controllers - Part 2-13: Individual Requirements for LED Module Controllers for DC or AC Power Supply
- JIS C 8153:2009 LED Module Controllers – Performance Requirements
- JIS C 61000-3-2:2011 Electromagnetic Compatibility – Part 3-2: Limit Value –

Harmonic Current Generation Limit Value

(Device with input current of less than 20A per phase)

JIS C 61000-4-5:2009 Electromagnetic Compatibility—Part 4-5:

Testing and Measuring Technology – Surge Immunity  
Testing

**(b) Road Lighting Equipment Specifications**

Fixture type is shown in Table 52-8.

**Table 52-8: LED Road Lighting Fixture Type**

Type	Fixture Type	Rated Luminous Flux
Pole-Head Type	White LED Road Light Fixture	> 14,700 lm

Note 1: The type is specified in JIS C 8105-2-3; 2: Must be at least 90% of the minimum rated luminous flux value.

**(c) Structure**

Fixtures must be durable, waterproof, weather resistant, and corrosion resistant, and maintenance inspections must be easy to conduct. During normal operations, mechanical, electrical and optical functions must be continuously sustained.

**(i) Fixture Geometry and Mass**

Fixture geometry is not expressly stipulated, but the pressure-receiving area must be less than 0.14 m<sup>2</sup> from the front direction and less than 0.15 m<sup>2</sup> from the side, and the mass must be less than 10 kg.

Values outside of these standard values must be checked using the prescribed calculations in JIL 1003 : 2009 “Light Pole Strength Calculation Standards.”

**(ii) Junction with Light Pole**

A  $\phi 60.5 \times 120$  adapter shall be used for the junction with the light pole, and the fixture must be designed to prevent rotation or falling due to vibrations, etc.

**(iii) Protection from the Intrusion of Solid Dust and Dirt Particles and Water Droplets**

Protection shall be greater than or equal to a standard of JIS C 8105-1 : 2013 IP23 (equivalent to conventional rain-proofing). Damage from solid, waterborne, or airborne dust and dirt must be prevented.

The housing for LED modules, reflecting plates, lenses, etc. must have a protection class greater than or equal to IP44, and designed to minimize the possibility of intrusion by solid dust and dirt particles which could decrease the luminescence of the components. In addition, if the LED module

controllers are housed within the fixtures, they must have a protection class greater than or equal to IP44.

(iv) Grounding Bolts

Pole support hardware must include grounding bolts.

(v) Set Marks

The fixtures must have “set marks” which indicate the proper location for mounting at the spot where the fixture will contact the pole.

(vi) Fixture Mounting Method

The method for mounting fixtures shall be standard linear light pole mounting, but must also be compatible with curved light pole mounting. Fixtures must be securely mounted in at least two places, (at least two bolts or at least two equivalent mountings with sufficient strength).

(vii) Fall Prevention Design

Even if the mounting holding the fixture to the pole becomes loose, the fixture must include a fall-prevention design such that the fixture will not rotate excessively or fall off.

The fixture fall prevention design shall employ a bolt (at least M6) which passes through a hole in one side of the pole adapter, as well as a fall-prevention wire connecting the fixture to the pole and a dedicated bolt (at least M6) which can secure this wire.

**(d) Component Materials and Parts**

The main materials and parts which make up the fixtures are listed below.

(i) Main Body

The main body of fixtures shall be made of a material (including coating, if necessary) equivalent to die-cast aluminum alloy meeting the JIS H 5302:2006 standard, with a strength, anti-rust, anti-corrosion rating equivalent to ADC12, and shall not have any cavities, cracks, rust, or coating unevenness which could cause damage.

(ii) Translucent Cover

Translucent covers shall have strength and translucency ratings compatible with JIS R 3206:2014 tempered glass with a standard thickness of at least 4.0 mm. The optical performance of components must be fully sustainable, and must be impervious to scratches, cracks, bubbles and clouding which could impede performance.

(iii) Reflecting Plates and Lenses

Control of light distribution of LED modules shall be achieved with reflecting plates, lenses, or a combination of the two. If reflecting plates are used, they

must be molded to JIS H 4000:2014 “aluminum and aluminum alloy plate and strip” standard, or molded from resin, and must be at least as durable as surface-treated material. If lenses are used, they must be molded from resin with maximum heat resistance and durability, or similar.

The combined LED modules, reflecting plates or lenses, and translucent covers must fully maintain their optical performance.

(iv) Rubber Seals

Seals must be highly elastic and heat-resistant, must not absorb moisture, and must be resistance to deterioration.

(v) Latches

If a latch design is used, to ensure the same quality as the original fixture, a chrome-plated JIS H 5301:2009 “Zinc Alloy Die-Cast” standard latch, synthetic resin baked finish JIS H 5302:2006 “Aluminum Alloy Die-Cast” standard latch, or stainless (SUS304 or equivalent) JIS G 4305:2012 “Cold-Rolled Stainless-Steel Sheet and Steel Strip” standard latch must be used.

If a bracket bolt design is used, to ensure the same quality as the original fixture, electro-galvanized steel plate (standard size > 2.3 mm) hardware or SUS304 JIS G 4305:2012 “Cold-Rolled Stainless-Steel Sheet and Steel Strip” hardware or material with equivalent strength and durability greater than or equal to 2.0 mm in thickness must be used.

If a portion of the light body could be given a latch function, it must have equivalent strength. In addition, it must be designed to be strong enough not to easily spring open due to vibrations or earthquakes.

(vi) Hinges and Hinge Axes

If a hinge design is used for the fixtures, a JIS G 4305:2012 “Cold-Rolled Stainless-Steel Sheet and Steel Strip” stainless (at least SUS304B or equivalent) hinge with a standard thickness of at least 1.5 mm must be used, and the hinge axis must be JIS G 4303:2012 “Stainless Steel Rod” stainless (at least SUS304B or equivalent).



Combined units of hinge and hinge axis may be used, but they must have straight equivalent to the above.

(vii) Fixture Internal Wiring

- ✓ Fixture internal wiring and external wiring shall be connected via a terminal block or waterproof connector.
- ✓ Fixture internal wiring shall be connected to the terminal block by crimp terminals only.

(viii) Terminal Blocks

If terminal blocks are used, the terminals must be porcelain, creepage distance

must be at least 6mm, and air clearance must be at least 4mm. Labels of , E,  or “earth” shall be included near the ground terminals.

(ix) Pole Support Hardware

Pole support hardware shall be electro-galvanized steel plate or surface-treated JIS H 5302:2006 “Aluminum Alloy Die-Cast” ADC12 or other material (including coating if needed) with equivalent strength, anti-rust and anti-corrosion properties.

(x) Coating

Rust-proofing treatment shall be applied to the main body, and then a top coat of at least one layer of synthetic resin-based paint shall be applied internally and externally. The coating must have equivalent strength, anti-rust and anti-corrosion properties as baked coating.

(e) Performance

Optical performance of fixtures must be measured according to the method standardized in JIS C 8105-5:2014, and must satisfy the performance indices and recommended values stipulated in “Road Lighting Facilities Installation Standards/Explanations” (October 2007, Japan Road Association) chapters 3, 4, and 7.

(i) Luminous Intensity Classification

Luminous intensity distribution shall use cut-off distribution as a standard, but may use semi-cut-off luminous intensity distribution if necessary due to installation conditions or the surrounding environment.

(ii) Luminosity Value

The luminous intensity for fixtures mounted on a linear light pole with a rated luminous flux of about 10,000 lm at a horizontal angle of ( $\phi$ ) 90 degrees must satisfy the values shown in Table 52-9.

**Table 52-9: Luminosity Value**

Luminous Intensity Type	Luminosity (cd/1,000 lm)	
	Vertical Angle ( $\theta$ ) 90 degrees	Vertical Angle ( $\theta$ ) 80 degrees
Semi-Cut-Off Type	< 30	< 120

(iii) Utilization Factor

The utilization factor must satisfy the values shown in Table 52-10 below for fixtures mounted on a linear lighting pole.



**Table 52-10: Utilization Factor**

Fixture Type	Area	Highway Width / Mounting Height			
		0.5	1.0	1.5	2.0
White LED Road Light Fixture	Road-Side	> 0.30	> 0.51	> 0.60	> 0.61
	Sidewalk-Side	< 0.21	< 0.29	—	—

(iv) Upward Light Flux Ratio (Upper Hemisphere Light Flux Ratio)

The upward light flux ratio (upper hemisphere light flux ratio) must be less than 5% for fixtures mounted on a linear lighting pole.

(v) Insulation Resistance

Must satisfy the capacities in (1) when measured according to the method standardized in JIS C 8105-1:2013.

- ✓ When tested as detailed in (2), insulation resistance must be greater than or equal to 5 MΩ. Also, when tested in the cold, it must be greater than or equal to 30 MΩ.
- ✓ For the insulation resistance test, lamps must be lit continuously until all parts of the fixture have reached roughly the same temperature. Then, the insulation resistance of both terminals and the non-charging metal parts must be measured with a 500 V Insulation Resistance Meter or other instrument with greater precision, as standardized in JIS C 1302:2014 “Insulation Resistance Meter.”

(vi) Voltage Resistance

Must satisfy the capacities in (1) when measured according to the method standardized in JIS C 8105-1:2013.

- ✓ Voltage resistance must withstand the voltage delivered when tested as detailed in (ii).
- ✓ The voltage resistance test must be conducted directly after the insulation resistance test, sending a test voltage (2U+1000 V) close to a sine wave of 50 Hz or 60 Hz in frequency between the charged parts and non-charged parts for about one minute, and checking that no abnormalities occur.
- ✓ If independent LED module controllers for installation outside the fixture are used, measurement shall include the combined fixture and controllers.

(vii) Thermal Shock Resistance

The thermal shock resistance of fixtures must satisfy the following capacities at the time of testing using the JIS C JIS C 8105-2-3:2011 standard method.

- ✓ When thermal shock resistance is tested according to (2), the fixture

exterior and translucent cover must not crack, warp, or break.

- ✓ For the thermal shock resistance test, the fixture should be illuminated as it would be for normal use, until all parts of the fixture have reached roughly the same temperature. At this point, water 10 °C colder than the surrounding temperature shall be poured on the translucent cover to simulate rain for the test. However, the simulated rainwater should be no colder than 4°C.

(viii) Vibration Resistance

When the fixture is securely mounted and subject to a vibration test of increasing vibrations of between 500 and 800 times per minute, with a double amplitude of 2 - 3 mm, for a total of five minutes, the bolts on the mounting must not have loosened, and the fixture must not be broken.

## (6) LED MODULES FOR ROAD LIGHTING

### Applicable Standards:

The following standards shall be applied to LED modules for road lighting, along with these specifications.

JIS C 8152-2:2014	White Lighting Luminous Diode (LED) Measurement Methods, Part 2:  LED modules and LED light engines
JIS C 8154:2009	General Lighting LED Modules – Safety Specifications
JIS C 8155:2010	General Lighting LED Modules – Required Performance

### (a) LED Module Performance

LED modules shall be contained within fixtures with a protection class rating high than IP44, as standardized in JIS C 8105-1 : 2013 “Lighting Components – Part 1: General Safety Requirement Rules,” and shall be designed for appropriate heat dissipation, to maintain the standard luminous flux continuously over the long term.

The initial characteristics of the combined module and module control device must satisfy Table 52-11, and satisfy also the requirements of LED Module Standard Luminous Flux for lighting equipment.

**Table 52-11: LED Module Initial Characteristics (Full Illumination)**

Type	Initial Characteristics (Rated)	
	Correlated Color Temperature (K)	Average Color Rendering Index Ra
White LED for Road Lighting	4500 ±2000	> 60

**(b) LED Module Lifespan**

**(i) Lifespan**

The total illumination time elapsed before the LED modules illuminated according to standard conditions cease to illuminate, or the total illumination time elapsed before their luminous flux falls below 80% of the value (LED module standard luminous flux) measured at initial illumination (regarded as non-lighting) shall be compared, and the shorter of the two-time spans shall be considered the lifespan of the LED modules.

**(ii) Rated Lifespan**

The published average value for the time elapsed until the survival rate calculated based on the number of units which have ceased to function in a group of LED modules of the same type manufactured at the same time falls to 50% shall be considered the rated lifespan, and the value is shown in Table 52-12.

**Table 52-12: LED Module Lifespan**

Type	Rated Lifespan (h)
White LED for Road Lighting	> 60,000

Alternatively, in addition to manufacturer testing, rated lifespan can be estimated logically based on the LED unit manufacturer's LED operation conditions specifications for temperature and current, the technical data showing the change over time of the optical performance maintenance rate, the LED element temperature depending on the condition of the fixture, etc.

Regarding LED module rated lifespan, fixtures must be engineered for heat dissipation greater than or equal to the value shown in Table 52-12, and LED modules must be selected accordingly.

**(iii) Method for Calculating Lifespan**

LED module lifespan testing must be conducted according to JIS C 8155:2010 Appendix C (Luminous Flux Maintenance Test and Lifespan Test Illumination Conditions).

The estimated lifespan of LED modules must be calculated using one of the methods below.

- ✓ Value estimated using Illuminating Engineering Society of North America (IES) LM-80 (Luminous Flux Maintenance Rate Measurement Method) and TM-21 (Long-Term Luminous Flux Maintenance Rate Estimation Method)
- ✓ Lifespan value estimated from the Arrhenius plot of temperature acceleration test results based on the use temperature

Lifespan estimation conditions shall be set as a fixture ambient temperature of 30 °C, with normal rated current flowing to the LED modules mounted in the fixture.

## (7) Led Module Control Units for Road Lighting

### (a) Applicable Standards

The following standards shall be applied to LED module controllers for road lighting, along with these specifications.

JIS C 8147-1:2011 Lamp Controllers - Part 1: General Rules and Safety Requirements

JIS C 8147-2-13:2014 Lamp Controllers - Part 2-13: Individual Requirements for LED Module Controllers for DC or AC Power Supply

JIS C 8153:2009 LED Module Controllers – Performance Requirements

JIS C 61000-3-2:2011 Electromagnetic Compatibility – Part 3-2: Limit Value – Harmonic Current Generation Limit Value

(Device with input current of less than 20A per phase)

JIS C 61000-4-5:2009 Electromagnetic Compatibility – Part 4-5: Testing and Measuring Technology – Surge Immunity Testing

### (b) LED Module Control Device Performance

#### (i) Design and Materials

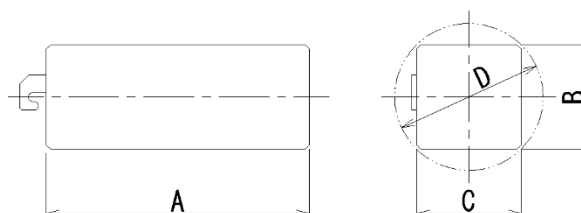
Design and materials are stipulated in JIS C 8147-2-13:2014.

#### (ii) Dimensions

If the devices are stored within the light poles, each part must be arrayed as in the figure shown here after, must fit within the reference dimensions shown in Table 52-13, must be easily mounted or taken out with the joint box.

Table 52-14 shows reference dimensions for pole internal diameter and LED module controllers which can be stored on the diagonal for LED Module control device mounting in a lighting taper pole.

If LED module controllers are housed within fixtures, their geometry and mass must satisfy the standards shown in in Sub-Clause (5)(c)(i) of this Sub-Section.



### Dimensions of LED Module Controllers to be Stored in Light Poles

**Table 52-13: LED Module Control Device Dimensions**

Length A (mm)	Width B (mm)	Height C (mm)	Application
<550	<125	<120	Stored in pole

Note 1: If more than one LED module controllers are used, sufficient consideration must be taken for whether they will fit inside the pole.

**Table 52-14: Lighting Taper Pole LED Module Control Device Mounting Location  
Internal Diameter Dimensions**

Pole Height (m)	Pole Type	LED Module Control Device Mounting Hook Position Internal Diameter D (mm)	Diagonal Dimensions for Internally Storable LED Module Controllers (mm)
10	Liner Type ; For 1 Lamp	152	147

#### (iii) Lead Wires

Lead wires must demonstrate performance equivalent to JIS C 3306:2000 “Vinyl Cord” or JIS C 3327:2000 “600V Rubber Cabtyre Cable,” with a nominal cross-sectional area of at least 0.75 mm<sup>2</sup>.

If insulated wires are used, wires with performance equivalent to JIS C 3307:2000 “600V Vinyl Insulated Wire (IV)” must be used for housing within poles, and JIS C 3317:2000 “Grade heat-resistant polyvinyl chloride insulated wires” must be used for housing within fixtures, and the nominal cross-sectional area must be at least 0.75 mm<sup>2</sup>.

For housing within poles, lead wires must be at least 700 mm in length.

#### (iv) Performance

LED Module controllers must have sufficient power supply capacity for the LED modules in their light fixture.

If LED module controllers are housed within poles, they must bear up over the long term to power being switched on or off once per day in response to temperature and humidity conditions inside the pole. If LED module controllers are housed within fixtures, the fixtures must have a protection class rating of at least IP44, as standardized in JIS C 8105-1:2013 “Lighting Components – Part 1: General Safety Requirement Rules,” so as to bear up over the long term to power being switched on or off once per day in response to temperature and humidity conditions inside the pole.

#### (v) Characteristics of Road Lighting LED Module Controllers

Rated input voltage of road lighting LED module controllers shall be AC200. The main characteristics of road lighting LED module controllers are shown in

Table 52-15.

**Table 52-15: Characteristics of Road Lighting LED Module Controllers**

Fixture Type	Rated Input Voltage (V)	Rated Input Current (A)	Rated Electricity Consumption (W)	Power Factor (%)
White LED Road Lighting Fixtures	415	<0.70	<120	>85

Note 2: If the rated input voltage exceeds 240 V, it can be combined with the transformer.

(vi) Humidity Resistance and Insulation

LED module controllers housed within light poles must satisfy the performance below when measured according to the method standardized in JIS C 8147-1:2011.

Controllers must be kept in continuously humidified container with relative humidity of 91% - 95% for over 48 hours, and directly after humidifying, about 500 V of DC voltage must be applied for one minute, and the insulation resistance measured must be greater than or equal to 2 MΩ.

(vii) Noise Characteristics

Noise terminal voltage from the light fixtures and noise power from the light fixtures must satisfy the performance listed below when measured by the method stipulated in the Electrical Appliances and Materials Safety Act.

If independent LED module controllers for installation outside the fixture are used, measurement shall include the combined fixture and controllers.

- ✓ Terminal Voltage 526.5 kHz - 5 MHz: < 56 dB  
5 MHz - 30 MHz: < 60 dB

- ✓ Noise Power 30 MHz - 300 MHz: < 55 dB

(viii) Harmonic Current

Relative limit values for fixtures whose active input power exceeds 25 W (Class C: lighting devices) shall be less than those standardized in JIS C 61000-3-2:2011.

If independent LED module controllers for installation outside the fixture are used, measurement shall include the combined fixture and controllers.

**Table 52-16: Relative Limit Values for Class C Devices**

Harmonic Degree n		Maximum Permissible Harmonic Currents as a Percentage of Light Fixture Fundamental Harmonic Input Current (%)
Even Harmonics	2	2
Odd Harmonics	3	$30 \times \lambda$ <sup>Note)</sup>

Harmonic Degree n		Maximum Permissible Harmonic Currents as a Percentage of Light Fixture Fundamental Harmonic Input Current (%)
	5	10
	7	7
	9	5
	$11 \leq n \leq 39$	3

Note:  $\lambda$  indicates circuit power factor

(ix) Surge Protection

Surge protection must be greater than or equal to that necessary for voltage loads of 15 kV for common mode (ground) and 2 kV for normal mode (wire), as standardized for class X conditions in JIS C 61000-4-5:2009.

If independent LED module controllers for installation outside the fixture are used, measurement shall include the combined fixture and controllers.

(x) Initial Luminous Flux Correction

A function must be included which automatically adjusts excess brightness at the time of installation to a standard brightness level (at least 80% of the rated luminous flux value). The initial luminous flux correction method shall be automatic, using light sensors to measure the interior brightness of the light fixtures, or using program control.

(c) **LED Module Control Device Lifespan**

(i) Lifespan

The total illumination time elapsed before the LED module controllers operating under standard conditions either break, or their output falls below the rated value and they become unusable, shall be considered the lifespan of the LED module controllers.

(ii) Rated Lifespan

The average value for the time elapsed until the lifespan survival rate of a group of LED module controllers of the same type manufactured at the same time falls to 50% shall be considered the rated lifespan, and the value is shown in Table 52-17.

**Table 52-17: LED Module Control Device Rated Lifespan**

Type	Rated Life Span (h)
White LED for Road Lighting	> 60,000

Circuits must be designed and parts selected such that components housed within fixtures or light poles for use may operate for longer than their rated lifespan.

(iii) Lifespan Calculation Method

The manufacturer shall report to the client on the basis for the engineered lifespan of the LED module controllers, achieved using one of the methods below.

Regarding the ambient temperature and installation conditions for estimating lifespan, if the LED module control device is housed within the fixture, the estimate shall use a fixture ambient temperature of 30 °C when mounted, and if the device is installed within the pole, the estimate shall use an ambient temperature of 40 °C, with the rated current being supplied to the LED modules.

- ✓ Lifespan value estimated from the Arrhenius plot of temperature acceleration test results based on the use temperature
- ✓ Lifespan value estimated based on calculations using the maximum temperature derating factor, etc. for the main components used
- ✓ Value calculated using lifespan value estimated via a method standardized by the LED module control device manufacturer and ambient temperature conditions during actual installation

**(8) Inspections**

LED roadway light fixtures (fixtures, LED modules, LED module controllers) shall be subject to the inspections of the following points.

**(a) In-House Inspection**

- Lighting Characteristics
- LED Module Controller Apparent Power
- Design
- Light Characteristics (cutoff light distribution, upward light flux ratio, lighting utilization factor)
- Insulation Characteristics
- Voltage Resistance
- Thermal Shock Resistance
- Vibration Resistance
- LED Module Capacity
- LED Module Lifespan
- Characteristics
- Humidity Resistance and Insulation
- Noise Characteristics
- Harmonic Current
- Lightning Surge Resistance
- Initial Luminous Flux Correction Function
- LED Module Controller Lifespan

**(b) On-Site Inspection**



- Luminosity shall be measured

## 5300. EMERGENCY FACILITIES

### (1) Description

#### (a) Emergency Facility Design

The emergency facilities are composed of the devices below.

- ✓ Tunnel Entrance Warning Signs (DL Board)
- ✓ Internal Tunnel Warning Signs (EL Board)
- ✓ Monitoring Control Panel
- ✓ Monitor Panel
- ✓ Emergency Telephone
- ✓ Digital Electronic Switchboard (PBX)
- ✓ Evacuation Guidance Display/Display Lights

#### (b) Applicable Standards

Unless otherwise specified, items in this list of specifications shall apply the following standards.

- ✓ International Electrotechnical Commission (IEC) Recommended Standard
- ✓ International Telecommunication Union-Telecommunication Standardization Sector Recommendations (ITU-T)
- ✓ International Standards (ISO)
- ✓ Japanese Industrial Standards (JIS)
- ✓ VCCI Association's Independent Standard Measures Operation Standards
- ✓ International Commission on Illumination (CIE) Standards
- ✓ Other related laws

### (2) Tunnel Entrance Warning Signs (DL Board)

#### (a) Applicable Standards

Applicable Standards
Facility Guidelines No. 8 Telecommunication Facilities. (NEXCO RI July 2017)
Facility Material Specifications Manual Electricity Variable Road Information Board Facilities. (NEXCO RI July 2017)
Facility Material Specifications Manual Electricity Evacuation Guidance Facility Standard Specifications Manual. (NEXCO RI July 2012)

Applicable Standards
Electronic Telecommunications Facilities Design Guidelines/Explanation (Electric Version) 2017 Edition. The Telecommunications Association
Electronic Telecommunications Facilities Installation Standard Diagrams January 2015. The Telecommunications Association

**(b) Device Specifications**

These facilities shall be composed of the following elements.

- ✓ Transmission Control Device
- ✓ Display Unit
- ✓ Name Unit
- ✓ Warning Unit
- ✓ Flashing Lamps
- ✓ Housing Unit
- ✓ Power Supply

**(c) Structure**

- ✓ The dimensions of the housing shall be at least 3540mm wide x at least 1950mm high × at least 1080mm deep. However, these dimensions exclude protruding elements.
- ✓ The weight of the housing must be less than 2000kg.
- ✓ The housing material must be of higher specification than SPCC (JIS G 3141) 2.3t or equivalent.
- ✓ The exterior of the housing must be pretreated with blast treatment followed by zinc spraying (JIS H 8300 TS-WF or TS-ES/Zn99.99(50)), and the interior must also be coated with a coating equivalent or better than primer, intermediate coating, and external coating with two layers of polyurethane resin.
- ✓ The waterproofing and dust-proofing of the housing must rank above IP43 protection class, as standardized in JIS C 0920 “protection classes (IP codes) for the exterior of electronic devices.”
- ✓ The top and back sides of the housing must include heat shielding plates, which must be made of a material high rated than aluminum alloy (JIS H 4000 A5052P) 2.0t or equivalent.
- ✓ Maintenance and inspections must be able to be conducted from the inside of the housing. Entry/exit doors must be designed with consideration for the work environment and for safety, and must be positioned in a location which makes inspection easy.
- ✓ Electrical noise must meet the VCCI Class A technological standard.

- ✓ The entry/exit doors to the housing must include a handle with a lock.
- ✓ The side of the housing must include air circulation windows which can be opened and shut.
- ✓ The interior of the housing must include lighting which can be used during maintenance and inspections.
- ✓ The housing must include a testing-in-progress sign. The sign must be designed so that it will only display when needed.

**(d) Display**

- ✓ The display shall be made up of display units, and each unit within the information board must be compatible with all other units. In addition, each display unit must be individually replaceable within the housing.
- ✓ The waterproofing of the display must rank above IPX5 protection class, as standardized in JIS C 0920 “protection classes (IP codes) for the exterior of electronic devices.”
- ✓ The display must be viewable by the drivers of moving cars, and must be angled three degrees forward with respect to the housing.
- ✓ The color of the display panel background must be equivalent to black (Munsell N1.5 without gloss).
- ✓ The display panel must be designed to prevent loss of visibility due to direct sunlight from above the lighting elements.
- ✓ The display panel must be designed to prevent loss of visibility due to rain droplets.

**(e) Main Performance**

**(i) Display Color and Display Chromaticity**

Display chromaticity must match the chromaticity coordinate points shown in Table 53-1 in the JIS Z 8110 “Colour Specification - Names of Light-source Colour” reference diagram 1, “General Chromaticity Distinctions for System Color Names.”

However, measurement conditions must match JIS Z 8703 “Test Location Standard Conditions,” and the measurement method must follow JIS Z 8724 “Methods of Colour Measurement-Light-Source Colour”.

Furthermore, the dominant wavelengths must be determined based on the intersection point between the spectrum locus and the line extension tying together the white point ( $x=0.333$ ,  $y=0.333$ ) and the display color chromaticity coordinates as specified in JIS Z 8701 “Colour Specification” / The CIE 1931 Standard Colorimetric System and the CIE 1964 Supplementary Standard Colorimetric System; Appendix: “Chromaticity Display Methods Based on Main Wavelengths (or Complementary Wavelengths) and Excitation Purity,” Table 53-1, “Dominant Wavelength.”

**Table 53-1: Display Color Chromaticity Coordinates and Dominant Wavelength**

Display Color	Chromaticity Coordinates		Dominant Wavelength
	x	y	
Red	0.697	0.303	623nm
Orange	0.614	0.385	597nm
Yellow	0.430	0.500	572nm
Yellow-Green	0.320	0.590	552nm
Green	0.210	0.490	510nm
White	0.290	0.300	481nm
Cyan	0.170	0.250	485nm

(ii) Display Unit Brightness

Measurement conditions must meet JIS Z 8703 “Standard Atmospheric Conditions for Testing”.

✓ Daytime Display

The brightness for each display color during daylight is stipulated in Table 53-2 below.

**Table 53-2: Daytime Display Brightness**

Display Color	Brightness
Red	Standard 1600cd/m <sup>2</sup>
Orange	Standard 2900cd/m <sup>2</sup>
Yellow	Standard 3800cd/m <sup>2</sup>
Yellow-Green	Standard 2200cd/m <sup>2</sup>
Green	Standard 2200cd/m <sup>2</sup>
White	Standard 4300cd/m <sup>2</sup>
Cyan	Standard 2700cd/m <sup>2</sup>

✓ Nighttime Display

The brightness for each display color during nighttime is stipulated in Table 53-3 below.

**Table 53-3: Nighttime Display Brightness**

Display Color	Brightness
Red	Standard 85cd/m <sup>2</sup>
Orange	Standard 205cd/m <sup>2</sup>
Yellow	Standard 205cd/m <sup>2</sup>
Yellow-Green	Standard 120cd/m <sup>2</sup>
Green	Standard 120cd/m <sup>2</sup>
White	Standard 230cd/m <sup>2</sup>
Cyan	Standard 145cd/m <sup>2</sup>

✓ Display Response Time

The time between receipt of the display control signal from the monitoring control panel and the illumination of the display must be less than three seconds.

**(f) Functions and Specifications**

**(i) Functions**

✓ Display Control Functions

The transmission control must control the display, flashing, etc. in accordance with the display control signal from the monitoring control panel, and send a status monitoring signal from the information boards to the monitoring control panel.

In addition, the illumination of the name unit shall be controlled by transmission control element in accordance with the switch between day and night displays.

✓ Character Array Equalization Function

Character array equalization and centering must take place automatically according to the number of characters.

✓ Control Information Holding Function

Display control signal data content will be held until a new display signal is received from the monitoring control panel.

✓ Lighting Time Equalization Function

Display characters must move at least 30mm vertically and horizontally, and display element lighting time must be equalized.

However, this does not include symbol displays.

Display character movement time interval: every 15 minutes  $\pm 10\%$

Movement time switch time: less than 500 $\mu$ s

✓ Display Character Holding Function

If two lighting elements in the character display malfunction at once, the character must be automatically displayed to avoid the malfunctioning units, regardless of the character array equalization function. Display units shall be arrayed in vertical lines of 16  $\times$  horizontal lines of 16, and breakdown detection units must match this.

If the character cannot be displayed to avoid the malfunctioning display units, character display will continue with the malfunctioning unit block switched off.

✓ Off-Switch Control Function

If the display light source electric power value exceeds the standards, shutoff control shall take place automatically. In addition, lighting must be restorable through remote control.

✓ Breakdown Output Function

When the following situations occur, a breakdown signal shall be sent as

output to the monitoring control panel:

- If a display unit malfunctions
- If the display light source electric power value exceeds the respective value herein specified for Power Consumption.

✓ Blackout-Response Functions

In response to a blackout of less than 250ms, the transmission control unit shall operate as it would at times of normal power.

✓ Brightness Adjustment Function

- To prevent loss of visibility during daytime display, display brightness must adjust automatically according to changes in the lighting conditions in front of the display.
- The difference in lighting between daytime display and nighttime display shall be 200Lx, and chattering at lighting conditions near this cutoff value shall be prevented.
- Display brightness shall be manually adjustable in response to dirtying or deterioration of the display elements.

(ii) Transmission Control Functions

- ✓ Display control signals, monitoring control signals, edit control signals, test control signals, and status monitoring signals shall be received and transmitted.
- ✓ In response to a monitoring request from the monitoring control panel, an output of status monitoring items listed in Table 53-4 shall be sent.

**Table 53-4: Status Monitoring Items**

Item	Content
Test	Under test control from the monitoring control panel
Breakdown	Power supply breakdown, unit breakdown and board breakdown
Manual	Information board (controller unit) is set to test mode (manual operation)
Congestion	Transmission error such as unregistered signal and control processing error, etc.

✓ Test Control Functions

Between the time when the transmission control unit receives the “test start” signal from the monitoring control panel and the time it receives the “test stop” signal, no display items will be displayed even if a display control signal is received, allowing for tests to be conducted on display control functions.

However, if the display is illuminated, the display board illumination should be shut off.

After the transmission control unit receives the “test start” or “test stop” signal

from the monitoring control panel, information board status monitoring items will be sent to the monitoring control panel.

(iii) Device Specifications

✓ Display

- Display character height shall be standardized at 450mm.
- The number of possible symbol patterns which can be registered must exceed 30.

✓ Surge Protection

Measures must be taken to ensure that surge protection satisfies the JIS C 5381-21 “Functions and Test Methods for Surge Protection Devices Connected to Transmission and Signal Circuits” category C2 standard.

✓ Display

- Functions
  - ① Lamp Functions
  - ② Brightness Switch
  - ③ Ensure Display Uniformity
  - ④ Brightness at the Angle of Radiation

- Display Functions

The display shall display characters and symbols as follows:

- ① 7 characters (Japanese) equivalent  $\times 2$  line display
- ② Symbol + 5 characters (Japanese) equivalent  $\times 2$  line display

However, symbols will be displayed at the left edge of the display board.

- Display Specifications

- ① Display Unit

- ✧ Display Elements: LED
    - ✧ Design: RGB collected method or combined method
    - ✧ Center Brightness:  $>5000\text{cd/m}^2$  (white: red, green, and blue simultaneous illumination)
    - ✧ Display unit dimensions shall be less than 160mm in width  $\times$  less than 160mm in height.

- ② Display Board

- ✧ Display dot array: at least 108 vertical rows  $\times$  at least 336 horizontal rows (excluding blank area)
    - (Symbol display area: at least 108 vertical rows  $\times$  at least 96 horizontal rows)
    - ✧ Display dot pitch: 10mm equivalent pitch

The blank area shall be located between the upper and low

character rows, excluding symbol display areas, and must be at least 120mm in height.

(iv) Name Unit Functions

✓ Functions

- Illumination Functions: The name unit shall be illuminated or shut off in response to a display control signal sent from the transmission control unit.
- White Area Average Brightness: The initial value for white area average brightness in the display board shall be at least 260cd/m<sup>2</sup>. However, the uniform brightness (maximum value/minimum value) for the same color shall be less than 4.
- Illumination Format: Illumination shall be provided by LEDs.

✓ Specifications

- Display Format: Internal illumination format
- Character Color: Display will be white characters on a green background.
- Display Board: Display unit dimensions shall be 2000mm in width × about 400mm in height, and must be made of a material with greater strength and weather resistance than methacrylic resin board (JIS K 6718-2) 8t or equivalent material.

(v) Warning Device Functions

- ✓ Alarm Sounding Function: A siren shall sound or cease sounding in response to a display control signal from the transmission control unit.

✓ Specifications:

- The speakers shall be outdoor-typehorn speakers (JIS C 5504).
- The siren volume must fall between 90 phon and 120 phon at a distance of 20m from the speaker.
- Siren sound shall be a repeated electronically generated compound wave.
- The length of time for which the siren sounds shall be set between zero and ten minutes.

(vi) Flashing Function

- ✓ Illumination: A display control signal from the transmission control unit shall interlock with the illumination of the display to control illumination or shutoff of one yellow flashing lamp or two red flashing lamps, and adjust the flashing between two levels of brightness. When red lamps are illuminated, they must be lit alternately.



- ✓ Daytime Display:
  - Red Lamp: > standard 7000 cd/m<sup>2</sup>
  - Yellow Lamp: > standard 7000 cd/m<sup>2</sup>
- ✓ Nighttime Display:
  - Red Lamp: standard 1800 cd/ m<sup>2</sup>
  - Yellow Lamp: standard 1800 cd/ m<sup>2</sup>
- ✓ Specifications
  - Display Elements
  - Display Element LEDs
  - Chromaticity
    - ✧ Red Lamps: Shall be in accordance with CIE S 004/E-2001 “Colors of Light Signals,” “Table 2 - Coordinates of Intersection Points of Allowed Chromaticity Area Boundaries,” “Red Light Signal Colors Class A1.”
    - ✧ Yellow Lamps: Shall be in accordance with CIE S 004/E-2001 “Colors of Light Signals,” “Table 2 - Coordinates of Intersection Points of Allowed Chromaticity Area Boundaries,” “Yellow Light Signal Colors.”

(vii) Lifespan

Flashing LED lifespan shall be measured under the temperature and humidity conditions in “JEITA ED-4701/100 [Semiconductor Device Environment and Durability Testing Methods (Lifespan Test I) Test Method 102 High-Temperature High-Humidity Bias Test Table 1 High-Temperature High-Humidity Preservation Test Conditions Test Conditions Code BJ],” and shall be considered the time elapsed until initial brightness falls by half, which must be at least 4000 hours.

**(g) Interface**

The conditions for the interface between the DL information board and the monitoring control panel are shown below:

(i) SHDSL Modem

- ✓ LAN-Side Interface
- ✓ Applicable Standards: 10BASE-T, 100BASE-TX
- ✓ Transmission Method IEEE802.3 / IEEE802.3u
- ✓ Transmission Speed 10 / 100Mbps
- ✓ No. of Ports 4 ports
- ✓ Applicable Connector RJ-45 connector

(ii) SHDSL-Side Interface

- ✓ Applicable Standards ITU-T G.991.2
- ✓ Transmission Speed 512kbps - 5.6Mbps
- ✓ Transmission Distance:
  - 10.2km (512kbps, 0.65mm, 2 wire time, theoretical value)
  - 3.4km (5.6Mbps, 0.65mm, 2 wire time, theoretical value)
- ✓ No. of Ports At least 2 ports
- ✓ Applicable Line Independently operated metal line (2W)
- ✓ Applicable Connector RJ-11

(h) **Operation Conditions**

Conditions under which these facilities can be operated normally are shown in Table 53-5.

**Table 53-5: Classification of Operation Conditions**

Operation Conditions
IEC60721-3-4 Environmental Conditions 4K2/4Z5/4Z7/4B1/4C2/4S3/4M4  K: Weather Conditions Z: Special Weather Conditions B: Wildlife Conditions C: Chemically Active Substances S: Mechanically Active Substances M: Mechanical Conditions

However, the lower temperature of the air surrounding the facility shall be - 20°C.

For details, refer to IEC 60721-3-4 “JIS C 60721-3-4 [Classification of Groups of Environmental Parameters and their Severities]”.

(i) **Power Supply**

(i) Input Conditions

Standard input voltage for these facilities is shown below.

AC three-phase three-wire 415V±10% (50Hz)

(ii) Power Consumption

Power consumption for these facilities must be less than 1200VA.

However, power consumed shall be capacity at 35% of full (daytime white) illumination, and exclude maintenance power.

(j) **Insulation Resistance**

Insulation resistance must be at least 10MΩ, and must be measured with a DC 500 V Insulation Resistance Meter. (Surge protection devices shall be excluded). Measurement locations are shown in Table 53-6.

**Table 53-6: Insulation Resistance Measurement Location and Measurement Conditions**

Measurement Location	Measurement Conditions
Between power supply terminal and grounding terminal	With earth removed
Between both transmission terminals	With external lines cut off
Between one transmission terminal and grounding terminal	With earth removed

**(k) Voltage Resistance**

Voltage resistance must result in no anomalies when AC 1500V is applied for one minute when input voltage is less than 250V, and AC 2000V is applied for one minute when input voltage is more than 250V. (Surge protection devices shall be excluded). Measurement locations are shown in Table 53-7.

**Table 53-7: Voltage Resistance Measurement Location and Measurement Conditions**

Measurement Location	Measurement Conditions
Between power supply input and housing	With control system and earth removed

**(l) Surge Protection**

Surge protection shall be as stipulated in JIS C 5381-1 “Surge Protection Devices Connected to Low-Voltage Systems: Characteristics and Test Methods,” Class II.

**(m) Spare Items**

Spare items for the facilities are shown in Table 53-8.

**Table 53-8: Spare Items**

No	Part Name	Quantity
1	Fuses	100%

**(3) Tunnel Entrance Warning Signs (EL) Board**

**(a) Device Specifications**

These facilities shall be composed of the following elements:

- ✓ Transmission Control Unit
- ✓ Display Unit
- ✓ Flashing Lamps
- ✓ Housing: The transmission control unit shall be housed within the display unit, and must include flashing lamps and a testing-in-progress sign

- ✓ Power Supply Unit: Shall be mounted on the housing, shall bring in an external power supply, and shall supply the electricity needed to power each component of the information board

**(b) Structure**

- (i) Housing dimensions shall be less than 2400mm wide × less than 800mm tall × less than 500mm deep. However, this excludes protruding elements.
- (ii) The housing shall weigh less than 550kg.
- (iii) The housing shall be made of an equivalent or better material than SPCC (JIS G 3141) 2.3t.
- (iv) The exterior of the housing must be pretreated with blast treatment followed by zinc spraying (JIS H 8300 TS-WF or TS-ES/Zn99.99(50)), and the interior must also be coated with a coating equivalent or better than primer, intermediate coating, and external coating with two layers of polyurethane resin.
- (v) The waterproofing and dust-proofing of the housing must rank above IP54 protection class, as standardized in JIS C 0920 “protection classes (IP codes) for the exterior of electronic devices.”
- (vi) Maintenance and inspections must be able to be conducted from the back side of the housing.
- (vii) Electrical noise must meet the VCCI Class A technological standard.
- (viii) The maintenance doors of the housing must not be easily opened and closed by a third party.
- (ix) The interior of the housing must include lighting which can be used during maintenance and inspections.
- (x) The housing must include a testing-in-progress sign. The sign must be designed so that it will only display when needed. The testing-in-process sign must have superior durability, and the mounting must be mechanically strong.

**(c) Display**

- (i) The display shall be made up of display units, and each unit within the information board must be compatible with all other units. In addition, each display unit must be individually replaceable from the back of the housing.
- (ii) The waterproofing of the display must rank above IPX5 protection class, as standardized in JIS C 0920 “protection classes (IP codes) for the exterior of electronic devices.”
- (iii) The color of the display panel background must be equivalent to black (Munsell N1.5 without gloss).
- (iv) The display panel must include tempered glass (JIS R 3206) 8t to protect against air and water pressure from cleaning, etc.

**(d) Main Performance**

(i) Display Color and Display Chromaticity

Display chromaticity must match the chromaticity coordinate points shown in Table 9 in the JIS Z 8110 “Color Display Methods – Light Source Color Names” reference diagram 1, “General Chromaticity Distinctions for System Color Names.”

However, measurement conditions must match JIS Z 8703 “Test Location Standard Conditions,” and the measurement method must follow JIS Z 8724 “Color Display Methods – Light Source Colors.”

Furthermore, the dominant wavelengths must be determined based on the intersection point between the spectrum locus and the line extension tying together the white point ( $x=0.333$ ,  $y=0.333$ ) and the display color chromaticity coordinates as specified in JIS Z 8701 “Colour Specification” / The CIE 1931 Standard Colorimetric System and the CIE 1964 Supplementary Standard Colorimetric System; Appendix: “Chromaticity Display Methods Based on Main Wavelengths (or Complementary Wavelengths) and Excitation Purity,” Table 53-9, “Dominant Wavelength.”

**Table 53-9: Display Color Chromaticity Coordinates and Dominant Wavelength**

Display Color	Chromaticity Coordinates		Dominant Wavelength
	x	y	
Red	0.697	0.303	623nm
Orange	0.614	0.385	597nm
Yellow	0.430	0.500	572nm
Yellow-Green	0.320	0.590	552nm
Green	0.210	0.490	510nm
White	0.290	0.300	481nm
Cyan	0.170	0.250	485nm

(ii) Display Unit Brightness

Measurement conditions must meet JIS Z 8703 “Test Location Standard Conditions.”

✓ Tunnel Internal Display

The brightness of each color in the tunnel internal display is shown in Table 53-10.

**Table 53-10: Tunnel Internal Display Brightness**

Display Color		Brightness
✓ D	Red	Standard 85cd/m <sup>2</sup>
i	Orange	Standard 205cd/m <sup>2</sup>
s	Yellow	Standard 205cd/m <sup>2</sup>
p	Yellow-Green	Standard 120cd/m <sup>2</sup>
l	Green	Standard 120cd/m <sup>2</sup>
a	White	Standard 230cd/m <sup>2</sup>
	Cyan	Standard 145cd/m <sup>2</sup>

y Response Time

The time between receipt of the display control signal from the monitoring control panel and the illumination of the display must be less than three seconds.

**(e) Functions and Specifications**

**(i) Functions**

- ✓ Display Control Functions: The transmission control unit must control the display, flashing, etc. in accordance with the display control signal from the monitoring control panel, and send a status monitoring signal from the information board to the monitoring control panel.
- ✓ Character Array Equalization Function: Character array equalization and centering must take place automatically according to the number of characters.
- ✓ Control Information Holding Function: Display control signal data content will be held until a new display signal is received from the monitoring control panel.
  - Lighting Time Equalization Function:
  - Display characters must move at least 30mm vertically and horizontally, and display element lighting time must be equalized.
  - Display character movement time interval: every 15 minutes  $\pm 10\%$
  - Movement time switch time: less than 500 $\mu$ s
- ✓ Display Character Holding Function: If a lighting element in the character display malfunctions, the character must continue to be displayed with the malfunctioning unit switched off. Display units shall be arrayed in vertical lines of 16  $\times$  horizontal lines of 16, and breakdown detection units must match this.
- ✓ Off-Switch Control Function: If the display light source electric power value exceeds the respective value herein specified for Power Consumption, shutoff control shall take place automatically. In addition, lighting must be restorable through remote control.
- ✓ Breakdown Output Function: When the following situations occur, a breakdown signal shall be sent as output to the monitoring control panel.
  - If a display unit malfunctions
  - If the display light source electric power value exceeds the respective value herein specified for Power Consumption
- ✓ Blackout-Response Functions: In response to a blackout of less than 250ms, the transmission control unit shall operate as it would at times of normal power.

- ✓ Brightness Adjustment Function: Display brightness shall be manually adjustable in response to dirtying or deterioration of the display elements.

(ii) Transmission Control Functions

- ✓ Display control signals, monitoring control signals, edit control signals, test control signals, and status monitoring signals shall be received and transmitted. In response to a monitoring request from the monitoring control panel, an output of status monitoring items listed in Table 53-11 shall be sent.

**Table 53-11: Status Monitoring Items**

Item	Content
Test	Under test control from the monitoring control panel
Breakdown	Power supply breakdown, unit breakdown and board breakdown
Manual	Information board (controller unit) is set to test mode (manual operation)
Traffic Jam	Transmission error such as unregistered signal and control processing error, etc.

✓ Test Control Function

Between the time when the transmission control unit receives the “test start” signal from the monitoring control panel and the time it receives the “test stop” signal, no display items will be displayed even if a display control signal is received, allowing for tests to be conducted on display control functions.

However, if the display is illuminated, the display board illumination should be shut off.

After the transmission control unit receives the “test start” or “test stop” signal from the monitoring control panel, information board status monitoring items will be sent to the monitoring control panel.

(iii) Device Specifications

✓ Display

- Display character height shall be standardized at 450mm.
- Surge Protection

Measures must be taken to ensure that surge protection satisfies the JIS C 5381-21 “Functions and Test Methods for Surge Protection Devices Connected to Transmission and Signal Circuits” category C2 standard.

✓ Display

- Functions
  - ① Lamp Functions
  - ② Ensure Display Uniformity

The display must appear uniform when viewed from any direction, front, left, right, above, or below.

However, the uniform brightness (maximum value/minimum value) for the same color shall be less than 1.37.

✓ Brightness at the Angle of Radiation

The display unit must display brightness of at least 1825cd/m<sup>2</sup> (daytime white) at  $\pm 10$  degrees horizontal and vertical.

(iv) Display Functions

✓ Display: Must be able to provide the following character display or dot-free display. Width 5 characters (Japanese) equivalent Nepalese characters

✓ Specifications:

- Display Unit
- Display Elements: LED
- Design: RGB collected method or combined method
- Center Brightness: > 5000cd/m<sup>2</sup> (white: red, green, and blue simultaneous illumination)
- Display unit dimensions shall be less than 160mm in width  $\times$  less than 160mm in height.
- Display unit lifespan shall be measured under the temperature and humidity conditions in “JEITA ED-4701/100 [Semiconductor Device Environment and Durability Testing Methods (Lifespan Test I) Test Method 102 High-Temperature High-Humidity Bias Test Table 1 High-Temperature High-Humidity Preservation Test Conditions Test Conditions Code B].” A 6000-hour acceleration test shall be conducted, and after 6000 hours have passed, the remaining brightness value after 10000 hours have passed shall be predicted based on the 6000-hour remaining brightness value and curve showing changes in brightness. This predicted value must be at least 50% of initial brightness. Alternatively, the remaining brightness value after a 10000-hour acceleration test must be at least 50% of initial brightness.

✓ Display Board

- Display dot array: more than 45 vertical rows  $\times$  more than 240 horizontal rows
- Display dot pitch: 10mm equivalent pitch

(v) Flashing Lamps

✓ Functions



- Illumination Functions: A display control signal from the transmission control unit shall interlock with the illumination of the display to control illumination or shutoff of one yellow flashing lamp or one red flashing lamp.
- Internal Tunnel Display
  - ✧ Read Lamp standard 1800 cd/m<sup>2</sup>
  - ✧ Yellow Lamp: standard 1800 cd/m<sup>2</sup>
- ✓ Specifications
  - Display Elements
  - Display Element LEDs
  - Chromaticity
    - ✧ Red Lamps: Shall be in accordance with CIE S 004/E-2001 “Colors of Light Signals,” “Table 2 - Coordinates of Intersection Points of Allowed Chromaticity Area Boundaries,” “Red Light Signal Colors Class A1.”
    - ✧ Yellow Lamps: Shall be in accordance with CIE S 004/E-2001 “Colors of Light Signals,” “Table 2 - Coordinates of Intersection Points of Allowed Chromaticity Area Boundaries,” “Yellow Light Signal Colors.”
- ✓ Lifespan: Flashing LED lifespan shall be measured under the temperature and humidity conditions in “JEITA ED-4701/100 [Semiconductor Device Environment and Durability Testing Methods (Lifespan Test I) Test Method 102 High-Temperature High-Humidity Bias Test Table 1 High-Temperature High-Humidity Preservation Test Conditions Test Conditions Code B],” and shall be considered the time elapsed until initial brightness falls by half, which must be at least 4000 hours.

**(f) Interface**

The conditions for the interface between the EL information board and the monitoring control panel are shown below.

- ✓ SHDSL Modem
  - LAN-Side Interface
  - Applicable Standards      10BASE-T, 100BASE-TX
  - Transmission Method      IEEE802.3/IEEE802.3u
  - Transmission Speed      10/100Mbps
  - No. of Ports      4 ports
  - Applicable Connector      RJ-45 connector

✓ SHDSL-Side Interface

- Applicable Standards ITU-T G.991.2
- Transmission Speed 512kbps-5.6Mbps
- Transmission Distance 10.2km (512kbps, 0.65mm, 2 wire time, theoretical value); and 3.4km (5.6Mbps, 0.65mm, 2 wire time, theoretical value)
- No. of Ports At least 2 ports
- Applicable Line Independently operated metal line (2W)
- Applicable Connector RJ-11

(g) **Operation Conditions**

Conditions under which these facilities can be operated normally are shown in Table 53-12.

**Table 53-12: Classification of Operation Conditions**

Operation Conditions
IEC60721-3-4 Environmental Conditions 4K2/4Z1/4Z4/4Z8/4B1/4C2/4S3/4M4  K: Weather Conditions Z: Special Weather Conditions B: Wildlife Conditions C: Chemically Active Substances S: Mechanically Active Substances M: Mechanical Conditions

For details, refer to IEC 60721-3-4 “JIS C 60721-3-4 [Classification of Groups of Environmental Parameters and their Severities]”.

(h) **Power Supply**

(i) Input Conditions

Standard input voltage for the facilities is shown below:

- ✓ AC three-phase three-wire 415V±10% (50Hz)

(ii) Power Consumption

Power consumption for these facilities must be less than 400VA.

However, power consumed shall be capacity at 35% of full (white) illumination, and exclude maintenance power.

(i) **Insulation Resistance**

Insulation resistance must be greater than 10MΩ, and must be measured with a DC 500 V Insulation Resistance Meter. (Surge protection devices shall be excluded). Measurement locations are shown in Table 53-13.

**Table 53-13: Insulation Resistance Measurement Locations and Measurement Conditions**

Measurement Locations	Measurement Conditions
Between power supply terminal and grounding terminal	With earth removed
Between both transmission terminals	With external lines cut off
Between one transmission terminal and grounding terminal	With earth removed

**(j) Voltage Resistance**

Voltage resistance must result in no anomalies when AC 1500V is applied for one minute when input voltage is less than 250V, and AC 2000V is applied for one minute when input voltage is more than 250V. (Surge protection devices shall be excluded). Measurement locations are shown in Table 53-14.

**Table 53-14: Voltage Resistance Measurement Locations and Measurement Conditions**

Measurement Location	Measurement Conditions
Between power supply input and housing	With control system and earth removed

**(k) Surge Protection**

Surge protection shall be as stipulated in JIS C 5381-1 “Surge Protection Devices Connected to Low-Voltage Systems: Characteristics and Test Methods,” Class II.

**(l) Spare Items**

Spare items for the facilities are shown in Table 53-15.

**Table 53-15: Spare Items**

No	Item	Quantity
1	Fuses	100%

**(4) Monitoring Control Panel**

**(a) Device Structure**

This facility shall consist of the following devices.

- ✓ Transmission Control Unit
- ✓ Power Supply
- ✓ Operating Control
- ✓ Display

**(b) Structure**

- (i) The housing must be electronically and mechanically sturdy, with a design adhering to JIS C-6010-2.
- (ii) The housing must be an indoor free-standing enclosed type, with a design making maintenance inspections easy.
- (iii) The elements of this facility which will be installed indoors (excluding hard disks and recording media) must have earthquake resistance adhering to JEM TR144 “Earthquake Resistance Design Guidelines for Power Distribution Panels/Control Panels,” with an earthquake resistance class equivalent to “General Buildings –Important Panels” Class A.  
For design purposes, horizontal seismic intensity must be at least 0.6 for

the first floor and basement, at least 1.0 for medium floors, and at least 1.5 for top floors and roof.

However, vertical seismic intensity for design purposes shall not adhere to JEM-TR144, but shall be half of the horizontal seismic intensity for design purposes.

- (iv) Electrical noise must meet the VCCI Class A technological standard.
- (v) The upper portion of the front panel of the housing must include a graphic panel.
- (vi) The housing must include a management nameplate.
- (vii) Housing dimensions shall be 700 mm in width × 1950mm in height × 500mm in depth.  
However, this excludes protruding elements.
- (viii) Housing shall be made from the materials shown below:  
Housing Body .....Protective Steel Plate SPCC  
(JIS G 3141) 1.6t  
Doors .....Protective Steel Plate SPCC  
(JIS G 3141) 2.3t
- (ix) Housing coating shall consist of base treatment followed by primer and a middle coat applied to both interior and exterior. The exterior shall be bake-finished with a double coating of melamine resin paint, while the interior shall be finished with at least one coat. Coating color and thickness are shown in Table 53-16.

**Table 53-16: Coating Color and Thickness**

	<b>Coating Color</b>	<b>Thickness</b>
Exterior	Munsell 5YR2/1.5 7 matte	> 60μm
Interior	Munsell 5YR2/1.5 7 matte	> 35μm

**(c) Main Capacities**

- (i) Display Control Signal Receipt Response Time: Regarding display control signal receipt response time, the monitoring control panel processing time between receipt of a display control signal by the upper station and a receipt completed signal being sent to the upper station shall be less than three seconds.
- (ii) Display Control Signal Processing Time: Regarding display control signal processing time, the monitoring control panel processing time between receipt of a display control signal from the upper station and display control signal data being sent to the information board shall be less than three seconds.
- (iii) Status Monitoring Signal Processing Time: Regarding status monitoring signal processing time, the monitoring control panel processing time between receipt of a status monitoring signal from the information board and a status monitoring signal being sent to the upper office shall be less than three seconds.

**(d) Number of Registered Display Items**

Display items can be expressed as a combination of four separate items: area 1, area 2, cause and action, and more than 1023 must be able to be registered communally to all connected information boards.

- (i) Number of Registered Character Codes and Symbol Pattern: Character codes may be registered. In addition, more than 30 symbol patterns must be able to be registered.

**(e) Functions and Specifications**

**(i) Transmission Control Unit**

- ✓ The transmission control unit shall function to send display control signals and status monitoring signals received from the upper station to each information board, and send status monitoring signals received from the information boards to the upper station.
- ✓ The transmission control unit shall function to send display control signals and test control signals received from the operation control to each information board, and send status monitoring signals received from the information boards to the operation control.
- ✓ The transmission control unit shall function to send monitoring control signals received from the operation control to each information board, and send status monitoring signals received from the information boards to the operation control.
- ✓ The transmission control unit shall function to convert display item numbers and symbols received from the upper station or operation control into display item data, and send it to the information boards.
- ✓ The transmission control unit shall function to compare display item numbers and symbols received from the upper station or operation control and display item numbers sent in status monitoring signals sent from the information boards, and if a discrepancy is found, send status display monitoring item congestion to the upper station.
- ✓ If information boards and the monitoring control panel recover from damage from a breakdown or blackout, the transmission control unit shall function to receive the latest display item numbers and symbols from the upper station, and send appropriate display item data to the information boards.
- ✓ The transmission control unit shall function to send status monitoring items from the information board status monitoring signals to the upper station or operation control in response to a monitoring request from the upper station or operation control.
- ✓ The status monitoring items to be sent are shown in Table 53-17.

**Table 53-17: Status Monitoring Items**

Item	Content
Test	Under test control from the monitoring control panel
Breakdown	Power supply breakdown, unit breakdown and board breakdown
Manual	Information board (controller unit) is set to test mode (manual operation)
Congestion	Transmission error such as unregistered signal and control processing error, etc.

- ✓ The transmission control unit shall function to monitor the information boards within a period of three seconds. In addition, if an anomaly is found in the information board status, the transmission control unit shall function to send status monitoring items to the upper station.
- ✓ Blackout-Response Functions. In response to a blackout of less than 250ms, the transmission control unit shall operate as it would at times of normal power.

(ii) Specifications

- ✓ No. of connected information boards
- ✓ DL-Type Information Board            2 boards
- ✓ EL-Type Information Board            6 boards

(iii) Operation Control

- ✓ Functions: Operation control shall serve the following operation functions:
  - Operation control shall switch between “remote” and “manual.”
  - “Remote” mode means that the information boards are controlled and monitored from the upper station.
  - “Manual” means that the information boards are controlled and monitored from operation control.
  - Operation control shall switch between “normal” and “maintenance.”
  - “Normal” mode means that the information board display can be controlled and status monitoring can be conducted.
  - “Maintenance” mode means that the most recent and past statuses of the information board can be checked.
  - Information boards can be selected.
  - Display items can be selected and controlled.
  - Monitoring requests can be selected and controlled.
  - Test control signals of “test start” and “test stop” can be sent.

- ✓ Specifications: Operation control shall be operated via a touch panel or similar.
- (iv) Display
  - ✓ Functions: The display shall function to show the content of information board displays and breakdown information.
  - ✓ Display items, symbol patterns and status for a given tunnel section (DL-type, EL-type) shall be displayed on the same screen.
  - ✓ The monitor will only display when the operation control is in use.
  - ✓ Monitor display shall have the ability to shut off automatically, and shutoff time must be able to be set in the initial settings.
  - ✓ Display items must be displayed on the monitor in the same pattern and color as they are displayed on the information boards.
  - ✓ Specifications: The display must be in color, allowing for the number of display characters and symbol patterns to be checked.

**(f) Interface**

**(i) SHDSL Modem**

- ✓ LAN-Side Interface
- ✓ Applicable Standards 10BASE-T, 100BASE-TX
- ✓ Transmission Method IEEE802.3/IEEE802.3u
- ✓ Transmission Speed 10/100Mbps
- ✓ No. of Ports 4 ports
- ✓ Applicable Connector RJ-45 connector

**(ii) SHDSL-Side Interface**

- ✓ Applicable Standards ITU-T G.991.2
- ✓ Transmission Speed 512kbps - 5.6Mbps
- ✓ Transmission Distance 10.2km (512kbps, 0.65mm, 2 wire time, theoretical value)
- ✓ 3.4km (5.6Mbps, 0.65mm, 2 wire time, theoretical value)
- ✓ No. of Ports at least 2 ports
- ✓ Applicable Line independently operated metal line (2W)
- ✓ Applicable Connector RJ-11

**(g) Operation Conditions**

Conditions under which these facilities can be operated normally are shown in Table 53-18.



**Table 53-18: Classification of Operation Conditions**

Operation Conditions
IEC60721-3-3 Environmental Conditions 3K3/3Z1/3B1/3C1/3S2/3M2  K: Weather Conditions Z: Special Weather Conditions B: Wildlife Conditions C: Chemically Active Substances S: Mechanically Active Substances M: Mechanical Conditions

For details, refer to IEC 60721-3-4 “JIS C 60721-3-4 [Classification of Groups of Environmental Parameters and their Severities]”.

**(h) Operation Conditions**

- (i) Power Supply: .....AC single-phase two-wire  
100V±10% 60Hz
- (2) Power Consumption: .....Power consumption for this  
facility is = .....< 1.0KVA

**(i) Insulation Resistance**

Insulation resistance for this facility must be at least as high as the values standardized in JIS C 0704, and measuring locations, etc. are shown in Table 53-19.

**Table 53-19: Insulation Resistance Measurement Locations and Measurement Conditions**

Measurement Locations	Measurement Conditions
Between power supply terminal and grounding terminal	With earth removed
Between both transmission terminals	With external lines cut off
Between one transmission terminal and grounding terminal	With earth removed

**(j) Voltage Resistance**

Voltage resistance for this facility must be at least as high as the values standardized in JIS C 0704, and measuring locations, etc. are shown in Table 53-20.

**Table 53-20: Voltage Resistance Measurement Location and Measurement Conditions**

Measurement Location	Measurement Conditions
Between power supply input and housing	With control system and earth removed

**(k) Spare Items**

Spare items for the facilities are shown in Table 53-21.

Table 53-21: Accessories

No	Item	Quantity
1	Fuses	100%

(5) Emergency Telephone

(a) Emergency Telephone

(i) Structure

- ✓ The emergency telephone shall be wall-mounted and installable on the back of the emergency telephone storage box.
- ✓ Operation and maintenance inspections must be easily performed from the front, and the design must be equivalent to or better than JIS C 0920 (protection classes for the exterior of electronic devices) IPX2 (Anti-dust: not specified, waterproofing: level 2).
- ✓ The housing must be made of JIS G 3141 (cold-rolled steel sheet and steel strip) SPCC t1.6 or better material.
- ✓ The housing must be coated with one coat of polyester resin or equivalent or better material with a powder coating finish, and the coating color must be manufacturer standard.
- ✓ Accessory hardware such as hinges, washers, hangers, etc. must be stainless steel.

(ii) Functions and Standards

- ✓ A receiver, reporting push-buttons, operation instruction plate, and management name plate (device name, model, serial number, manufacturing year and month, and manufacturer) must be included. The management name plate must be mounted in an easily visible location. Mounting hardware must also be included.

There shall be no more than four reporting push-buttons, and the reporting locations shall be set to the police, fire department, and highway manager.

- ✓ The hook switch shall be opened and closed through the weight of the receiver.
- ✓ Electronic noise shall meet VCCI Class B technological standards.
- ✓ The line shall have a surge absorber with surge current resistance of at least 1250A (8/20μs).
- ✓ The following basic functions shall be included:
  - Call Function: A call shall be made automatically when the receiver is unhooked, the dial tone sounds, and a reporting button is pressed.
  - Call Receipt Function: The ringer will sound when an incoming call is received, and unhooking the receiver shall allow the parties on

each end of the call to speak to one another.

- Lock-Out Function: This function shall prevent a single terminal from monopolizing the line for more than a set time.
  - A timer installed within the housing (or lockout signal receipt) will disconnect the emergency telephone from the line. In addition, hanging the receiver on the hook will return operation to normal.
  - Contact Signal Function: A contact signal output shall be sent out when the receiver is placed on the hook or taken off the hook.
  - Signal Selection Function: This function shall allow a DP signal (20 pulse per second system) or PB signal to be selected. It must include an easy-to-operate toggle switch.
  - Anti-Noise Function: This function shall reduce ambient noise, and make the conversation easier to hear in the tunnel road environment.
- ✓ The following maintenance functions must be present.
- Volume Adjustment Function Receiver volume must be easily adjustable.
  - Number Registration Function: Reporting numbers shall be easily set (register/edit/delete) via a switch installed on the housing, etc.
- ✓ Power Supply System: station power supply DC -48V

**(b) Emergency Telephone Storage Box (Wall-Mounted Type)**

**(i) Structure**

- ✓ Must be a wall-mounted type which can be mounted from the back, with an emergency telephone storage box in which to store the emergency telephone, a display lamp, and a power supply.
- ✓ Maintenance inspections must be easily performed from the front, and the design must be equivalent to or better than JIS C 0920 (protection classes for the exterior of electronic devices) IPX5 (Anti-dust: not specified, waterproofing: level 5).
- ✓ The housing must be made of JIS G 4305 (cold-rolled steel sheet and steel strip) SUS304 t1.5 or better material.
- ✓ The housing must be finish-coated with two coats of urethane resin paint or equivalent or better material, and the coating thickness must be at least 50μm. Coating color must be Munsell N7.0 with gloss.

**(ii) Functions and Standards**

- ✓ Emergency Telephone Signboard Display Content. Emergency telephone signboard display content is shown below:
  - Background: Green
  - “Emergency Telephone” characters: White (characters shall be

rounded gothic) or “SOS” characters: White (characters shall be rounded gothic)

- Telephone Mark: Black (mark shall be surrounded with a white field)
- The display lamp shall use an internally-illuminated white acrylic panel, with an LED light source ( $< 15\text{VA}$ ). The content of the display shall read “Emergency Telephone” (green characters, rounded gothic font) or “SOS” (green characters, rounded gothic font)

✓ Power Supply

An MCCB shall be installed, including space for a step-down transformer.

Voltage used shall be single-phase two-wire  $100\text{V} \pm 10\%$  50/60Hz

(c) **Emergency Telephone Storage Box (Box-Type)**

(i) Structure

- ✓ The telephone box must ensure safety and clear speaking during calls, and include an emergency telephone rack on which to store the emergency telephone. In addition, space must be provided for mounting push-button reporting devices (Type II) and a panel explaining push-button reporting.
- ✓ Maintenance inspections must be easily performed, and the design must be equivalent to or better than JIS C 0920 (protection classes for the exterior of electronic devices) IPX3 (Anti-dust: not specified, waterproofing: level 3).
- ✓ The materials used shall meet the following standards.

(ii) Functions and Standards

- ✓ A management name plate (device name, model, serial number, manufacturing year and month, manufacturer), and management display plate (acrylic plate, etc.) must be mounted in an easily visible location. Must include frame and mounting hardware.
- ✓ Doors must be easy for telephone users to open. After use, they must automatically shut firmly, and not open on their own. The front of the doors must bear the lettering “Emergency Telephone” (white, rounded gothic font) or “Emergency Telephone SOS” (white, rounded gothic font).
- ✓ The light source for the internal lighting shall be LED ( $< 40\text{VA}$ ), and must include an MCCB and power supply transformer.

(a) Input Voltage      single-phase two-wire  $100\text{V} \pm 10\%$

(d) **Digital Electronic Switchboard (PBX)**

(i) System Outline

The system shall be made up of the electronic switchboard and telephones, and shall be installed for the following calls.

- ✓ Calls between the emergency telephones and the administrative office phone
- ✓ Internal extension-to-extension calls

(ii) Structure

- ✓ The housing must have superior strength and rust-proofing.
- ✓ Coating color shall be manufacturer standard.

(iii) Functions and Standards

- ✓ Telephone Switchboard Body
  - Control System                      stored program control system
  - Processing System                  distributed control system
  - Speech Path System                time-division PCM system
  - Office-Line Response System
    - ✧ office-line relay
    - ✧ Direct-line system
    - ✧ Dial-in System
    - ✧ Direct-in-line system

(v) Speech Path .....time-division 1-stage speech path

(vi) Controller.....at least 32-bit microprocessor

(vii) Main Recorder .....compact flash

(viii) Input-Output Unit .....telnet client

(ix) Redundancy .....two-layer

Two-layer redundancy must include an operational unit which is always switched on, and a backup unit which only switches on if the operational unit breaks down. There must be no cyclic switching between operational and backup.

(x) Cooling Conditions: fan-modulated forced-air cooling system (long-life fan)

(xi) Line Conditions:

- ✓ General Internal Line: Series resistance < 1200Ω (DP), < 800Ω (PD) (including resistance inside the telephone itself)
- ✓ Leakage Resistance: 20kΩ

(xii) Environmental Conditions

- ✓ Temperature 0 to 40°C
- ✓ Humidity 20 to 80% RH (no condensation)

(xiii) Power Supply Voltage.....AC operation single-phase  
two-wire 100V±10% 50/60Hz

(xiv) Line Structure

- ✓ Line Type Installation
- ✓ Emergency Telephone Line 2 Lines

(e) **Monitor Panel**

(i) Design

- ✓ Must be an indoor wall-mounted type, on which operation and maintenance inspections can easily be performed from the front, and must be designed with special consideration for electrical safety.
- ✓ The housing shall be steel plate equivalent to or better than JIS G 3141 (cold-rolled steel sheet and steel strip) SPCC t1.2.
- ✓ Housing coating shall be bake-finished with least two coats of melamine resin paint or equivalent or better material. Coating thickness must be at least 50µm. Coating color shall be manufacturer standard.

(ii) Functions

✓ Performance

- Monitoring items are shown below:
  - ✧ Automatic Reporting (lamp displays red)
  - ✧ Manual Reporting (lamp displays red)
  - ✧ Information Board Interlocking in Progress: (lamp displays red)
  - ✧ Information Board Testing in Progress: (lamp displays orange)
- When a warning signal of “automatic reporting” or “manual reporting” is received, the associated monitoring lamp and “information board interlocking in progress” shall illuminate, and a warning buzzer will sound, which can be turned off with the warning buzzer off-switch.
- If a blackout occurs, blackout backup batteries will sustain normal operation for 40 minutes.
- If information boards are being tested, “information board testing in progress” shall display on the monitor, and the buzzer will not sound.

✓ Electrical Standards

- Power Supply
  - ✧ Input: single-phase two-wire 100V±10% 50/60Hz
  - ✧ Capacity: <100VA
- ✓ Transmission Lines: Signal delivery to/from the monitoring control panel shall be a no-voltage contact.
- ✓ Voltage resistance and insulation resistance
  - Power Supply Input Terminal – Housing: AC1000 V for one minute; >10MΩ on 500 V Insulation Resistance Meter
  - Signal Input Terminal – Housing: >1.5MΩ on 250 V Insulation Resistance Meter
  - Between Signal Input Terminals: >1.5MΩ on 250 V Insulation Resistance Meter

**(f) Spare Items**

Spare items for the facilities are shown in Table 53-22.

**Table 53-22: Accessories**

No.	Item	Quantity
1	Fuses	100%

**(6) Evacuation Guidance Display/Display Lights**

**(a) Applicable Standards / Types**

Any items not expressly stipulated in these specifications shall adhere to the following standards.

**(i) Applicable Regulations and Standards**

- ✓ International Electrotechnical Commission (IEC) Recommended Standard
- ✓ International Standards (ISO)
- ✓ International Commission on Illumination (CIE) Standards
- ✓ Japanese Industrial Standards (JIS)
- ✓ Japan Lighting Manufacturers Association Standards (JIL)
- ✓ Electrical Appliance and Material Safety Law (1961, Law No. 234)
- ✓ Other related laws

**(ii) Types**

Display board/ display lamp types are shown in Table 53-23.

**Table 53-23: Display Board / Display Lamp Types**

Type	Item	Description
S1(A)	Guidance Display	Shall be mounted on tunnel wall surfaces

Type	Item	Description
	Board (Surface Mounted)	except for emergency parking strip, and shall display the direction and distance to the tunnel mouth or evacuation connector tunnel.
S1(B)		Shall be mounted on the tunnel wall surfaces of the opposite traffic lane from the evacuation connector tunnel, indicating the presence of the evacuation connector tunnel.
S3	Emergency Exit Display Lamp	Shall be mounted on the tunnel wall surfaces of the opposite traffic lane from the evacuation connector tunnel, indicating the presence of the evacuation connector tunnel.
S4	Emergency Exit Display Lamp (With Warning Light)	Shall be mounted on tunnel wall surfaces next to the entrance to the evacuation connector tunnel, indicating the presence of the evacuation connector tunnel.
S5	Warning Lamp	Shall be mounted on tunnel wall surfaces next to the entrance to the evacuation connector tunnel, indicating the presence of the evacuation connector tunnel while warning against sudden movements out into the traffic lane.
S6	Emergency Parking Strip /Emergency Telephone Display Lamp (Double-Sided Display)	Shall be mounted on tunnel wall surfaces near the face-to-face traffic tunnel emergency parking strip, indicating the presence of the emergency parking strip and emergency telephone.

However, the display board / display lamp light source shall be LED.

**(b) Structure**

- (i) Body and Waterproofing Functions: The structure must be equivalent to or better than JIS C 0920 “[protection classes (IP codes) for the exterior of electronic devices] 3. Performance” IPX5.
- (ii) Body: Must be made of cold-rolled stainless-steel sheet.
- (iii) Lamps must have superior corrosion resistance, and consideration must be taken regarding crevice corrosion, stress corrosion, and electrolytic corrosion from contact between different metals.
- (iv) Lamps must be easily and sturdily mounted on tunnel walls either directly or using mounting hardware.
- (v) Display boards / display lamps must be mounted in locations where the light sources and mounting will not loosen, disconnect, or fall due to vibration stimulation during use or during inspections.
- (vi) Display boards / display lamps must be easily and safely opened and shut for exchange of light sources and maintenance inspections.
- (vii) The front surface of light fixtures must not have any projections which could interfere with cleaning using spinning brushes, etc.
- (viii) Power supply shall be fed into the light fixtures either via direct cable or via cable tube.



- (ix) Bolt holes for the mounting and mounting hardware must be vertically and horizontally adjustable.
- (x) Display board / display lamp interior must allow input power from batteries to be shut on or off during maintenance inspections and parts replacement.
- (xi) Fixture interiors shall include terminal blocks to connect to outside power lines.
- (xii) Fixture interiors shall include grounding terminals.
- (xiii) Batteries stored in display boards / display lamps must have functions equivalent or superior to “JIS C 8705 [cylindrical sealed nickel-cadmium storage batteries]”.
- (xiv) Translucent covers must have functions equivalent or superior to float-tempered glass under “JIS R 3206 [Tempered Glass]” standard.
- (xv) Display board / display lamp insulation resistance and voltage resistance shall be as stipulated in “JIS C 8105-1 [Lighting Fixtures – Part 1: General Rules for Safety Requirements] Chapter 10 Insulation Resistance and Voltage Resistance.”

**(c) Optical Performance**

- ✓ Display Board / Display Lamp
  - The initial value for average brightness of the white portions of the display boards must be at least the value of the Table 53-24 value divided by the luminous flux maintenance rate shown in Clause 6.5: “Specifications / Operation Conditions”.

**Table 53-24: Brightness (cd/m<sup>2</sup>)**

Type	Item	Average Brightness
		Front
S1(A)	Guidance Display Board (Surface-Mounted Type)	130
S1(B)		
S2(A)	Guidance Display Board (Embedded Type)	130
S2(B)		
S3	Emergency Exit Display Lamp	220
S4	Emergency Exit Display Lamp (With Warning Lamp)	220
S5	Hazard Warning Lamp	200
S6(A)	Emergency Parking Strip • Emergency Telephone Display Lamp (One-Sided)	150
S6(B)	Emergency Parking Strip • Emergency Telephone Display Lamp (Two-Sided)	150

Display board/display lamp light distribution is stipulated in “JIL 5502 [Emergency Lighting and Guideline for Evacuation System for Equipment Technical Standards]”.

**(d) Functions and Specifications**

**(i) Functions**

- ✓ Mounting Function: Display boards / display lamps must be sturdily mounted on tunnel wall surfaces.
- ✓ Storage Functions: Light sources and lamps must be stored within the light fixtures.
- ✓ Maintenance Functions: Internal maintenance inspections and light source replacement must be performed easily while display boards / display lamps remain mounted on tunnel walls.
- ✓ Display Functions: Display board display content must be easily readable when the light source is illuminated.
- ✓ Blackout Backup Functions:
  - The instant commercial power blacks out, power supply will switch to backup batteries which will keep lamps illuminated for at least 30 minutes.
  - Blackout conditions are shown below:
    - ✧ The average brightness of the white portion of the display board surface of display boards / display lamps must be at least 50% of the value shown in Table 53-24.
    - ✧ S1 display board / display lamp luminous intensity must be at least 50% at an 87 degrees horizontal angle from the front surface.
    - ✧ Warning lamp luminous intensity shall be at least 70% at a three degrees horizontal angle relative to the front surface of the display board.

**(e) Specifications / Operation Conditions**

**(i) Specifications**

- ✓ Display Board/Display Lamp Display Color and Dimensions: Display board/display lamp color and dimensions are shown in the design diagrams.
- ✓ Warning Lamp Dimensions and Mounting Locations: Warning lamp dimensions shall be greater than 90mm in diameter, and they shall be mounted on the lower portion of the display lamps.
- ✓ Luminous Flux Maintenance Rate at Expected End of Light Source Lifespan: The luminous flux maintenance factor at the expected end of light source lifespan must exceed the following values:
  - ✧ Luminous Flux Maintenance Rate at Expected End of Light Source Lifespan

Light Source	Expected Lifespan	Lumen
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	(Hours)	Maintenance Factor
LED	4.0×104	0.5

(ii) Operation Conditions

Conditions under which the display board / display lamps can function properly are shown in Table 53-25.

**Table 53-25: Classification of Operation Conditions**

Type	Item	Average Brightness Front
S1(A)	Guidance Display Board (Surface-Mounted Type)	130
S1(B)		
S2(A)	Guidance Display Board (Embedded Type)	130
S2(B)		
S3	Emergency Exit Display Lamp	220
S4	Emergency Exit Display Lamp (With Warning Lamp)	220
S5	Hazard Warning Lamp	200
S6(A)	Emergency Parking Strip • Emergency Telephone Display Lamp (One-Sided)	150
S6(B)	Emergency Parking Strip • Emergency Telephone Display Lamp (Two-Sided)	150

For details, refer to IEC 60721-3-4 “JIS C 60721-3-4 [Classification of Groups of Environmental Parameters and their Severities]”.

However, the temperature of the air surrounding the facility shall be as follows:

- ✓ Temperature of the air surrounding the facility = -10°C to +40°C

(iii) Power Supply

The standard input voltage for these facilities is shown below:

- ✓ Three-Phase Three-Wire Type 415V±10% (50Hz)

(iv) Load Capacity

The load capacity of the sign board / display lamps is shown below:

Sign Board / Display Lamp Load Capacity

Type	Load Capacity (VA)
	LED
S1(A)	50
S1(B)	50
S3	30
S4	35
S5	30
S6(B)	40

**(7) Quality Management**

The department of the manufacturing company directly involved with manufacture of the devices (final inspection department, etc.) must have an ISO9001-certified quality management system (engineering, development, manufacture, installation, and utility services quality guarantee model), or must have a quality management system and structure under an auditor who has equivalent certification.

**5400. REMOTE MONITORING AND CONTROL SYSTEM**

**(1) Description**

**(a) System Components**

The Tunnel Management System shall consist of the following facilities and devices.

- ✓ Monitoring control equipment
- ✓ FM radio rebroadcasting system (including loudspeaker equipment)
- ✓ Radio communication auxiliary system (including VHF radio for road administrator)
- ✓ CCTV camera equipment

**(b) Applicable Standards**

The System shall comply with these Specifications, and laws, regulations, rules and specifications listed here below.

<b>Applicable Standards</b>
Part 5 CCTV Facilities in “Standard Design Specifications Vol. 8 Communications Facilities” (NEXCO RI, July 2014)
Part 7 FM Radio Rebroadcasting Facilities in Tunnels in “Standard Design Specifications Vol. 8 Communications Facilities” (NEXCO RI, July 2014)
Part 7 Digital Mobile Radio Communication Facilities in “Standard Design Specifications Vol. 8 Communications Facilities” (NEXCO RI, July 2017)
“Standard Specifications, etc. for FM Radio Rebroadcasting Facilities in Tunnels”, Specification No. 17212 (NEXCO RI, July 2017)
“Standard Specifications, etc. for CCTV Facilities”, Specification No. 17219 (NEXCO RI, July 2017)
“Standard Specifications, etc. for Intelligent Remote-Control Monitoring Equipment Vol. 2”, Specification No. 17210 (NEXCO RI, July 2017)
“(Draft) Specifications for CCTV Facilities” (Ministry of Land, Infrastructure, Transport and Tourism, January 2017)
“(Draft) Specifications for Radio Rebroadcasting Facilities in Tunnels (with interruption function)” (Ministry of Land, Infrastructure, Transport and Tourism, January 2017)

Applicable Standards
“Standard Specifications for Digital Land Mobile Communication Systems (K-λ)”, MLIT Specification for Communication Facilities No. 55 (Ministry of Land, Infrastructure, Transport and Tourism, October 2015)
“Degrees of Protection Provided by Enclosures” (IP Code), IEC 60529
“Degrees of Protection Provided by Enclosures for Electrical Equipment” (JIS C 0920), Japanese Industrial Standards

For any matters referred to in multiple documents, these Specifications shall prevail.

The System shall be manufactured, installed, tested, and test-operated under the quality assurance and quality control system in compliance with ISO 9001. The manufacturers are required to have a copy of ISO 9001 issued by a public, independent organization.

## (2) Basic Requirements

### (a) Basic Design

The Tunnel Management System is a system that shall be installed in the Control Office of the East Electric Room, and monitor and control disaster prevention facilities in the tunnel (such as emergency, ventilation, lighting and other facilities).

The System shall enable operators to monitor the real-time states of facilities and alerts from the operation terminal and large screen display in the Control Office. It shall also provide road users with appropriate information through appropriate road boards and radio broadcasting.

### (b) Durability

The system shall be operated 24 hours a day, 365 days a year, the hardware must be durable for continuous operation.

The System shall be operated 24 hours a day and 365 days a year. The hardware shall be reliable enough for continuous operations.

The integrated management server shall represent the core of the System, and secure redundancy so that defect of any component shall not adversely affect the entire System. In case of any trouble with the operation system hardware of the integrated management server or application programs to be created, the backup system hardware shall automatically take over the operations for continuous operations of the entire System.

### (c) System Extensibility

The System shall be easily linked to other systems, and have additional functions for possible future system extensions.

It shall also easily incorporate additional facilities through revisions to relevant

definitions and settings.

**(d) Power Supply**

The Telecommunication Machine Room in the East Electric Room, and equipment in the Control Office shall be powered at 100V AC via the uninterruptible power system. Other equipment shall be compatible with 220V AC, single phase 50Hz.

**(3) Monitoring Control Equipment**

**(a) Application**

This section shall apply to components, etc. of the monitoring control equipment to be installed in the tunnel (hereinafter referred to as the “Equipment”).

**(b) System Overview**

The system overview of the Equipment shall be as follows.

The Equipment shall:

- Generate the present state information about data from slave stations, and chronologically store and process various data necessary to present the history information.
- Monitor changes in the state of facilities and systems in the tunnel, and judge whether to issue alerts.
- Arithmetically process measurements recorded regularly and when necessary for facilities and systems in the tunnel, and aggregate data on daily and monthly bases.
- Arithmetically process and present search results of information about equipment monitored and equipment, for which control order is made.
- Issue alerts in response to the results of judgments.
- Deliver information about the tunnel to the website, and generate and process the contents.
- Display all the camera views and screens (screens to monitor and control the state of the tunnel) generated on the integrated management server on the large screen display.

**(c) Service Space**

The Equipment shall be installed in the East and West Electric Rooms, both of which are indoors.

**(d) Ambient Conditions**

- Temperature: indoor, 0°C to 40°C  
However, 10°C to 35°C for general information devices
- Humidity: indoor, 10 to 85%RH  
However, 20 to 80%RH (non-condensing humidity) for general information devices

(e) **Structures**

Individual server equipment and racks shall have the following structures.

- The Equipment shall be made of durable and rust preventive steel.
- Stand-alone devices shall be earthquake-resistant to prevent accidents due to horizontal displacement, falling or drop of any parts.
- Devices shall be mounted on steel racks, which shall be fixed directly and horizontally on concrete floors.
- Devices to be placed on the free access floor shall be fixed with bolts on special racks, which shall be placed in a hole created in the floor. Special racks shall have a structure, in which bolts used to fix the devices on the concrete floor are visible.

(f) **Components of the Equipment**

The Equipment shall consist of the following components and devices.

**Table 54-1: Components of the Monitoring Control Equipment**

Name	Specifications	Unit	Q'ty	Notes
Integrated management server equipment				
Processing Server #1 (integrated management server)		unit	1	
Processing Server #2 (integrated management server)		unit	1	
Maintenance console / KVM switch		unit	1	
Layer 3 Ethernet switch	48 or more ports	unit	1	
Server rack	W700×H2000 ×D1000	unit	1	
Facility management transmission equipment				
PLC		unit	1	
Media converter		unit	1	
Cabinet	W600×H2000 ×D600	unit	1	
Junction terminal equipment #A	W600×H2000 ×D600	unit	1	
Facility management transmission equipment #2	W600×H2000 ×D600	unit	1	West Electric Room
Large Screen display	Consists of four screens	set	1	
Multi-vision controller	Mounted on large screen display	unit	1	
Layer 2 Ethernet switch	24 or more ports Mounted on large screen display	unit	1	

Operation terminal (Disaster prevention system / Facility system / Transportation system)		unit	1	
Desk (OA desk)		unit	1	

**(g) Specifications of Components**

Components of the Equipment shall conform with the following specifications.

**(i) Integrated management server equipment**

- ✓ Integrated management server: The server shall have a dual structure consisting of operation and backup systems. In case of any trouble with the operation system hardware or application programs to be created, the backup system shall automatically take over their operations for continuous operations of the entire System.
- Processing server #1 (operation system)
  - ✧ CPU: Xeon E5-2620 v4 processor 2.10GHz x 2 or equivalent
  - ✧ Main memory: 32GB or larger
  - ✧ Hard disk: 300GB×3 (RAID 1, with hot spare) or more
  - ✧ Optical drive: DVD-ROM
  - ✧ LAN interface: 10/100/1000BASE-T × 4 or more ports
  - ✧ OS: Linux, Windows or equivalent
  - ✧ Structure: Rack-mounted
  - ✧ Power: AC100V 50/60Hz (dual power supply)
- Processing server #2 (backup system)
  - ✧ Equivalent to the specifications of Processing Server #1
- Functional specifications (software)
  - ✧ File processing: The server shall generate the present state information about data from slave stations, and chronologically store and process various data necessary to present the history information.
  - ✧ Facility monitoring processing: The server shall monitor changes in the state of facilities and systems in the tunnel, and judge whether to issue alerts.
  - ✧ Measurement operation processing: The server shall arithmetically process measurements recorded regularly and when necessary for facilities and systems in the tunnel, and aggregate data on daily and monthly bases.
  - ✧ Individual control processing: The server shall conduct



interlocking processing of control and order information to facilities in the tunnel. It shall deliver control outputs to facilities on site via slave stations.

- ✧ History processing: The server shall arithmetically process and present search results of information about equipment monitored and equipment, for which control order is made.
- ✧ Alert output processing: The server shall issue alerts in response to the results of judgments.
- ✧ Telecommunication processing (for PLC): The server shall, with PLC and network connection, process reception and transmission of monitoring and control information.
- ✧ -Information to and from PLC shall be in accordance with Table 54-3 “Items to Be Handled by Monitoring Control Equipment (East and West Electric Rooms)”.
- ✧ Telecommunication processing (for emergency facilities): The server shall, with emergency facilities and network connection, process reception and transmission of information for road display boards.
- ✧ Telecommunication processing (for FM radio rebroadcasting system):
  - The server shall, with FM radio rebroadcasting system and network connection, process reception and transmission of monitoring information.
  - Information to and from the FM radio rebroadcasting system shall be as follows:
    - Information to be received: State monitoring information
    - Information to be transmitted: Fire interlocking signals
- ✧ Telecommunication processing (CCTV camera equipment): The server shall, with CCTV camera equipment and network connection, process communications of monitoring information and the state of CCTV camera.
- ✧ Telecommunication processing (for multi-vision controller): The server shall, with multi-vision controller and network connection, process reception and transmission of information, and provide information to display on the large screen display.
- ✧ Web processing:
  - The server shall deliver information about the tunnel on the

website, and generate and process the contents.

- Information to be provided shall be for monitoring, control and measuring. Screen types are listed in Table 54-2.
- The language used for web processing shall be English.

**Table 54-2: Screen Types of Monitoring Control Equipment**

Type	Contents
Current state diagram	Schematic diagrams display monitoring data of the tunnel.
Current state table	Tables give lists of monitoring data of the tunnel in terms of facility and system. FM radio rebroadcasting system / CCTV camera equipment Emergency facilities Fire extinguishing facilities / power receiving / transforming facilities / lighting facilities / ventilation facilities/ emergency telephone facilities VHF radio for road administrator Other facilities
History	History shows lists of facility, alarm and system logs.
Measurements	Measurements show lists of measurements of power receiving and distributing facilities, and ventilation facilities. Measurements shall show lists of their current values, daily compilation and monthly compilation.
Facility control	Guidance on control and operation The lamps of operable buttons flash according to the monitoring state. Operators shall press buttons for intended controlling.

- ✧ User management: The control and maintenance settings shall be subject to access control by IP addresses.
- ✧ Maintenance settings (Stop processing of data distribution to other devices): The server shall have a function of stopping data distribution to other devices for maintenance and inspection.
- Maintenance console / KVM switch: Maintenance console and KVM switch shall be used to switch display operations of Processing Servers #1 and #2 for maintenance of the integrated management server. The specifications are as follows:
  - ✧ Display: 17-inch WXGA or equivalent; Minimum 1280×768, full color
  - ✧ Input device: Keyboard
  - ✧ Pointing device: Touchpad with 3 buttons
  - ✧ CPU switcher: 8 or more input ports, 1 or more output ports
  - ✧ Form: Rack-mounted
  - ✧ Power: AC100V 50/60Hz
  - ✧ Power consumption: 100W or below

- Layer 3 Ethernet switch: The switch shall be used to transmit IP data, and control routing of multicast images.
  - ✧ Structure: Rack-mounted
  - ✧ Backplane capacity: 170 Gbps or more
  - ✧ No. of interfaces: 10/100/1000BASE-T interface x 48 or more ports
  - ✧ Compatible standards: 10BASE-T: IEEE802.3
    - 100BASE-TX: IEEE802.3u
    - 1000BASE-T: IEEE802.3ab
  - ✧ Packet transmission capacity: maximum 100Mpps or more
  - ✧ Routing protocol: OSPF
    - Software compatible with the protocol mounted
  - ✧ IP multicast: Supporting IGMPv2, IGMPv3, PIM-Sparse mode, and PIM-SSM
    - Operable as BSR and C-BSR
    - Operable as RP and C-RP
  - ✧ Priority control: The switch is capable of priority control of traffics in accordance with COS, IP precedence and DSCP value of IEEE802.1p.
  - ✧ VLAN: The switch can support 1000 or more functions.
    - The switch can support VLAN for each port.
    - It can also configure tag VLAN (IEEE802.1Q).
  - ✧ Fault bypass: The switch can support independent spanning tree protocol for each VLAN (including tag VLAN).
  - ✧ Multicast: The switch shall transmit multicast packets only to relevant ports.
    - (Function equivalent to IGMP snooping)
  - ✧ Management protocol: SNMP (v1, v2, v3)
  - ✧ Power: AC100V 50Hz/60Hz (dual power supply)
  - ✧ Maximum power consumption: approx. 250W
- Server rack
  - ✧ Structure: Indoor rack
    - Stand-alone, steel
  - ✧ External dimensions: Width: 700mm

Height: 2000mm

Depth: 1000mm

(except protruding parts)

(ii) Facility Management Transmission Equipment

✓ PLC:

PLC shall input and control changes in the state of monitoring information of facilities in the tunnel, and process reception and transmission of monitoring and control information with devices at the higher rank station.

- Items to be handled: Table 54-3 lists items to be handled by the equipment. The number of items in Table 54-3 refers to the total number of items to be monitored or controlled at the East and West Electric Rooms.

**Table 54-3: Items to Be Handled by Monitoring Control Equipment (East and West Electric Rooms)**

Item	Type	No. (maximum No.)	Interface
Emergency facilities	Monitoring	—	(*) Transmission (TCP/IP), contents of VMS display
Fire extinguishing facilities	Monitoring	128	Contact
	Monitoring	BCD3 digits	Contact
Power receiving / transforming facilities	Monitoring	128	Contact
Lighting facilities	Monitoring	64	Contact
Ventilation facilities	Monitoring	128	Contact
Emergency telephone facilities	Monitoring	32	Contact
VHF radio auxiliary equipment	Monitoring	8	Contact, monitoring information from base station
FM radio rebroadcasting system	Monitoring	—	(**) Transmission (TCP/IP),
CCTV camera equipment	Monitoring	—	(***) Transmission (TCP/IP),
Other facilities	Monitoring	32	Contact
Power receiving / transforming facilities	Measuring	8	DC4-20mA
Ventilation facilities	Measuring	6	DC4-20mA
Emergency facilities	Control	—	(*) Transmission (TCP/IP), control of VMS
Fire extinguishing facilities	Control	16	Contact
Power receiving / transforming facilities	Control	64	Contact
Lighting facilities	Control	32	Contact
Ventilation facilities	Control	32	Contact

VMS: Variable Message Signboard

(\*) Communications with the emergency facilities shall be made through the integrated management server and network connection, rather than via PLC.

(\*\*) Communications interfaced with the FM radio rebroadcasting system shall be made through the integrated management server and network connection, rather than via PLC.

(\*\*\*) Communications interfaced with CCTV camera equipment shall be made through the integrated management

server and network connection, rather than via PLC.

- Interface specifications
  - ✧ Communication processing unit  
Interface: IEEE802.3 10BASE-T/100BASE-TX compatible
  - ✧ Monitoring input unit  
Interface: Continuous non-voltage, normal open  
Input specifications: DC24V 4mA
  - ✧ Measurement input unit  
Interface: Analog signal  
Input specifications: DC0 to 1mA, 4 to 20mA
  - ✧ Control output unit (for fire extinguishing and ventilation facilities)  
Interface: Instantaneous non-voltage, normal open (1sec or longer/pulse)  
Output specifications: DC24V 1A
  - ✧ Control output unit (for power receiving / transforming, and lighting facilities)  
Interface: Pulse control (approx. 1 sec)  
Output specifications: DC100V 0.2A or lower
- Power unit: AC100V, 50Hz/60Hz
- Functional specifications (software)
  - ✧ Communication processing (Integrated management server): The equipment shall process reception and transmission of monitoring and control information through network connection with the higher rank station (integrated management server).
  - ✧ Transmission of state-change signal: The equipment shall transmit only a state-change signal when the state of monitoring information changes.
  - ✧ Fixed-cycle transmission: The equipment shall transmit measurement information at a fixed-cycle to the higher rank station.
  - ✧ On-demand transmission: The equipment shall transmit individual control, monitoring and measurement information, and information about the state of slave stations to the higher rank station only on demand.
  - ✧ Information storage: The equipment shall store history of certain states and fault signals, and transmit the data on demand from the

higher rank station.

- ✧ Time adding function: The equipment shall add the time of monitoring and measuring at the internal clock of slave stations, and transmit the time with monitoring and measuring signals.
- ✧ Time synchronization: The equipment shall synchronize the clock of slave stations by calibration signals from the higher rank station.
- ✧ Health check: The equipment shall periodically send diagnostic information of the network from slave to the higher rank station to check the soundness of the network.
- ✓ Media converter: Media converter shall convert signals in LAN cables (copper wire) to signals for optical fiber cables (SM).
  - LAN interface: 10/100BASE-TX interface x 1 port
  - Optical interface: 100BASE-FX interface x 1 port
  - Interface: SC connector
  - Transmission distance: within 5km
- ✓ Server rack
  - Structure: Indoor rack  
Stand-alone, steel
  - External dimensions:  
Width: 600mm  
Height: 2000mm  
Depth: 600mm  
(except protruding parts)

(iii) Junction terminal equipment #A

- ✓ Terminal block:  
No. of terminals: 1000 or more

- ✓ Cabinet
  - Structure: Indoor rack  
Stand-alone, steel
  - External dimensions: Width: 600mm  
Height: 2000mm  
Depth: 600mm  
(except protruding parts)

(iv) Facility management transmission equipment #2

✓ Terminal unit:

No. of terminals: More than the number of items to be handled with contact converter

✓ Media converter

Media converter shall convert signals in LAN cables (copper wire) to signals for optical fiber cables (SM).

- LAN interface: 10/100BASE-TX interface x 1 port
  - Optical interface: 100BASE-FX interface x 1 port
- Interface: SC connector
- Transmission distance: within 5km

✓ PLC2

Contact converter shall convert the protocol of monitoring and control signals at the West Electrical Room for transmission on LAN cables.

- Items to be handled: Table 54-4 lists items to be handled by the equipment. The number of items in Table 54-4 refers to the number of items to be monitored or controlled at the East Electric Room.

**Table 54-4: Items to Be Handled by Monitoring Control Equipment (West Electric Room)**

Item	Type	No. of items (maximum No.)	Interface
Emergency facilities	Monitoring	0	
Fire extinguishing facilities	Monitoring	0	
Power receiving / transforming facilities	Monitoring	64	Contact
Lighting facilities	Monitoring	32	Contact
Ventilation facilities	Monitoring	0	
Emergency telephone facilities	Monitoring	0	
Other facilities	Monitoring	16	Contact
Power receiving / transforming facilities	Measuring	4	DC4-20mA
Ventilation facilities	Measuring	0	
Emergency facilities	Control	0	
Fire extinguishing facilities	Control	0	
Power receiving / transforming facilities	Control	32	Contact
Lighting facilities	Control	32	Contact
Ventilation facilities	Control	0	

- Interface specifications

- ✧ Communication processing unit:

Interface: IEEE802.3 10BASE-T/100BASE-TX compatible

- ✧ Monitoring input unit:

Interface: Continuous non-voltage, normal open

Input specifications: DC24V 4mA

✧ Measurement input unit:

Interface: Analog signal

Input specifications: DC0 to 1mA, 4 to 20mA

✧ Control output unit (for power receiving / transforming facilities):

Interface: Pulse control (approx. 1 sec)

Output specifications: DC100V 0.2A or below

- Power unit: AC100V 50Hz/60Hz

- Functional specifications (software):

- ✧ Communication processing (PLC):

- The equipment shall process reception and transmission of monitoring and control information through network connection with the higher rank station (PLC).

- ✧ Transmission of state-change signal:

- The equipment shall transmit only a state-change signal when the state of monitoring information changes.

- ✧ Fixed-cycle transmission:

- The equipment shall transmit measurement information at a fixed-cycle to the higher rank station.

- ✧ On-demand transmission:

- The equipment shall transmit individual control, monitoring and measurement information, and information about the state of slave stations to the higher rank station only on demand.

- ✧ Information storage:

- The equipment shall store history of certain states and fault signals, and transmit the data regularly or on demand from the higher rank station.

- ✧ Time adding function:

- The equipment shall add the time of monitoring and measuring at the internal clock of slave stations, and transmit the time with monitoring and measuring signals.

- ✧ Time synchronization:

- The equipment shall synchronize the clock of slave stations by calibration signals from the higher rank station.

- ✧ Health check:



The equipment shall periodically send diagnostic information of the network from slave to the higher rank station to check the soundness of the network.

- Optical terminal unit: The unit shall store optical fiber cables with at least eight cores (including backup cables).
  - ✧ No. of fusion splices: 8 or more cores
  - ✧ Connector: SC connector
  - ✧ No. of adapters: 8 or more
- Server rack
  - ✧ Structure: Indoor rack; Stand-alone, steel
  - ✧ External dimensions: Width: 600mm  
Height: 2000mm  
Depth: 600mm  
(except protruding parts)

(v) Large screen display

Large screen display shall be controlled by the multi-vision controller, and provide video images and information to the Tunnel Management Office.

- ✓ Liquid crystal display
  - Structure: 4 screens (2 x 2), which can be viewed as a single large monitor.
  - Resolutions: 1366×768 dots or higher/screen
  - Screen size: 55-inch or equivalent/screen
  - Display color: 16,770,000 colors or more
  - Video input: HDMI (HDCP)
  - Quantity: 4 units
- ✓ Display mount
  - Overall dimensions: approx. W2700×H2350×D800mm
  - Rack unit:
    - ✧ EIA 19-inch rack or equivalent
    - ✧ The rack shall have space to place devices underneath the display mount unit. The space shall have a door.
  - The rack shall have a capacity for the multi-vision controller and layer 2 Ethernet switch.
  - Others

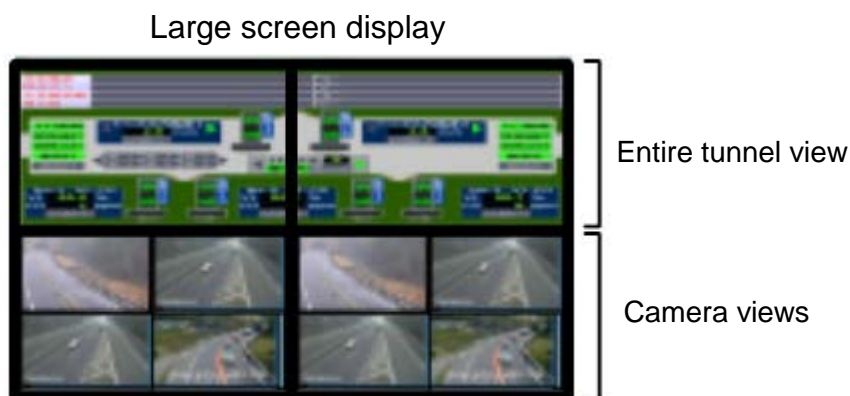
- ✧ Display mount shall include metal fittings, decorative panels, and channel base.
- ✧ Display mount shall have decorative panels so that cables are unnecessarily visible from outside.

(vi) Multi-vision controller

Multi-vision controller shall display all the camera views and screens (screens to monitor and control the state of the tunnel) generated on the integrated management server on the large screen display.

The controller can flexibly display images on the large screen display or selective component screens (location, the number of images displayed, image size, etc.).

- ✓ Specifications and functions
  - The controller shall collectively manage camera views and web contents for tunnel monitoring, and display them on the large screen display.
  - The controller shall have an IP decoder to directly capture IP image data of camera views and display them on the large screen display.
  - Display patterns shall be registered in advance.
  - Display modes can be changed when necessary. (automatic patrolling, manual changeover)
- ✓ Example screen layouts



- ✓ Device specifications (display control unit)
  - CPU: Approx. 3.50GHz x 1 or more
  - Main memory: 16GB or more
  - Embedded storage: SSD 250GB or higher x 1
  - Optical drive: DVD-ROM
  - LAN interface: 10/100/1000BASE-T x 2 or more

- Local console output: RGB, DVI or equivalent x 1 or more
  - OS: Linux, Windows or equivalent
  - Structure: Rack-mounted or stationary
  - No. of images displayed: 17 or more
  - Input connector: LAN or HDMI
  - Maximum input resolution: 1920 x 1080 or more
  - No. of monitor outputs: 4 or more
  - Output connector: DVI-D or HDMI, display port
  - Maximum output resolution: 1920 x 1080 or more
  - Others: Various display control software embedded, Sequential display, seamless display with multiple monitors
- ✓ Device specifications (LAN-DEC unit)
- Structure: Rack-mounted, or a slot-mounted display control unit
  - Input IP stream: H.264 (same as streaming method for encoder for camera)
  - No. of images displayed: 17 or more
  - Connector: DVI-D or HDMI, display port
  - Others Capable of system expansion in response to the number of cameras for input of video images

(vii) Layer 2 Ethernet switch

- ✓ Structure: Rack-mounted
- ✓ Backplane capacity: 100Gbps or more
- ✓ No. of interfaces: 10/100/1000BASE-T interface x 24 ports or more
- ✓ Compatible standards:
  - 10BASE-T: IEEE802.3
  - 100BASE-TX: IEEE802.3u
  - 1000BASE-T: IEEE802.3ab
- ✓ Packet transfer capacity: Maximum 70Mpps or higher
- ✓ Priority control

The switch is capable of priority control of traffics in accordance with COS, IP precedence and DSCP value of IEEE802.1p.

- ✓ VLAN: The switch can support 1000 or more functions.

The switch can support VLAN for each port.

It can also configure tag VLAN (IEEE802.1Q).

- ✓ Fault bypass: The switch can support independent spanning tree protocol for each VLAN (including tag VLAN).
- Multicast: The switch shall transmit multicast packets only to relevant ports. (Function equivalent to IGMP snooping)
- ✓ Management protocol: SNMP (v1, v2, v3)
- ✓ Power: AC100V 50Hz/60Hz
- ✓ Maximum power consumption: approx. 38W

(viii) Operation terminal (disaster prevention system / facility system / transportation system)

Operators shall use web browsers to access the integrated management server, and monitor and control tunnel facilities on the web screens provided.

Operation terminals for disaster prevention, facility and transportation systems shall all have the common functions, and operators shall select screens to display.

- ✓ Function: Browsing screens to monitor and control the state of the tunnel
- ✓ Controlling tunnel facilities
- ✓ OS: Windows (64bit) or equivalent
- ✓ Operating environment: 24-hour continuous operation
- ✓ Display language: English
- ✓ Quantity: 1 unit

(ix) Desk (OA desk)

- ✓ Type: General-purpose product (OA desk)
- ✓ External dimensions: approx. W1200mm×H700mm×D1150mm  
(except protruding parts)
- ✓ Color: To be instructed
- ✓ Others: Device rack inclusive
- ✓ Quantity: 1 unit

**(4) FM Radio Rebroadcasting System (Including Loudspeaker Equipment)**

**(a) Application**

This section shall apply to components, etc. of the FM radio rebroadcasting system and loudspeaker equipment to be installed in the Project (hereinafter referred to as the “Equipment”).

**(b) System Overview**

The system overview of the Equipment shall be as follows.

(i) FM Radio Rebroadcasting System

- ✓ The Equipment shall receive and amplify radio broadcast signals, and rebroadcast signals through guide wires in the tunnel in normal circumstances. In emergency, it shall provide interruptive broadcast to all the channels through the memory playback unit of the Equipment or microphone.
- ✓ FM radio rebroadcasting system shall follow the AF-relay method (audio relay).
- ✓ Leaky coaxial cables (LCX) shall be applied to FM radio facilities inside the tunnel. LCX shall also be used for VHF radio for road administrator and other purposes.

(ii) Loudspeaker equipment

- ✓ Loudspeaker equipment shall provide interruptive announcement from the FM radio broadcasting equipment to the entrance and midsection of the tunnel. It shall have a function of monitoring and testing amplified broadcasting.

(c) **Service Space**

- (i) FM radio rebroadcasting system and loudspeaker equipment: FM receiving antenna, speaker unit and microphone box shall be designed for outdoor use, and others for indoor use.
- (ii) VHF radio auxiliary equipment: Connection terminal box, and duplexer and terminator shall be designed for outdoor use, and duplexer for indoor use.

(d) **Ambient Conditions**

- ✓ Temperature:
  - outdoor and inside the tunnel, -15°C to 50°C
  - Indoor, 0°C to 40°C
  - However, 10°C to 35°C for general information devices
- ✓ Humidity: relative humidity of 85%RH or below
  - However, 20 to 80%RH (non-condensing humidity) for general information devices
- ✓ Wind speed: Maximum instantaneous wind speed: 60m/s (for outdoor devices only)

(e) **Structures**

Individual server equipment and racks shall have the following structures.

- ✓ The Equipment shall be made of durable and rust preventive steel.

- ✓ Stand-alone devices shall be earthquake-resistant to prevent accidents due to horizontal displacement, falling or drop of any parts.
- ✓ Devices shall be mounted on steel racks, which shall be fixed directly and horizontally on concrete floors.
- ✓ Devices to be placed on the free access floor shall be fixed with bolts on special racks, which shall be placed in a hole created in the floor. Special racks shall have a structure, in which bolts used to fix the devices on the concrete floor are visible.

**(f) Components of the Equipment**

The Equipment shall consist of the components and devices in Table 54-5 and Table 54-6.

**Table 54-5: Components of FM Radio Rebroadcasting System**

Item	Requirements	Unit	Q'ty
FM receiving antenna	Yagi-antenna/3EL	unit	8
FM radio broadcasting equipment			
FM receiver unit		CH	8
FM broadcast switching unit		unit	2
FM transmitter unit	3W	CH	8
FM output mixer unit	8ch	unit	1
Fixed attenuator		unit	1
Operation control unit (IP)		unit	1
Voice conversion unit	VoIP (1ch)	unit	1
Layer 2 Ethernet switch	8 or more ports	unit	1
Voice level adjustment unit		unit	1
Voice memory unit		unit	1
Power supply unit		unit	1
Terminal unit		unit	1
Cabinet	W570×H2350×D600	unit	1
FM radio rebroadcasting system operation console			
PC (keyboard/mouse)		set	1
Software		set	1
Display unit		unit	1
Microphone unit		unit	1
Speaker unit		unit	1
Audio amplification unit		unit	1
Voice transmitter unit	VoIP (1ch)	unit	1
Layer 2 Ethernet switch	8 or more ports	unit	1
Desk (OA desk)	Including terminal unit	unit	1
Spare parts / accessories		set	1
Guide sign board		board	2

**Table 54-6: Components of Loudspeaker Equipment**

Item	Requirements	Unit	Q'ty
Loudspeaker equipment			
Pre-amplifier unit		unit	3

Item	Requirements	Unit	Q'ty
Power amplifier unit #1	for emergency parking zone (120W)	unit	1
Power amplifier unit #2	for evacuation connection tunnel (60W)	unit	1
Power amplifier unit #3	for tunnel entrance (60W)	unit	1
Monitor panel unit		unit	1
Power supply unit		unit	1
Terminal unit		unit	1
Cabinet	W570×H2350×D600	unit	1
Loudspeaker for tunnel entrance	25W	unit	2
Loudspeaker for emergency parking zone	15W	unit	6
Loudspeaker for evacuation connection tunnel	5W	unit	7
Microphone box		unit	8

**(g) Specifications of Components (FM Radio Rebroadcasting System)**

Components of the Equipment shall conform with the following specifications:

(i) FM receiving antenna

- ✓ Structures, etc.

FM receiving antenna shall have the following specifications:

- Type: Yagi three-element antenna
- Structure: support-mounted, waterproof
- Connection: N connector
- Survival wind speed: Maximum instantaneous wind speed: 60m/s (when mounted to support)

✓ Electrical specifications

- Received frequency:
  - CH1, 91.2MHz
  - CH2, 95.6MHz
  - CH3, 96.1MHz
  - CH4, 99.4MHz
  - CH5, 104.2MHz
  - CH6, 105.4MHz
  - CH7, 106.3MHz
  - CH8, 106.7MHz
- Directional characteristics: unidirectional
- Gain: 5.5dBi or higher

- Characteristic impedance: 50Ω, unbalanced
- (ii) (FM radio broadcasting equipment
  - ✓ FM receiver unit
    - Received frequency:
      - CH1, 91.2MHz
      - CH2, 95.6MHz
      - CH3, 96.1MHz
      - CH4, 99.4MHz
      - CH5, 104.2MHz
      - CH6, 105.4MHz
      - CH7, 106.3MHz
      - CH8, 106.7MHz
    - Input impedance: 50Ω
    - Input level: 40 to 90dBμV (standard level: 60dBμV)
    - Output impedance: 600Ω, balanced
    - Output level: 0dBm
    - No. of channels: 8 channels
  - ✓ FM broadcast switching unit
    - Input frequency: 10.7MHz
    - Input/output impedance: 600Ω, balanced
    - Input level: to be matched with FM receiver unit
    - Output level: to be matched with FM transmitter unit
    - No. of switchable inputs: 7 inputs
    - No. of switchable outputs: 10 outputs
  - ✓ FM transmitter unit
    - Transmit frequency:
      - CH1, 91.2MHz
      - CH2, 95.6MHz
      - CH3, 96.1MHz
      - CH4, 99.4MHz
      - CH5, 104.2MHz
      - CH6, 105.4MHz
      - CH7, 106.3MHz



CH8, 106.7MHz

- Input impedance: 600Ω, balanced
- Input level: 0dBm
- Output impedance: 50Ω, unbalanced
- Transmission output: Rated 3W/ch
- Spurious: at least -40db below the fundamental emission
- Transmit frequency deviation: within  $\pm 1 \times 10^{-5}$
- Alarm display: output abnormality and power abnormality
- Monitor: Transmit output display
- No. of channels: 8 channels
- Modulated input frequency band: 200Hz to 7.5kHz
- Maximum frequency deviation:  $\pm 75$ kHz (100% deviation)
- Pre-emphasis: 50μs or 75μs
- Distortion factor: 1.5% or below (1kHz, 100% deviation)

✓ FM output mixer unit

- Input frequency: object frequency within the range in 87.5MHz and 108MHz
- Input/output impedance: 50Ω, unbalanced
- Passing power: Rated 3W/ch
- Passing loss: 10dB/ch or below
- Mixed frequency: 8 waves

✓ Fixed attenuator

- Attenuation: Selectable from 3dB, 6dB, and 9dB

✓ Operation control unit (IP)

Operation control unit shall control interruptive broadcast from the FM radio rebroadcasting system operation console at the Control Office, and have various monitoring functions.

- The unit shall rebroadcast radio broadcast in normal circumstances, and provide the following interruptive broadcast in emergency.

✧ Interruption of radio broadcasting

- Priority order of interruptive broadcast control:

Priority 1: Microphone box

Priority 2: Microphone unit on cabinet rack

Priority 3: FM radio rebroadcasting system operation console

- Monitoring display function
  - ✧ The unit shall monitor audio outputs of transmitter units.
  - ✧ The unit shall, through audio output indicator, monitor meters corresponding to a monitor selected.
  - ✧ The unit shall display whereabouts of defects in case of abnormality with transmit outputs or any device including breakage of guide wires.
- Display language: English
- Conditions of interface with the FM radio rebroadcasting system
  - ✧ Items to be delivered shall be according to Table 54-7.

**Table 54-7: Items Monitored/Controlled by FM Radio Rebroadcasting System**

No.	Items monitored/controlled	Control	Monitoring
1	Radio broadcasting, interruptive	○	○
2	Radio broadcasting, interruptive (backup)	○	○
3	Broadcasting from loudspeaker for emergency parking zone	○	○
4	Broadcasting from loudspeaker for emergency parking zone (backup)	○	○
5	Broadcasting from loudspeaker for tunnel entrance	○	○
6	Broadcasting from loudspeaker for tunnel entrance (backup)	○	○
7	Broadcasting from loudspeaker for evacuation connection tunnel	○	○
8	Broadcasting from loudspeaker for evacuation connection tunnel (backup)	○	○
9	Monitor changeover	○	○
10	Monitor changeover (backup)	○	○
11	Monitoring FM CH1	○	○
12	Monitoring FM CH2	○	○
13	Monitoring FM CH3	○	○
14	Monitoring FM CH4	○	○
15	Monitoring FM CH5	○	○
16	Monitoring FM CH6	○	○
17	Monitoring FM CH7	○	○
18	Monitoring FM CH8	○	○
19	Monitoring loudspeaker for emergency parking zone	○	○
20	Monitoring loudspeaker for tunnel entrance	○	○
21	Monitoring loudspeaker for evacuation connection tunnel	○	○
22	Microphone unit on cabinet rack in use		○
23	Microphone box in use		○
24	Radio, output abnormality		○
25	Radio, output abnormality (backup)		○
26	Radio, power abnormality		○
27	Radio, power abnormality (backup)		○
28	Loudspeaker, output abnormality		○

No.	Items monitored/controlled	Control	Monitoring
29	Loudspeaker, output abnormality (backup)		○
30	Loudspeaker, power abnormality		○
31	Loudspeaker, power abnormality (backup)		○

✓ Voice conversion unit

Voice conversion unit shall convert voice-band signals to digital data, and transmit it to LAN. Conversely, it shall also convert voice data received from LAN to voice-band signals.

- Usage: Voice interruption and signal monitoring
- Line interface: 4-line
  - ✧ Interface: 10BASE-T/100BASE-TX (auto-negotiation)
  - ✧ Physical specification: RJ-45
- Frequency band:  $\pm 3\text{dB}$  in the range of 200Hz and 22kHz (standard of 1kHz)
- Voice input unit:
  - ✧ No. of inputs: 2 channels/unit
  - ✧ Input impedance:  $600\Omega$
  - ✧ Input level: -10dBm (rated)
- Voice output unit:
  - ✧ No. of outputs: 2 channels/unit
  - ✧ Output impedance:  $600\Omega$
  - ✧ Output level: -10dBm (rated)

✓ Layer 2 Ethernet switch

- Compliance standards: IEEE802.3 (10BASE-T)
- IEEE802.3u (100BASE-TX)
- Interface for devices:
- Interface: 10/100BASE-TX
- Cable: UTP cable (Category 5 or higher)
- Connector: RJ-45
- Port: 8 or more ports

✓ Voice level adjustment unit

Voice level adjustment unit shall have a function of fine-tuning the voice level.

- Line input: -10dBm to 0dBm (standard of 1kHz)

- Signal/noise ratio: 50dB or higher
- Distortion factor: 3% or below (1kHz)

✓ Voice memory unit

Voice memory unit shall play interruptive broadcast and voice from loudspeaker. It shall also play voice recorded in a digital storage medium.

- Playback frequency band:  $\pm 3\text{dB}$  in the range of 200Hz and 22kHz (standard of 1kHz)
- Output level: -10dBm (rated)
- Playback time: 30 secs/set of sentences
- Broadcasting announcement: 8 sets of sentences

✓ Power supply unit

- Single-phase AC two-line: AC100V $\pm 10\%$ , 50Hz/60Hz
- Power consumption: 1600VA or below

✓ Terminal unit

Terminal unit shall connect various units. It shall also have connection terminals with external devices.

✓ Cabinet

- Structure: Indoor rack  
Stand-alone, steel
- External dimensions: Width: 570mm  
Height: 2350mm  
Depth: 600mm  
(except protruding parts)

(iii) FM radio rebroadcasting system operation console

FM radio rebroadcasting system operation console shall provide interruptive broadcast to the tunnel when radio rebroadcasting is in service. It shall also display the operational status of broadcasting equipment. Emergency broadcasting command console shall provide interruptive broadcast to radio rebroadcasting. The basic functions are as follows.

The operation console shall be equipped with the functions of a server, if necessary.

- ✓ PC (keyboard/mouse), software, display unit, microphone unit, and speaker unit
- Functions and electrical characteristics
  - ✧ CPU: operating frequency of 1.6GHz or more

- ✧ Main memory: 2GB or more
- ✧ Hard disk: 320GB or more
- ✧ Network: IEEE802.3 10/100BASE-TX compatible
- ✧ Sound: Line input, line output, microphone input
- ✧ Display: 17-inch LCD or equivalent
- ✧ Input device: Keyboard
- ✧ Pointing device: Two-button mouse or equivalent
- ✧ Microphone: Upright microphone
- ✧ Speaker: Stereo speaker for PC (with volume)
- ✧ Power: AC100V 50Hz/60Hz
- ✧ OS: Windows OS
- Display and operations
  - ✧ Selection and display of broadcasting site  
Select Name: Nagdhunga Tunnel
  - ✧ Changeover of sound source  
Microphone  
Fixed phrases in the voice memory unit
  - ✧ Changeover and display of broadcasting monitor  
Display unit shall enable to monitor radio broadcast. It shall enable to monitor and display screens and channels selected.
  - ✧ Items monitored and displayed  
Items to be monitored and displayed shall be according to Table 54-7: “Items Monitored/Controlled by FM Radio Rebroadcasting System”.  
The console shall give alarm (buzzer, etc.) when any of the following abnormalities is displayed.
    - Radio, output abnormality
    - Radio, power abnormality
    - Loudspeaker, output abnormality
    - Loudspeaker, power abnormality
  - ✧ History  
The operation console shall store and display history of signal

information about interlocking broadcasts provided.

The history screen shall consist of a facility history screen displaying items monitored by the broadcasting equipment, and a broadcast history screen displaying phrases and announcements made in the past.

✧ Display language: English

- Communication processing for integrated management server:

The operation console shall communicate with the integrated management server to transmit and receive the following signals.

✧ Communication protocol: TCP/IP

✧ Target tunnel: Nagdhunga Tunnel

✧ Receiving information: Emergency information in the tunnel

✧ Transmitting information: Information about defects of FM radio rebroadcasting system

- Interlocking broadcast processing

The operation console shall automatically or semi-automatically process interlocking broadcast when receiving emergency information.

✧ Automatic mode: The operation console shall automatically play interruptive broadcast to the tunnel in response to emergency signals.

✧ Semi-automatic mode: When receiving emergency information, the operation console shall enable operators to play interruptive broadcast after taking confirmation procedures.

✓ Audio amplification unit

Audio amplification unit shall compensate for audio signal characteristics transmitted from the FM radio rebroadcasting system operation console, and transmit monitor audio signals.

- Microphone input: 1 system (600Ω, unbalanced)
- Line input: -20dBm to 0dBm (standard of 1kHz)
- Line output: 0dBm
- Speaker output: 1 system
- Monitor: Audio line level display

✓ Voice conversion unit

Voice conversion unit shall convert voice-band signals to digital data, and

transmit it to LAN. Conversely, it shall also convert voice data received from LAN to voice-band signals.

- Usage: Voice interruption and signal monitoring
- Line interface: 4-line
- Interface: 10BASE-T/100BASE-TX (auto-negotiation)
- Physical specification: RJ-45
- Frequency band:  $\pm 3\text{dB}$  in the range of 200Hz and 22kHz (standard of 1kHz)
- Voice input unit:
  - ✧ No. of inputs: 2 channels/unit
  - ✧ Input impedance:  $600\Omega$
  - ✧ Input level: -10dBm (rated)
- Voice output unit:
  - ✧ No. of outputs: 2 channels/unit
  - ✧ Output impedance:  $600\Omega$
  - ✧ Output level: -10dBm (rated)

✓ 4) Layer 2 Ethernet switch

- Compliance standards:
  - ✧ IEEE802.3 (10BASE-T)
  - ✧ IEEE802.3u (100BASE-TX)
- Interface for devices:
  - ✧ Interface: 10/100BASE-TX
  - ✧ Cable: UTP cable (Category 5 or higher)
  - ✧ Connector: RJ-45
  - ✧ Port: 8 or more ports

✓ Desk (OA desk)

- Type: General-purpose product (OA desk)
- External dimensions: approx. W1200mm×H700mm×D1150mm; (except protruding parts)
- Color: To be instructed
- Others: Device rack inclusive

(iv) Spare parts and accessories

The following spare parts and accessories shall be supplied:

- ✓ Lamp and fuse: 100% of items currently used
- ✓ Relay: One each of the types used
- ✓ Test cable: One each of the types used

The following documents shall be attached to the System:

- ✓ Test report: 1 copy
- ✓ User's manual: 1 copy

(v) Guide sign board

Guide sign boards shall be placed on the walls of both sides of the tunnel entrance to inform that radio rebroadcasting service is in progress inside the tunnel. Other specifications shall be according to design drawings.

- ✓ Guide display method: Reflective
- ✓ Material: Aluminum alloy
- ✓ Display surface: Reflective sheet of capsule-lens type
- ✓ Contents: Guide on "FM Radio"
- ✓ Size: See the drawing
- ✓ Quantity: 2 boards

**(h) Specifications of Components (Loudspeaker Equipment)**

Components of loudspeaker equipment shall conform with the following specifications:

(i) Loudspeaker equipment

- ✓ Pre-amplifier unit
  - Voice input: -10 to 0dBm, 600Ω, balanced
  - Voice output: 0dBm, 600Ω, balanced
  - Frequency characteristics: 60 to 7,000Hz, within  $\pm 3$ dB
  - Signal/noise ratio: 60dB or higher
  - Distortion factor: 3% or below (1kHz)
  - Parametric equalizer:
    - ✧ Correction frequency range: 3 frequencies to be selected from the 1/3 octave band width in the range between 20 and 20,000Hz
    - ✧ Correction level:  $\pm 12$ dB
- ✓ Power amplifier unit #1 (for emergency parking zone)
  - Voice input: 0dBm, 600Ω / high impedance switchable, balanced



- Voice output: 120W
- Load impedance: 100V, load line
- Frequency characteristics: 50 to 7,000Hz, within  $\pm 3$ dB
- Signal/noise ratio: 65dB or higher
- Distortion factor: 3% or below (1kHz)
- ✓ Power amplifier unit #2 (for evacuation connection tunnel)
  - Voice input: 0dBm, 600 $\Omega$  / high impedance switchable, balanced
  - Voice output: 60W
  - Load impedance: 100V, load line
  - Frequency characteristics: 50 to 7,000Hz, within  $\pm 3$ dB
  - Signal/noise ratio: 65dB or higher
  - Distortion factor: 3% or below (1kHz)
- ✓ Power amplifier unit #3 (for tunnel entrance)
  - Voice input: 0dBm, 600 $\Omega$  / high impedance switchable, balanced
  - Voice output: 60W
  - Load impedance: 100V, load line
  - Frequency characteristics: 50 to 7,000Hz, within  $\pm 3$ dB
  - Signal/noise ratio: 65dB or higher
  - Distortion factor: 3% or below (1kHz)
- ✓ Monitor panel unit
  - Monitor panel: capable of monitoring each speaker line system, up to 6 systems
  - Speaker: 0.5W (rated)
- ✓ Power supply unit
  - Single-phase AC two-line: AC100V $\pm 10\%$ , 50Hz/60Hz
  - Power consumption: 2000VA or below

✓ Terminal unit

Terminal unit shall connect various units. It shall also have connection terminals with external devices.

✓ Cabinet

- Structure: Indoor rack  
Stand-alone, steel

- External dimensions:  
Width: 570mm  
Height: 2350mm  
Depth: 600mm  
(except protruding parts)

(ii) Loudspeaker for tunnel entrance

- ✓ Type: Horn speaker
- ✓ Playback frequency band: 400Hz to 5,000Hz (at least 20db below output sound pressure level)
- ✓ Rated input: 25W
- ✓ Sound pressure level: 110dB or higher (at 1W/1m)
- ✓ Rated impedance: 400Ω

(iii) Loudspeaker for emergency parking zone

- ✓ Type: Horn speaker
- ✓ Playback frequency band: 400Hz to 5,000Hz (at least 20db below output sound pressure level)
- ✓ Rated input: 15W
- ✓ Sound pressure level: 106dB or higher (at 1W/1m)
- ✓ Rated impedance: 670Ω

(iv) Loudspeaker for evacuation connection tunnel

- ✓ Type: Horn speaker
- ✓ Playback frequency band: 400Hz to 5,000Hz (at least 20db below output sound pressure level)
- ✓ Rated input: 5W
- ✓ Sound pressure level: 104dB or higher (at 1W/1m)
- ✓ Rated impedance: 2000Ω

(v) Microphone box

Microphone box shall be installed inside the tunnel, and have a function of simultaneously delivering announcement from the embedded microphone to all the broadcasting systems.

- ✓ Overview

Microphone box shall be steel-made, electrically and mechanically durable, and dust- and rainproof. It shall be mountable to the tunnel entrance and emergency parking zone.

- ✓ External dimensions

The standard dimensions are as follows:

- External dimensions:  
Width: 250mm  
Height: 250mm  
Depth: 150mm  
(except protruding parts)
- ✓ Painting color: Munsell N5, gloss
- ✓ Electrical specifications:
  - Power system: Supply voltage + 24V  $\pm$ 10% (to be supplied by the loudspeaker equipment)
  - Microphone : Close-talking hand microphone (with press talk switch)
  - Frequency characteristics: 300Hz to 3.4kHz, within  $\pm$ 15dB
  - Output level: 0dBm, 600 $\Omega$ , balanced
  - Load current: 65mA or below
  - Others: Microphone box shall have indicators showing that signals from the microphone are being transmitted, and that the microphone is in use.

**(5) VHF Radio Auxiliary Equipment (Including VHF Radio For Road Administrator)**

**(a) Application**

This section shall apply to components, etc. of the VHF radio auxiliary equipment to be installed in the Nagdhunga Tunnel (hereinafter referred to as the “Equipment”).

**(b) System Overview**

The system overview of the Equipment shall be as follows.

- (i) VHF radio for road administrator
  - ✓ VHF Radio for road administrator shall consist of base station, mobile station (portable radio), and operating console.
- (ii) VHF radio auxiliary equipment
  - ✓ VHF radio auxiliary equipment shall be used for communications in and outside the road tunnel to secure smooth maintenance and administrative duties in normal circumstances, and emergency transmission of various information in emergency.
  - ✓ VHF radio for administrator: The Equipment shall use leaky coaxial cables (LCX), which shall be also for FM radio facilities, to enable

radio communications between the fixed radio in the Electric Room (bandwidth of 150MHz) and VHF radios for administrators inside the Nagdhunga Tunnel and both entrances.

- ✓ Firefighting radio: The Equipment shall use leaky coaxial cables (LCX) to communicate with firefighting radio (bandwidth of 150MHz) in the tunnel, which shall be connected to the connection terminal box installed at the entrance.
- ✓ Police radio: The Equipment shall use leaky coaxial cables (LCX) to communicate with police radio (bandwidth of 150MHz) in the tunnel, which shall be connected to the connection terminal box installed at the entrance.

**(c) Service Space**

**(i) VHF Radio for road administrator**

Base station and operating console shall be designed for indoor use, and mobile station (portable radio) for outdoor use.

**(ii) VHF radio auxiliary equipment**

Connection terminal box, and duplexer and terminator shall be designed for outdoor use, and duplexer for indoor use.

**(d) Ambient Conditions**

- ✓ Temperature:  
Outdoor and inside the tunnel, -15°C to 50°C  
Indoor, 0°C to 40°C  
However, 10°C to 35°C for general information devices
- ✓ Humidity:  
relative humidity of 85%RH or below  
However, 20 to 80%RH (non-condensing humidity) for general information equipment
- ✓ Wind speed: Maximum instantaneous wind speed: 60m/s (for outdoor devices only)

**(e) Structures**

Individual server equipment and racks shall have the following structures.

- ✓ The Equipment shall be made of durable and rust preventive steel.
- ✓ Stand-alone devices shall be earthquake-resistant to prevent accidents due to horizontal displacement, falling or drop of any parts.
- ✓ Devices shall be mounted on steel racks, which shall be fixed directly

and horizontally on concrete floors.

- ✓ Devices to be placed on the free access floor shall be fixed with bolts on special racks, which shall be placed in a hole created in the floor. Special racks shall have a structure, in which bolts used to fix the devices on the concrete floor are visible.

**(f) Components of the Equipment**

The Equipment shall consist of the following components and devices.

**Table 54-8: Components of VHF Radio Auxiliary Equipment**

Name	Specifications	Unit	Q'ty
VHF Radio for road administrator		set	1
Operating console		set	1
Base station		set	1
Base station antenna	Yagi three-element antenna	unit	2
Distributor	Two-distributor (1:9)	unit	1
Portable radio		unit	12
Duplexer		unit	1
Duplexer and terminator		unit	1
Connection terminal box (for police radio)		unit	2
Connection terminal box (for firefighting radio)		unit	2
Leaky Coaxial cable	L-LCX-43D-65-HR	m	1500
Leaky Coaxial cable	L-LCX-43D-55-HR	m	1168

**(g) Specifications of Components (VHF Radio for road administrator)**

**(i) System functions**

- ✓ Group talk: The Equipment shall have a group talk function for point-to-multipoint communication, which provides information from a single user to multiple users with portable radios in the same group.
- ✓ Concurrent talk (all group talk): The Equipment shall have a concurrent talk function for broadcast communication, a special type of group talk, which provides information to all radios under the system or mobile stations in a specific area.
- ✓ Direct talk between mobile stations: The Equipment shall have a function to enable multiple mobile stations to communicate directly with each other, rather than via the base station.
- ✓ Voice and data security: The Equipment shall have a scramble function to make digital voice and data unintelligible at unidentified receivers.
- ✓ Text message transmission: The Equipment shall have a function to send fixed-phrase and free-text messages in individual address communications between the command console and mobile stations.

- Fixed-phrase message: up to 12 characters
- Free-text message: up to 50 characters from the console

(ii) Operating console

Operating console shall be used for voice calls and text messages, and have the following functions.

✓ Functions

- Group talk/concurrent talk
- Text message
  - ✧ Fixed-phrase message: up to 12 characters
  - ✧ Free-text message: up to 50 characters from the console
- Monitoring
  - ✧ Operating console shall monitor alarms and status of the base station.

✓ Specifications

- OS: Windows (64bit) or equivalent
- Operating environment: 24-hour continuous operation
- Display language: English
- Sound: Line input, line output, microphone input
- Display: 17-inch LCD or equivalent

(iii) Base station

✓ Functions

- Redundancy: Base station shall have redundant structures. It shall consist of components for use and backup, and have the following redundant units.
  - ✧ Radio units
  - ✧ Power units

When detecting alarm signals, Base station shall automatically switch from the units in use to backup units.

- Stand-alone

Base station shall be operable in the stand-alone mode when detecting network failure.

✓ Specifications

- Radio frequency bandwidth: band of 150MHz
- Frequency: 146 to 162MHz

- Frequency spacing: 6.25kHz
- Antenna power: Range of 1 to 20W
- Modulation: 4FSK modulation type
- Access: SCPC
- Communication: half-duplex with 2 frequencies
- Transmission speed: 4.8kbps
- Voice encoding speed: 3.6kbps (including error-correction code)
- Voice encoding method: AMBE+2 enhanced half-rate
- Frame length: 80ms
- Transmission/reception performance: in compliance with the following “Requirements for transmitter/receiver”
- Power unit: Single-phase AC two-line: AC100V, 50Hz/60Hz

✓ External output

Base station shall output monitoring signals about the state of devices to PLC of the monitoring control equipment.

Interface for PLC shall be non-voltage continuous contact signals.

(iv) Requirements for Transmitter/Receiver

✓ Transmitter

- Allowable deviation from the frequency: Transmitter shall satisfy the following allowable deviations from the specified frequency.

**Table 54-9: Allowable Deviation from Frequency**

(unit: ppm)

150MHz bandwidth	Base station	±2.5
	Mobile station	±2.5

- Allowable spurious or unwanted emission levels: The values shall comply with the following table.

**Table 54-10: Allowable Spurious or Unwanted Emission Levels**

Antenna power	Allowable out-of-band spurious emission level	Allowable spurious-band unwanted emission level
More than 1W but 50W or lower	2.5μW or lower, or 60db lower than the average power at the basic frequency	2.5μW or lower, or 60dB lower than the carrier power at the basic frequency

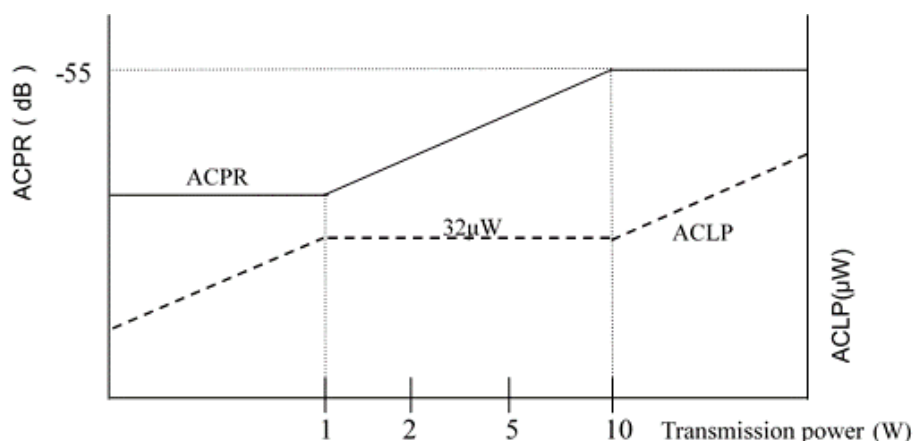
1W or lower	2.5μW or lower	2.5μW or lower
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- Allowable occupied bandwidth: Allowable occupied bandwidth shall be 5.8kHz or lower
- Allowable antenna power deviation: Allowable antenna power deviation shall be 20% above the upper limit and 50% below the lower limit.
- Adjacent channel leakage power:

The amount of power in the band of  $\pm 2\text{kHz}$  from the frequency 6.25kHz away from the designated carrier frequency shall be as follows:

When the transmission output is 1W or below, the ACLP shall be lower than -45db then transmission power. When the output exceeds 1W, the ACLP shall be -55dB or lower or 32μW or lower.

Standard values of the adjacent channel power ratio (ACPR) and adjacent channel leakage power (ACLP) shall be in accordance with the details shown in Figure 54-1:



**Figure 54-1: Standard Values of Adjacent Channel Power Ratio (ACPR) and Adjacent Channel Leakage Power (ACLP)**

- Body radiation: Body radiation shall be 2.5μW or below
- Allowable deviation of transmission speed: Allowable deviation of transmission speed shall be within  $\pm 5.0 \times 10^{-6}$
- Frequency deflection: When a code string of “+3, +3, -3, -3, +3, +3, -3, -3” is repeatedly input as modulated signals, the frequency deflection shall fall under the range of 1083Hz and 1324Hz. The standard frequency deviation for the code string shall be  $\pm 1203\text{Hz}$  ( $4 / \pi \times 945 = \pm 1203\text{Hz}$ , based on the frequency deviation of  $\pm 945\text{Hz}$  corresponding to symbol  $\pm 3$ ), and shall not be deviated by  $\pm 10\%$



from the standard value.

- Modulation accuracy: The modulation accuracy (FSK error) shall be 5% or below. FSK error is defined as the root mean squared (r.m.s) in percentage of the frequency shift at symbol locations.

✓ Receiver

- Frequency variation of local oscillator: Specific regulations shall not be defined for the frequency variation of local oscillator.
- Receiving sensitivity: When signals modulated with two pseudo-noise (PN) codes of bit period of 511 code length are bit transmitted, and the bit error rate (BER) for static and fading channels are  $1 \times 10^{-2}$  and  $3 \times 10^{-2}$ , respectively, the receiving input level shall take the value provided in Table 54-11.

Specific regulations shall not be defined for diversity receiving characteristics.

**Table 54-11: Receiving Sensitivity**

BER	$1 \times 10^{-2}$ (static)	$3 \times 10^{-2}$ (fading)
Receiving input level	0 dBμV (standard sensitivity) or lower	5.0 dBμV or lower (Non-diversity)

Fading condition: Rayleigh fading with the maximum Doppler frequency of 7.5Hz at 150MHz band

- Spurious response: Together with the desired wave with the standard sensitivity of 3dB, when the bit error rate is  $1 \times 10^{-2}$  because of non-modulated interfering wave detuned from the desired wave by 12.5kHz or more, the ratio of the interfering wave and desired wave levels shall be 53dB or higher.
- Adjacent channel selectivity: Together with the desired wave with the standard sensitivity of 3dB, when the bit error rate is  $1 \times 10^{-2}$  because of interfering wave modulated by digital signals detuned by 6.25kHz (two pseudo-noise codes of bit period of 32,767 code length), the ratio of the interfering wave and desired wave levels shall be 42dB or higher.
- Intermodulation characteristic: Together with the desired wave with the standard sensitivity of 3dB, the bit error rate is  $1 \times 10^{-2}$  because of two non-modulated interfering waves detuned from the desired wave by 12.5kHz and 25kHz, respectively, the ratio of the interfering wave and desired wave levels shall be 53dB or higher.
- Strength of secondary radiated emissions: The strength of secondary radiated emissions shall be 4nW or below.
- Body radiation: Body radiation shall be 4nW or below at 1GHz or

below, and 20nW or below at the range between 1 and 3GHz.

(v) Base station antenna

- ✓ Type: Yagi three-element antenna
- ✓ Structure: Pole-mounted, waterproof
- ✓ Connection: N connector
- ✓ Survival wind speed: Maximum instantaneous wind speed: 60m/s  
(when mounted to pole)
- ✓ Frequency: Specific frequency
- ✓ Gain: 8dBi or higher
- ✓ Characteristic impedance: 50Ω, unbalanced

(vi) Distributor

- ✓ Type: 150MHz bandwidth, two-distributor
- ✓ Distribution ratio: 1:9
- ✓ Input/output impedance: 50Ω
- ✓ Input/output connector: N connector

(vii) Portable radio

- ✓ Operational functions
  - Portable radio shall have a function of switching communication channels.
  - Portable radio shall have a function of switching communication modes (concurrent talk, group talk and direct talk between mobile stations).
  - Portable radio shall have a volume adjustment function.
  - Portable radio shall have a function of power cutoff.
  - Portable radio shall have a function of disabling key operations (key lock) to prevent incorrect operations. It shall, however, transmit and receive communications even when locked.
- ✓ Display functions
  - Portable radio shall display the status of direct talks between mobile stations.
  - Portable radio shall display the status of communication modes (concurrent talk, group talk and direct talk between mobile stations).
  - Portable radio shall have an indicator showing that transmission is in progress.
  - Portable radio shall identify the electric field strength of radio

waves received.

- The display unit shall have a backlight.
- Portable radio shall display the status of power on/off.

✓ Maintenance functions

Portable radio shall have the following maintenance functions.

- Measuring transmission output levels
- Transmitting test patterns for measuring BER
- Preventing incorrect use
- Having an earphone jack

✓ Specifications

- Radio frequency bandwidth: band of 150MHz
- Frequency: 146 to 162MHz
- Frequency spacing: 6.25kHz
- Antenna power: Range of 1 to 5W
- Modulation: 4FSK modulation type
- Access: SCPC
- Communication: half-duplex with 2 frequencies or with 1 frequency
- Transmission speed: 4.8kbps
- Voice encoding speed: 3.6kbps (including error-correction code)
- Voice encoding method: AMBE+2 enhanced half-rate
- Frame length: 80ms
- Transmission/reception performance: Same as VHF radio base station
- Dust- and waterproof: JIS C 0920 IP57 or higher
- External dimensions: Approx. W62.5×H97.5×D30mm (except protruding parts) (Excluding battery and antenna)
- Weight: Approx. 120g (excluding battery and antenna)
- Serviceable time: Approx. 8 hours  
(when continuously used of 5% for transmission, 5% of reception and 90% of stand-by)

**(h) Specifications of Components (VHF radio auxiliary equipment)**

Components of the VHF radio auxiliary equipment shall conform with the following specifications:

(i) Duplexer

Duplexer shall be installed in the Electric Room and use leaky coaxial cables (LCX), together with other equipment. The specifications are as follows.

✓ Structures

Cabinet shall conform with the following specifications:

- Type: Stand-alone, steel
- External dimensions:
  - ✧ Width: 570mm
  - ✧ Height: 2350mm
  - ✧ Depth: 600mm
- Painting color: Munsell 5Y7/1, semi-gloss (approx.)

✓ Standards

- Allowable input: 10W/wave
- Frequency bandwidth: band of 80 to 150MHz
- Impedance: 50Ω, unbalanced
- Matching: VSWR 1.5 or below

✓ Duplex frequency

- Frequency for administrator: band of 150MHz
- Frequency for police radio: band of 150MHz
- Frequency for firefighting radio: band of 150MHz
- Frequency for FM: band of 80MHz

✓ Performance

- Insertion loss:
  - ✧ 5dB or below at band of 150MHz
  - ✧ 1.5dB or below at band of 80MHz
- -50dB or below with leakage between terminals or at frequencies of channels for other organizations
- VSWR: 1.5 or below
- Rated power: 10W / channel

(ii) Duplexer and terminator

Duplexer and terminator shall be installed at the entrance of the tunnel to enable different equipment to use leaky coaxial cables (LCX). The specifications are as follows.

✓ Structures

- Type: Stand-alone, steel-made, outdoor use (IP44)
- External dimensions:
  - ✧ Width: 760mm
  - ✧ Height: 940mm
  - ✧ Depth: 580mm
- Processing: Main body:
  - ✧ SUS304
  - ✧ Stand: hot-dip galvanizing
- Painting color: Munsell 10YR2/1, semi-gloss (approx.)
- ✓ Standards
  - Allowable input: 10W
  - Frequency bandwidth: band of 80 to 150MHz
  - Impedance: 50Ω, unbalanced
  - Matching: VSWR 1.2 or below
- ✓ Passing frequency
  - Frequency for police radio: band of 150MHz
  - Frequency for firefighting radio: band of 150MHz
  - Frequency for administrator: band of 150MHz
- ✓ Terminal frequency
  - Frequency for FM: band of 80MHz
- ✓ Performance
  - Insertion loss: 5dB or below at band of 150MHz
  - leakage between terminals: -50dB or below at frequencies of channels for other organizations
  - VSWR: 1.2 or below
  - Rated power: 10W

(iii) Connection terminal box

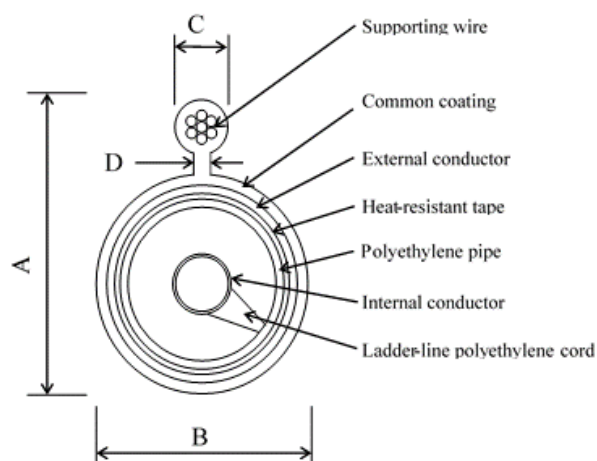
Connection terminal box shall be installed at the entrance of the tunnel, and connected to firefighting and police radios to enable these radios to use leaky coaxial cables (LCX). The specifications are as follows.

- ✓ Structures
  - Type: Stand-alone, steel, outdoor (IP44)
  - External dimensions:
    - ✧ Width: 400mm

- ✧ Height: 1300mm
- ✧ Depth: 430mm
- Processing: Main body:
  - ✧ SUS304
  - ✧ Support unit: hot-dip galvanizing
- Painting color: Munsell 10YR2/1, semi-gloss (approx.)
- ✓ Standards
  - Connector with radio: N connector x 1 unit
  - Accessories:
    - ✧ Terminating register: 50Ω/1W
    - ✧ N connector structure: 1 unit
    - ✧ Coaxial cable: 5D-2V × 10m
    - ✧ Double-ended N-P connector: 1 unit
    - ✧ Conversion connector: N-J/BNC-P x 1 unit

(iv) Leaky coaxial cables (LCX)

- ✓ Structures
  - Internal conductor: material: copper pipe
  - Insulator: Ladder-line polyethylene (spiral winding), polyethylene pipe and heat-resistant tape
  - External conductor: Aluminum longitudinally supporting tape (with leaky slot)  
Horizontally wrapped with plastic tape
  - Common coating: Cables and supporting wires are placed in parallel and coated with heat- and flame resistant black polyethylene
  - Outer diameter:
    - ✧ A: approx. 68mm
    - ✧ B: approx. 51mm
    - ✧ C: approx. 13mm
    - ✧ D: approx. 4mm
  - Others: Heat-resistant



✓ Standards

- Useful frequency:
  - ✧ band of 80MHz, 87 to 107MHz
  - ✧ band of 150MHz, 137 to 170MHz
- Standard attenuation:
  - band of 80MHz:*
    - ✧ L-LCX-43D-65-HR, 8.0 to 9.5dB/km
    - ✧ L-LCX-43D-55-HR, 8.5 to 10dB/km
  - band of 150MHz:*
    - ✧ L-LCX-43D-65-HR, 11dB/km
    - ✧ L-LCX-43D-55-HR, 12dB/km
- Standard coupling loss:
  - band of 80MHz:*
    - ✧ L-LCX-43D-65-HR, 73dB
    - ✧ L-LCX-43D-55-HR, 63dB
  - band of 150MHz:*
    - ✧ L-LCX-43D-65-HR, 70dB
    - ✧ L-LCX-43D-55-HR, 60dB

Where:

L	- LCX	- □D	- □	- HR
*1	*2	*3	*4	*5

\*1: L: Low loss type or N/A: general type

- \*2: LCX: Leaky Coaxial Cable
- \*3: Outer diameter of insulator e.g. 43D: 43mm
- \*4: D: Characteristic impedance, e.g. 50Ω
- \*5: HR: Heat-Resistant or N/A: general type

## **(6) CCTV CAMERA EQUIPMENT**

### **(a) Application**

This section shall apply to components, etc. of the CCTV camera equipment to be installed in the Nagdhunga Tunnel (hereinafter referred to as the “Equipment”).

### **(b) System Overview**

The system overview of the Equipment shall be as follows:

- ✓ CCTV shall be installed outside the tunnel to monitor vehicles passing through the tunnel and tollgate.
- ✓ CCTV shall be installed inside the tunnel to monitor emergency exits and evacuation routes.
- ✓ CCTV shall be installed inside the tunnel to monitor vehicles passing through, emergency exits, emergency parking zone and other fixed points. When an accident or disaster occurs, CCTV shall monitor firefighting and evacuation activities, and the state of the accident or disaster.
- ✓ The Equipment shall collectively record and deliver video images from all the cameras.

### **(c) Service Space**

CCTV for outside and inside the tunnel, and control panels shall be designed for outdoor use, and other components for indoor use.

### **(d) Ambient Conditions**

- ✓ Temperature:
  - outdoor and inside the tunnel, -10°C to 40°C
  - Indoor, 0°C to 40°CHowever, 10°C to 35°C for general information devices
- ✓ Humidity:
  - outdoor and inside the tunnel, 10% to 90%RH
  - indoor, 10% to 85%RHHowever, 20 to 80%RH (non-condensing humidity) for general information devices



- ✓ Wind speed: Maximum instantaneous wind speed: 60m/s (non-destructive)  
(for outdoor devices only)

**(e) Structures**

Individual server equipment and racks shall have the following structures.

- ✓ The Equipment shall be made of durable and rust preventive steel.
- ✓ Stand-alone devices shall be earthquake-resistant to prevent accidents due to horizontal displacement, falling or drop of any parts.
- ✓ Devices shall be mounted on steel racks, which shall be fixed directly and horizontally on concrete floors.
- ✓ Devices to be placed on the free access floor shall be fixed with bolts on special racks, which shall be placed in a hole created in the floor. Special racks shall have a structure, in which bolts used to fix the devices on the concrete floor are visible.

**(f) Components of the Equipment**

The Equipment shall consist of the components and devices shown in Table 54-12.

**Table 54-12: Components of CCTV Camera Equipment**

Item	Requirements	Unit	Q'ty
CCTV for outside tunnel (PTZ)		unit	4
CCTV for inside tunnel (PTZ)		unit	4
CCTV for inside tunnel (Fixed)		unit	9
CCTV control panel #1	for CCTV for outside tunnel (PTZ)	unit	4
CCTV control panel #2	for CCTV for inside tunnel (PTZ)	unit	4
CCTV control panel #3	for CCTV for inside tunnel (Fixed)	unit	9
CCTV control equipment			
<b>Video storage server</b>		unit	1
Media converter		unit	17
Layer 2 Ethernet switch	24 or more ports	unit	1
Server rack	W700×H2000×D1000	unit	1
Optical terminal box	W700×H2000×D500	unit	1
Operation terminal for CCTV		unit	1

**(g) Specifications of Components**

Components of the Equipment shall conform with the following specifications:

**(i) CCTV for outside tunnel (PTZ)**

CCTV shall be installed outside the tunnel to monitor vehicles passing

through the tunnel and tollgate.

✓ Functions

- CCTV shall have infrared LED (adjustable floodlight of 30 levels) that enables to see 300m ahead of the camera at night.
- CCTV shall, when infrared LED is on, automatically enter the night mode (black/white) and follow lights.
- The minimum object illuminance shall be 0.0001lx (when the electronic sensitivity function is off (movie), black/white).
- CCTV shall be dust- and waterproof, equivalent to IP66.
- CCTV shall rotate horizontally 360 degrees (when the wind speed is 40m/s).
- CCTV shall output video images equivalent to full HD (1920 x 1080).

✓ Electrical specifications

- Image sensor: Single CMOS (2/3 inches)
- Maximum resolution: 1920×1080 or higher
- Minimum object illuminance:
  - ✧ 0.0001lx or lower (electronic sensitivity is off (movie), black/white).
- Zoom ratio: 25x or higher optical zoom
- Angle of view: Horizontal, including the range from 51° to 3°
- Illumination: F1.8 or higher
- Focus: Manual, automatic
- Structure: JIS C 0920, IP code: IP66 (dust- and waterproof)
- Type: Stationary
- Rotating angle:
  - ✧ Horizontal: 360° endless rotation
  - ✧ Vertical: +20° to -70° or more
- Maximum rotating speed:
  - ✧ Horizontal: 180°/sec
  - ✧ Vertical: 60°/sec
- Positioning accuracy: ±0.1° or below
- Presetting: Registration/control of 255 points
- Illumination:

- ✧ Infrared LED x 1
- ✧ Approx. 850mm
- ✧ Adjustable floodlight of 30 levels
- Survival wind speed: 40m/s (manual mode only)
- Dimensions, weight, power consumption:
  - ✧ Approx. 750(W)×450(H)×500(D)
  - ✧ Approx. 30kg
  - ✧ Maximum 400W or below

(ii) CCTV for inside tunnel (PTZ)

CCTV shall be installed inside the tunnel to monitor emergency exits and evacuation routes.

✓ Functions

- CCTV shall be suspended from the ceiling more than 2.0 to 2.5 meters above the evacuation routes so as not to interfere with evacuation.
- The minimum object illuminance shall be 0.05lx (when the electronic sensitivity function is off (movie), black/white).
- CCTV shall be dust- and waterproof, equivalent to IP66.
- CCTV shall rotate horizontally 360 degrees (when the wind speed is 40m/s).
- CCTV shall output video images equivalent to full HD (1920 x 1080).

✓ Electrical specifications

- Image sensor: Single CMOS (1/2.8 inches)
- Maximum resolution: 1920×1080 or higher
- Minimum object illuminance: 00.05lx or lower (electronic sensitivity is off (movie), black/white).
- Zoom ratio: 30x or higher optical zoom
- Angle of view: Horizontal, including the range from 63° to 3°
- Illumination: F1.6 or higher
- Focus: Manual, automatic
- Structure: JIS C 0920, IP code: IP66 (dust- and waterproof)
- Type: Suspended from the ceiling
- Rotating angle:
  - ✧ Horizontal: 360° endless rotation

- ✧ Vertical: +90° to -90°
- Maximum rotating speed:
  - ✧ Horizontal: 180°/sec
  - ✧ Vertical: 90°/sec
- Positioning accuracy:  $\pm 0.3^\circ$  or below
- Presetting: Registration/control of 255 points
- Survival wind speed: 40m/s (manual mode only)
- Dimensions, weight, power consumption:
  - ✧ Approx. 300(W)×300(H)×250(D)
  - ✧ Approx. 9kg
  - ✧ Maximum 90W or below

(iii) CCTV for inside tunnel (Fixed)

CCTV shall be installed inside the tunnel to monitor vehicles passing through, emergency exits, emergency parking zone and other fixed points. When an accident or disaster occurs, CCTV shall monitor firefighting and evacuation activities, and the state of the accident or disaster.

✓ Functions

- CCTV shall be installed on the side faces of the tunnel. In consideration of the optical angle, and to avoid inferior video images due to reflection of the headlight of vehicles, CCTV shall be installed to see running vehicles from behind. In addition, for easier maintenance and inspection, CCTV shall be placed some 2.5 meters above the road surface.
- CCTV shall be dust- and waterproof, equivalent to IP66.
- CCTV shall be fixed to immediately capture changes in the status (from normal circumstances).
- CCTV shall output video images equivalent to full HD (1920 x 1080).

✓ Electrical specifications

- Image sensor: Single CMOS (1/2.8 inches)
- Maximum resolution: 1920×1080 or higher
- Minimum object illuminance: 0.05lx or lower (electronic sensitivity is off (movie), black/white).
- Zoom ratio: 3x or higher optical zoom (preset)
- Angle of view: Horizontal, 109° to 37° (preset)
- Illumination: F1.2 or higher

- Structure: JIS C 0920, IP code: IP66 (dust- and waterproof)
- Type: Wall-mounted
- Dimensions, weight, power consumption:
  - ✧ Approx. 120(W)×220(H)×360(D)
  - ✧ Approx. 2kg
  - ✧ Maximum 4W

(iv) CCTV control Panel #1

CCTV control panel shall be placed stand-alone or mounted to a pole near CCTV for outside tunnel (PTZ) to store devices and components to supply power to the camera and accessories, and transmit video images and control signals of the camera. The relevant conductive wires for signal transmission, except for optical fiber cables, shall be connected to protector.

✓ Outdoor case

- Structure: Stand-alone or pole-mounted  
Stainless steel  
JIS C 0920, IP code: IP55 (dust- and jet-proof)
- External dimensions:
  - ✧ Width: 580mm
  - ✧ Height: 650mm
  - ✧ Depth: 240mm(except protruding parts)

✓ Encoder

Encoder shall output digital video images with the resolution of full HD (1920×1080) in IP transmission format (H.264, multicast).

- Input video signal: Full HD (1920×1080) × 1 channel
- Output signal: LAN (10/100M Ethernet)  
IP transmission format (H.264, multicast)

✓ Media converter

Media converter shall convert signals in LAN cables (copper wire) to signals for optical fiber cables (SM).

- LAN interface: 10/100BASE-TX interface x 1 port
- Optical interface: 100BASE-FX interface x 1 port
  - ✧ Interface: SC connector
  - ✧ Transmission distance: within 5km

✓ Optical terminal box

Optical terminal box shall store optical fiber cables with at least eight cores (including backup cables).

- No. of fusion splices: 8 cores or more
- Connector: SC connector
- No. of adapters: 8 or more

✓ Power supply converter and video protector

Power supply converter shall step down the input voltage, and supply power to the camera and auxiliary equipment. Protector shall be applied to signal and power cables.

- Input voltage: AC220V $\pm$ 10%
- Output voltage: AC100V $\pm$ 10%
- Protector: Protector shall be applied to signal and power cables.

(v) CCTV control panel #2

CCTV control panel shall be mounted to the wall near CCTV for inside tunnel (PTZ) to store devices and components to supply power to the camera and accessories, and transmit video images and control signals of the camera. The relevant conductive wires for signal transmission, except for optical fiber cables, shall be connected to protector.

✓ Outdoor case

- Structure:
  - ✧ Wall-mounted
  - ✧ Stainless steelJIS C 0920, IP code: IP55 (dust- and jet-proof)
- External dimensions:
  - ✧ Width: 500mm
  - ✧ Height: 800mm
  - ✧ Depth: 200mm(except protruding parts)

✓ Encoder

Encoder shall output digital video images with the resolution of full HD (1920 $\times$ 1080) in IP transmission format (H.264, multicast).

- Input video signal: Full HD (1920 $\times$ 1080)  $\times$  1 channel
- Output signal: LAN (10/100M Ethernet)  
IP transmission format (H.264, multicast)

✓ Media converter

Media converter shall convert signals in LAN cables (copper wire) to signals for optical fiber cables (SM).

- LAN interface: 10/100BASE-TX interface x 1 port
- Optical interface: 100BASE-FX interface x 1 port
  - ✧ Interface: SC connector
  - ✧ Transmission distance: within 5km

✓ Optical terminal box

Optical terminal box shall store optical fiber cables with at least eight cores (including backup cables).

- No. of fusion splices: 8 or more cores
- Connector: SC connector
- No. of adapters: 8 or more

✓ Power supply converter and video protector

Power supply converter shall step down the input voltage, and supply power to the camera and auxiliary equipment. Protector shall be applied to signal and power cables.

- Input voltage: AC220V $\pm$ 10%
- Output voltage: AC100V $\pm$ 10%
- Protector: Protector shall be applied to signal and power cables.

(vi) CCTV control panel #3

CCTV control panel shall be mounted to the wall near CCTV for inside tunnel (Fixed) to store devices and components to supply power to the camera and accessories, and transmit video images and control signals of the camera. The relevant conductive wires for signal transmission, except for optical fiber cables, shall be connected to protector.

✓ Outdoor case

- Structure:
  - ✧ Wall-mounted
  - ✧ Stainless steel
- JIS C 0920, IP code: IP55 (dust- and jet-proof)
- External dimensions:
  - ✧ Width: 500mm
  - ✧ Height: 800mm

✧ Depth: 200mm

(except protruding parts)

✓ Encoder

Encoder shall output digital video images with the resolution of full HD (1920×1080) in IP transmission format (H.264, multicast).

- Input video signal: Full HD (1920×1080) × 1 channel
- Output signal:

✧ LAN (10/100M Ethernet)

✧ IP transmission format (H.264, multicast)

✓ Media converter

Media converter shall convert signals in LAN cables (copper wire) to signals for optical fiber cables (SM).

- LAN interface: 10/100BASE-TX interface x 1 port
- Optical interface: 100BASE-FX interface x 1 port

✧ Interface: SC connector

✧ Transmission distance: within 5km

✓ Optical terminal box

Optical terminal box shall store optical fiber cables with at least eight cores (including backup cables).

- No. of fusion splices: 8 or more cores
- Connector: SC connector
- No. of adapters: 8 or more

✓ Power supply converter and video protector

Power supply converter shall step down the input voltage, and supply power to the camera and auxiliary equipment. Protector shall be applied to signal and power cables.

- Input voltage: AC220V±10%
- Output voltage: AC100V±10%
- Protector: Protector shall be applied to signal and power cables.

✓ Power superimposing unit

Power superimposing unit shall superimpose the voltage necessary for operation of video cables of the camera.

(vii) CCTV control equipment

CCTV control equipment shall collectively record and deliver video images



from all the cameras.

✓ Video storage server

- Video storage and operational functions:

Video storage server shall store video image data for maximum two weeks (14 days). Data shall be automatically deleted after a period of two weeks.

It shall enable to view and download video image data recorded and stored from operation terminal for CCTV.

✧ Camera view data: 17 camera units or more

✧ Data format: H.264, 1920×1080, 6Mbps

✧ Storage period: 17 units x 2 weeks (14 days) or longer

Data shall be automatically deleted after a period of two weeks.

✧ Viewing function: The server shall be able to view and download video image data recorded and stored.

✧ Camera control: The server shall have various functions to control the camera.

- CCTV camera monitoring: Video storage server shall be connected to the CCTV control panels on the network to monitor the state of CCTV camera (the state of video input, delivery, etc.).

- Communication processing for integrated management server: The operation console shall communicate with the integrated management server to transmit and receive the following signals.

✧ Communication protocol: TCP/IP

✧ Transmitting information: Information about the monitoring state of CCTV camera

✓ Media converter

Media converter shall convert signals in LAN cables (copper wire) to signals for optical fiber cables (SM).

- LAN interface: 10/100BASE-TX interface x 1 port

- Optical interface: 100BASE-FX interface x 1 port

Interface: SC connector

Transmission distance: within 5km

- Quantity: 17 units

✓ Layer 2 Ethernet switch

- Structure: Rack-mounted

- Backplane capacity: 100Gbps or more
- No. of interfaces: 10/100/1000BASE-T interface x 24 or more ports
- Compatible standards:
  - 10BASE-T: IEEE802.3
  - 100BASE-TX: IEEE802.3u
  - 1000BASE-T: IEEE802.3ab
- Packet transmission capacity: maximum 70Mpps or more
- Priority control: The switch is capable of priority control of traffics in accordance with COS, IP precedence and DSCP value of IEEE802.1p.
- VLAN:
  - The switch can support 1000 or more functions.
  - The switch can support VLAN for each port.
  - It can also configure tag VLAN (IEEE802.1Q).
- Fault bypass: The switch can support independent spanning tree protocol for each VLAN (including tag VLAN).
- Multicast: The switch shall transmit multicast packets only to relevant ports. (Function equivalent to IGMP snooping)
- Management protocol: SNMP (v1, v2, v3)
- Power: AC100V 50Hz/60Hz
- Maximum power consumption: approx. 38W

✓ Server rack

- Structure:
  - ✧ Indoor rack
  - ✧ Stand-alone, steel
- External dimensions:
  - ✧ Width: 700mm
  - ✧ Height: 2000mm
  - ✧ Depth: 1000mm

(except protruding parts)

(viii) Optical terminal box

Optical terminal box shall store optical fiber cables from 17 camera units and the West Electric Room.

- No. of fusion splices: 480 or more cores

- Connector: SC connector
- No. of adapters: 480 or more
- No. of cables contained:
  - ✧ 24 or more optical fiber cables
  - ✧ 24 or more optical fiber cords
- Server rack
- Structure:
  - ✧ Indoor rack
  - ✧ Stand-alone, steel
- External dimensions:
  - ✧ Width: 700mm
  - ✧ Height: 2000mm
  - ✧ Depth: 500mm

(except protruding parts)

(ix) Operation terminal for CCTV

Operation terminal for CCTV shall display camera views, and control the rotation of the cameras. It shall also access to the video storage server to download video image data stored.

- ✓ Functions:
  - Viewing video images of the camera
  - Controlling the camera
  - Writing data stored in the video storage server
- ✓ OS: Windows (64bit) or equivalent
- ✓ Operating environment: 24-hour continuous operation
- ✓ Display language: English

**(7) Test, Installation and Trial Operation**

Installation, tests and trial operations of the System shall be conducted in accordance with the relevant drawings. Factory Acceptance Test (FAT) and Site Acceptance Test (SAT) shall be conducted in the following manner to demonstrate that the System performance meets the specifications, equipment manufacturing specifications and other relevant documents.

**(a) Factory Acceptance Test (FAT)**

Factory Acceptance Test (FAT) shall be conducted at the manufacturing factory in accordance with the test plan and procedure manual. Upon the

completion, the following test reports and documents shall be submitted.

- (i) Test reports chiefly to confirm physical performance
  - Test report to confirm the performance of components, materials and parts
  - For general equipment and materials including appliance products, test data on their catalogs and manuals
  - Test report to confirm the performance of equipment, which consists of multiple components and materials
- (ii) Test reports chiefly to confirm theoretical performance
  - Test report to confirm the performance of components and materials, and functions
  - Test report to confirm the functions of equipment, which consists of multiple components and materials.
  - Test report to confirm the functions of devices that are combined with other devices when used

**(b) Site Acceptance Test (SAT)**

Comprehensive test and adjustment shall be conducted on site to check the operation of the entire System.

The Contractor shall create and obtain the approval for a test plan for SAT, and submit the results of the test and adjustment in the form of Site Test Report.

**(8) Spare Parts**

To ensure efficient and continuous operations of the System, spare parts shall be supplied for equipment, components and devices, which could adversely affect the system operation or need to be promptly repaired if they suffer from any defect.

Spare parts to be procured as part of the System shall be listed in Table 54-13.

**Table 54-13: Spare Parts List**

Item	Requirements	Q'ty	Unit
VHF radio auxiliary equipment / FM radio rebroadcasting system			
FM broadcasting equipment			
FM transmitter unit		1	unit
Voice conversion unit, VoIP		1	unit
Voice memory unit		1	unit
FM receiver unit		1	unit
Loudspeaker equipment			
Power amplifier unit (120W)		1	unit
Power amplifier unit (60W)		1	unit

Item	Requirements	Q'ty	Unit
Pre-amplifier unit		1	unit
VHF Radio for road administrator			
Base station (radio unit)		1	unit
Base station (power unit)		1	unit
Portable radio		1	unit
CCTV camera equipment			
CCTV camera			
CCTV for outside tunnel (PTZ)		1	unit
CCTV for inside tunnel (PTZ)		1	unit
CCTV for inside tunnel (Fixed)		1	unit
Control panel			
Encoder	for CCTV control panels #1, #2 and #3	2	unit
Protector for power supply	for CCTV control panels #1 and #2	1	unit
Protector for controller	for CCTV control panels #1 and #2	1	unit
Video protector	for CCTV control panels #1 and #2	1	unit
Power superimposing unit	for CCTV control panel #3	1	unit
Video protector (power superimposing)	for CCTV control panel #3	1	unit
Monitoring control equipment			
PLC			
Communication processing unit	PLC, PLC2, software-bundled	2	unit
Monitoring input unit		2	unit
Measurement input unit		2	unit
Control output unit		2	unit
Relay unit	Relay unit (to replace 1 contact)	10	unit
Power unit	Power unit (for communication processing unit)	2	unit
DC power supply	Power unit (for monitoring control unit)	2	unit

## 5500. TUNNEL VENTILATION SYSTEM

### (1) General

#### (a) Description

These works consist of the Tunnel Ventilation System Dust Countermeasure Plan that shall be installed for the Project and shall be composed of at least the following items:

- Details of ventilation systems during excavation and supporting evidence for details (target environment of tunnel opening, selection of construction

equipment for tunneling operation, estimation of dust/toxic gas emission and the necessary ventilation capacity, plan of ventilation system with flexible ducts and dust collector)

- Treatment at source of dust generation
- Measurement, evaluation, treatment and recording of dust concentration
- Maintenance of ventilation system
- Use of respiratory protective equipment
- Occupational health education
- Installation of facilities for rest

And shall comply with the requirements of these Specifications.

**(b) System Configuration**

The ventilation system adopts a longitudinal-flow jet fan, for which ventilation equipment consists of the following equipment:

- Jet Fan Equipment
- Ventilation Control Equipment
- Measuring Equipment

**(c) Applicable Standards**

The System shall comply with these Specifications, and laws, regulations, rules and specifications listed in the following table.

Applicable Standards
Technical Standards of Tunnel Ventilation. Japan Road Association 2008
Standard Design Specifications Vol. 7 Machinery, Book 2 Tunnel Ventilation Facilities. NEXCO RI 2015
Traffic Volume of Road. Japan Road Association 1984
Road Tunnel Emergency Facilities Installation, Standards and Remarks. Japan Road Association 2001

The system shall be manufactured, installed, tested and commissioned in accordance with ISO 9001 compliant quality assurance and quality control systems. Manufacturers must be organizations granted an ISO 9001 certificate by a public independent body.

**(d) Scope of Works for Ventilation System**

Table 55-1 describes the scope of works that shall be performed for the establishment of the Ventilation System.

The Contractor shall also explain the system operation to the Facility Manager before completion, and this explanation of operation shall also be included in the construction scope of this project.

**Table 55-1: Scope of Work for Ventilation System**

Equipment/Facility	Unit	Qty.	Construction Content
Jet fan. Model JFX-1250	Units	15	Fabrication and installation
Soot visibility measuring equipment	Set	2	Fabrication and installation
Carbon monoxide measuring equipment	Units	2	Fabrication and installation
Air flow direction and velocity meter	Units	2	Fabrication and installation
Ventilation measurement control board	Panel	1	Fabrication and installation
Ventilation operation board	Panel	1	Fabrication and installation
Ventilation inverter control board	Panel	4	Fabrication and installation
Manual switchbox (for 2 units). Class 1 heat-resistant specifications	Panel	4	Fabrication and installation
Manual switchbox (for 2 units)	Panel	3	Fabrication and installation
Manual switchbox (for 1 unit)	Panel	1	Fabrication and installation
Power conduit between each equipment and board. Scope shall be based on drawings.	Set	1	Installation
Inspection	Set	1	
Comprehensive commissioning adjustments	Set	1	

**(e) Design Criteria**

The required structural and traffic conditions for the design of ventilation facilities are the following: (Refer to Table 55-2)

- (i) Traffic method: Two-lanes, two-ways of traffic
- (ii) Design speed: 60 km/h
- (iii) Tunnel length and inclination
  - Lr=2688m, +3.5%:2649m, -0.5%:39m
- (iv) Tunnel cross sectional area:  $A_r=71.6\text{m}^2$
- (v) Hydraulic diameter  $D_r$

Hydraulic diameter can be calculated from the following equation

$$D_r = 4 \cdot A_r / S_r \quad \text{: Cross section perimeter (} S_r=32.9\text{m)}$$

Hydraulic diameter is as follows from the equation:  $D_r=8.7\text{ m}$

- (vi) Lane width: 3.5 m
- (vii) Shoulder width: 0.5 m
- (viii) Altitude: 1292–1385 m, avg. 1339 m

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**(2) Basic Requirements**

**(a) Basic Design**

(i) Ventilation system: Longitudinal-flow jet fan

(ii) Ventilation control method

Normal control: Feed-Back (FB) control, program control (as backup in case FB control fails)

Emergency control: fire connected control (low-speed ventilation control), fire manual control.

(iii) Jet fan placement

Four jet fans are required to serve as evacuation support control (low-speed ventilation control) and firefighting support control (exhausting). For the low-speed ventilation control, if a jet fan runs within 500 m in front or behind the fire point, it will cause smoke to spread and hinder evacuation conditions. Thus, jet fans located within 500 m in front or behind a fire point must not run during a fire.

To ensure this, jet fans are positioned near the portals on each end to permit low-speed ventilation control regardless of the fire point position.

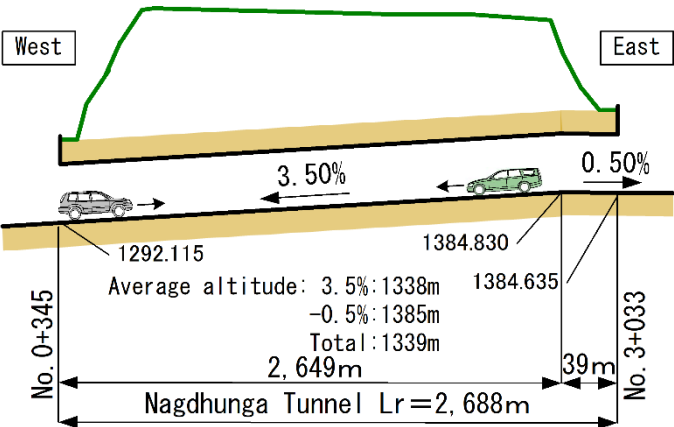
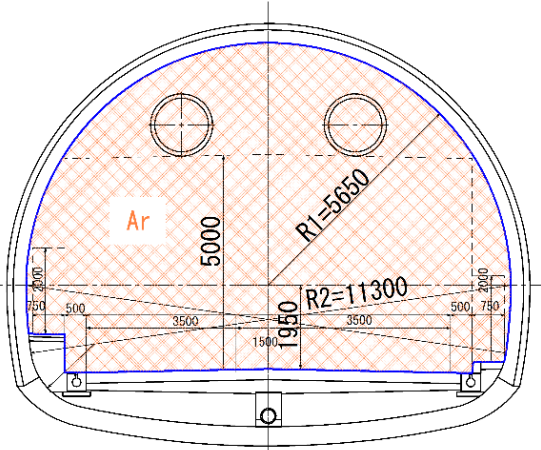
(iv) Operation

During normal conditions, the ventilation measurement control board in the Eastern Power Room collects measured data from VI, CO, and AV meters, determines the proper ventilation volume and direction, and sends run/stop commands to the ventilation inverter control board as well as ventilation control center (a separate project).

During fire conditions, after the fire emergency signal is input, normal control is immediately suspended and the system switches to low-speed ventilation control to improve evacuation conditions. Once evacuation is complete, firefighting support is provided via fire manual control.



Table 55-2: Design Criteria

Item	Description
Tunnel	2688 m
Longitudinal Section	 <p>West East</p> <p>3.50% 0.50%</p> <p>1292.115 1384.830</p> <p>Average altitude: 3.5%:1338m -0.5%:1385m Total:1339m</p> <p>2,649m</p> <p>Nagdhunga Tunnel Lr=2,688m</p> <p>No. 0+345 No. 3+033</p>
Cross Section	 <p>Ar</p> <p>5000</p> <p>R1=5650</p> <p>R2=11300</p> <p>1950</p> <p>3500</p>
Cross Section Area	$A_r = 71.6 \text{ m}^2$
Traffic Conditions	2-lanes, 2-ways of traffic
Designed Speed	60 km/h

**(b) Durability**

The system shall be operated 24 hours a day, 365 days a year, the hardware must be durable for continuous operation.

**(c) Facility Expandability**

Ventilation equipment has been strengthened due to the world environmental considerations regarding to the global warming and the regulations global climate issues are strictly addressed to control and minimize the automobile's gas emission.

To address future equipment changes or modifications, the system must be

easily adaptable, and shall facilitate the installation of additional basic equipment, etc., in a relative ease way.

**(d) Supplied Power**

- ✓ Ventilation inverter control board:
  - from the ventilation transformer board: 3-phase 3-wire 415V 50 Hz
  - from the ventilation measurement control board: single-phase 2-wire 105V 50 HZ
- ✓ Tunnel measuring equipment:
  - from on-site transformer board: single-phase 2-wire 220V 50 HZ
- ✓ Ventilation measurement control board, ventilation operation board:
  - from the I/O board: single-phase 2-wire 105V 50 HZ

**(3) Ventilation Control Equipment**

**(a) System Overview**

An outline of the system for facilities is described below:

**(i) Control under normal conditions**

- ✓ During normal conditions, the ventilation measurement control board in the Eastern Power Room collects measured data from VI, CO, and AV meters, determines the proper ventilation volume and direction, and sends run/stop commands to the ventilation inverter control board and ventilation control center (a separate project).
- ✓ It must be possible to use program control or manual control modes as a backup if measurement control fails.

**(ii) Control under emergency conditions**

- ✓ Once a fire signal is input, normal control is immediately suspended and the system switches to fire connected control (low-speed ventilation control) to improve evacuation conditions. After evacuation is complete, firefighting support is provided via fire manual control.
- ✓ Low-speed ventilation control, which is implemented to prevent the spread of smoke from the fire, shall be implemented as follows:
  - Control starts within 30 seconds after a fire is detected.
  - Wind speed is lowered to approximately  $\pm 2$  m/s below wind speed at the roadway within 90 seconds after fire detection.
  - Wind speed is lowered to approximately  $\pm 0.5$  m/s below wind speed at the roadway within 210 seconds after fire detection.
  - Wind speed shall remain at approximately  $\pm 0.5$  m/s below wind speed at the roadway until evacuation is complete.
  - Measurement signal processing
- ✓ Measured data shall be averaged by a measurement processing unit

that is incorporated into the ventilation measurement control board installed in the Eastern Power Room.

(iv) Control and monitoring of west jet fans

- ✓ Control and monitoring of jet fans installed on the west side shall be performed by the ventilation operation board installed in the Western Power Room.
- ✓ The ventilation interlock shall have protective function for times when jet fans are switched between forward and reverse as well as a fire manual control function.

(v) Inverter control

- ✓ The eight jet fans used for fire control shall employ inverter control (rotation speed control) in order to ensure the responsiveness of low-speed ventilation control and to provide energy savings for ventilation in regular operation, and the rest 7 jet fans shall employ unit number control

(vi) Control and monitoring from a remote supervisory control facility (separate facility)

- ✓ Switching of control modes, manual control, etc., and state monitoring from a remote supervisory control facility (separate facility) must be possible.

**(b) Location of Use**

The location of use shall be indoors at the Eastern Power Room and West Power Room.

**(c) Ambient Conditions**

- ✓ Temperature: Indoor 0°C to +40°C
- ✓ Humidity: Indoor 10% to 85% RH

Note that there must be no condensation.

**(d) Structure**

The structure of each unit shall be as described below:

**Table 55-3: Configuration of Ventilation Control Facilities**

Item	Description	Standards	Unit	Qty.	Location
Ventilation measurement control board	Indoor freestanding enclosed control panel	JEM 1459	Panel	1	Eastern Power Room
Ventilation operation board	Indoor freestanding enclosed control panel	JEM 1459	Panel	1	Eastern Power Room
Ventilation inverter control board	Indoor freestanding enclosed type	JEM 1425	Panel	2	Eastern Power Room
			Panel	2	Western Power Room

- ✓ The enclosure shall be durable and highly resistant to rusting, and have

performance equal to or better than steel plate (hot rolled steel sheet).

- ✓ Installation of freestanding equipment shall include seismic countermeasures to prevent accidents such as horizontal shifting, overturning, falling, etc., in the event of an earthquake.
- ✓ Temperature rises in the board's internal components and various parts shall meet compliance standards under the conditions listed above in Ambient Conditions, and remain within a temperature range not detrimental to any part.

**(e) Ventilation Measurement Control Board and Ventilation Operation Board Specifications**

**(i) Major fittings**

The major fittings of the ventilation measurement control board and ventilation operation board are as follows:

**Table 55-4: Major Fittings of the Ventilation Measurement Control Board**

Item	Equipment	Ventilation measurement Control board	Ventilation operation board
Major board-mounted fittings	Indicator light array: Indication of operation and failure	○	○
	Control mode switchover switch: Push button	○	○
	Manual control switch	○	—
	Fire manual control switch	○	○
	Alarm, failure return, lamp test switch	○	○
	Graphic panel (touch-panel type) Display operation and measured values Set airflow for each notch's jet fan Set control target values, control cycle, etc. Set protection timer Set program control Set date/time Failure history	○	—
Control unit		○	○
Measurement processing unit	VI processing Unit, CO processing unit, AV processing unit	○	—
Recording unit		○	—
Power supply		○	○
Interface	For measurement equipment	○	—
	For ventilation inverter board	○	—
	For ventilation control center	○	—
	For ventilation operation board	○	—
	For ventilation measurement control board	—	○
	For power receiving and distribution facilities	○	—

Item	Equipment	Ventilation measurement Control board	Ventilation operation board
	For emergency equipment	○	—
	For remote supervisory control facility	○	—

(ii) Control switchover

The ventilation control block is as shown in the drawings. The control switchover and operating locations shall be as described below.

**Table 55-5: Control Switchover and Operating Locations**

Operation	Content	Operating location				
		Ventilation measurement Control board	Ventilation Interlocking board	Remote monitoring Control unit (separate equipment)	Ventilation INV Board	Ventilation C/C Board (separate)
Running mode switchover	Independent–Interconnected	○	○	—	—	—
Operating location switchover	Remote–Direct	○	—	○	—	—
User-operation mode switchover	Auto–Manual	○	—	○	—	—
Control method switchover	Measurement–Program	○	—	○	—	—
Manual airflow-direction control	Forward–Reverse	○	—	○	—	—
Manual notch operation	Notches 0–8	○	—	○	—	—
Fire control system mode switchover	Fire (connected)–Fire (manual)	○	○	○	—	—
Fire-mode manual notch operation	Forward, reverse, stop	○	○	○	—	—
Independent operation (independent control)	Operate–Stop	—	—	—	○	○

(iii) Control functions of the ventilation measurement control board and

ventilation operation board shall be as described below:

**Table 55-6: Control Switchover and Operating Location**

Function	Purpose	Ventilation measurement Control board	Ventilation Interlocking board
Connected control	Manual control, automatic control, fire manual control switch, fire connected control	○	—
Manual control	Notch control is initiated by an operating switch on the ventilation control board during inspections or when automatic measurement control has failed. There shall be roughly 0–8 air flow notches.	○	—
Automatic control	Perform measurement control or program control.	○	—
Measurement control (Notch configuration circuit)	Determine jet fan airflow volume and direction based on measurements from the VI, CO and AV meters in the tunnel.	○	—
Program control	Automatically perform a preset operating pattern as a backup when the automatic measurement control has failed. Air flow notches shall have a setting function with 4 patterns of 'Weekday, Holiday, Saturday, and Special Day', wherein 24 hours of setting is possible in 1 hour increments. It shall also be easy to set the number of units and airflow direction on-site.	○	—
Override control when concentrations worsen	During automatic control, override control of all ventilator fans is executed if VI or CO values deteriorate to abnormal levels.	○	—
Fire manual control	An operating switch drives fans in a normal or reverse direction to exhaust smoke in the event of a fire.	○	○
Fire connected control	Execute fire mode operation (low-speed ventilation control), which is automatically set when a fire hazard signal is input.	○	—
Exclusion of failed equipment/Compensation with operational equipment	Exclude jet fans that have failed and compensate with operational equipment.	○	—
Lead fan switching	Switch the leading fan in a nonstop rotational schedule ("rotary endless") to ensure that jet fan running times through the ventilation C/C board are spread equally among fans.	○	—
Sequential activation	Relating to jet fan control through ventilation C/C board, activate jet fans one at a time due to capacity of the power source.	○	—
Forward/reverse switching protection	Relating to jet fan control through ventilation C/C board, install a protective timer as sudden switching from forward to reverse puts excessive load on the motor.	○	○
Acceleration/deceleration time switching protection	Relating to jet fan control through the ventilation INV board, install a protective timer to protect the motor against sudden acceleration/deceleration of rotating speed.	○	○

Function	Purpose	Ventilation measurement Control board	Ventilation Interlocking board
Control during power failure	Switch to measurement control with four jet fans during a power failure due to limitations of in-house power generation.	○	—
Control during power recovery	In manual mode: Continue 0 notch In automatic mode: Use measurement control with measured values at time of power recovery	○	—
Operating switch	Switching between modes, operating air volume, etc., shall be performed by a push button switch.	○	○
Touch panel	Display of jet fan operation and measured values Set/change the number of operating fans, target concentration, program, date and time, etc., by notch. View failure history	○	—
Array and status display unit	Fault indicator lamp lights to indicate a failed device. Status indicator lamp lights to indicate control and operating status of jet fans.	○	—
Measurement processing	Data required for ventilation control is processed upon receiving a measurement signal from monitoring equipment in the tunnel.	○	—
Recording unit	At least six months of data is recorded for number of jet fan notches and VI/CO/AV values.	○	—
Alarm processing	A warning buzzer sounds when equipment has failed.	○	○

- (iv) Signal connection between ventilation measurement control board and other boards

The number of signal connections between the ventilation measurement control board and other boards is as below.

**Table 55-7: Number of Signal Connections on Ventilation Measurement Control Board**

Equipment	Type	Number of points (Max. number)	Interface
Measuring equipment	Monitoring	38	Contact: DC 24V 50mA or more
	Measurement	6	DC 4–20mA
Ventilation operation board	Control	9	Contact: DC 24V 50mA or more
	Control (INV airflow)	1	Analog: DC 4–20mA
	Monitoring	21	Contact: DC 24V 50mA or more
Ventilation inverter board (1) Eastern Power Room	Control	4	Contact: DC 24V 50mA or more
	Control (INV airflow)	1	Analog: DC 4–20mA
	Monitoring	8	Contact: DC 24V

Equipment	Type	Number of points (Max. number)	Interface
			50mA or more
Ventilation control Center (1) (2) Eastern Power Room	Control	7	Contact: DC 110V 50mA or more
	Monitoring	8	Contact: DC 24V 50mA or more
Relay terminal board (distributors)	Monitoring	2	Contact: DC 24V 50mA or more
Relay terminal board (for emergency use)	Monitoring	2	Contact: DC 24V 50mA or more
Relay terminal board (remote supervisory control facility)	Control	19	Contact: DC 24V 50mA or more
	Monitoring	72	Contact: DC 24V 50mA or more
	Measurement	6	Analog: DC 4–20mA

**Table 55-8: Number of Signal Connections on Ventilation Operation Board**

Equipment	Type	Number of points (Max. number)	Interface
Ventilation inverter board (1) Western Power Room	Control	4	Contact: DC 24V 50mA or more
	Control (INV airflow)	1	Analog: DC 4–20mA
	Monitoring	8	Contact: DC 24V 50mA or more
Ventilation control center (1) Western Power Room	Control	7	Contact: DC 110V 50mA or more
	Monitoring	8	Contact: DC 24V 50mA or more
Ventilation control Center (2) Eastern Electric Room	Control	4	Contact: DC 110V 50mA or more
	Monitoring	4	Contact: DC 24V 50mA or more

**(f) Ventilation Inverter Control Board Specifications**

**(i) Major fittings**

The ventilation inverter control board consists of a main board and sub board with 2 panels/4 jet fans. Major fittings on both panels shall be as follows.

**Table 55-9: Major Fittings on the Ventilation Inverter Board**

Item	Equipment	Ventilation inverter board (1) (main board)	Ventilation inverter board (2) (sub board)
Major fittings	Controller	○	—
	Programmable display (display of jet fan and inverter operating status as well as independent control of jet	○	—



	fans)		
	Inverter section ✓ Circuit breaker ✓ 12-phase rectifier transformer ✓ AC reactor ✓ Input noise filter ✓ AC drive ✓ Feedback type sine wave filter ✓ Zero-phase AC unit ✓ Earth-fault overcurrent relay	○	○
Interface	Ventilation measurement control board or ventilation operation board	○	—

(ii) Specifications

- ✓ Measures to control high harmonics

The harmonic control method shall be a feedback type sinusoidal filter.

Harmonic current shall be under the maximum values listed in the table below:

**Table 55-10: Maximum Harmonic Current per 1 kW Contract Command**

(Units: mA/kW)

Receiving-side voltage	5 <sup>th</sup> order	7 <sup>th</sup> order	11 <sup>th</sup> order	13 <sup>th</sup> order	17 <sup>th</sup> order	19 <sup>th</sup> order	23 <sup>rd</sup> order	Over 23 <sup>rd</sup> order
22 kV	1.8	1.3	0.82	0.69	0.53	0.47	0.39	0.36

- ✓ Measures to control surge voltage: Output voltage amplitude shall no more than 700V to inhibit surge voltage generated by jet fan motors.
- ✓ Measures to control noise: Leakage current shall be no more than 300mA to inhibit noise to AM radio broadcast waves and metal circuits from electromagnetic noise.

**(4) Jet Fan Equipment**

**(a) Application**

This section applies to jet fans and other equipment (collectively referred to as “equipment”).

**(b) Equipment Overview**

(i) Location of Use

Location of use shall be inside the tunnel.

(ii) Ambient Conditions

- ✓ Temperatures: Outdoor - 10°C to + 40°C
- ✓ Humidity: Outdoor 85% RH maximum

**(c) Structure**

(i) Equipment configuration

**Table 55-11: Jet Fan Equipment Configuration**

Equipment	Type	Specifications	Unit	Qty.
Jet fan	Motor Driven In-Tunnel Axial Flow Type. High Velocity Type	JFX-1250	Units	15
Hanging fittings			Set	15
Manual switchbox	Outdoor wall-mounted enclosed type	Class 1 heat resistance	Panel	4 for 2 units
			Panel	3 for 2 units
			Panel	1 for one unit

(ii) Materials to be used

The following material, or alternatively material with equivalent or higher specifications shall be used.

**Table 55-12: Material to be used for Jet Fan Equipment**

Category	Usage	Material/Standard	Standard
Jet fan	Casing	Stainless Steel Plate (SUS304)	JIS G 4303
	Perforated sheet metal	Stainless Steel Plate (SUS304)	JIS G 4303
	Exterior plate	Stainless Steel Plate (SUS304)	JIS G 4303
	Impeller	Aluminum alloy casting	
	Silencer	Glass wool	
Hanging fittings	Hanging fittings	Rolled Steels for General Structure (SS400)	JIS G 3101
	Mechanical anchor bolts	Stainless Steel Plate (SUS304)	JIS G 4303
Manual switchbox	Enclosure	Stainless Steel Plate (SUS304)	JIS G 4304 or JIS G 4305

(iii) Coating: Coating and paint specifications for the jet fan shall be as shown below. Color of the top coat shall comply with instructions from supervision staff.

**Table 55-13: Jet Fan Paint Specifications**

Painted parts	Surface treatment	Construction location	Process	Paint type	Standard thickness (μm)
Exterior and ventilation panel	Surface preparation by blasting, degreasing (wiping with solvent)	Factory	Primary primer	Epoxy primer	Total, min. 40 μm
			Top coat	Epoxy resin paint	

Impeller	Surface preparation by blasting Degreasing (wiping with solvent)	Factory	Undercoat	Epoxy resin paint	Total, min. 120 $\mu$ m
			Middle coat	Epoxy resin paint	
			Top coat	Epoxy resin paint	

Note 1: In principle, factory painting shall be airless spray painted.

Note 2: In principle, touch-up painting shall be brush painted.

Note 3: Jet fan hanging fittings shall be zinc hot-dip galvanizing HDZ55 (JIS H8641).

However, threaded sections shall be HDZ35 galvanized.

(iv) Structure

✓ Casing

- Casing shall be structured with appropriate detachable sections to make inspection and maintenance convenient.
- Casing shall comprise grade SUS304 austenite type stainless steel of JIS G 4304 (Hot-rolled Stainless Steel Plate, Sheet and Strip) or JIS G 4305 (Cold-rolled Stainless Steel Plate, Sheet and Strip) standards, with a steel plate welded structure frame and stainless-steel exterior plate of thickness at least 1.5 mm.
- Casing shall be structured to adequately attenuate noise by packing the casing's inner and outer cylinder wall with sound absorbing material, and protecting with a perforated stainless steel plate (SUS304, t=min. 1.5 mm) to prevent the sound absorbing material from dispersing during operation.
- Air inlet and discharge ports shall be of satisfactory shapes that minimize air flow separation, vortex formation, etc.

✓ Electric motor

- The motor shall be a fully closed type with Class F insulation or better, and shall have sufficient dielectric strength and sealing performance to withstand the environments and air currents it will be subjected to in the tunnel.
- Between the motor and the casing, lead wires must not be directly exposed to airflow.
- In principle, bearings shall be rolling bearings, have ample ability to withstand long-term continuous operation, and have excellent sealing performance.
- The motor shall have ample ability to withstand the complicated start/stop etc. operation it will be subjected to in performing tunnel ventilation.

✓ Impeller

- The impeller shall have corrosion resistance properties conforming to JIS H5202 (Aluminium Alloy Castings), JIS H4140 (Aluminium and Aluminium Alloy Forgings), or to equivalent or higher corrosion resistance. It shall also have excellent balance between operation and quietness, etc., and be sufficiently strong to withstand high-speed revolution.
  - Impeller balance shall meet or exceed G6.3 of JIS B 0905 (Rotating Machines—Balance Quality Requirements of Rigid Rotors).
  - Impeller mounting on the motor shaft shall be secure, stable, and have sufficient strength to withstand fatigue.
  - Wing surfaces of the blades shall have a smooth and precise airfoil shape, and be of equal performance properties.
- ✓ Hanging fittings
- Hanging fittings shall consist of metal hanging fittings and turnbuckles. The hanging fittings shall be attached to the tunnel ceiling with stainless steel anchor bolts and the jet fan shall be hung with turnbuckles.
  - Hanging fittings shall have sufficient strength and durability with finished surfaces that conform to (HDZ55) (JIS H8641) Zinc Hot Dip Galvanizing.
- ✓ Manual switchbox: Switch box shall have an opening door in front and be secured in the back with stainless anchor bolts.

**(d) Jet Fan Specifications**

The jet fan shall be composed of a casing, an impeller and an electric motor, etc. It shall have ample ability to withstand the water, smoke, dust, vehicle exhaust gas, etc., that it will be subjected to in the tunnel, and shall be structured in a manner that provides reasonably quiet operation. The jet fan shall be structured in a manner that conveniently facilitates tasks such as transporting, installation, disassembly, assembly, and cleaning, and its parts and assemblies shall have excellent compatibility.

Jet specifications shall be as follows:

**Table 55-14: Jet Fan Specifications**

Painted parts	Surface treatment	Construction location	Process	Paint Type	Standard thickness (μm)
Exterior and ventilation panel	Surface preparation by blasting, degreasing (wiping with solvent)	Factory	Primary primer	Epoxy primer	Total, min. 40 μm
			Top coat	Epoxy resin paint	

Painted parts	Surface treatment	Construction location	Process	Paint Type	Standard thickness (μm)
Impeller	Surface preparation by blasting Degreasing (wiping with solvent)	Factory	Undercoat	Epoxy resin paint	Total, min. 120 μm
			Middle coat	Epoxy resin paint	
			Top coat	Epoxy resin paint	

Note 1: Noise is the average value of two points, the inlet side and casing side

Note 2: The motor shall conform to JIS C 4213 “Low-voltage: Three-phase Squirrel-cage Induction Motors (Low-voltage Top Runner Motor)”

## (5) Measuring Equipment

### (a) Equipment Overview

- (i) Location of Use: Location of use shall be inside the tunnel.
- (ii) Ambient Conditions
  - ✓ Temperature: Outdoor - 10°C to + 40°C
  - ✓ Humidity: Outdoor 85% RH maximum
- (iii) Equipment configuration

**Table 55-15: Measuring Equipment Configuration**

Equipment	Specifications	Unit	Qty.
Soot Visibility Measuring Equipment (VI Meter)	Optical fiber calibration	Set	2
Carbon Monoxide Measuring Equipment (CO Meter)	Controlled potential electrolysis	Units	2
Air Flow Direction and Velocity Meter (AV Meter)	Ultrasonic	Units	2

### (c) Soot Visibility Measuring Equipment (VI Meter)

- (i) Equipment configuration
  - Equipment configuration per set shall be as follows
  - ✓ Light emitter (with power supply and control cable)
  - ✓ Light receiver (with power supply, control cable, and fiber optic cable)
  - ✓ Light emitter power supply box
  - ✓ Light receiver power supply box
- (ii) Equipment specifications
  - ✓ Measurement method: Continuous optical modulation method or equivalent
  - ✓ Measurement target:

Luminous visibility in the tunnel's atmosphere

The overall spectral reflectance of the measurement is based on luminous sensitivity under tunnel lighting.

- ✓ Measurement distance: 100 m (In case of 90 m, convert to a 100 m scale visibility)
- ✓ Measurement range: Visibility 0–100%
- ✓ Measurement accuracy: Within  $\pm 2\%$  of the maximum scale value
- ✓ Response time: Within 10 seconds for 90% all graduations
- ✓ Measurement output: An electric signal corresponding to strength or weakness of intermittent light.
- ✓ Measurement input: Light emitter, max. 13VA; light receiver, max. 37VA
- ✓ Contact output: Power off of emitter/receiver sent to control unit
- ✓ Contact input: Calibration command from control unit
- ✓ Calibration: Automatic calibration method using optical fiber
- ✓ Light source: LED
- ✓ Light receiving element: Silicon photodiode

(iii) Structure

- ✓ Light receiver
  - Type: Outdoor wall-mounted type
  - Material: Stainless steel plate SUS 304 (JIS G 4305)
  - Light emitting/receiving components in particular shall be resistant to dust, splashing/dripping water, and humidity. The front lens must not cloud even when exposed to high outdoor humidity.
  - Light emitting/receiving components shall have an inner cylinder that can be pulled out to facilitate easy cleaning of dust or other particulate matter inside the hood.
- ✓ Power supply box
  - Type: Outdoor wall-mounted type
  - Material: Stainless steel plate SUS304 (JIS G 4304 or JIS G4305)

**(d) Carbon Monoxide Measuring Equipment (CO Meter)**

(i) Equipment specifications

Equipment shall have the following specifications.

- ✓ Measurement method: Continuous measurement with controlled potential electrolysis and a calibrating function.
- ✓ Measurement target: Carbon monoxide in the air

- ✓ Measurement range: 0-300 ppm as standard.
  - ✓ Calibration method: One manual calibration every six months using calibration gas
  - ✓ Repeatability:
    - Within  $\pm 3$  ppm at 0–150 ppm
    - Within  $\pm 10$  ppm at 151–300 ppm
  - ✓ Measurement accuracy:
    - Within  $\pm 6$  ppm at 0–150 ppm
    - Within  $\pm 15$  ppm at 151–300 ppm(Under once-per-month calibration conditions)
  - ✓ Response time: 90% of responses within 2 min 30 sec or less (conduit length not included)
  - ✓ Measurement output: C 4–20mA
  - ✓ Contact output: Contact output to the control unit is as follows:
    - Flow rate decrease
    - Power off
    - Checking
  - ✓ Sampling point filter: Built-in type
- (ii) Structure
- ✓ The structure shall comprise steel plated outer covering, have excellent electrical properties, mechanical durability, and anticorrosive properties, and shall also be easy to perform inspection and maintenance on. In terms of design, it must be fabricated in a manner that includes resistance to vehicle emissions, splashing/dripping water, humidity and other concerns.
  - ✓ Type and material:
    - Type: Outdoor wall-mounted enclosed type or outdoor freestanding enclosed type (JEM 1459)
    - Material: Stainless steel plate SUS 304 (JIS G 4305)

**(f) Air Flow Direction and Velocity Meter (AV Meter)**

**(i) Equipment configuration**

The wind direction wind speed measurement device in the tunnel shall consist of a measurement unit and control unit. Configuration per set of air flow direction and velocity meter (AV meter) shall be as below.

- ✓ Ultrasonic probe (detector) : 1 unit
  - ✓ Converter box (holds the converter): 1 unit
  - ✓ Probe converter cable (accessory) : 1 pair
- (ii) Equipment specifications**
- ✓ Measurement method: Coordinate conversion of two component wind

speeds by time division duplexer type ultrasonic pulse propagation

- ✓ Measurement direction: In a horizontal direction parallel to the tunnel wall
  - ✓ Measurement range: 0 to  $\pm 15$  m/s
  - ✓ Measurement accuracy: Within  $\pm 4\%$  of the maximum scale value (within  $\pm 0.3$  m/s if wind speed is 5.0 m/s or less)
  - ✓ Responsivity: Average travel time, 10 sec (sampling time: 0.05 seconds)
  - ✓ Contact output:  
Items output to the control unit are as follows:
    - Failure
    - Checking
  - ✓ Calibration: Zero and full-scale power calibration by manual switch
- (iii) Structure
- ✓ Type and material (converter)
    - Type: Outdoor wall-mounted enclosed type
    - Material: Stainless steel plate SUS304 (JIS G 4304 or JIS G4305)

## (6) Spare Parts

### (a) Ventilation Control Equipment

**Table 55-16: Spare Parts for the Ventilation Measurement Control Board and Ventilation Operation Board**

Part	Specifications	Qty.
Various fuses	—	100%
Relay	Excluding printed board mounting hardware	1 of each type

While manufacturer's standards must be followed regarding spare parts for the ventilation inverter control board, the following parts, which are expected to need replacing within 10 years of service, must also be prepared as spare parts.

**Table 55-17: Spare Parts for Ventilation Inverter Control Board**

Equipment Category	Product	Qty.
AC drive	Inverter unit	2 pc. One in each power room
Sequencer etc.	Internal battery	2 pc.
	CPU unit	2 set
	Touch panel	2 set
	Other units	2 set
Other	Board cooling fan	4 pc. Number for all boards
	DFSA condenser	8 pc. Amount for jet fans



**(b) Measuring Equipment**

**Table 55-18: Spare Parts for Soot Visibility Measuring Equipment (VI Meter)**

Part	Specifications	Qty.
Fuse	—	100%
VI meter light source lamp	LED	100%

**Table 55-19: Spare Parts for Carbon Monoxide Measuring Equipment (CO Meter)**

Part	Qty.
Fuse	100%
Filter element	100%
Relay	1 of each type
NOx absorbent	1 set / 500g
Span gas cylinder	1 pcs.
Pressure reducing valve	1 pc.
Connection tube	1 set 1 m (including accessories)

**Table 55-20: Spare Parts for Air Flow Direction and Velocity Meter (AV Meter)**

Part	Specifications	Qty.
Fuse	—	100%

**(7) INSPECTION AND TESTING ADJUSTMENTS**

**(a) Inspection (including checks) On-Site Verification by Supervision Staff**

This project's stage-reviews shall be as follows. Note that the review method and schedule must be decided in consultation with supervisory staff.

- ✓ Materials verification (jet fan, measuring, and ventilation control equipment)
- ✓ Dimensions verification (jet fan, measuring, and ventilation control equipment)
- ✓ Functions verification (jet fan, measuring, and ventilation control equipment)
- ✓ Performance check (jet fan, measuring, and ventilation control equipment)
- ✓ Paint/coatings verification (jet fan, measuring, and ventilation control equipment)
- ✓ On-site commissioning adjustments (equipment overall)

The above verifications and checks shall be carried out in accordance with the following schedule:

**Table 55-21: Items for Inspection and On-Site Verification**

Sub-item	Implementation period
1. Materials verification	(Factory) After delivery, before production begins (Site) After delivery, before installation begins
2. Dimensions verification	(Factory) During trial shop assembly (Site) When installation completes
3. Functions verification	(Factory) When trial shop assembly completes (Site) When installation completes
4. Dimensions verification	(Factory) When production completes (Site) When installation completes
5. Paint/coatings verification	(Factory) When production completes (Site) When installation completes
6. On-site commissioning adjustments	(Site) When installation completes

**(b) Inspection and Testing Adjustments**

**(i) Materials verification**

- ✓ During factory production: In managing materials, the materials shall be verified based on the materials and other items listed in this Specifications document and Approved Drawings.

Jet fan equipment shall also undergo non-destructive testing.

Item to be Verified		Remarks
Impeller	Blades	Radiographic flaw detection (all items)
		Penetrant inspection (all items) +Radiographic flaw detection (10% of items)
	Hub	X-ray flaw detection
Hanging fittings		Penetrant inspection (all items)

- ✓ When installed at site: Electrical materials to be used during site installation shall be inspected when delivered to the site.

**(ii) Dimensions verification**

- ✓ During factory production

Item to be Verified		
Jet fan equipment	External dimensions	Diameter
		Length (in axial direction)
	Hanging fitting dimensions	
	Gaps between impeller tip and casing	
Measuring and ventilation control equipment	External dimensions	Assembled state
	External appearance	Placement of board mounted fixtures

✓ When installed at site

Item to be Verified			Remarks
Jet fan equipment	Anchor bolt static load test		29.5 KN (over 15 times actual load)
	Distance between casing and road surface		Past clearance
	Installation spacing	Portal distance	
		Distance between jet fans	
Measuring and ventilation control equipment	Installation location	Placement distance	
		Installation height	

(iii) Functions verification

✓ During factory production

Item to be Verified			Remarks
Jet fan equipment	Anchor bolt static load test		29.5 KN (over 15 times actual load)
	Distance between casing and road surface		Past clearance
	Installation spacing	Portal distance	
		Distance between jet fans	
Measuring and ventilation control equipment	Installation location	Placement distance	
		Installation height	

✓ When installed at site

Item to be Verified		Reference standard	Remarks
Jet fan equipment	Voltage	Internal standards	Verify values
	Current		
	Power		
	Vibration	JIS B 8364	Shall be according to Approved Drawings
VI meter	Light emitter/receiver reference voltage		Shall be according to Approved Drawings

Item to be Verified		Reference standard	Remarks
	Contact signal input/output		
	Communication function, fault signal		
	Precision of operation, responsivity		
CO meter	Operating test		Shall be according to Approved Drawings
	Reproducibility		
	Alarm output		
AV meter	Output		Shall be according to Approved Drawings
	Operating conditions		
Ventilation Control Equipment	Lamp test		All lamps must illuminate
	Insulation resistance		Shall meet or exceed specified value
	Ground resistance		Shall meet or exceed specified value
Verifying measures to control high harmonics	High harmonic current		Shall not exceed the values listed in this Detailed Technical Specification
	Output voltage amplitude at the manual switchbox terminal block		
	Leakage current		

(iii) Performance test

✓ During factory production

Item to be Verified		Reference standard	Remarks
Jet fan	Rotational speed	JIS B 8330	Verify rotational speed and direction
	Air flow (volume)		Shall meet or exceed specified value
	Wind pressure		
	Voltage		Verify values
	Current		
	Power		
	Shaft power		Shall not exceed electric motor output
	Bearing vibration		Vibration tolerance shall conform to JIS B 8330 Measurement points shall be according to

Item to be Verified		Reference standard	Remarks
			Approved Drawings
	Noise	JIS B 8346	Shall be according to Approved Drawings
	Starting time and starting current until reaching rated rotation		Verify values
	Moving parts inside the casing		Visual confirmation (after Performance Check test run)
Motor	Insulation resistance test	JIS C 4213 JEC 2713 JIS 4034-1	Shall be according to Approved Drawings
	Withstand voltage test		Shall withstand the test voltage
	Temperature test		Shall be according to Approved Drawings
	Characteristics test		
VI meter	Accuracy automated test		Shall be according to Approved Drawings
	Response speed		
	Insulation resistance test		
	Dielectric strength test		
	Power consumption		
CO meter	Reproducibility		Shall be according to Approved Drawings
	Response speed		
	Check fluctuation of power supply voltage		
AV meter	Output		Shall be according to Approved Drawings
	Operating conditions		
	Voltage		
Ventilation Control Equipment	Insulation resistance test		Shall be according to Approved Drawings
	Grounding resistance test		
Measures to control high harmonics	High harmonic current measurement		Verify values
	Measure output voltage amplitude at the manual switchbox		

Item to be Verified		Reference standard	Remarks
	terminal block		
	Measure leakage current		

✓ When installed at site

Verify that site results match the performance check at the time of factory production.

(iv) Paint/coatings verification

For paint/coating verification, conduct visual inspection of base material, coating thickness, and coating appearance during factory production.

When installed at site, perform visual inspection of paint/coating.

(v) On-site commissioning adjustments

Item to be Verified		Remarks
Comprehensive commissioning	Vibration	There must be no abnormal vibration
	Noise	There must be no abnormal noise
Mechanism operation test		Check the operation of the instrument panel commands, illumination of indicator lights, and operation of various switches.
Sequence test	Interlock	Verify that each control mode works properly Verify the operation of alarms, etc., during failure
	Protective circuit formation	Verify the time from protection circuit formation to stop (warning)
Ventilation air velocity test		Measure air velocity and natural wind speed in the tunnel at each equipment and notch
Comprehensive interoperability test	Verify interoperability of the remote supervisory control facility	Each monitoring and control item must operate properly
	Interoperability test with emergency equipment and firefighting equipment	Fire signal and fire point must be properly input
	Interoperability test with power receiving and distribution equipment	Power failure and recovery control modes must operate properly

## 5600. TUNNEL FIRE FIGHTING SYSTEM

### (1) Fire Hydrants

#### (a) Overview and Configuration

Fire hydrants are installed on the inner wall of the tunnel. By operating the handle provided on the front of the 'fore tilting door' containing a nozzle, hydrant opening lever, etc., it will tilt forward to provide the tools necessary to extinguish fires. The equipment configuration shall be as follows:

Item	Quantity	
	Type A Hydrant	Type B Hydrant
Cabinet box	1 set	1 set
Shelf	1 set	1 set
Nozzle	1 set	1 set
Hose	1 pc.	1 pc.
Hose guide	1 set	1 set
Red signal light	1 pc.	1 pc.
Fire hydrant valve	1 pc.	1 pc.
Automatic pressure regulating valve	1 pc.	1 pc.
Combined automatic drainage and air release valve	1 pc.	1 pc.
Pump activation switch	1 pc.	1 pc.
Pump activation interlock switch	1 pc.	1 pc.
Push button alarm	1 pc.	1 pc.
Telephone jack	1 pc.	1 pc.
Circuit terminal	1 set	1 set
Equipment name plate	1 set	1 set
Water supply outlet	—	1 pc.
Fire extinguisher	2 pc.	2 pc.
Maintenance valve	1 pc.	1 pc.
Other accessories	1 set	1 set

#### (b) Specifications

- (i) Type: Fore tilting door with internal hose-attached fire hydrant
- (ii) Operating pressure range: 0.47–1.77 MPa (5–18 kgf/cm<sup>2</sup>)
- (iii) Cabinet box

The cabinet box shall have a structure divided into front cabinet A and rear cabinet B which are assembled with stainless steel bolts (SUS304). The cabinet box shall also have a plate attached that lists the name, type, manufacture date, manufacture number, and manufacturer name. The fire hydrant's fore tilting door shall be equipped with a handle, grip, equipment nameplate and instruction plate.

- ✓ Material

- Cabinet box: SUS304
- Handle: SCS13

- ✓ Coating: After applying heat-cured epoxy powder coating, the front surface and visible frame surface shall be finished with a urethane resin coating.

(iv) Shelf

- ✓ Material: SUS304 shaped steel
- ✓ Surface treatment: Unpainted

(v) Nozzle

The nozzle shall be able to change the shape of discharged water stream between a straight stream pattern and wide spray pattern.

- ✓ Type: Grip head switchable variable spray nozzle
- ✓ Discharge water pressure and flow rate:
  - Straight stream pattern 0.29 MPa (3.0 kgf/cm<sup>2</sup>) 130L/min (-0% to +10%)
  - Wide spray pattern 0.29 MPa (3.0gf/cm<sup>2</sup>) 130L/min (-0% to +10%)
- ✓ Effective range: min. 20 m (when using straight stream)
- ✓ Maximum spray expansion angle: 100°
- ✓ Nominal diameter: 40A
- ✓ Material: AC7A

(vi) Hose

The hose shall be shape-retaining and stored in its wrapped form inside the box.

- ✓ Type: shape-retaining gummed cloth hose
- ✓ Stored length: 30 m
- ✓ Nominal diameter: 32A
- ✓ Material: Main material, polyester

(vii) Hose guide

The fore tilting door shall have a hose guide attached to ensure the hose can be pulled out smoothly.

- ✓ Material: SUS304

(viii) Fire hydrant valve

The fire hydrant valve shall be equipped with a cam which causes an interlock switch to activate when the ball valve, which is opened/closed via a connected wire, is operated by lever on the fore tilting door.



- ✓ Type: Ball valve
- ✓ Nominal diameter: 32A
- ✓ Material
  - Body: CAC406
  - Wire: SUS304

(ix) Automatic pressure regulating valve

An automatic pressure regulating valve shall be provided to adjust the discharge pressure of the nozzle, keeping it constant regardless of fluctuation in the hydrant's primary pressure. Its specifications shall be as follows.

- ✓ Type: Bellofram type automatic pressure regulating valve
- ✓ Nominal diameter: 32A
- ✓ Material: CAC406

(x) Combined automatic drainage and air release valve

There shall be valve that combines the functions of draining residual water that has collected in the fire hydrant valve's secondary side, and aspirate the air required to drain water that remains in the hose after being used to discharge water.

- ✓ Type: Flat seated automatic drain valve/air release valve
- ✓ Nominal diameter: 15A
- ✓ Material: CAC406

(xi) Red signal light

- ✓ Type: Jetproof structure
- ✓ Lamp: LED lamp
- ✓ Cover globe: Red methacrylic resin
- ✓ Rating: AC 100V  $\pm$  10% 10mA

(xii) Pump activation switch

- ✓ Type: Jetproof structure with non-locking push button switch
- ✓ Contact rating: AC 110V/DC 110V 5A/2.2A
- ✓ Contact configuration: 1a

(xiii) Pump activation interlock switch

- ✓ Type: Jetproof structure, limit switch
- ✓ Contact rating: AC 125V/DC 125V 10A/0.4A
- ✓ Contact configuration: 1a

(xiv) Push button alarm

The push button notification system shall conform to the standards set by the Ministry of Home Affairs for P-type Grade 1 Transmitting Devices, and shall be constructed with a jetproof push button switch.

- ✓ Transmitter body
  - Material
    - ✧ Body: SUS304
    - ✧ Resin glass: Methacrylic resin
  - Coating: Uncoated
- ✓ Push button switch
  - Type: Non-locking push button switch
  - Contact rating: AC 110V/DC 110V 5A/2.2A
  - Contact configuration: 1a, 1b

(xv) Telephone jack

- ✓ Type: Plug-in telephone jack
- ✓ Standard: Japan Fire Alarms Manufacturer's Association, Unified Standard

(xvi) Circuit terminal

A terminal block shall be set inside a sealed cabinet box with a jetproof structure that includes cable connectors at the cable feed-in/draw-out location.

- ✓ Cabinet box
  - Material
    - ✧ Body: ABS resin
    - ✧ Lid: Polycarbonate resin
- ✓ Terminal block
  - Synthetic resin

(xvii) Water supply outlet (Type B fire hydrant only)

The hydrants, which supply water to firefighting vehicles, etc., shall have the following specifications.

- ✓ Format: 65A×90° fire department dedicated outlet tap
- ✓ Nominal diameter: 65A
- ✓ Hose connection method: Plug-in type
- ✓ Material: CAC406

(xviii) Fire extinguisher

- ✓ Type: ABC powder type fire extinguisher, 6.0 kg
- ✓ Extinguishable fire types: A-5, B-12, C-1

- ✓ Skirt: Corrosion resistant coating

(xix) Maintenance valve

A maintenance valve shall be provided to temporarily interrupt water supply to the hose to allow maintenance and inspection to be conducted. Its specifications shall be as follows.

- ✓ Type: Spring-type flow switching valve
- ✓ Nominal diameter: 32A
- ✓ Material: CAC406

**(2) Exterior Water Supply Outlet**

**(a) Overview**

An exterior water supply outlet shall be installed near the tunnel entrance for firefighting as well as to provide water to fire engines and for tunnel cleaning, etc.

A water supply outlet shall also be installed near the tunnel entrance to enable fire engines, etc. to supply water to the distribution main.

**(b) Specifications**

(i) Water supply outlet

- ✓ Type: Wall embedded dual outlet water supply outlet
- ✓ Discharge port: 65 mm×2 outlets
- ✓ Hose connection port: Plug-in type
- ✓ Material
  - Body: FCD450
  - Main section: CAC406
- ✓ Maximum working pressure
  - East portal: 1.37 MPa (14 kgf/cm<sup>2</sup>)
  - West portal: 1.77 MPa (18 kgf/cm<sup>2</sup>)
- ✓ Connection flange
  - East portal: JIS10K FF 100A
  - West portal: JIS16K FF 100A

(ii) Water outlet

- ✓ Type: Wall embedded dual outlet
- ✓ Discharge port: 65 mm×2 outlets
- ✓ Hose connection port: Plug-in type
- ✓ Material
  - Body: FCD450

- Main section: CAC406
- ✓ Maximum working pressure
  - East portal: 1.37 MPa (14 kgf/cm<sup>2</sup>)
  - West portal: 1.77 MPa (18 kgf/cm<sup>2</sup>)
- ✓ Connection flange
  - East portal: JIS10K FF 100A
  - West portal: JIS16K FF 100A
- (iii) Coating
  - ✓ Inside: Two coats of primer
  - ✓ Outside: Two coats of a nickel primer under a silver painted finish.

Parts, white bronze plating

### (3) Fire Pump

#### (a) Overview and Specifications

Firefighting pumps are used to supply the water required by fire hydrants, water supply outlets and the like. They shall comply with the requirements of “Standard Specifications for Public Buildings Construction - Machine and Equipment Construction” (Volume 3, Chapter 1, para. 12, sect. 1.12.1) [published by “Japanese Public Buildings Association”, 2016 for the Ministry of Land, Infrastructure, Transport and Tourism of Japan] with the specifications listed below:

Item		Specification
Pump	Model	Multistage centrifugal pump
	Discharge rate	1190 l/min
	Total pumping head	59 m
	Diameter	125A×125A
Electric motor	Format	Fully enclosed splash-proof three-phase induction motor
	Rating	Continuous
	Output	22 kW
	Rated voltage	400V
	Rotational speed	1500 rpm
	Frequency	50 Hz
	Insulation type	Min. Class E
	Activation method	Star-delta starting
Accessories		Compound pressure gauge Pressure gauge Drain cock Joint cover Phase flange Foundation bolt Nameplate Space heater Other necessary accessories

#### (4) Automatic Water Supply System

##### (a) Overview and Specifications

The automatic water supply system consists of a pump and pressure tank. A drop in pressure in the pressure tank will activate the pump to supply of water to replenish water in the tunnel's water distribution main, compensate for water leaks, etc. They shall comply with “Standard Specifications for Public Buildings Construction - Machine and Equipment Construction” (Volume 5, Chapter 1, para. 2, sect. 1.2.3) [published by “Japanese Public Buildings Association”, 2016], with the specifications listed below:

Item		Specification
Pump	Model	Multistage centrifugal pump
	Discharge rate	60 l/min
	Total pumping head	11 m
Electric motor	Format	Fully enclosed splash-proof three-phase induction motor
	Rating	Continuous
	Output	0.4 kW
	Rated voltage	3φ 3W 200V
	Rotational speed	3000 rpm
	Frequency	50 Hz
	Insulation type	Min. Class E
	Activation method	Direct activation
Accessories		Pressure tank Pressure sensor Terminal box Phase flange Foundation bolt Nameplate Other necessary accessories

Note) Operation is to be performed alternately.

#### (5) Water Intake Pump

##### (a) Overview and Specifications

The water intake pump, which supplies water to the water tank, shall have the following specifications.

Item		Specification
Pump	Model	Submersible pump
	Discharge rate	90 l/min
	Total pumping head	114 m
	Diameter	40 A
Electric motor	Format	Water sealed three-phase induction motor
	Rating	Continuous
	Output	5.5 kW
	Rated voltage	3φ 3W 200V
	Rotational speed	3000 rpm
	Frequency	50 Hz

	Insulation type	Min. Class E
	Activation method	Direct activation
Accessories	Compound pressure gauge Underwater cable Cable band Phase flange Nameplate Other necessary accessories	

## (6) Motorized Ball Valve (Inlet Valve)

### (a) Overview and Specifications

A discharge valve shall be installed to prevent the main distribution pipe from freezing. It shall have the following specifications.

Item		Specification
Valve body	Format	Flanged electric ball valve
	Nominal diameter	40A JIS10K FF
	Material	Body-FC200
	Maximum working pressure	1.37Mpa (14 kgf/cm <sup>2</sup> )
Electric motor	Format	3-phase induction motor (4-pole)
	Rating	10 min.
	Rated voltage	200V
	Frequency	50 Hz
	Output	40 W
	Torque	125 N/m
	Insulation class	Class E
	Space heater	8 W

## (7) Automatic Air Vent Valve

### (a) Overview and Specifications

An automatic air vent valve shall be installed on piping to release air trapped when filling the distribution main pipe. It shall have the following specifications.

Item	Specification
Format	Automatic Air Vent Valve
Nominal diameter	20 A
Material	Pump room: CAC406 (main unit), SUS304 (float) Intake tank: SUS304 (main body), SUS304 (float)
Maximum working pressure	Pump room: 0.98 MPa (10 kgf/cm <sup>2</sup> ) Intake tank: 1.96 MPa (20 kgf/cm <sup>2</sup> )

## (8) Safety Valve

### (a) Overview and Specifications

The safety valve is installed to prevent the pressure inside the main pipe from

rising above a certain value. Its specifications shall be as follows.

Item	Specification
Format	Safety Valve
Nominal diameter	50 A
Material	Pump room: FC200 (body) Intake tank: SCPH2 (body)
Maximum working pressure	Pump room: 0.98 MPa (10 kgf/cm <sup>2</sup> ) Intake tank: 1.96 MPa (20 kgf/cm <sup>2</sup> )

## (9) Flow Regulation Valve

### (a) Overview and Specifications

A flow regulation valve shall be installed for water intake of the distribution main to regulate the volume of water taken in. Its specifications shall be as follows.

Item	Specification
Format	Flow Regulation Valve
Nominal diameter	40 A
Material	Body: FC 200
Maximum working pressure	1.37 MPa (14 kgf/cm <sup>2</sup> )
Confined flow	90 l/min

## (10) Disaster Prevention Reception Panel

### (a) Overview

A disaster prevention reception panel (hereinafter, “disaster prevention panel”) displays the occurrence of a fire or similar disaster upon receiving a signal from a device such as a push button alarm, etc. It can start up firefighting equipment as well as sending signals to a remote supervisory control facility, ventilation equipment, warning display equipment, lighting equipment, CCTV equipment, and the like.

### (b) Applicable Legislation and Standards

- Japan Fire regulations and standards
- Japan Industrial Standard (JIS)
- Japanese Electrotechnical Committee standards (JEC)
- Japan Electrical Manufacturers' Association (JEM)
- Japan Electrical equipment technical standards
- Other relevant laws, regulations and standards

In addition to the above-mentioned items, equipment and facilities shall also conform to “Technical Standards Relating to Receivers” prescribed by ordinance of the Ministry of Internal Affairs and Communications of Japan.

Equivalent international standards will be allowed if duly justified by the Contractor, and approved by the Engineer.

(c) **General Matters**

- (i) Indoor temperature and humidity
  - ✓ Temperature: +5°C to +35°C
  - ✓ Humidity: Max. 85% (no condensation permitted)
- (ii) Model
  - Indoor freestanding enclosed type
- (iii) Structure
  - ✓ Material and thickness [Cold-reduced Carbon Steel Sheet and Strip (JIS G 3141)]
    - Door: minimum t3.2
    - Side: minimum t1.6
    - Ceiling: minimum t1.6
  - ✓ Cable lead-in and feed-out methods
    - In principle, cables shall be led-in/fed-out from under the board.
  - ✓ External wiring connection
    - External wiring must be implemented accurately. Terminals, etc., shall be appropriate for the thickness, type and voltage of the wire to be connected, and not function abnormally when exposed to dust or moisture.
  - ✓ Doors and handles
    - A hinged door with a lock shall be installed on the front and rear sides.
  - ✓ Equipment in the board
    - Internal lighting (AC 100V fluorescent lighting)
      - Each hinged door shall be equipped with at least one light.
    - ✧ Lights shall automatically turn on or off when the door is opened or closed.
    - ✧ Outlet for internal inspection (AC 100V)
    - ✧ Phone: A telephone check for maintenance phones or plug-in phones shall be provided.
  - ✓ Circuit protection
    - Power reception circuit: A surge absorber capable of withstanding an impulse current of at least 2,000A shall be installed between each line.
    - I/O circuit (for emergency equipment installed in tunnel): A surge absorber capable of withstanding an impulse current of at least 2,000A shall be installed between each signal line, common line, and line-to-ground. A protective circuit shall also be provided for



each circuit to prevent a total board failure due to short-circuiting on the secondary side.

- Signal input circuit: A variable type 1–15 second delay function shall be provided on push button alarms and fire hydrant activation signal circuits to provide time to determine if the signal was a malfunction caused by the lightning surge, etc.

(iv) Electric system

- ✓ The power receiving system shall be a dual power supply consisting of:
  - an uninterruptible power supply (emergency power source) that receives power from emergency power supply equipment in the event of a commercial power outage, and
  - general commercial power supply (for internal lighting, etc.).

The temporary power interruption time of the emergency power supply shall be no more than 250m.

- ✓ The power receiving system shall be configured as follows:
  - Emergency power supply: AC single-phase two-wire,  $100V \pm 10\%$ , 50 Hz
  - General power supply: AC single-phase two-wire,  $100V \pm 10\%$ , 50 Hz
- ✓ Supplied Power: Power supply to monitoring equipment shall be as follows:
  - Fire hydrant: DC 48V
  - Fire detector: DC 48V
  - Red signal light: AC single phase 2-wire,  $100V \pm 10\%$ , 50 Hz

(v) Grounding

The cabinet ground shall be Class D grounding at one location.

(vi) Commercial frequency withstand voltage

- ✓ 100V circuit: 1,000V to ground
- ✓ Circuits of 60V or less: 500V to ground

However, the semiconductor applied circuit shall be short-circuited or separated.

(vii) Wiring scheme

The wire type and color coating wire shall conform to standards of JEM 1425. However, the wire color coating does not need to follow this standard when using specialized insulated wire for the main circuit or when using specialized wires such as shielded wire. Further, this paragraph does not apply to the wiring of small circuits such as electronic circuits or the internal wiring of devices such as relays.

(viii) Coating

- ✓ Method: Coating shall be a semi-gloss melamine baked enamel.
- ✓ Coating color: Munsell 5Y7/1.

**(d) Installation Location and Number of Panels**

Installation location	Number of panels
Communication equipment room	1

**(e) Input Power**

Supply board	Voltage specification	Frequency	Remarks
Eastern communication room distribution board	AC 100V±10%, 1φ2W	50 Hz	Emergency power supply
Eastern Power Room House transformers (2)	AC 100V±10%, 1φ2W		Miscellaneous power sources

**(f) Functional Specifications**

The following functions shall be provided:

- ✓ Receive signals from fire detectors, circuit monitoring, detector testing
- ✓ Receive signals from push button alarms, circuit monitoring.
- ✓ Receive signals from fire hydrants and water supply outlets, circuit monitoring.
- ✓ Receive signals from connection line to emergency tunnel door
- ✓ Relay signals to the fire pump control board
- ✓ Relay signals to the remote supervisory control facility
- ✓ Send signals to ventilation control board
- ✓ Send signals to lighting equipment
- ✓ Send signals to CCTV equipment
- ✓ Send signals to warning display panel

**(g) Monitoring Control System**

The control and display functions shall be as follows.

**(i) Control**

Control functions shall conform to the following table.

Note that in the following table, items listed as follows commands from remote supervisory control facility (hereinafter, “remote facility”) only apply if the remote facility has the function in question.

Control Functions and Methods - Part 1

Control function	Control method	Content
Operating location switchover “Remote (distant) – Direct (straight)”	Switched over on control unit	Remote: Remotely controls emergency equipment via commands from remote control facilities Direct: Directly control using the operating unit
Selection of control method “Auto–Manual”	Switched over on control unit or follows commands from remote facility	Auto: Starts firefighting pump in conjunction with the operation of other emergency equipment (fire hydrant, pump start push button, push button alarm system, fire detector). Manual: Starts firefighting pump in conjunction with operation of the operating unit or emergency equipment (excluding fire detector). Receives commands from remote facility and starts firefighting pump
Full recovery operation “Recover”	Push button on operating unit or follows commands from remote facility	When in automatic mode, restores emergency equipment, operating unit displays, and outputs to other equipment, and returns to a monitoring state. Note that failures are excluded.
Selection of interlocking method “Independent–Interlocked”	Switched over on control unit or follows commands from remote facility	Blocks fire signal output to the warning display panel
Blocks external signals “Block External Signals”	Push button on operating unit	Blocks the output to other equipment (automatic notification warning, preliminary warning, automatic warnings, automatic notice section, and manual notice section) except for to the pump control board and other disaster prevention panels.

Control Functions and Methods - Part 2

Control function		Control mode		Control method
		Automatic	Manual	
Fire pump	Start (operate)	○	—	Operates in unison with fire hydrants, water supply outlets, push button alarm system, and fire detectors
		—	○	Operates in unison with fire hydrants, water supply outlets, and push button alarm system

Control function		Control mode		Control method
		Automatic	Manual	
		○	○	Operated by operating unit, or follows commands from remote facility
	Stop	—	○	Operated by operating unit, or follows commands from remote facility
		○	—	Operated by operating unit, or receives recovery commands from remote facility

### Control Functions and Methods - Part 3

Control function		Control method
System testing (Detector Test+Operation/Continuity Test)	Start	Follows commands from remote facility
	Stop	Remote: Switched by the operating unit (remote → direct) or follows commands from remote facility Direct: Switched by the operating unit (direct → remote) or follows stop operation
Periodic system testing (Detector Test+Operation/Continuity Test)	Start	Automatically started from disaster prevention panel when in remote mode
	Stop	Automatically stopped from disaster prevention panel when in remote mode
Detector test	Start	Operated by operating unit. Can only be started when in direct mode.
	Stop	Direct: Switched by the operating unit (direct → remote) or follows stop operation
Operation/continuity test	Start	Operated by operating unit. Can only be started when in direct mode.
	Stop	Direct: Switched by the operating unit (direct → remote) or follows recovery operation

#### (ii) Other notable matters

- ✓ If only one fire detector has been triggered the status is set as “preliminary warning” and a preliminary warning signal shall be output to equipment except for radio rebroadcasting equipment, ventilation equipment and the warning display panel to call attention to the status.
- ✓ If two or more fire detectors have been triggered, the status is set as “fire” and fire signal shall be output to all equipment.

- ✓ The push button alarm system shall comprise direct/parallel circuits consisting of 'a' and 'b' contacts, and a warning shall be displayed if either are activated.

The system should also be able to detect a disconnection or short-circuit as an abnormality in the push button circuit.

- ✓ If a push button alarm has been sent or firefighting pump is activated, all red signal lights shall flash intermittently.

#### (h) Board Display Items

In principle, the items to be displayed shall conform to the following table.

BL: Bell; BZ: Buzzer

Control function		Control method
System testing (Detector Test+Operation/Continuity Test)	Start	Follows commands from remote facility
	Stop	Remote: Switched by the operating unit (remote → direct) or follows commands from remote facility Direct: Switched by the operating unit (direct → remote) or follows stop operation
Periodic system testing (Detector Test+Operation/Continuity Test)	Start	Automatically started from disaster prevention panel when in remote mode
	Stop	Automatically stopped from disaster prevention panel when in remote mode
Detector test	Start	Operated by operating unit. Can only be started when in direct mode.
	Stop	Direct: Switched by the operating unit (direct → remote) or follows stop operation
Operation/continuity test	Start	Operated by operating unit. Can only be started when in direct mode.
	Stop	Direct: Switched by the operating unit (direct → remote) or follows recovery operation

Items not listed above that are functionally required shall also be provided.

#### (i) Board Operational Items

Item	Number of items	Remarks
Remote–Direct	1 each	
Auto–Manual	1 each	
Warning display panel, Independent–Interlocked	1 each	
Firefighting pump, Operate–Stop	1 each	
Recovery	1	
Sound stop	2	Primary sound, failure alert sound
Block external signals	1	

Item	Number of items	Remarks
Test unit	1 set	Including lamp testing

Items not listed above that are functionally required shall also be provided.

**(j) Other Equipment Inputs and Outputs**

Signals shall be relayed by a separately installed relay terminal board.

**(i) Remote supervisory control facility**

✓ Contact input specifications

Contact method	Non-voltage 'a' contact method
Contact capacity	DC 24V, 50mA or more
Duration	1 pulse signal per second, contact closes when there is a signal

✓ Controls from remote supervisory control facility

Item	Number of items
Auto-Manual	1 each
Fire detector test, Start-Stop	1 each
Firefighting pump, Operate-Stop	1 each
Warning display panel, Independent-Interlocked	1 each
Recover	1

✓ Contact output specifications

Contact method:	Non-voltage 'a' contact method
Contact capacity:	DC 24V or 48V, 100mA or less
Duration:	Continuous signal, contact closes if signal present

✓ Outputs to remote supervisory control facility

Item	Number of items	Remarks
Disaster prevention panel:		
direct (mode)	1	
manual (mode)	1	
Warning display panel, independent	1	
Disaster prevention inspection in progress	1	
Automatic notice section	55	
Manual notice section	14	
Automatic notification warning	1	
Fire detector, preliminary warning	1	
Fire hydrant, in use	1	
Fire extinguishing pump:		
independent	1	
operating	1	
failure	1	
Automatic water supply system:		
operating	2	No.1, No.2

Item	Number of items	Remarks
failure	2	
abnormal pressure	1	
Water intake pump		No.1, No.2
operating	2	
failure	2	
Intake valve:		
open	1	
failure	1	
Main water tank, water level	3	Overfilled, low water, dry
Intake tank, water level	1	Dry
Connection line to emergency tunnel door, open	14	
Testing	1	
Detector test:		
fault detected unit number	1 set	BCD code
contaminated	1	
contamination warning	1	
circuit failure	1	
Manual alarm system, circuit failure	1	
Fire hydrant, circuit disconnection	1	
Connection line to emergency tunnel door, circuit disconnection	1	
Fire detector, short-circuit	1	
Disaster prevention panel, failure	1	
Firefighting pump control board, failure	1	
Water intake pump control board, failure	1	

Items not listed above that are functionally required shall also be provided.

(ii) Other equipment

✓ Contact output specifications

Contact method:	Non-voltage 'a' contact method
Contact capacity:	DC 24V or 48V, 100mA or less However, output to lighting only shall be DC 110V 100mA or less
Duration:	Continuous signal, contact closes if signal present

✓ Outputs to tunnel ventilation equipment from disaster prevention panel

Item	No. of items	Remarks
Automatic notice section	1	2 or more detectors have been triggered
Manual notice section	1	

✓ Outputs to warning display panel from disaster prevention panel

Item	No. of items	Remarks
Automatic notice section	1	2 or more detectors have been triggered

Manual notice section	1	
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✓ Outputs to CCTV equipment from disaster prevention panel

Item	No. of items	Remarks
Automatic notice section	55	1 or more detectors have been triggered
Manual notice section	14	

✓ Outputs to lighting equipment from disaster prevention panel

Item	No. of items	Remarks
Automatic notice section	1	1 or more detectors have been triggered
Manual notice section	1	

✓ Outputs to rebroadcasting equipment (AM/FM shared) from disaster prevention panel

Item	No. of items	Remarks
Automatic notice section	2	2 or more detectors have been triggered
Manual notice section	2	

## (11) Fire Pump Control Board

### (a) Overview

The fire pump control board receives signals from the disaster prevention panel, water level gauges, etc., and then controls various pumps and accessories and sends signals.

### (b) Applicable standards

- ✓ Japanese Electricity Business Act
- ✓ Japanese Electrical Appliance and Material Safety Law
- ✓ Japanese Ministerial Ordinances that set technical standards related to electrical equipment
- ✓ Japan Electrical Manufacturers' Association (JEM)
- ✓ Japan Industrial Standard (JIS)

Equivalent international standards will be allowed if duly justified by the Contractor, and approved by the Engineer.

### (c) General Matters

- (i) Overload and open-phase protection devices shall be equipped for each motor. Overload and open-phase protection devices shall automatically prevent the occurrence of overcurrent due to overload or open phase, preventing motor burnout.  
However, in the case of firefighting pumps, they shall not be halted due



to failures from overload or open phase.

- (ii) Ammeters shall be extended scale ammeters (with red pointers) and be provided for each electric motor.
- (iii) Capacity of the leading power factor capacitor shall be selected as follows: for 200V motors it shall be selected based on power supply regulations of electric power companies; for 400V/high voltage motors it shall be selected such that power factor after improvement at the rated output is at least 90%.
- (iv) Operating and stopped status indicator lights shall be provided for each motor, and protective relay operational indicators shall be provided for each protective relay.
- (v) Model: Indoor freestanding enclosed type
- (vi) Structure

- ✓ Material and thickness [Cold-reduced Carbon Steel Sheet and Strip (JIS G 3141)]
  - Door: minimum t3.2
  - Side plate: minimum t1.6
  - Ceiling plate: minimum t1.6
- ✓ Lead-in and feed-out methods: In principle, cables shall be led-in/fed-out from under the board.
- ✓ Doors and handles

Freestanding types shall have a hinged door on the front.

The opening direction shall be either left hinge (right handle) or right hinge (left handle) and those lined-up in the same row of a board shall all be consistent in configuration and opening direction.

The handle rotating direction shall be as follow:

- Left hinged: Door opens by turning the handle clockwise.
- Right hinged: Door opens by turning the handle counterclockwise.

Door handles shall have a key lock, using Takigen model A-140 (key, No.200).

- (vii) Equipment in the board

- ✓ Internal lighting (AC 100V fluorescent lighting)

Each hinged door shall be equipped with at least one light.

Lights shall automatically turn on or off when the door is opened or closed.

- ✓ Outlet for internal inspection (AC 100V)

(viii) Coating

- ✓ Substrate treatment: Parkerizing
- ✓ Undercoating:
  - 1 coat of melamine primer
  - 1 coat of melamine surface coating
- ✓ Top coating: 2 coats of melamine resin baked enamel
- ✓ Coating color: Munsell 5Y7/1 semi-gloss (both inside and outside)
- ✓ Thickness: 40 µm minimum

(d) Installation Location and Number of Panels

Installation location	No. of panels
Pump room	1

(e) Input Power

Supply board	Voltage specification	Frequency	Remarks
Eastern Power Room Maintenance switching No.1	AC415V±10%, 3φ3W	50 Hz	In-house power generation circuit
Eastern Power Room Maintenance switching No.2	AC210V±10%, 3φ3W		

(f) Load Capacity

Load	Voltage specification	Load Capacity	Remarks
Fire pump	AC 400V	22 kW	Star-delta starting
Automatic Water Supply System	AC200V	0.4 kW×2	Full-voltage starting
Intake valve		0.04 kW	
Heater to prevent condensation		0.05 kW	Fire pump
Control circuit		0.3 kVA	
Miscellaneous power sources		0.6 kVA	

However, the automatic water supply system and intake pump shall be operated by automatically alternating.

(g) Monitoring method

(i) Control mode

- ✓ Firefighting pump start/stop is controlled by a signal from the disaster prevention panel
- ✓ Each pump's start/stop is controlled by a push button switch on the control board.
- ✓ Each valve's open/close is controlled by a push button switch on the

control board.

(ii) Display method: Display shall be illuminating type.

(iii) Board mounted equipment

✓ Operation

- “Independent–Interconnected” switchover switch
- Pump 'Operate–Stop' push button switch
- Valve 'open-close' push button switch

✓ Display

- Instruments (ammeter, voltmeter, hour meter)
- Status indicator lamps for various board mounted operating switches
- Status indicator lamps for fires, various pumps, and water level.

Items not listed above that are functionally required shall also be provided.

#### (h) Monitoring Control Items

Type \ Item	Control	Display	Remarks
Fire	—	1	
Firefighting pump:			
• Independent–Interconnected	1	1 each	
• operate–stop	1 each	1 each	
• failure	—	1	
Automatic water supply system:			
• Auto–Manual	1	1 each	
• operate–stop	2 each	2 each	No.1, No.2
• failure	—	2	No.1, No.2
• abnormal pressure	—	1	
Water intake pump, independent	—	1	
Water intake pump:			
• Auto–Manual	1	1 each	
• operate–stop	1 each	1 each	
• failure	—	2	No.1, No.2
Water intake valve:			
• Auto–Manual	1	1 each	
• open–close	1 each	1 each	
• failure	—	1	
Main water tank, water level	—	6	Overfilled, standard level, low water, dry Water intake pump, Operate–Stop
Intake tank, water level	—	1	Dry

Type \ Item	Control	Display	Remarks
Fire hydrant, in use	—	1	
Firefighting pump control board, failure	—	1	
Water intake pump control board, failure	—	1	
Power supply	—	1	
Sound stop	—	1	
Lamp test	1	—	
Temperature control	1	—	
Pressure regulator	1	—	

Items not listed above that are functionally required shall also be provided.

(i) **Signal Relay with Other Equipment**

(i) Disaster Prevention Reception Panel

✓ Contact input specifications

Contact method:	Non-voltage 'a' contact method
Contact capacity:	DC 24V or 48V, 50mA or over
Duration:	Continuous signal, contact closes if signal present

✓ Inputs from disaster prevention panel

Item	No. of items
Fire	1
Firefighting pump:	
• operate command	1
• Stop command	1
Fire hydrant, in use	1

✓ Contact output specifications

Contact method:	Non-voltage 'a' contact method
Contact capacity:	DC 24V or 48V, 100mA or less
Duration:	Continuous signal, contact closes if signal present

✓ Outputs to disaster prevention panel

Item	Number of items	Remarks
Fire extinguishing pump:		
• independent	1	
• operating	1	
• failure	1	
Automatic water supply system:		
• operating	2	No.1, No.2
• failure	2	No.1, No.2
• abnormal pressure	1	
Water intake pump:		

Item	Number of items	Remarks
• operating	2	No.1, No.2
• failure	2	No.1, No.2
Intake valve:		
• open	1	
• failure	1	
Main water tank, water level	5	Overfilled, low water, dry Water intake pump, Operate-Stop
Intake tank, water level	1	Dry
Water distribution system, checking	1	
Firefighting pump control board, failure	1	
Water intake pump control board, failure	1	

Items not listed above that are functionally required shall also be provided.

## (12) Water Intake Pump Control Board

### (a) Overview

The water intake pump control board receives signals from the fire fighting pump control board, and controls pumps and sends signals to the main tank to maintain water supply.

### (b) Applicable standards

- ✓ Japanese Electricity Business Act
- ✓ Japanese Electrical Appliance and Material Safety Law
- ✓ Japanese Ministerial Ordinances that set technical standards related to electrical equipment
- ✓ Japan Electrical Manufacturers' Association (JEM)
- ✓ Japan Industrial Standard (JIS)

Equivalent international standards will be allowed if duly justified by the Contractor, and approved by the Engineer.

### (c) General Matters

- (i) Overload and open-phase protection devices shall be equipped for each motor. Overload and open-phase protection devices shall automatically prevent the occurrence of overcurrent due to overload or open phase, preventing motor burnout.
- (ii) Ammeters shall be extended scale ammeters (with red pointers) and be provided for each electric motor.
- (iii) For 200V motors, capacity of the leading power factor capacitor shall be

selected based on power supply regulations of electric power companies.

- (iv) Operating and stopped status indicator lights shall be provided for each motor, and protective relay operational indicators shall be provided for each protective relay.
- (v) Model: Outdoor standing type
- (vi) Structure
  - ✓ Material and thickness [Cold-reduced Carbon Steel Sheet and Strip (JIS G 3141)]
    - Outdoor standing type
      - Door: minimum t2.3
      - Side plate: minimum t2.3
      - Ceiling plate: minimum t2.3
  - ✓ Lead-in and feed-out methods: In principle, cables shall be led-in/fed-out from under the board.
  - ✓ Doors and handles: A hinged door with a lock shall be installed on the front.
- (vii) Equipment in the board
  - ✓ Internal lighting (AC 100V fluorescent lighting)
 

For freestanding types, each hinged door shall be equipped with at least one light.

Lights shall automatically turn on or off when the door is opened or closed.
  - ✓ Outlet for internal inspection (AC 100V)
- (viii) Coating: Finishing shall be zinc hot-dip galvanizing (HDZ35)

**(d) Installation Location and Number of Panels**

Installation location	No. of panels
Naubise entrance	1

**(e) Input Power**

Supply board	Voltage specification	Frequency
Western Power Room Maintenance switching No.2	AC210V±10%, 3φ3W	50 Hz

**(f) Load Capacity**

Load	Voltage specification	Load Capacity	Remarks
Water intake pump	AC200V	5.5 kW×2	Full-voltage starting
Control circuit		0.3 kVA	

Miscellaneous power sources		0.6 kVA	
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However, the water intake pump shall be operated by automatically alternating.

**(g) Monitoring method**

(i) Control mode

- ✓ Water intake pump start/stop is controlled by the signal from the firefighting pump control board.
- ✓ Water intake pump start/stop is controlled by a push button switch on the control board.

(ii) Display method: Display shall be illuminating type.

(iii) Board mounted equipment

- ✓ Operation
  - “Independent–Interconnected” switchover switch
  - Pump 'Operate–Stop' push button switch
- ✓ Display
  - Instruments (ammeter, voltmeter, hour meter)
  - Status indicator lamps for various board mounted operating switches
  - Status indicator lamps for fires and various pumps

Items not listed above that are functionally required shall also be provided.

**(h) Monitoring Control Items**

Type \ Item	Control	Display	Remarks
Fire	—	1	
Firefighting pump, operating	—	1	
Water intake pump:			
• Independent–Interconnected	1	1 each	
• operate–stop	2 each	2 each	No.1, No.2
• failure	—	2	No.1, No.2
Water intake pump control board, failure	—	1	
Intake tank, water level	—	1	Dry
Power supply	—	1	
Lamp test	1	—	

Items not listed above that are functionally required shall also be provided.

**(i) Signal Relay with Other Equipment**

(i) Fire pump control board

✓ Contact input specifications

Contact method:	Non-voltage 'a' contact method
Contact capacity:	DC 24V or 48V, 50mA or over
Duration:	Continuous signal, contact closes if signal present

✓ Inputs from the firefighting pump control board

Item	No. of items
Fire	1
Firefighting pump:	
• operating	1
Water intake pump:	
• operate command	1
• stop command	1

✓ Contact output specifications

Contact method:	Non-voltage 'a' contact method
Contact capacity:	DC 24V or 48V, 100mA or less
Duration:	Continuous signal, contact closes if signal present

✓ Outputs to the firefighting pump control board

Item	No. of items	Remarks
Water intake pump:		
• independent	1	
• operating	2	No.1, No.2
• failure	2	No.1, No.2
Intake tank, water level	1	Dry
Water intake pump control board, failure	1	

Items not listed above that are functionally required shall also be provided.

### (13) Terminal Board

#### (a) Overview

The terminal board relays the electrical circuits of equipment in the tunnel.

#### (b) General Matters

(i) Model: Outdoor wall-embedded type

(ii) Structure

- ✓ Structure: The terminal board shall have a double structure comprising an inner box and outer box. The front panel of the outer box shall be fastened with stainless steel bolts.
- ✓ Material and thickness: Cold-rolled Stainless Steel Plate, Sheet and Strip (JIS G 4305), minimum t1.5
- ✓ Waterproof (inner box only): Jetproof structure JIS C 0920



(Degrees of Protection Provided by Enclosures)

- ✓ Heat resistance: Insulation (of rock wool at least 25 mm thick) shall be fitted on the inside of the outer box (excluding the back surface) to provide heat resistance.

(iii) Coating: Based on consultation with the contracting party.

#### (14) Fire Detectors

##### (a) Overview

Fire detectors automatically detect fires that break out in the tunnel and notify the Disaster Prevention Panel of its location.

##### (b) Applicable Legislation and Standards

- ✓ Japan Fire regulations and standards
- ✓ Japan Industrial Standard (JIS)
- ✓ Japan Electrical equipment technical standards

Equivalent international standards will be allowed if duly justified by the Contractor, and approved by the Engineer.

##### (c) General Matters

- (i) Ambient temperature: -20°C to +50°C.
- (ii) Detection method: Dual-wavelength flicker detection method
- (iii) Method: Direct sending (P) method
- (iv) Structure
  - ✓ Material and thickness
    - Fire detector body: Aluminum Alloy Die Castings (JIS H 5302) ADC12
    - Fire detector box, front plate, shade plate  
Cold-rolled Stainless Steel Plate, Sheet and Strip (JIS G 4305), minimum t1.2
  - ✓ Light sensor window: The light sensor window shall have a streamlined shape that resists adhesion of suspended pollutants to reduce the amount of contamination that adheres to it.
  - ✓ Waterproofing
    - Watertight structure JIS C 0920
    - (Degrees of Protection Provided by Enclosures)
- (v) Electric system
  - ✓ Power supply voltage: DC 48V (+10%, -20%)
  - ✓ Current consumption
    - When monitoring: 13 mA

- When operating: 35 mA
- When testing: 50 mA

(vi) Coating: Based on consultation with the contracting party.

**(d) Functions**

- (i) Fire detection: Opposing view commonality detection
- (ii) Monitoring range and sensitivity: Within a 0-85% sensor contamination rate, the fire detector shall can detect a 0.5m<sup>2</sup> (0.7×0.7 m flash pan) gasoline fire (2 l or more of vehicle gasoline) within 50 m at 90° to its left and right and 20m in front (max. distance in the diagonal direction is 53.9 m) and activate within 30 seconds. Wind speed when burning shall be no more than 12 m/sec.
- (iii) Non-activating conditions: The detector shall not activate under the following conditions subjected to its sensor window.
  - ✓ 5000 lx incandescent light bulb with a filament temperature of 2856±50 K
  - ✓ 10,000 lx sodium light
  - ✓ 10,000 lx fluorescent light
  - ✓ 10,000 lx natural light
  - ✓ 1,000 lx revolving light (yellow, red, blue, green, violet)
- (iv) Functionality testing: Detectors shall have a function allows them to be tested from the disaster prevention panel while being installed in the tunnel.
- (v) Operation check: It must be possible to visually check if a detector is operating by the presence of an LED light etc.
  - LED: Red, green (2 on each left and right)
  - Normal monitoring: Lights off
  - Triggered: Red LED brightly flashes intermittently
  - After being triggered: Red LED dimly flashes intermittently
  - When testing: Green LED flashes intermittently
- (vi) Contaminated/inoperative signal output: A signal shall be sent to warn when optical light has fallen below 85%. Further, a contamination warning signal shall be sent when optical light has fallen below 75%.
- (vii) Contamination compensation: Detector sensitivity shall automatically compensate for sensor window contamination based on the light sensor window contamination measurement in the detector test. The detector shall can maintain the prescribed sensitivity up to an 85% contamination rate (optical light reduction rate).
- (viii) Self shutdown

To protect against powerful surges, detectors shall be equipped with resistive protection that acts as a fuse to avoid adverse impact on the system caused by a short circuit, etc., of electronic parts.

In the unlikely event that an overcurrent occurs in the internal circuit, the protective resistor will open, causing the detector to shut itself down and output a failure signal.

- (ix) Self-diagnosis: Even during normal monitoring and detector testing, the detector shall perform a self-diagnosis of its circuits and output a circuit failure signal if a circuit failure is detected.

## (15) Push Button Alarms (In Emergency Phone Boxes)

### (a) Overview and Configuration

A push button alarm shall be installed in every emergency phone box with the following configuration.

Component	Quantity
Cabinet box	1 set
Push button alarm	1 pc.
Telephone jack	1 pc.
Circuit terminal	1 set
Equipment name plate	1 set

### (b) Specifications

- (i) Cabinet box
  - ✓ Material: SPCC t1.6
  - ✓ Coating: Heat cured epoxy powder coating (Munsell 7.1R 3.6/12.8)
- (ii) Push button alarm: The push button notification system shall conform to the standards set by the Ministry of Home Affairs for P-type Grade 1 Transmitting Devices, and shall be constructed with a jetproof push button switch.
  - ✓ Transmitter body
    - Material
      - ① Body: SUS304
      - ② Acrylic glass: Methacrylic resin
    - Coating
      - ① Front: Heat cured epoxy powder coating (Munsell 7.1R 3.6/12.8)
  - ✓ Push button switch
    - Name: Non-locking push button switch
    - Contact rating: AC 110V/DC 110V 5A/2.2A
    - Contact configuration: 1a, 1b

- (iii) Telephone jack: Shall be of a jetproof structure.
  - ✓ Name: Plug-in telephone jack
  - ✓ Standard: Japan Fire Alarms Manufacturer's Association, Unified Standard  
(equivalent to the Defense Agency old standard JJ-033)
- (iv) Circuit terminal
  - ✓ Material: Synthetic resin
- (v) Equipment name plate
  - ✓ Material: Methacrylic resin
  - ✓ Lettering: Florescent red

# **(16) Pump Start Push Button Box**

## **(a) Overview and Configuration**

The pump start push button box shall have the following configuration.

Component	Quantity
Cabinet box	1 set
Pump start push button	1 pc.
Telephone jack	1 pc.
Circuit terminal	1 set
Equipment name plate	1 set

## **(b) Specifications**

- (i) Cabinet box [Cold-rolled Stainless Steel Plate, Sheet and Strip (JIS G 4305)]
  - ✓ Material: minimum t1.2
  - ✓ Coating: Based on consultation with the contracting party.
- (ii) Pump start push button
  - ✓ Type: Jetproof structure with non-locking push button switch
  - ✓ Contact rating: AC 110V/DC 110V 5A/2.2A
  - ✓ Contact configuration: 1a
- (iii) Telephone jack: Shall be of a jetproof structure.
  - ✓ Name: Plug-in telephone jack
  - ✓ Standard: Japan Fire Alarms Manufacturer's Association, Unified Standard  
(equivalent to the Defense Agency old standard JJ-033)
- (iv) Circuit terminal
  - ✓ Material: Synthetic resin

- (v) Equipment name plate
  - ✓ Material: Methacrylic resin
  - ✓ Lettering: Black on white background

## 5700. DISTRIBUTION LINE

### (1) Description

This product is a tube for protecting the cable inside the tunnel. Since it has a rectangular structure, it has high external pressure strength and position stability is good when laying multiple stages, so that a nozzle stand like a cylindrical tube becomes unnecessary and it is possible to compactly form a multi-channel line, Since the pipe is in close contact with the pipe, backfilling is very easy and curved piping is also easy. In addition, since the pipe material is lightweight and has flexibility, it has good workability, has high water barrier against external water pressure, and has low wire resistance

### (2) Basic Requirement

Protective tubes shall meet the following criteria

Item	Characteristic value
Density(kg/m3)	942 more
Tensile yield stress(MPa)	19.6 more

## 5800. MEASUREMENT AND PAYMENT

### (1) Measurement

The works for the Tunnel Facilities shall be measured in lump sum but summarized in each Sub-Section herein described, prorating the actually provided and installed items against the total of each Sub-Section shown here below. The items to be counted shall be only those duly installed, tested in accordance with the requirements of this Specifications, and approved by the Engineer.

For final measurement, each Sub-Item shall be measured counting only the items that have been satisfactorily tested according to the Quality Control and Commissioning herein described, and in accordance with Clause 509(3): “Testing and Commissioning” and conforming the requirements of Clause 9: “Test on Completion” of the Conditions of Contract, and after confirmation of proper function of the established system, satisfying all requirements of these Specifications, in accordance with the Drawings, and approved by Engineer.

### (2) Payment

The works for the Tunnel Facilities, measured as described above, shall be paid under this Section in lump sum which shall be the full and the final compensation to the Contractor as per Clause 112 including the cost for Design Review and

Updating, provision of all materials, equipment, all operations required for construction as shown in the Drawings and described in this Item including drawings, tests, cabling, civil works and all other ancillary works and any incidental work needed to complete the work as per these Specifications and/or directed by the Engineer.

Item No.	Description	Unit
<b>5000</b>	<b>Tunnel Facilities</b>	
5100	Tunnel Power Supply System	lump sum
5200	Tunnel Lighting System	lump sum
5300	Tunnel Emergency Facilities	lump sum
5400	Remote Monitoring And Control System	lump sum
5500	Tunnel Ventilation System	lump sum
5600	Tunnel Fire Fighting System	lump sum
5700	Tunnel Distribution line	lump sum

## 5100 Tunnel Power Supply System

### (1) Power Receiving & Distribution Facility (East Electric Room)

Item	Standard	Quantity	Unit
Lead-in Switch Board (1) A Line	3P DS 12kV 1200A LA 14kV 5kA×3 Voltage Detector	1	Panel
Lead -in Switch Board (2) B Line	3P DS 12kV 1200A LA 14kV 5kA×3 Voltage Detector	1	Panel
Draw-in Board(1) A Line	3P DS 12kV 1200A	1	Panel
Draw-in Board(1) B Line	3P DS 12kV 1200A	1	Panel
Receiving Panel(1) A Line	VCB 12kV 630A 25kA	1	Panel
Receiving Panel (1) B Line	VCB 12kV 630A 25kA	1	Panel
Ventilation Transformer(1)—Primary Board Ventilation Transformer(2)—Primary Board	VCB 12kV 630A 25kA×2	1	Panel
Lighting Transformer—Primary Board West Electrical Room Transmission Board(1) A Line	VCB 12kV 630A 25kA×2	1	Panel
Bus Connecting Board (1)	VCB 12kV 630A 25kA	1	Panel
Bus Connecting Board (2)	VCB 12kV 630A 25kA	1	Panel
Generator Connecting Panel West Electrical Room Transmission Board(2) B Line	VCB 12kV 630A 25kA×2	1	Panel
Generator Power Switch Board	3P DT-DS 12kV 1200A LA 14kV 5kA×3	1	Panel
West Electric Power Transmission Board Generator Circuit Maintenance power board	VCB 12kV 630A 25kA×2	1	Panel
West Electric Room Transmission Switching Board	3P DT-DS 12kV 1200A	1	Panel
Ventilation transformer board (1)	3 φ Tr 300kVA (Mold)	1	Panel
Ventilation transformer secondary board (1)	3P MCCB 550V	1	Panel
Ventilation transformer board (2)	3 φ Tr 300kVA (Mold)	1	Panel
Ventilation transformer secondary board (2)	3P MCCB 460V	1	Panel
Lighting transformer board	3 φ Tr 300kVA (Mold)	1	Panel
Lighting transformer secondary board	3P MCCB 460V	1	Panel
Transformer Board in Electric Room (1)	3 φ Tr 75kVA (Mold)	1	Panel
Transformer Board in Electric Room (2)	Scott 75kVA (Mold)	1	Panel
Lighting Control Board	Automatic Dimming Device	1	Panel
Tunnel Lighting Board (1)	MCCB 2P MCCB 3P MC	1	Panel
Tunnel Lighting Board (2)	MCCB 3P	1	Panel
Uninterruptive Power Device Input & Output Board	Tr 3 φ 10kVA (Dry Type) Scott Tr 30kVA	1	Panel
Uninterruptive Power Device Inverter Board	Regular Inverter Feeding System INV 3 φ 30kVA CONV	1	Panel
Uninterruptive Power Device Battery Board	BATT MSE Long Battery Life 100Ah/180Cell	1	Panel

Item	Standard	Quantity	Unit
CVV Cable	CVV-S 3.5sq-4C	22	m
IV Wire	IV 14sq	43	m
HV XLPE AL Cable	11kV HV XLPE Alumium 400sq-3C	18	m
HV XLPE AL Cable	11kV HV XLPE Alumium 240sq-3C	211	m
CV Cable	600V CV 150sq-3C	105	m
	600V CV 100sq-3C	58	m
	600V CV 38sq-3C	170	m
	600V CV 22sq-3C	45	m
	600V CV 14sq-3C	36	m
	600V CV 8sq-3C	181	m
	600V CV 8sq-2C	89	m
	600V CV 5.5sq-3C	77	m
	600V CV 5.5sq-2C	357	m
CVV Cable	CVV-S 3.5sq-4C	12.3	m
	CVV 2sq-15C	19.4	m
	CVV 2sq-10C	51.4	m
	CVV 2sq-5C	65.6	m
	CVV 2sq-4C	71.7	m
	CVV 2sq-3C	53.8	m
IV Wire	IV 60sq	10.7	m
	IV 38sq	225.6	m
		15.4	m
		128.9	m
Terminal Treatment	11kV HV XLPE Alumium 400sq-3C	13	Set
	11kV HV XLPE Alumium 240sq-3C	6	Set
	600V CV 150sq-3C	1	Set
	600V CV 100sq-3C	2	Set
	600V CV 38sq-3C	2	Set
	600V CV 22sq-3C	2	Set
	600V CV 14sq-3C	2	Set
IV Wire	IV 60sq	8	m
	IV 5.5sq	24	m
Impact Resistance Hard	HIVE (36)	25	m
Polyvinyl Conduit	HIVE (22)	18	m
Ground Copper plate	900*900*1.5t	3	Set
Ground Pole	φ 14*1500 with lead terminal	2	Set



(2) Power Receiving & Distribution Facility (West Electric Room)

Item	Standard	Quantity	Unit
Draw-in board (1) A Line	3P DS 12kV 1200A	1	Panel
Draw-in board(2) Bline	3P DT-DS 12kV 1200A	1	Panel
Receiving Panel (1) A Line	VCB 12kV 630A 25kA	1	Panel
Receiving Panel(2) Bline	VCB 12kV 630A 25kA	1	Panel
Maintenance Power	VCB 12kV 630A 25kA	1	Panel
Ventilation Transformer(1)—Primary Board	VCB 12kV 630A 25kA×2	1	Panel
Ventilation Transformer(2)—Primary Board	VCB 12kV 630A 25kA×2	1	Panel
Lighting Transformer Primary Board	VCB 12kV 630A 25kA×2	1	Panel
Spare Board	VCB 12kV 630A 25kA	1	Panel
Bus Connecting Board	VCB 12kV 630A 25kA	1	Panel
Ventilation transformer board (1)	3 φ Tr 300kVA (Mold)	1	Panel
Ventilation transformer secondary board (1)	3P MCCB 550V	1	Panel
Ventilation transformer board (2)	3 φ Tr 300kVA (Mold)	1	Panel
Ventilation transformer secondary board (2)	3P MCCB 460V	1	Panel
Lighting transformer board	3 φ Tr 200kVA (Mold)	1	Panel
Lighting transformer secondary board	3P MCCB 460V	1	Panel
Transformer Board in Electric Room (1)	3 φ Tr 75kVA (Mold)	1	Panel
Transformer Board in Electric Room (2)	Scott 75kVA (Mold)	1	Panel
Lighting Control Board	Automatic Dimming Device	1	Panel
Tunnel Lighting Board (1)	MCCB 2P MCCB 3P MC	1	Panel
Tunnel Lighting Board (2)	MCCB 3P	1	Panel
Uninterruptive Power Device	Tr 3 φ 10kVA (Dry Type)	1	Panel
Input & Output Board	Scott Tr 20kVA	1	Panel
Uninterruptive Power Device	Regular Inverter Feeding System	1	Panel
Inverter Board	INV 3 φ 20kVA CONV	1	Panel
Uninterruptive Power Device	BATT MSE Long Life Battery Type	1	Panel
Battery Board	100Ah/180Cell	1	Panel
DC Power Supply Device For Control	BATT MSE Type CONV 3 φ Thyristor 50Ah/54Cell	1	Panel
Maintenance Switching Board No.1	3 φ 415V System	1	Panel
Maintenance Switching Board No.2	3 φ 220 System 1 φ 220V 105V System	1	Panel
Grounding Terminal Board	With Ground Terminal 7 ET2 A, A(LA), B, C, D, A (Communication)	1	Panel
Control Center For Ventilation (1)	MCCB 3P MC SC	1	Panel
Control Center For Ventilation (2)	MCCB 3P MC SC	1	Panel
HV XLPE AL Cable	11kV HV XLPE Alumium 240sq-3C	307	m
HV XLPE AL Cable	11kV HV XLPE Alumium 240sq-3C	5498	m
HV XLPE AL Cable	11kV HV XLPE Alumium 240sq-3C	85	m
CV Cable	600V CV 150sq-3C	77	m
	600V CV 100sq-3C	50	m
	600V CV 100sq-2C	13	m
	600V CV 38sq-3C	36	m
	600V CV 38sq-2C	26	m
	600V CV 14sq-3C	18	m
	600V CV 8sq-3C	60	m
	600V CV 8sq-2C	63	m
	600V CV 5.5sq-3C	244	m
	600V CV 5.5sq-C	271	m
CVV Cable	CVV 2sq-10C	66	m
	CVV 2sq-5C	55	m
	CVV 2sq-4C	78	m
	CVV 2sq-3C	44	m
I VWire	IV 60sq	25	m
	IV 38sq	75	m

Item	Standard	Quantity	Unit
	IV 22sq	14	m
	IV 14sq	88	m
Terminal Treatment	11kV HV XLPE Alumium 240sq-3C	10	Set
	600V CV 150sq-3C	10	Set
	600V CV 100sq-3C	2	Set
	600V CV 100sq-2C	2	Set
	600V CV 38sq-3C	4	Set
	600V CV 38sq-2C	4	Set
	600V CV 14sq-3C	2	Set
Straight Connecting	6.6kV CVT 60sq	23	Set
IV Wire	IV 100sq	21	m
	IV 60sq	10	m
	IV 5.5sq	27	m
Impact Resistance Hard Polyvinyl Conduit	HIVE (36)	23	m
	HIVE (22)	21	m
Ground Copper Plate	900*900*1.5t	3	Set
Ground Pole	φ 14*1500	2	Set

### (3) Generator Facility

Item	Standard	Quantity	Unit
AC Generator	11kV 50Hz 625kVA or more	1	Set
Diesel Engine	Radiator cooling type 546 kW or more	1	Set
Generator board	VCB 12kV 630A 25kA	1	Panel
Automatic Starting Board		1	Panel
DC Supply Board for Starting		1	Panel
Exhaust silencer	85dB(A)	1	Set
Fuel Discharge Tank	Including light oil 900 frame	1	Set
Wing Pump	Diameter For 20A	1	Set
Fuel Transfer Pump	0.75kW	2	Set
Oil Filter Port Box	With Indicator	1	Set
Air Supply Fan	Damper with Hood 5.5 kW	2	Set
Air Supply Hood	Bird Wire Netting For Prevention	1	Set
Exhaust Hood	With Damper Hood	1	Set
Carbon Steel Pipe For piping	SGP-250A	8.7	m
	SGP- 65A	6.8	m
	SGP- 40A	7.6	m
	SGP- 32A	13.6	m
	SGP- 25A	29.6	m
Gate Valve	For SGP- 25A	7	Set
Check Valve	For SGP- 25A	2	Set
Reducer	200A×250A	1	Set
Reducing Elbow	40A×40A×25A	1	Set
Exhaust Deflection Tube	200A-250L	1	Set
Fuel Flexible Pipe	65A-300L	1	Set
	40A-300L	3	Set
	25A-300L	7	Set
	32A-300L	1	Set
Vent Hole	32A	2	Set
Rock Wool Insulation	75t	16.1	m <sup>2</sup>
Galvanized Steel Plate	0.5t	13.6	m <sup>2</sup>
HV XLPE AL Cable	11kV HV XLPE Alumium 240sq-3C	16.5	m
CV Cable	CV 8sq-2C	11.8	m
	CV 5.5sq-3C	11.8	m
	CV 3.5sq-4C	15.4	m
	CV 3.5sq-3C	24.2	m
CVV Cable	CVV 2sq-13C	11.8	m
	CVV 2sq-3C	27	m
CV Cable	CV 3.5sq-4C	7.8	m
	CV 3.5sq-3C	8.7	m
CVV Cable	CVV 2sq-3C	8.7	m
CVV Cable	CVV 2sq-3C	4.5	m
Terminal Treatment	11kV HV XLPE Alumium 240sq-3C	2	Set
Polyethylene Lined Steel Pipe	PE 22	4.5	m

## 5200 Tunnel Lighting System

Item	Standard	Quantity	Unit
Basic Lighting Lamp	Aluminium LED108W	274	Set
	Aluminium LED36W	176	Set
Entrance Lighting Lamp	Aluminium LED280W	250	Set
	Aluminium LED240W	40	Set
	Aluminium LED200W	28	Set
	Aluminium LED160W	14	Set
	Aluminium LED120W	38	Set
	Aluminium LED80W	56	Set
	Aluminium LED60W	9	Set
	Aluminium LED40W	14	Set
Division Switch	For SUS press type 3 Circuits	6	Set
	For SUS press type 2 Circuits	6	Set
	For SUS press type 1 Circuit	4	Set
ELB Board		13	Set
Automatic Dimming Device	4 Steps	2	Panel
Light Receiver	Luminance type	2	Set
LED Road Lighting Lamp	LED150W	4	Set
Joint Box	For Connection	4	Set
For evacuation tunnel inside	LED30W	236	Set
600V CV Cable	CV3. 5Sq-3C	274	m
600V CV Cable	CV5. 5Sq-3C	54	m
600V CVV Cable	CVV3. 5Sq-3C	26	m
600V CVV Cable	CVV3. 5Sq-4C	26	m
600V CVV Cable	CVV2. 0Sq-3C	4	m
Signal Cable	FCPEV-S0. 9-5P	26	m
600V IV Wire	IV22Sq	4	m
600V CV Cable	CV3. 5Sq-3C	4371	m
600V CV Cable	CV5. 5Sq-3C	252	m
600V CVV Cable	CVV3. 5Sq-3C	217	m
600V CVV Cable	CVV3. 5Sq-4C	217	m
600V CVV Cable	CVV2. 0Sq-3C	1624	m
Signal Cable	FCPEV-S0. 9-5P	184	m
600V IV Wire	IV22Sq	216	m
600V CV Cable	CV3. 5Sq-3C	152	m
600V CV Cable	CV5. 5Sq-3C	40	m
600V CVV Cable	CVV3. 5Sq-3C	32	m
600V CVV Cable	CVV3. 5Sq-4C	32	m
600V IV Wire	IV22Sq	32	m
600V CV Cable	CV3. 5Sq-3C	9879.5	m

Item	Standard	Quantity	Unit
600V CV Cable	CV5. 5Sq-3C	2875	m
600V CVV Cable	CVV3. 5Sq-3C	5245.3	m
600V CVV Cable	CVV3. 5Sq-4C	1213.6	m
600V IV Wire	IV22Sq	5293.3	m
600V FP Cable	FP3. 5Sq-3C	4581.2	m
Prefabricated Branching Material for FP		92	Set
Prefabricated Branching Material		826	Set
Cable Rack	W150 Standard section	4010	m
	W200 Standard section	1180	m
	W150 Parking Area Section	186	m
	W150 Parking Area Corner	30	m
Bracket	W150 Standard section	1348	Set
	W200 Standard section	400	Set
	W150 Parking Area Section	66	Set
	W150 Parking Area Corner	24	Set
Concrete anchor	M10×70 (SUS)	3676	Set
600V CV Cable	CV3. 5Sq-3C	45	m
600V IV Wire	IV3. 5Sq	29	m
600V CV Cable	CV3. 5Sq-3C	140	m
600V IV Wire	IV3. 5Sq	140	m
600V CV Cable	CV3. 5Sq-3C	2962.14	m
600V IV Wire	IV3. 5Sq	2962.14	m
	Prefabricated Branching Material	236	Set
	T-shaped branch material	8	Set
Cable Support Bracket	L=100 SUS	2964	Set
Cable Hold Bracket		2964	Set
Concrete anchor	M6×45 (SUS)	2964	Set

### 5300 Tunnel Emergency Facilities

Item	Standards	Quantity	Unit
Evacuation guide display board		27	panel
Evacuation guide display board		7	panel
Emergency exit display lamp		7	panel
Emergency exit display lamp (with caution)		7	panel
Warning not to rush out display lamp		7	panel
Emergency parking area • Emergency telephone		6	panel
600V CV cable	CV3. 5Sq-3C	35	m
600V CV cable	CV3. 5Sq-3C	5417	m
DL type information boards		2	panel
EL type information board		6	panel
Monitoring control panel type III		1	panel
Monitor panel		6	panel
Emergency phone		18	stand
Storage box		12	panel
Emergency telephone box		6	panel
P B X		1	panel
Control cable	FCPEV-S0. 9-10P	104	m
Control cable	FCPEV-S0. 9-5P	104	m
Control cable	FCPEV-S0. 9-10P	88	m
Control cable	FCPEV-S0. 9-5P	88	m
600V CV cable	CV3. 5Sq-3C	40	m
600V CV cable	CV8. 0Sq-2C	10	m
600V CV cable	CV5. 5Sq-2C	10	m
Control cable	FCPEV-S0. 9-10P	11280	m
Control cable	FCPEV-S0. 9-5P	12821	m
600V CV cable	CV3. 5Sq-3C	5774	m
600V CV cable	CV8. 0Sq-2C	2644	m
600V CV cable	CV5. 5Sq-2C	2034	m

## 5400 Tunnel Monitoring and Control System

### (1) Monitoring control

Item	Standards	Quantity	Unit
Integrated management server rack		1	set
Processing unit 1 (integrated management server)		1	stand
Processing unit 2 (integrated management server)		1	stand
Maintenance console / KVM switch		1	stand
L2SW		1	stand
Storage rack	W700×H2000×D1000	1	frame
Transmission rack for facility management 1		1	rack
PLC		1	stand
Storage rack	W600×H2000×D600	1	rack
Relay terminal board A	W600×H2000×D600	1	stand
Transmission rack for facility management 2	W600×H2000×D600	1	stand
Large display monitor device	W4000×H2350×D800	1	stand
Multi-vision control device	Implementation on monitor board	1	stand
L2SW	Implementation on monitor board	1	stand
Operation terminal (disaster prevention system / facility system / traffic system)		1	stand
Console (OA desk)		1	stand
LAN cable	Cat5e-4P	3.0	m
LAN cable	Cat5e-4P	41.5	m
Communication cable	Optical cord (4 core code)	10.0	m
Power cable	CV5.5sq-2C	15.0	m
Power cable	CV5.5sq-2C	80.0	m
Power cable	IV5.5sq	10.0	m

## (2) Radio Rebroadcasting System & Wireless Communication System

Item	Standards	Quantity	Unit
FM receiving antenna	Yagi antenna / 3EL	8	unit
FM receiver		8	CH
FM broadcast switching unit		2	stand
FM transmitter unit	3W	8	CH
FM output mixing unit	8ch	1	set
Attenuator		1	stand
Operation control unit (IP)		1	stand
Radio voice conversion unit	VoIP(1ch)	1	stand
L2SW		1	stand
Audio level adjustment section		1	stand
Voice memory section		1	stand
Power supply part		1	stand
Terminal part		1	stand
PC (KB・mouse)		1	set
Software		1	set
Display unit		1	stand
Microphone		1	stand
Speaker		1	stand
Audio amplification unit		1	stand
Radio voice conversion unit	VoIP(1ch)	1	stand
L2SW		1	stand
Storage table (OA desk)	Including the terminal unit	1	stand
Spare and accessories		1	set
Sign plate		2	panel
10D-2V	10D-2V	19.0	m
10D-2V	10D-2V	4.0	m
10D-2V	10D-2V	37.5	m
10D-2V	10D-2V	18.0	m
10D-2W	10D-2W	76.0	m
10D-2W	10D-2W	28.0	m
10D-2W	10D-2W	92.0	m
10D-2W	10D-2W	1676.0	m
50mm or less	L-LCX-43D-55-HR	1168.0	m
50mm or less	L-LCX-43D-65-HR	1500.0	m
CX-20D	CX-20D	25.5	m
CX-20D	CX-20D	226.0	m
DCX	DCX-10D-HR	21.5	m
DCX-10D-HR	DCX-10D-HR	10.5	m
LAN cable	Cat5e-4P	34.0	m
Thick steel conduit	G28	27.0	m
Post-installed anchor	M12	526.0	set
Post-installed anchor	M12 (anchor metal fitting)	76.0	set
Centering and positioning	L-LCX	2668.0	m
Connector	N-J-43D	24.0	set
Connector	NJ-CX20D	8.0	set
Connector	N-P-10D	24.0	set
Connector	NP-10W	16.0	set
Connector	N-P-DCX-10D	26.0	set



Item	Standards	Quantity	Unit
Fixing clip	S-DC31DC28	6.0	set
Falling prevention band	L-LCX	526.0	set
Anchor metal fitting	One side anchor metal fitting (L-LCX)	14.0	set
Anchor metal fitting	Both sides anchor metal fitting (L-LCX)	5.0	set
Pull Box	250×250×200(SUS)	1.0	set
Fixing channel	S-D1S15	6.0	set
Intermediate hanger metal fitting	L-LCX	526.0	set
Power cable	CV5.5sq-2C	33.0	m
Power cable	IV5.5sq	6.0	m
Preamplifier		3	stand
Power amplifier 1	Emergency parking area (120W)	1	stand
Power amplifier 2	For evacuation connecting tunnel(60W)	1	stand
Power amplifier 3	For portal (60W)	1	stand
Monitor unit		1	stand
Power supply unit		1	stand
Terminal unit		1	stand
Storage rack	W570×H2350×D600	1	rack
Loudspeaker for portal	25W	2	stand
Loudspeaker for emergency parking area	15W	6	stand
Loudspeaker for evacuation connecting tunnel	5W	7	stand
Microphone box		8	stand
Thick steel conduit	G28	166.6	m
Different fittings	G28-FEP30	13.0	set
Connection kit (straight connection)	Resin injection type	5.0	set
Connection kit (branch connection)	Resin injection type	10.0	set
Fixing clip	S-DC31DC28	17.0	set
Communication cable	FCPEV-S1.2sq-5P	6.3	m
Communication cable	FCPEV-S1.2sq-5P	8.0	m
Communication cable	FCPEV-S1.2sq-5P	4825.2	m
Communication cable	FCPEV-S1.2sq-5P	34.6	m
Pull Box	200×200×100(SUS)	13.0	set
Fixing channel	S-D1S15	6.0	set
Power cable	CV3.5sq-2C	9418.5	m
Power cable	CV3.5sq-2C	62.5	m
Power cable	CV5.5sq-2C	11.0	m
Power cable	FP3.5sq-2C	162.4	m
Power cable	FP3.5sq-2C	27.0	m
Wireless device for road manager		1	stand
Wireless operation terminal for management		1	stand
Radio base station device		1	stand
Base station antenna	3 element Yagi antenna	2	unit
Distributor	2 distribution (1: 9)	1	stand
Portable wireless device		12	stand
Shared device		1	stand
Shared termination unit		1	stand
Wireless connection terminal box (POLICE)		2	stand
Wireless connection terminal box (FIRE)		2	stand

### (3) Closed Circuit Television System

Item	Standards	Quantity	Unit
Outside camera (turning)		4	stand
Inside camera (turning)		4	stand
Inside camera (turning)		9	stand
CCTV control panel 1 Outside camera (turning)		4	stand
CCTV control panel 2 Inside camera (turning)		4	stand
CCTV control panel 3 Inside camera (turning)		9	stand
CCTV control device		1	set
Image storage server		1	stand
Media Converter		17	stand
LSW		1	stand
Storage rack	W700×H2000×D1000	1	rack
Optical terminal box	W700×H2000×D500	1	stand
Operation terminal (CCTV system)		1	stand
LAN cable	Cat5e-4P	17.0	m
Thick steel conduit	G22	57.8	m
Thick steel conduit	G28	15.3	m
Metal flexible conduit	#24	12.0	m
Metal flexible conduit	#30	9.0	m
Closure	SO-BD	13.0	set
Combination coupling	G22-#24	20.0	set
Combination coupling	G28-#30	9.0	set
Connection kit (straight line connection)	Resin injection type	2.0	set
Connection kit (branch connection)	Resin injection type	11.0	set
Fixing clip	S-DC25DC22	132.0	set
Fixing clip	S-DC31DC28	18.0	set
Optical cable	SM-20C	2755.5	m
Optical cable	SM-20C	9.5	m
Optical cable	SM-40C	1704.0	m
Optical cable	SM-40C	9.5	m
Optical cable	SM-4C	89.6	m
Optical cable	SM-4C	5.2	m
Optical cable	SM-4C	387.0	m
Optical cable	SM-8C	16.2	m
Optical cable	SM-8C	7.0	m
Optical cable	SM-8C	1169.5	m
Optical cable	SM-8C	11.5	m
Box connector	#24	16.0	set
Box connector	#30	9.0	set
Fixing channel	S-D1S15	52.0	set
Communication cable	Optical cord (4 core code)	187.0	m
Power cable	CV3.5sq-3C	32.4	m
Power cable	CV3.5sq-3C	12.0	m
Power cable	CV3.5sq-3C	4920.5	m
Power cable	CV3.5sq-3C	26.0	m
Power cable	CV5.5sq-2C	22.0	m
Power cable	FP2.0sq-2C	57.2	m
Power cable	FP2.0sq-2C	5.2	m
Power cable	HIV5.5sq	26.0	m
Power cable	IV5.5sq	2.0	m

## 5500 Tunnel Ventilation System

Item	Standards	Quantity	Unit
Jet fan	JFX-1250 (High wind speed type)	15	set
Jet fan mounting fitting (Turnbuckle)	A-L L1=610 L2=250	16	set
Jet fan mounting fitting (Turnbuckle)	A-C L1=730 L2=350	16	set
Jet fan mounting fitting (Turnbuckle)	A-R L1=1480 L2=900	16	set
Jet fan mounting fitting (Turnbuckle)	B-L L1=1480 L2=900	14	set
Jet fan mounting fitting (Turnbuckle)	B-C L1=730 L2=350	14	set
Jet fan mounting fitting (Turnbuckle)	B-R L1=610 L2=250	14	set
Manual switch box (for two unit)	MCCB3P×225AF (Grade A heat-resistant) × 2	4	panel
Manual switch box (for two unit)	MCCB3P×225AF×2	3	panel
Manual switch box (for one unit)	MCCB3P×225AF×1	1	panel
Ventilation measurement control panel	W1000×H2350×D1000 FB control, inverter control, low wind speed reduction control, measurement processing unit	1	panel
Ventilation ganged board	W800×H2350×D800 With flue gas manual function	1	panel
Inverter control board for ventilation	W1400×H2350×D1200	4	panel
CO meter	Constant potential electrolysis including mounting fitting	2	set
VI meter (projection)	Constant potential electrolysis including mounting fitting	2	set
VI meter (reception)	Constant potential electrolysis including mounting fitting	2	set
VI meter power box	W420×H400×D120(SUS304-2t) Exclusive cable (attached)	4	panel
AV meter	Ultrasonic including mounting fitting	2	set
AV meter converter box	W600×H600×D200(SUS304-2t) Exclusive cable (attached)	2	panel
600vCV cable 2C	CV 3.5sq-2C	51.7	m
600vCV cable 3C	CV 38sq-3C	56.4	m
600vCV cable 3C	CV 60sq-3C	58.5	m
600vCV cable 3C	CV 100sq-3C	14.8	m
600vCV cable 3C	CV 150sq-3C	70.8	m
600vIV wire	IV 3.5sq	2.9	m
600vIV wire	IV 38sq	2.9	m
600vCVV cable	CVV 2sq-3C	8.3	m
600vCVV cable	CVV 2sq-10C	8.3	m
600vCVV cable	CVV 2sq-15C	6.9	m
600vCVV cable	CVV 2sq-20C	28.2	m
FCPEV signal cable	FCPEV0.65-70P	8.3	m
FCPEV-S signal cable	FCPEV-S0.9-30P	33.8	m
Terminal connection	CVV 2sq-3C	2	place
Terminal connection	CVV 2sq-10C	2	place
Terminal connection	CVV 2sq-15C	2	place
Terminal connection	CVV 2sq-20C	10	place
Terminal connection	FCPEV0.65-70P	2	place
Terminal connection	FCPEV-S0.9-30P	3	place
600vCV cable 2C	CV 3.5sq-2C	2072.2	m
600vCV cable 3C	CV 38sq-3C	1939.6	m
600vCV cable 3C	CV 60sq-3C	3852.2	m
600vCV cable 3C	CV 100sq-3C	1823.2	m
FCPEV-S signal cable	FCPEV-S0.9-5P	10	m
FCPEV-S signal cable	FCPEV-S0.9-10P	835	m
FCPEV-S signal cable	FCPEV-S0.9-15P	730	m
FCPEV-S signal cable	FCPEV-S0.9-20P	903	m
FCPEV-S signal cable	FCPEV-S0.9-30P	2970.8	m
600vCV cable 2C	CV3.5sq-2C	20.2	m
600vCV cable 3C	CV 38sq-3C	18.9	m
600vFPC cable 3C	FPC 38sq-3C	21.6	m
600vCV cable 4C	CV 38sq-4C	77.8	m
600vFPC cable 4C	FPC 38sq-4C	90.8	m
600vIV wire	IV3.5sq	20.2	m
600vIV wire	IV 14sq	21.6	m
FCPEV-S signal cable	FCPEV-S0.9-3P	5.6	m
FCPEV-S signal cable	FCPEV-S0.9-5P	14.6	m

Item	Standards	Quantity	Unit
Straight connection	CV3.5sq-2C×CV3.5sq-2C	4	place
Straight connection	CV38sq-3C×CV38sq-3C	2	place
Straight connection	CV38sq-3C×FPC38sq-3C	4	place
Straight connection	CV60sq-3C×CV38sq-3C	3	place
Straight connection	CV60sq-3C×CV60sq-3C	10	place
Straight connection	CV60sq-3C×FPC38sq-3C	4	place
Straight connection	CV100sq-3C×CV100sq-3C	6	place
Straight connection	CV100sq-3C×CV38sq-3C	2	place
Straight connection	0.9φ-15P×0.9-10P	1	place
Straight connection	0.9φ-15P×0.9-15P	1	place
Straight connection	0.9φ-15P×0.9-20P	1	place
Straight connection	0.9φ-30P×0.9-30P	5	place
Branch connection	CV 3.5sq×3.5sq×3.5sq	6	place
Branch connection	0.9φ-10P×5P×5P	1	place
Branch connection	0.9φ-10P×3P×10P	1	place
Branch connection	0.9φ-15P×5P×10P	1	place
Branch connection	0.9φ-20P×5P×15P	1	place
Branch connection	0.9φ-20P×3P×20P	1	place
Branch connection	0.9φ-30P×5P×20P	1	place
Branch connection	0.9φ-30P×5P×30P	1	place
Terminal connection	3P	2	place
Terminal connection	5P	6	place
Thick steel conduit	G22	23.6	m
Thick steel conduit	G28	192.8	m
Thick steel conduit	G36	2.8	m
Thick steel conduit	G42	135.8	m
Thick steel conduit	G54	10.4	m
Metal Flexible Conduit	φ 24×200L	4	set
Metal Flexible Conduit	φ 24×400L	12	set
Metal Flexible Conduit	φ 24×700L	2	set
Metal Flexible Conduit	φ 24×900L	2	set
Metal Flexible Conduit	φ 38×700L	4	set
Metal Flexible Conduit	φ 50×400L	7	set
Metal Flexible Conduit	φ 50×700L	8	set
Metal Flexible Conduit	φ 50×900L	7	set
Metal Flexible Conduit	φ 50×2000L	15	set
Metal Flexible Conduit	φ 63×400L	8	set
Fixing channel	30mm×40mm×100mm(SUS)	118	set
Fixing channel	30mm×40mm×150mm(SUS)	18	set
Fixing channel	30mm×40mm×200mm(SUS)	42	set
Fixing clip	For 22 (SUS)	36	set
Fixing clip	For 28 (SUS)	104	set
Fixing clip	For 36 (SUS)	8	set
Fixing clip	For 42 (SUS)	74	set
Fixing clip	For 54 (SUS)	16	set
U bolted support hardware	For G42-1 row (SUS)	16	set
U bolted support hardware	For G42-2 row (SUS)	14	set
Concrete anchor	M6×45(SUS)	238	set
Concrete anchor	M8×60(SUS)	60	set
Pull Box	PB200W×200H×100D(SUS)	4	panel
Concrete anchor	M8×60(SUS)	16	set

## 5600 Tunnel Fire Fighting System

Item	Standards	Quantity	Unit
Disaster prevention receiving board	Indoor self-standing type	1	panel
Disaster prevention receiving board	Indoor self-standing type	1	panel
Intake pump control panel	Indoor self-standing type	1	panel
Terminal board	20P	7	set
Fire detector		61	set
Fire detector	With light-shielding	5	set
Push-button alarm		3	set
Pump start button box	Outside type	2	set
FCPEV-S cable	FCPEV-S 0.9φ-100P	16.4	m
FCPEV-S cable	FCPEV-S 0.9φ-50P	15.3	m
FCPEV-S cable	FCPEV-S 0.9φ-20P	47	m
FCPEV-S cable	FCPEV-S 0.9φ-10P	16.4	m
CV cable	CV 5.5sq-2C	15.3	m
CV cable	CV 3.5sq-2C	28.1	m
CVV-S cable	CVV-S 8sq-2C	15.3	m
CVV cable	CVV 2sq-4C	15.3	m
IV wire	IV 3.5sq	15.3	m
FCPEV-S cable	FCPEV-S 0.9φ-50P	5.1	m
FCPEV-S cable	FCPEV-S 0.9φ-20P	10.2	m
CV cable	CV 14sq-3C	5.4	m
CV cable	CV 5.5sq-3C	5.5	m
CV cable	CV 3.5sq-3C	7.5	m
CV cable	CV 3.5sq-2C	13.6	m
CVV cable	CVV 2sq-4C	5.1	m
IV wire	IV 5.5sq	5.2	m
IV wire	IV 3.5sq	18	m
FCPEV-S cable	FCPEV-S 0.9φ-20P	2.7	m
FCPEV-S cable	FCPEV-S 0.9φ-10P	2.7	m
CV cable	CV 14sq-3C	2.7	m
CV cable	CV 5.5sq-3C	12.2	m
CV cable	CV 3.5sq-4C	5.7	m
CV cable	CV 3.5sq-3C	17.3	m
CV cable	CV 3.5sq-2C	6.1	m
CVV cable	CVV 2sq-8C	5.7	m
CVV cable	CVV 2sq-4C	25.8	m
IV wire	IV 5.5sq	8.8	m
IV wire	IV 3.5sq	7.3	m
Automatic water feeder supplied cable		7.3	m
FCPEV-S cable	FCPEV-S 0.9φ-20P	2.8	m
FCPEV-S cable	FCPEV-S 0.9φ-15P	16.8	m
FCPEV-S cable	FCPEV-S 0.9φ-7P	61.3	m
FCPEV-S cable	FCPEV-S 0.9φ-5P	1164.5	m
FCPEV-S cable	FCPEV-S 0.9φ-1P	188.3	m
CV cable	CV 5.5sq-2C	588.6	m
CVV cable	CVV 2sq-4C	29	m
CVV-S cable	CVV-S 3.5sq-2C	19.6	m
IV wire	IV 3.5sq	297	m

Item	Standards	Quantity	Unit
FCPEV-S cable	FCPEV-S 0.9φ-100P	227.4	m
FCPEV-S cable	FCPEV-S 0.9φ-70P	800	m
FCPEV-S cable	FCPEV-S 0.9φ-50P	800	m
FCPEV-S cable	FCPEV-S 0.9φ-30P	400	m
FCPEV-S cable	FCPEV-S 0.9φ-20P	48.2	m
FCPEV-S cable	FCPEV-S 0.9φ-15P	400	m
FCPEV-S cable	FCPEV-S 0.9φ-10P	3388	m
FCPEV-S cable	FCPEV-S 0.9φ-7P	480	m
FCPEV-S cable	FCPEV-S 0.9φ-5P	5415.5	m
FCPEV-S cable	FCPEV-S 0.9φ-3P	375	m
FCPEV-S cable	FCPEV-S 0.9φ-2P	340	m
CV cable	CV 14sq-3C	48.2	m
CV cable	CV 5.5sq-3C	1.9	m
CV cable	CV 5.5sq-2C	2737.3	m
CV cable	CV 3.5sq-3C	48.2	m
CVV-S cable	CVV-S 8sq-2C	2618.8	m
CVV cable	CVV 2sq-4C	13.6	m
CVV cable	CVV 2sq-3C	10.4	m
IV wire	IV 5.5sq	48.2	m
IV wire	IV 3.5sq	15.4	m
Intake pump supplied cable		23.4	m
Metal flexible conduit	#50	1.4	m
Metal flexible conduit	#38	3.1	m
Metal flexible conduit	#30	1	m
Metal flexible conduit	#24	1	m
Thick steel conduit	G36	254.1	m
Thick steel conduit	G28	46.2	m
Thick steel conduit	G22	301.9	m
Thick steel conduit	G22	185.5	m
SUS flexible	#36×500L	4	set
SUS flexible	#36×400L	3	set
SUS flexible	#28×500L	42	set
SUS flexible	#22×800L	2	set
SUS flexible	#22×500L	8	set
SUS flexible	#22×400L	29	set
Rigid polyethylene conduit with wave	FEP40	13	m
Rigid polyethylene conduit with wave	FEP30	37.2	m
Different pipe connecting material	FEP40-G36	2	set
Pull box	400×200×150	2	piece
Pull box	200×200×200	1	piece
Pull box	200×200×150	1	piece
Pull box	150×150×100	27	piece
FCPEV-S cable	FCPEV-S 0.9φ-50P	4	place
FCPEV-S cable	FCPEV-S 0.9φ-20P	5	place
FCPEV-S cable	FCPEV-S 0.9φ-15P	6	place
FCPEV-S cable	FCPEV-S 0.9φ-10P	2	place
FCPEV-S cable	FCPEV-S 0.9φ-7P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-5P	133	place
CV cable	CV 14sq-3C	2	place
CV cable	CV 5.5sq-3C	6	place
CV cable	CV 5.5sq-2C	110	place
CV cable	CV 3.5sq-4C	2	place
CV cable	CV 3.5sq-3C	6	place
CV cable	CV 3.5sq-2C	5	place

Item	Standards	Quantity	Unit
CVV-S cable	CVV-S 8sq-2C	1	place
CVV-S cable	CVV-S 3.5sq-2C	7	place
CVV cable	CVV 2sq-8C	2	place
CVV cable	CVV 2sq-4C	10	place
CVV cable	CVV 2sq-3C	1	place
IV wire	IV 5.5sq	4	place
IV wire	IV 3.5sq	6	place
Automatic water feeder supplied cable		2	place
Intake pump supplied cable		4	place
CVV-S cable	CVV-S 8sq-2C/3.5sq-2C	1	place
FCPEV-S cable	FCPEV-S 0.9φ-10P	6	place
FCPEV-S cable	FCPEV-S 0.9φ-100P/70P/20P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-70P/15P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-70P/50P/15P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-50P/15P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-70P/30P/15P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-30P/15P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-10P/7P/3P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-7P/3P	2	place
FCPEV-S cable	FCPEV-S 0.9φ-7P/5P/3P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-5P/3P	6	place
FCPEV-S cable	FCPEV-S 0.9φ-3P	55	place
CVV-S cable	CVV-S 8sq-2C/3.5sq-2C	1	place
IV wire	IV 3.5sq	6	place
FCPEV-S cable	FCPEV-S 0.9φ-100P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-10P	1	place
FCPEV-S cable	FCPEV-S 0.9φ-5P	130	place
Cable nameplate		644	sheet
Pump start button box mounting bracket	W=5,428kg, SUS	2	set
Breakwater tube	VP75	1.2	m
Intake pump	Water spiral, 90L / min × 114m × 5.5kw	2	stand
Gate valve	40A, screw, 16K	2	stand
Check valve (shock absorption)	40A, flange, 20K	2	stand
Strainer	Y-shaped, 40A, screw, 16K	2	stand
Safety valve	50A, flange, 20K	1	stand
Flexible joint	Buried type, 40A × 500L, flanges, 16K	1	stand
SGP-PD (in tank)	40A	3,096	m
SGP-PD (in tank)	Processing pipe T1	2	set
SGP-PD (in tank)	Processing pipe T2	2	set
SGP-PB (in drain)	40A	0.188	m
SGP-W (in drain)	50A	0.45	m
SGP-PB (in drain)	Processing pipe T3	4	set
SGP-PB (in drain)	Processing pipe T4	2	set
SGP-PB (in drain)	Processing pipe T5	1	set
SGP-PB (in drain)	Processing pipe T6	1	set
SGP-PB (in drain)	Processing pipe T7	1	set
SGP-PD(Buried)	40A	0.5	m
SGP-PD(Buried)	Processing pipe T1	3	set
SGP-PD(Buried)	Processing pipe T2	2	set
Elbow 90°	40A, screw, lining	4	piece
Cheese	40A, screw, lining	2	piece
Different diameter socket	50A × 40A, screw, lining	1	piece
Nipple	40A, screw, lining	1	piece
Elbow 90°	50A, screw, white	1	piece
Phase flange	50A, screw, JIS10K, white	1	sheet
Flange bolts and nuts	M16 × 60L, for 40A (16K), HDZ35	56	set
Flange bolts and nuts	M16 × 60L, for 50A (16K), HDZ35	8	set
Flange bolts and nuts	M16 × 60L, for 50A (10K), HDZ35	4	set
Piping support bracket	PS-T1, HDZ35	4	set
Piping insulation (in drain)	40A, PF20mm, colored aluminum glass cloth	2.779	m
Piping insulation (in drain)	50A, PF20mm, colored aluminum glass cloth	0.15	m

Item	Standards	Quantity	Unit
Warm valves (in drain)	40A, PF, stainless steel plate	2	place
Warm valves (in drain)	50A, PF, stainless steel plate	1	place
Fire hydrant A type	Push button + with fire extinguisher	42	stand
Fire hydrant B type	Push button + Fire extinguiher + with hydrant	13	stand
Fire extinguisher	ABC powder 6kg	110	set
Ball valve	40A, screw, 10K, pipe end proof corrosion	27	stand
Ball valve	40A, screw, 16K	15	stand
Ball valve	65A, flange, 10K	9	stand
Ball valve	65A, flange, 16K	4	stand
SCP-PB (outdoor)	40A	72.87	m
SCP-PB (outdoor)	65A	14.443	m
SCP-PB (outdoor)	80A	7.2	m
SCP-PB (outdoor)	Processing pipe H1	19	set
SCP-PB (outdoor)	Processing pipe H2	13	set
SCP-PB (outdoor)	Processing pipe H3	4	set
SCP-PB (outdoor)	Processing pipe H4	4	set
Elbow 90°	40A, screw, pipe end proof corrosion	54	piece
Elbow 90°	40A, screw, lining	30	piece
Elbow 90°	65A, screw, pipe end proof corrosion	18	piece
Elbow 90°	40A, screw, lining	8	piece
Different diameters elbow	80Ax40A, screw, pipe end proof corrosion	27	piece
Different diameters elbow	80Ax40A, screw, lining	15	piece
Different diameters elbow	80Ax65A, screw, pipe end proof corrosion	9	piece
Different diameters elbow	80Ax65A, screw, lining	4	piece
Phase flange	65A, screw, JIS10K, pipe end proof corrosion	18	sheet
Phase flange	80A, screw, JIS10K, pipe end proof corrosion	36	sheet
Flange bolts and nuts	M16 × 65L, for 65A (10K), HDZ35	72	set
Flange bolts and nuts	M16 × 65L, for 65A (16K), HDZ36	64	set
Flange bolts and nuts	M16 × 65L, for 80A (10K), HDZ37	288	set
Flange bolts and nuts	M20x75L, for 80A (16K), HDZ35	152	set
Support bracket for fire hydrant	PS-A1, SUS	55	set
Piping support bracket	PS-H1, HDZ35	84	set
Piping support bracket	PS-H2, HDZ35	26	set
Piping insulation (in tunnel)	40A, PF20mm, aluminum glass cloth	85.47	m
Piping insulation (in tunnel)	65A, PF20mm, aluminum glass cloth	23.985	m
Piping insulation (in tunnel)	80A, PF20mm, aluminum glass cloth	11	m
Warm valves (in the tunnel)	65A, PF, stainless plate	13	place
Outdoor hydrant supply port	Integrated, 16K	1	stand
Outdoor hydrant supply port	Integrated, 10K	1	stand
Outdoor hydrant supply port storage box		2	stand
Check valve (wafer type)	100A, 20K, stainless	1	stand
Check valve (wafer type)	100A, 10K, stainless	1	stand
Butterfly Valves	Wafer-shaped, 100A, 20K	2	stand
Butterfly Valves	Wafer-shaped, 100A, 10K	2	stand
SCP-PB (outdoor)	Processing pipe Q1	2	set
SCP-PB (outdoor)	Processing pipe Q2	1	set
SCP-PB (outdoor)	Processing pipe Q3	1	set
SCP-PB (outdoor)	Processing pipe Q4	1	set
SCP-PB (outdoor)	Processing pipe Q5	1	set
SCP-PB (outdoor)	Processing pipe Q6	1	set
SCP-PB (outdoor)	Processing pipe Q8	2	set
SCP-PB (outdoor)	Processing pipe Q9	1	set
SCP-PB (outdoor)	Processing pipe Q10	1	set
SCP-PB (outdoor)	Processing pipe Q11	1	set
SCP-PB (outdoor)	Processing pipe Q12	1	set
SCP-PB (outdoor)	Processing pipe Q13	1	set
SCP-PD (buried)	Processing pipe Q7	1	set
SCP-PD (buried)	Processing pipe Q14	1	set



Item	Standards	Quantity	Unit
Flange bolts and nuts	M20x80L, for 100A (16K) , HDZ35	56	set
Flange bolts and nuts	M16x70L, for 100A (10K) , HDZ35	56	set
Flange bolts and nuts	M20 × 150L, check valve for 100A (20K), HDZ35	8	set
Flange bolts and nuts	M16 × 130L, check valve for 100A (10K), HDZ35	8	set
Flange bolts and nuts	M20 × 130L, Butterfly valve for 100A (20K), HDZ35	16	set
Flange bolts and nuts	M16 × 120L, Butterfly valve for 100A (10K), HDZ35	16	set
Piping support bracket	PS-Q1, HDZ35	2	set
Piping support bracket	PS-Q2, HDZ35	2	set
Piping insulation (outdoor exposure)	100A, PF25mm, stainless	4,566	m
valves warm (outdoor exposure)	100A, PF, stainless plate	10	place
Butterfly Valves	Wafer-shaped, 150A, 10K	4	stand
Butterfly Valves	Wafer-shaped, 150A, 16K	9	stand
Butterfly Valves	Wafer-shaped, 150A, 20K	2	stand
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x5000L, mortar lining	474	set
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x4540L, mortar lining	38	set
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x4034L, mortar lining	10	set
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x4000L, mortar lining	4	set
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x3480L, mortar lining	3	set
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x3136L, mortar lining	6	set
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x2654L, mortar lining	3	set
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x2114L, mortar lining	1	set
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x1964L, mortar lining	1	set
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x1380L, mortar lining	3	set
T-shaped ductile cast iron pipe (3 type) straight pipe	φ150x1260L, mortar lining	3	set
T-shaped ductile cast iron profiled pipe T-shaped tube with a flange	φ150xφ75, flange JIS10K	36	set
T-shaped ductile cast iron profiled pipe T-shaped tube with a flange	φ150xφ75, flange JIS16K	19	set
Flange type ductile cast iron profiled tube flange length pipe	φ150, flange JIS10K	1	set
Flange type ductile cast iron profiled tube flange length pipe	φ150, flange JIS16K	1	set
T-shaped ductile cast iron profiled tube short pipe No. 1	φ150, flange JIS10K	4	set
T-shaped ductile cast iron profiled tube short pipe No. 1	φ150, flange JIS16K	12	set
T-shaped ductile cast iron profiled tube short pipe No. 2	φ150, flange JIS10K	5	set
T-shaped ductile cast iron profiled tube short pipe No. 2	φ150, flange JIS16K	11	set
T-shaped ductile cast iron profiled pipe bend 45 °	φ150	12	set
Flange bolts and nuts	M20x80L, for 150A (10K) , HDZ35	8	set
Flange bolts and nuts	M22x90L, for 150A (16K) , HDZ35	12	set
Flange bolts and nuts	M20 × 130L, Butterfly valve for 150A (10K), HDZ35	32	set
Flange bolts and nuts	M22 × 150L, Butterfly valve for 150A (16K), HDZ35	108	set
Flange bolts and nuts	M22 × 150L, Butterfly valve for 150A (20K), HDZ36	24	set
Separation prevention bracket	φ150	24	set
Piping support bracket	PS-C1, HDZ35	1226	set
Fire pump	Multi-stage spiral, 1190L / min × 59m × 22kw	1	stand
Automatic water supply equipment (constant pressure water supply unit)	Alone alternately, 60L / min × 11m × 0.4kw	1	set
Gate valve	150A, flange, 10K, lining	7	stand
Gate valve	100A, flange, 10K, lining	2	stand
Gate valve	65A, flange, 10K, lining	3	stand
Gate valve	50A, screw, 10K, pipe end proof corrosion	1	stand
Gate valve	40A, screw, 10K, pipe end proof corrosion	4	stand
Gate valve	32A, screw, 10K, pipe end proof corrosion	6	stand
Gate valve	20A, screw, 10K, pipe end proof corrosion	2	stand

Item	Standards	Quantity	Unit
Check valve (shock absorption)	150A, flange, 10K, lining	1	stand
Check valve (shock absorption)	32A, screw, 10K, pipe end proof corrosion	1	stand
Check valve (swing type)	32A, screw, 10K, pipe end proof corrosion	2	stand
Globe valve	65A, screw, 10K	1	stand
Strainer	Y-shaped, 150A, flange, 10K, lining	1	stand
Flexible joint	150A × 800L, flange, 10K	3	stand
Flexible joint	65A × 800L, flange, 10K	2	stand
Flexible joint	40A × 500L, flange, 10K	1	stand
Flexible joint	2A × 300L, flange, 10K	5	stand
Flexible joint	Buried type, 150A × 800L, flanges, 10K	1	stand
Flow meter	65A, screw, 10K	1	stand
Overheating prevention orifice	20A, screw, 10K	1	stand
Safety valve	50A, flange, 10K	1	stand
Air vent valve	20A, screw, 10K	1	stand
Constant flow valve	40A, flange, 10K	1	stand
Intake valve (electric ball valve)	40A, flange, 10K	1	stand
SCP-PB (machine room)	Processing pipe P1	1	set
SCP-PB (machine room)	Processing pipe P2	3	set
SCP-PB (machine room)	Processing pipe P3	1	set
SCP-PB (machine room)	Processing pipe P14	1	set
SCP-PB (machine room)	Processing pipe P15	1	set
SCP-PB (machine room)	Processing pipe P16	1	set
SCP-PB (machine room)	Processing pipe P17	1	set
SCP-PB (machine room)	Processing pipe P18	1	set
SCP-PB (machine room)	Processing pipe P19	1	set
SCP-PB (machine room)	Processing pipe P20	1	set
SCP-PB (machine room)	Processing pipe P21	1	set
SCP-PB (machine room)	Processing pipe P22	1	set
SCP-PB (machine room)	Processing pipe P23	1	set
SCP-PB (machine room)	Processing pipe P24	1	set
SCP-PB (machine room)	Processing pipe P25	1	set
SCP-PB (outdoor)	Processing pipe P2	3	set
SCP-PB (outdoor)	Processing pipe P4	2	set
SCP-PB (outdoor)	Processing pipe P5	1	set
SCP-PB (outdoor)	Processing pipe P6	1	set
SCP-PB (outdoor)	Processing pipe P7	1	set
SCP-PB (outdoor)	Processing pipe P8	2	set
SCP-PB (outdoor)	Processing pipe P9	1	set
SCP-PB (outdoor)	Processing pipe P10	1	set
SCP-PB (outdoor)	Processing pipe P11	2	set
SCP-PB (outdoor)	Processing pipe P34	2	set
SCP-PD (in the tank)	Processing pipe P12	2	set
SCP-PD (in the tank)	Processing pipe P13	2	set
SCP-PD (in the tank)	Processing pipe P28	2	set
SCP-PD (in the tank)	Processing pipe P29	2	set
SCP-PD (in the tank)	Processing pipe P30	2	set
SCP-PD (in the tank)	Processing pipe P31	2	set
SCP-PD (in the tank)	Processing pipe P32	2	set
SCP-PD (in the tank)	Processing pipe P33	2	set
SCP-PD (buried)	Processing pipe P26	1	set
SCP-PD (buried)	Processing pipe P27	1	set
SCP-PB (machine room)	65A	2.37	m
SCP-PB (machine room)	50A	0.3	m
SCP-PB (machine room)	40A	3.158	m
SCP-PB (machine room)	32A	7.683	m
SCP-PB (machine room)	20A	2	m
SCP-W (machine room)	50A	0.65	m
SCP-W (machine room)	15A	0.2	m
SCP-PB (outdoor)	65A	11.343	m
SCP-PB (outdoor)	40A	12.023	m
SCP-PB (outdoor)	32A	17.95	m
SCP-W (outdoor)	100A	4.7	m
SCP-PD (in the tank)	32A	1.8	m

Item	Standards	Quantity	Unit
Elbow 90°	65A, screw, pipe end proof corrosion	7	piece
Elbow 90°	40A, screw, pipe end proof corrosion	7	piece
Elbow 90°	32A, screw, pipe end proof corrosion	10	piece
Elbow 90°	20A, screw, pipe end proof corrosion	1	piece
Cheese	65A, screw, pipe end proof corrosion	1	piece
Cheese	40A, screw, pipe end proof corrosion	1	piece
Cheese	32A, screw, pipe end proof corrosion	2	piece
Different diameters cheese	65Ax20A, screw, pipe end proof corrosion	2	piece
Socket	32A, screw, pipe end proof corrosion	2	piece
Different diameters cheese	32Ax25A, screw, pipe end proof corrosion	2	piece
Nipple	32A, screw, pipe end proof corrosion	5	piece
Nipple	25A, screw, pipe end proof corrosion	2	piece
Nipple	20A, screw, pipe end proof corrosion	2	piece
Union	32A, screw, pipe end proof corrosion	1	piece
Union	20A, screw, pipe end proof corrosion	1	piece
Phase flange	65A, screw, JIS10K, pipe end proof corrosion	13	sheet
Phase flange	50A, screw, JIS10K, pipe end proof corrosion	1	sheet
Phase flange	40A, screw, JIS10K, pipe end proof corrosion	8	sheet
Phase flange	32A, screw, JIS10K, pipe end proof corrosion	18	sheet
Elbow 90°	100A, screw, white	4	piece
Elbow 90°	50A, screw, white	1	piece
Elbow 90°	15A, screw, white	1	piece
Different diameters elbow	15Ax10A, screw, white	1	piece
Nipple	100A, screw, white	4	piece
Nipple	10A, screw, white	1	piece
Phase flange	100A, screw, JIS10K, white	4	sheet
Phase flange	50A, screw, JIS10K, white	1	sheet
Flange bolts and nuts	M20x80L, for 150A (10K) , HDZ35	424	set
Flange bolts and nuts	M20x75L, for 125A (10K) , HDZ35	16	set
Flange bolts and nuts	M16x70L, for 100A (10K) , HDZ35	80	set
Flange bolts and nuts	M16x65L, for 65A (10K) , HDZ35	52	set
Flange bolts and nuts	M16x60L, for 50A (10K) , HDZ35	8	set
Flange bolts and nuts	M16x60L, for 40A (10K) , HDZ35	28	set
Flange bolts and nuts	M16x60L, for 32A (10K) , HDZ35	64	set
Piping support bracket	PS-P1, HDZ35	1	set
Piping support bracket	PS-P2, HDZ35	8	set
Piping support bracket	PS-P3, HDZ35	2	set
Piping support bracket	PS-P4, HDZ35	6	set
Piping support bracket	PS-P5, HDZ35	3	set
Piping support bracket	PS-P6, HDZ35	1	set
Piping support bracket	PS-P7, HDZ35	6	set
Piping support bracket	PS-P8, HDZ35	3	set
Piping support bracket	PS-P9, HDZ35	7	set
Piping support bracket	PS-P10, HDZ35	2	set
Piping support bracket	PS-P11, HDZ35	2	set
Piping support bracket	PS-P12, HDZ35	4	set
Piping support bracket	PS-P13, HDZ35	3	set
Piping support bracket	PS-P14, HDZ35	1	set
Piping support bracket	PS-P15, HDZ35	6	set
Piping insulation (machine room)	150A, PF25mm, aluminum glass cloth	11.441	m
Piping insulation (machine room)	65A, PF20mm, aluminum glass cloth	2.645	m
Piping insulation (machine room)	50A, PF20mm, aluminum glass cloth	0.3	m
Piping insulation (machine room)	40A, PF20mm, aluminum glass cloth	3.308	m
Piping insulation (machine room)	32A, PF20mm, aluminum glass cloth	8.001	m
Piping insulation (machine room)	25A, PF20mm, aluminum glass cloth	0.096	m
Piping insulation (machine room)	20A, PF20mm, aluminum glass cloth	2.141	m
Piping insulation (outdoor exposure)	150A, PF25mm, stainless steel plate	21.24	m
Piping insulation (outdoor exposure)	100A, PF25mm, stainless steel plate	0.4	m
Piping insulation (outdoor exposure)	65A, PF20mm, stainless steel plate	10.193	m
Piping insulation (outdoor exposure)	40A, PF20mm, stainless steel plate	10.873	m
Piping insulation (outdoor exposure)	32A, PF20mm, stainless steel plate	17.9	m

Item	Standards	Quantity	Unit
Valves heat insulation (machine room)	150A, PF, stainless steel plate	8	place
Valves heat insulation (machine room)	65A, PF, stainless steel plate	3	place
Valves heat insulation (machine room)	50A, PF, stainless steel plate	1	place
Valves heat insulation (machine room)	40A, PF, stainless steel plate	2	place
Valves heat insulation (machine room)	32A, PF, stainless steel plate	3	place
Valves heat insulation (machine room)	20A, PF, stainless steel plate	1	place
Valves heat insulation (outdoor exposure)	150A, PF, stainless steel plate	4	place
Valves heat insulation (outdoor exposure)	100A, PF, stainless steel plate	2	place
Valves heat insulation (outdoor exposure)	65A, PF, stainless steel plate	3	place
Valves heat insulation (outdoor exposure)	40A, PF, stainless steel plate	1	place
Valves heat insulation (outdoor exposure)	32A, PF, stainless steel plate	2	place
Flexible joint	Buried type, 150A × 800L, flanges, 10K	1	stand
Gate valve	20A, screw, 10K, pipe end proofcorrosion	1	stand
Air vent valve	20A, threaded, 10K	1	stand
SGP-PD (buried)	Processing pipe K6	1	set
SGP-PD (buried)	Processing pipe K7	1	set
SGP-PD (buried)	Processing pipe K8	1	set
SGP-PD (buried)	20A	1.3	m
SGP-PB (outdoor)	20A	0.4	m
SGP-W (outdoor)	15A	0.2	m
T-shaped ductile cast iron pipe (three) straight pipe	φ150×5000L, mortar lining	2	set
T-shaped ductile cast iron pipe (three) straight pipe	φ150×4845L, mortar lining	1	set
T-shaped ductile cast iron pipe (three) straight pipe	φ150×4000L, mortar lining	1	set
T-shaped ductile cast iron pipe (three) straight pipe	φ150×2230L, mortar lining	1	set
T-shaped ductile cast iron pipe (three) straight pipe	φ150 × 1410L, mortar lining	1	set
T-shaped ductile cast iron profiled tube short pipe No. 1	φ150, flange JIS10K	1	set
T-shaped ductile cast iron profiled tube short pipe No. 2	φ150, flange JIS10K	1	set
T-shaped ductile cast iron profiled T-shaped pipe with a flange	φ150 × φ100, flange JIS10K	1	set
T-shaped ductile cast iron profiled tube bend 90°	φ150	1	set
Elbow 90°	20A, screw, pipe end proof corrosion	2	piece
Nipple	20A, screw, pipe end proof corrosion	2	piece
Flange flange	20A, screw, JIS10K, pipe end proof corrosion	2	sheet
Elbow 90°	15A, screw, white	1	piece
Different diameters elbow	15A×10A, screw, white	1	piece
Nipple	10A, screw, white	1	piece
Flange bolts and nuts	M20×80L, for 150A (10K) , HDZ35	40	set
Flange bolts and nuts	M12×55L, for 20A (10K) , HDZ35	4	set
Separation prevention bracket	φ150	9	set
Piping support bracket	PS-K1, HDZ35	2	set
Air vent valve storage box	SUS	1	set
Piping insulation (outdoor exposure)	20A, PF20mm, stainless steel plate	0.542	m
Valves warm (outdoor exposure)	20A, PF, stainless steel plate	1	place
Flexible joint	Buried type, 150A × 800L, flanges, 16K	1	stand
SGP-PD (buried)	Processing pipe K1	1	set
SGP-PD (buried)	Processing pipe K2	1	set
SGP-PD (buried)	Processing pipe K3	1	set
SGP-PD (buried)	Processing pipe K4	1	set
SGP-PD (buried)	Processing pipe K5	1	set
T-shaped ductile cast iron pipe (three) straight pipe	φ100 × 4030L, mortar lining	8	set
T-shaped ductile cast iron pipe (three) straight pipe	φ100 × 3550L, mortar lining	1	set
T-shaped ductile cast iron pipe (three) straight pipe	φ100 × 3000L, mortar lining	2	set
T-shaped ductile cast iron pipe (three) straight pipe	φ100 × 1624L, mortar lining	1	set
T-shaped ductile cast iron pipe (three) straight pipe	φ100 × 1019L, mortar lining	1	set
T-shaped ductile cast iron profiled tube short pipe No. 1	φ100, flange JIS16K	1	set
T-shaped ductile cast iron profiled tube short pipe No. 2	φ100, flange JIS16K	1	set
T-shaped ductile cast iron profiled T-shaped pipe with a flange	φ100 × φ100, flange JIS16K	1	set
T-shaped ductile cast iron profiled tube bend 90°	φ100	1	set
Flange bolts and nuts	M22 × 90L, for 150A (16K), HDZ35	60	set
Flange bolts and nuts	M20 × 80L, for 100A (16K), HDZ35	16	set
Separation prevention bracket	φ100	16	set

**5700 Tunnel Distribution Line**

Item	Standard	Quantity	Unit
Steel conduit Pipe	φ 250	54	m
	φ 200	435	m
Multiple Conduit	φ 80	973	m
	φ 50	6084	m
Hand Hole	□900×900	29	Panel
Multiple Conduit	φ 80	13432	m
Multiple Conduit	φ 50	56867	m
Inner Hand Hole	TYPE-A	48	Set
Inner Hand Hole	TYPE-B	53	Set
Thick Steel Conduit pipe	G104	5484	m
Pipe Support Bracket	Concrete Anchor etc	1371	Set
Pull Box (WP, SUS)	400x1000x150	23	Set

Ministry of Physical Infrastructure and Transport,  
Department of Roads



Government of Nepal



# **NAGDHUNGA TUNNEL CONSTRUCTION PROJECT**

LOAN AGREEMENT No. (NE-P10)

CONTRACT No. DOR-NTCP-W-ICB-01

## **BIDDING DOCUMENTS**

### **PART 2: WORKS REQUIREMENTS (SECTION VI)**

#### **VI-I: Standard Specifications for Water Supply Works (SSWS)**

#### **VOLUME III**



## SECTION VI-I: STANDARD SPECIFICATIONS FOR WATER SUPPLY WORKS (SSWS)

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APPENDIX: Bill of Quantities for Water Supply Works

## **Section VI-I:**

The Specifications contained herein shall be read in conjunction with the Special Provisions to Standard Specifications (SPSS) referred to as Section VI-C (Volume-I and Volume-II) by the corresponding numbering of Clauses so that Sections VI-B, VI-C and VI-I together comprise the specifications that shall be respected for performing the works of the Project.

The Special Provisions to Standard Specifications are set out below (the Clauses of the standard specifications that were not modified by these provisions shall remain and shall be respected).

Where there is any ambiguity or discrepancy between the Standard Specifications (Section VI-B), the Special Provisions (Section VI-C) and these Specifications (Section VI-I) contained in this section; the specifications (Section VI-I) shall have preference, prevail and shall govern for the works of Water Supply.

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## **SECTION 8000: WATER SUPPLY WORKS**

### **8001 GENERAL**

#### **(1) Applicable Items of the Standard Specifications**

The requirements and specifications of the Sections VI-B and VI-C (e.g. accommodation of traffic, environmental protection works, project safety, civil works, etc.) shall be applied accordingly for those works that are commonly required or contained on the Water Supply Works.

The Technical Specifications of this Section cover principles, responsibilities, and requirements for items that will be applicable to all civil, electrical, mechanical, and building works pertinent to the Water Supply Works.

They shall be read in conjunction with the Conditions of Contract, the Bills of Quantities (BOQ) and the Drawings.

If the Contractor requires additional specifications for more explicit description of the Works or to supplement the existing specifications, or any other specifications to complete the Works, the Contractor shall submit such additional or supplementary specifications for the approval by the Engineer. All costs incurred for the additional specifications under the clause are deemed to be included in other unit rates quoted in the Bill of Quantities.

#### **(2) Scopes**

The activities to be undertaken include the following:

- (a) The Contractor's supply items include manufacture, collection, transportation and delivery to Site. The Contractor will be responsible for ensuring that all procedures are adequately covered and that the materials fully conform with the Contract requirements. These responsibilities will include all necessary charges or dues related to insurance, freight, taxes (including customs and excise duties, surcharges etc.) and all testing and inspections for quality control.
- (b) To provide all necessary staff (including civil engineers, administrators, Site supervision personnel) and workmen (including all necessary specialists, operators, tradesmen, artisans etc. in addition to semi-skilled and unskilled workers) necessary for execution of the works through to completion.
- (c) To provide all equipment, machinery, tools etc. and related spares, maintenance and consumables necessary for implementation of the Works.
- (d) To undertake all operations necessary to complete the Works. These operations shall include: excavation, provision, haulage and installation of suitable bedding and backfill material and disposal of surplus excavated material; distribution, laying and jointing of pipes; installation of all special pipe work, valves etc. and construction of all related concrete or other activities together with all testing and disinfection of completed Works.
- (f) To prepare project records and drawings in accordance of the relevant specifications of Section 111 and Section 117 of the SPSS.

- (g) All the above activities shall be performed in a professional way and with good engineering and/or constructional practice. Upon completion of the Works the scheme shall be fully operational with minimum disruption or inconvenience to interested parties, including land owners, and there shall be no outstanding matters requiring attention.

### **(3) Access to and Possession of Site**

The stipulations of Clause 2.1: “Right of Access to the Site” of the General Conditions of Contract and Particular Conditions of Contract, and relevant requirements specified in Section-VI(B) and Section VI(C) shall be applied accordingly.

### **(4) Protection of Overhead and Underground Services**

The Contractor will be held responsible for any damage to known services (i.e. overhead services that are visible within the Site and underground services shown on the drawings) and he shall take all necessary measures to protect them. All work or protective measures shall be subject to approval of the Engineer. In the event of a service being damaged he shall inform the Engineer and the authority concerned, the Contractor shall not repair any such service unless instructed to do so.

Where no underground services are shown on the drawings or scheduled but the possibility of their presence can reasonably be inferred, the Contractor shall, in collaboration with the Engineer, ascertain whether any such services exist within the relevant section of the Site. The Contractor shall complete such an investigation well in advance of the start of construction work in the said section and he shall submit a report in good time to enable the Engineer to make whatever arrangements are necessary for the protection, removal or diversion of the services before any construction activities commences.

As soon as any underground service not shown on the drawings is discovered, it shall be deemed to be a known service and the Contractor will be held responsible for any subsequent damage to it. If such a service is damaged during the course of its discovery, the cost of making good such damage will be met by the Employer unless he establishes that the Contractor did not exercise reasonable diligence and that the damage was avoidable.

Where the authority concerned elects to carry out on its own account any alterations or protective measures, the Contractor shall co-operate with and allow such authority reasonable access and sufficient space and time to carry out the required work.

### **(5) Site Drainage**

The Contractor shall keep each Section of the Works well drained until the Engineer certifies that it is substantially complete and shall ensure that, so far as is practicable, all work is carried out in the dry. Site areas shall be kept well drained and free from standing water except where this is impracticable having regard to methods of Temporary Works properly adopted by the Contractor.

The Contractor shall provide, operate and maintain in sufficient quantity such pumping equipment, well points, pipes and other equipment as may be necessary to minimize

damage, inconvenience and interference and shall construct, operate and maintain all temporary coffer-dams, sumps, ditches, drains and other temporary works as may be necessary to remove water from the Site while construction is in progress. Such Temporary Works and construction equipment shall not be removed without the approval of the Engineer.

Notwithstanding any approval by the Engineer of the Contractor's arrangements for the removal of water, the Contractor shall be responsible for the sufficiency thereof and for keeping the Works safe at all times and for making good at his own expense any damage to the Works.

The Contractor shall be responsible to keep the Site clear of water at whatever pump rate is found necessary.

The Contractor's site drainage facilities shall not cause pollution in any local watercourses, he shall be responsible for any legal action resulting from pollution events.

#### **(6) Operation and Maintenance Manual**

The Contractor shall operate and maintain the entire Water Supply system continuously for seven days. During this period all the system shall operate smoothly with required flow and pressure. Any shortcomings shall be rectified immediately. At the seventh day, a joint committee composed by the Employer, the Engineer, the Water Users Service Committee (WUSC) and Contractor have to set the performance targets which will be based for the Defects Notification Period.

After completion of operation and maintenance for seven days, the Contractor shall submit Operation and Maintenance Manuals of each equipment.

### **8002 STANDARDS AND CODES AND ABBREVIATIONS**

The Works shall be carried out in accordance with the relevant quality standards, test procedures or codes of practice, collectively referred to as Reference Standards, listed in Section 113: "National Specifications" of the Special Provisions to the Standard Specifications [Section VI(c)]. The applicable issue of any Reference Standard shall, unless otherwise stated in the Specification, be the issue current at the date two months preceding the date for submission of the tenders for the contract. The Contractor shall familiarize himself fully with the requirements of such standards.

The Contractor may propose, at no extra cost to the Employer, the use of any alternative relevant authoritative internationally recognized Reference Standard. The Engineer shall decide whether or not the use of such alternative will be allowed as a Reference Standard.

The Contractor shall obtain and keep on Site at least one copy of each approved Reference Standard and each Reference Standard referred to in the Specifications, and will make these accessible to the Engineer at any time upon request.

The Contractor shall obtain the Reference Standards from the addresses given below :

NS:            Nepalese Standardization Office, Balaju, Kathmandu, Nepal

ISO:	International Organization for Standardization, Rue de Varembe, Geneva, Switzerland
DIN:	Deutsche Industrie Norm (German Industry Standard) from Deutsche Normenausschuss, Beuth-Vertrieb, P.O. Box 1045, W-1000, Berlin 30, Federal Republic of Germany
BSI:	British Standards Institution, 389 Chiswick High Road, London W4 4BR, England
AASHTO:	American Association of State Highway and Transportation Officials, Suite 341 National Press Building, Washington, D.C. 2004, U.S.A.
ASTM:	American Society for Testing and Materials, 2501 Race St., Philadelphia, PA 19103, U.S.A.
AWS:	American Welding Society, Inc., 2501 N.W. 7th St., Miami, FL 33125, U.S.A.
AWWA:	American Water Works Association, 6666 West Quincy Ave. Denver, Colorado 80235, U.S.A.
IS:	Indian Standards, ManakBhawan - 9, Bahadur Shah Jafar Marg, New Delhi, 11002

### 8003 CIVIL ENGINEERING AND BUILDING WORKS

The requirements specified in the Standard Specifications (Section VI(B)) and Special Provisions to the Standard Specifications (Section VI(C)) shall be satisfied in performing the Works for Water Supply, as applicable and as approved by the Engineer:

- ♦ Section 100: ..... “General”
- ♦ Section 102: ..... “Accommodation of Traffic”
- ♦ Section 200: ..... “Site Clearance”
- ♦ Section 202: ..... “Dismantling Culverts, Bridges, other Structures and Pavement”
- ♦ Section 400: ..... “Fencing”
- ♦ Section 500: ..... “Quality Control”
- ♦ Section 600: ..... “Materials and Testing of Materials”
- ♦ Section 700: ..... “Pipe Drains, Pipe Culverts and Concrete Channels”
- ♦ Section 900: ..... “Earthworks”
- ♦ Section 904: ..... “Explosives and Blasting”
- ♦ Section 2000: ..... “Concrete for Structures”
- ♦ Section 2200: ..... “Structural Steel Work”
- ♦ Section 1400: ..... “Kerbs and Footpaths”
- ♦ Section 2500: ..... “Brickworks for Structures”
- ♦ Section 3000: ..... “Method of Explorations”

And others as applicable or as instructed by the Engineer.

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## 8004 OTHER SUPPLEMENTARY WORKS

### (1) Waterstops

The Contractor shall supply and fix waterstops in all joints in members which are to be water-retaining and where shown on the Drawings.

Waterstops built into joints shall be made of PVC, rubber or similar approved material. They shall be obtained from manufactures approved by the Engineer and shall be stored, fixed and jointed in accordance with the manufacture's instruction. They shall be fabricated into the longest practicable units complete with angles and junctions at the manufacture's works and shall be made continuous throughout the structure below highest water level and where shown on the Drawings. The number of joints in the waterstop made on Site shall be kept to a minimum.

Where waterstop joints are vulcanized or welded on Site, jointing shall be performed strictly in accordance with the supplier's instructions and recommendations. The tensile strength of the spliced waterstop at a factory-made splice shall be at least 90% of the waterstop's tensile strength, when tested according to BS 903, or equivalent standard, with the spliced joint in the middle portion of the dumb-bell test specimen and the tensile force applied normally to the direction of the splice. The tensile strength of a waterstop spliced at the Site shall be 80% of the original strength of the waterstops. The edge bulb section shall be circular for waterstops installed within concrete sections; trapezoidal for waterstops installed at the base of slabs.

The Contractor shall supply the manufacturer's test certificates for each consignment of waterstops delivered to Site and shall, in addition, supply to the Engineer sufficient of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate standard test procedure, if ordered.

### (2) Plumbing and House Drainage Works

#### (a) Scope

This specification covers the general requirements for plumbing and sanitary installation required in general building construction.

#### (b) Interpretations

The following specifications of the Section VI(b): Standard Specifications and Section VI(c): Special Provisions to the Standard Specifications shall, inter alia, form part of and shall be read in conjunction with this specification:

- ◆ Pressure Pipelines
- ◆ Sewers

#### (c) Application

This specification contains clauses that are generally applicable to plumbing, sanitary installations, house water supply and drainage work, and associated work.

#### (d) Materials

All pipes, fittings, and sanitary ware shall be of selected quality approved by the Engineer. It shall be suitable for the intended purpose and appropriately matched to each other. All pipes, fittings, and sanitary ware shall be supplied complete with all necessary fixing, coupling, and jointing material.

Pipes for water supply shall be of galvanized seamless steel, cast or spun iron, ductile cast iron, PVC, HDPE, or other method approved by the Engineer and shall be jointed by fitting, screwing, or welding, as applicable.

Pipes for drainage may be cast iron, ductile cast iron, vitrified clay (glazed earthenware), PVC/PE, AC, concrete, or other method approved by the Engineer.

All fittings shall be supplied according to the pipes required, whether or not specifically called for in the drawings.

All sanitary equipment, lavatories, cisterns, urinals, toilets, water fountains, floor drains, gullies, petrol and oil traps, etc., shall conform to the relevant applicable standards as shown below or equivalent.

- ♦ NS 246-2048 & NS 383-2054 ..... : cast iron drain pipes and fittings
- ♦ BS 1211..... : spun iron pipes and fittings
- ♦ NS199-2046..... : galvanized pipes and fittings
- ♦ NS40-2040..... : HDPE pipes and fittings
- ♦ NS206-2046..... : PVC pipe and fittings
- ♦ NS104-2042..... : covers and frames
- ♦ IS774, IS2556 ..... : white ceramic sanitary ware
- ♦ BS1010 part 2 or IS 781 ..... : stopcocks & taps

#### (e) Construction Equipment

The apparatus used for the line, level, and positional control of pipe laying and installation work shall be accurate, sturdy, and in good operational condition. The Contractor may use any acceptable device for such control.

In addition to the pumps, gauges, storage tank, tools, pipes, fittings, specials, and bracing necessary for the tests required, the Contractor shall provide all plugs for the temporary stopping off of pipelines for the purposes of testing.

#### (f) Construction And Workmanship

##### ♦ Sanitary Fixtures:

All fixtures specified or shown on the drawings shall be furnished and set by the Contractor in a neat and workmanlike manner, making connections with all supply, waste, soil and vent pipes, as specified or as directed. General requirements for fixtures shall be the following:



- ✓ A sample of each type of fixture shall be subject to the approval by the Engineer. The samples shall be completely fitted and set up at the building or in some other convenient approved place.
  - ✓ The approved fixture samples shall not be removed and shall be protected at all times during the construction period for comparison purposes. All fixtures of poorer quality than the approved samples will be cause for rejection.
  - ✓ All ceramic fixtures shall, unless otherwise shown on the drawings or directed, be of white vitreous china thoroughly fused, producing a white material which, when fractured, shall show a homogeneous mass with close grain and free from pores. All surfaces coming in contact with walls, floors, or surfaces of other fixtures shall be reasonably flat.
  - ✓ Enameled cast iron shall be of an approved quality and thickness. Porcelain enamel coat shall be applied so that the enamel will be smooth, of even thickness, white and free from craze, discoloration and chips. Exterior exposed surfaces not required to be enameled shall be treated with one coat of filler at the factories. The Contractor shall be responsible for any revisions of connections required to adapt the roughing sleeves and openings to the particular fixture he proposes to use.
  - ✓ All fixtures shall bear the manufacturer's guarantee label or trademark for identification purposes.
  - ✓ All fixtures requiring hot and cold water shall have the cold-water tap on the right hand side of the fixture and the hot water on the left hand side of the fixture.
  - ✓ All fixtures shall be of the same manufacture, unless otherwise directed by the Engineer.
  - ✓ The location of each fixture and the fixing method of ceramic fixtures shall be as shown on the drawings or as directed by the Engineer.
  - ✓ After fixtures have been mounted, the Contractor shall before leaving the job, thoroughly clean all fixtures furnished and mounted under this contract, remove all plates, stickers, rust stains and other foreign matters or discolorations on fixtures, leaving every part in perfect condition and ready for use.
- ◆ Piping:
- ✓ The Contractor shall submit to the Engineer a piping diagram for approval. This diagram shall show the symbols of the sanitary fixtures connected with both, the potable water supply and the drainage system. Valves, diameter of pipes, materials, etc., shall be indicated in the diagram. The limit of the work to be executed inside the building shall begin and end 1 m beyond the outer line of the structure, unless otherwise directed.

- ✓ All supply lines shall be designed for a nominal pressure of 1 MPa (10 bar), unless otherwise directed.
- ✓ Before covering the pipes, pressure tests shall be carried out to the satisfaction of the Engineer.
- ✓ The wastewater shall be drained through septic tank, soak away drains or pits, or drainage system, as applicable, by use of vitrified clay pipes or PVC/PE pipes as directed or shown on the drawings. Great care shall be taken in setting out and determining the general levels and falls of drain pipes, so that a fall giving a self-cleaning velocity shall be obtained.
- ◆ Fixing:
  - ✓ W.C. commodes shall be fixed to the floor with C.P. brass screws or by means or 75 mm long 6.5 mm dia counter sunk bolts and nuts embedded in the concrete floor or as per the instruction of the Engineer. The base of the pedestal of the commodes shall squarely rest on the finished floor. Any gap between the finished floor and the pedestal shall be filled with white mastic mixed with pigment to match the shade of floor or as directed by the Engineer.
  - ✓ The W.C. Pan (Indian or Orissa) shall be laid in floor sloping towards the pan in a workmanlike manner, care being taken not to damage the W.C. pan, etc. in the process of fixing. If damaged in any way, it shall be replaced at no cost to the Employer. The pans, etc. shall be fixed on a proper base of cement concrete 1:2:4 mix (1 cement: 2 coarse sand: 4 stone ballast of 20 mm nominal size) taking care that the cushion is uniform and even without having any hollows between the W.C. pan and finished floor. The work shall be neatly done and no hair cracks shall be visible. Joint between the outlet of the W.C. pan and ceramic 'P' or 'S' trap shall be made with neat cement, yarn, linseed oil, white lead and waterproofing compound and made leak proof. The outlet of the ceramic traps shall be centrally placed in the rubber gasket of the socket of the HDPE pipe and shall have no leakage.
  - ✓ Flush valves shall be installed exposed as shown on the drawing, in accordance with the manufacturer's instruction or as directed by the Engineer. The C.P. long flush bend pipe shall be fixed to the water closet with the help of a rubber adapter and shall show no signs of leakage.
  - ✓ Washbasins shall be supported on bracket(s) as per the manufacturer's instruction and/or on vitreous china pedestals or as directed by the Engineer. There shall not be any gap between top edge of the basin and finished face of wall.
  - ✓ Urinals shall be fixed to the wall by means of C.P. brass screws as per the manufacturers instruction and/or directed by the Engineer. There shall not be any gap between the back edge of the urinal and finished face of the wall.

### **(g) Tests and Acceptance**

All water services shall be subjected to a hydraulic test pressure 1.5 times the working pressure maintained for a period of two hours during which time there shall be no appreciable drop in pressure and no visible leakage.

All soil waste and vent pipes shall be subjected to an air test as described in the clause for “Testing and Acceptance” of “Sewers and Stormwater Drainage”.

All drainage pipe work shall be subjected to a hydraulic test pressure of 150 mm head at the highest fitting, maintained for a period of four hours there shall be no appreciable drop in pressure and no visible leaks.

The Contractor shall include for providing all necessary appliances and labour at these tests.

All water service pipe work shall be flushed through upon completion of installation, to ensure cleanliness.

All drainage pipe work shall be rodded through upon completion of installation to ensure cleanliness.

### **(3) Finishes**

#### **(a) Scope**

This specification covers the general construction requirements for finishes, such as plastering, flooring, painting, roofing, water proofing, etc., required in general building construction (e.g. operators quarters, guardhouse, etc.).

#### **(b) Interpretations**

##### ♦ Supporting Specifications:

The following specifications of the Section VI(b): Standard Specifications and Section VI(c): Special Provisions to the Standard Specifications shall, inter alia, form part of and shall be read in conjunction with this specification:

- ✓ Section 100: General
- ✓ Section 900: Earthworks
- ✓ Section 2000: Concrete
- ✓ Section 2500: Brickwork/Stonework

##### ♦ Application

This specification contains clauses that are generally applicable to finishes on walls, floors, and roofs of buildings and associated work.

#### **(c) Materials**

Cement, sand, water, and coarse aggregates required for finishing work shall be as mentioned in the relevant clauses of the Standard Specifications (Section VI(B)) and respective SPSS (Section VI(C)).

Ceramic tiles shall be 200 x 100 x 6 mm size unless otherwise shown or specified on the drawings or directed by the Engineer. They shall either be ceramic vitreous tiles, with colours as selected by the Engineer, or approved glazed tiles conforming with IS 777 or equivalent. Granular material (e.g. marble chips) for in-situ flooring, screeds, and skirting shall be as approved by the Engineer.

The Contractor shall submit samples of tiles for selection and approval by the Engineer, and all tiles used shall conform to the approved samples with regard to size, quality, texture and colour.

The materials for painting and colour washing of internal and external walls and similar surfaces shall conform to the requirements of the relevant applicable standards (e.g. IS 5410 or equivalent). The Contractor shall get prior approval of the Engineer of the brand and shade of all paint materials.

Pigments and other necessary additives to produce coloured plasters and mortars shall conform to the relevant applicable standards (e.g. IS 57 or equivalent) and shall be applied the rate of 1% by weight of cement or to produce a colour and texture indicated on the drawings or as directed by the Engineer. The sample of such colour plaster shall be subjected to approval of the Engineer before applying in the work.

Caulking compounds shall be of approved manufacture such as to provide a continuous waterproof barrier installed with exposed caulking smoothly recessed from the finished steel or brick surface.

Corrugated Galvanized Iron (CGI) sheets and ridge for the roofing shall be of 26 gauge thickness having heavy coating meeting the requirements of NS 141-2042. There should be NS mark on the sheets. Brand of the CGI sheets shall be approved by the Engineer prior to its placement.

#### **(d) Construction Equipment**

Construction Equipment shall be suitable for applying the specified flooring and coating systems and for obtaining the specified results. If, however, consistent and satisfactory results are not achieved with the equipment used by the Contractor, the Engineer may order the Contractor to obtain and use such Construction Equipment as may be necessary to achieve the required results.

#### **(e) Construction and Workmanship**

##### **♦ Plaster:**

The surface to be plastered shall be brushed clean. Mortar joints of brick/stone masonry or hollow concrete walls to be plastered shall be raked to a depth of approximately 12mm, and the surface brushed down with a stiff brush and thoroughly wetted. The surface shall be free of all dust, loose materials, grease, etc.

Before starting plasterwork, the contractor shall prepare a sample panel of plastering of a size at least 1 m<sup>2</sup> for the approval of the Engineer. The sample shall be prepared in an area designated by the Engineer. The Contractor shall obtain approval before

starting work and preserve the approved sample intact until all plastering is completed.

Plaster shall be applied in two coats. The thickness of the first coat shall be just sufficient to fill all unevenness of the surface. The first coat shall be applied with even, firm pressure to ensure good bond, shall be cross-scratched and shall be moist cured. After the first coat has properly cured, and been allowed to dry thoroughly, the surface shall be dampened before applying the finish coat. The finish coat shall be steel trowel finished to a smooth, even, burnished surface, completely free from defects or trowel marks. The thickness of plaster in total shall not be less than 12 mm. Wall plastering shall be started from top and work down to the floor. Ceiling plastering shall be completed before starting the wall plastering. To ensure uniform thickness and vertical plaster face, plumb guider strips may be applied as required.

If required to achieve the smooth, burnished finish, the surface shall be finished with lime putty of just sufficient thickness to fill in uneven surface or defects due to coarse sand in the plaster mix. Lime mortar finish shall be applied immediately after the finish has set sufficiently firm.

In order to obtain additional strength at external angled corners, the corners shall be dusted with cement during the steel trowel finishing of the finish coat.

Care shall be taken to ensure that finished plaster surfaces shall be plumb, square, straight, and true to line. All arises and corners shall be straight, clean, and sharp.

Curing of Plaster works:

Moist curing shall be accomplished by keeping the plaster uniformly damp by suitable means. Moist curing shall start during application and continue for not less than 7 days.

Approval by the Engineer of Plaster Work:

All plasterwork shall be subject to approval of the Engineer, and work failing to meet the requirements of the specifications or not being to the satisfaction of the Engineer shall be removed and reapplied at the Contractor's expense.

♦ Pointing:

Where external faces of the mortared masonry work will be backfilled or otherwise permanently covered up, the mortared joint shall be finished flush to the faces of the adjacent brick/stone work.

Where mortared masonry faces will remain exposed or as specified in the drawings and BOQ, the mortar joints shall be pointed to a consistent style to the approval of the Engineer. Pointing shall be carried out using 1:3 by volume of cement and sand or as shown in the drawing. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The pointing, if not otherwise mentioned, shall be ruled type for which it shall, while work is still green, be ruled along the center with half round tools of such width as may be specified by the Engineer. The excess mortar shall be taken off from the edge of the lines and shall not be unnecessarily plastered

over the exposed stone/brick works.

♦ Tiles:

Wall surface shall be brushed clean, wetted, and fitted with an approximately 12 mm thick level and plumb scratch coat of cement mortar 1:3 applied. The scratch coat shall be moist cured for at least 24hrs before the application of a floating coat. Before applying this floating coat, the scratch coat shall be thoroughly wetted. The floating coat, a plastic mix of neat cement of approximately 3 mm thickness shall be applied even, and with screed to true plane. The floating coat shall be applied over areas no larger than can be covered with tiles while the mortar is still plastic (half set). Glazed tiles shall be soaked, completely immersed in clean water, at least 30 min. and drained.

Tiles shall be installed by applying a skin coat of a plastic mix of neat cement to backs of tiles and firmly pressing them into the floating coat to true plane and position. White cement shall be used for the skin coat where white joints are required.

Tiles shall be installed by dusting a thin layer of dry cement over the setting bed worked lightly with trowel or brush until damp, and tiles shall then be set with straight uniform joints 1 mm or less in width, accurately aligned in both directions and tamped solidly to the bed.

During the process of setting tiles, continuous horizontal and vertical cuts every 40 to 60 cm shall be made through the floating coat while plastic, using the point of a trowel turned edge wise. Care shall be taken to prevent cutting into the scratch coat.

Where full size tiles cannot be laid, they shall be cut (sawn) to the required size and the edges rubbed smooth to ensure a true and straight joint.

Joints in tile work shall be accurately aligned with horizontal joints level and vertical joints plumb. The joints shall be maintained uniformly wide by aligning spacer lugs on tile edges if tiles are so manufactured or by use of wetted strings.

The layout of tile work shall be so that no tile less than half size occurs. Where tiles must be cut at edges or penetrations, the cut edges shall be carefully fitted and neatly ground. No chipped, cracked or broken tile shall be used and all defective work shall be replaced and repaired to the satisfaction of the Engineer and at the Contractor's expense.

After tiles have been set firm and joint strings removed, tiles shall be dampened and joints grouted full with a plastic mix of neat cement by trowel, brush or finger application. Unless otherwise directed, grout shall be made with white cement. During grouting all excess grout shall be cleaned off the tile surface with damp cloth sponges.

Where the setting bed is applied directly to a concrete slab, the slab surface shall be thoroughly wetted, with no free water left standing, and sprinkled with dry cement. The setting bed shall be 1:5 cement mortars and shall be placed to the required level, grade and slope and tamped firmly. Cement mortar at a rate of 4.4 kg per square meter shall then be spread. The floor tiles shall then be placed in position and tapped with a

wooden mallet until the tiles are properly bedded in line and level.

Where the setting bed is applied over a waterproofing membrane, metal reinforcing wire mesh shall be installed lapped at least one full mesh at edges and supported so as to be located approximately mid-height of setting bed. At edges where wall tiles are foreseen, the mesh shall be turned up at least 80 mm.

All finishing tile work shall be adequately protected from damage during the progress of construction and any damage shall be repaired to the satisfaction of the Engineer at the Contractor's expense.

♦ Cast In-situ Floors, Screed, Skirting:

Before placing of in-situ concrete flooring, the base shall be made rough and watered, and given a cement wash. A first concrete layer shall then be laid to the depth required. After laying, the concrete shall be compacted by hand or mechanical means, and leveled with wooden floats. Within one hour of laying the bottom layer, the second and finishing layer shall be placed and the surface tamped lightly, before finishing it off perfectly level with a straight edge float and trowel. The finishing layer shall consist of cement-sand mixed at 1:1.

Cement skirting shall consist of 20 mm thick cement mortar mixed at 1:3 (cement: sand). The cement skirting shall be applied to the wall surface to the line, levels and dimensions, and finished with a floating coat of neat cement.

Curing and protection of cast in situ floor shall be in accordance with the requirements of Clauses relevant to "Concrete" and "Plaster".

♦ Waterproof Cement Paint:

The contents of each fresh container of the paint shall be loosened by rolling or shaking the container before opening for the first time. To one volume of water in a clean container, an equal volume of cement paint shall be added and stirred well to achieve a uniform consistency. No further dilution will be permitted.

The cement paint powder shall be kept secured from exposure to atmosphere by properly tying up the polythene liner in the container and keeping the lid firmly closed.

The cement paint shall be used within two hours of mixing and shall be kept stirring during use.

For application, the base surface shall be cleaned by use of a stiff brush to remove loose dust and dirt. The base surface shall be thoroughly wetted and water allowed to run off.

The first coat shall be well brushed in a manner to give a good bond of the paint with the surface. The second and subsequent coats shall be brushed or sprayed as approved.

The cement paint shall be applied at the following, but not limited, rate:

- ✓ on brickwork.....2 kg/m<sup>2</sup>
- ✓ on in situ concrete.....3.5 kg/m<sup>2</sup>



- ✓ on concrete blocks .....2 kg/m<sup>2</sup>
- ✓ on cement sand rendering ..... 3.2 kg/m<sup>2</sup>

The curing of the waterproof cement paint shall be carried out by application of fine water spray at an interval of 6 to 8hrs after the application of the paint for duration of at least 7d.

The finished surface shall be protected from any damages, staining, etc., by approved means.

♦ Oil Bound Distemper:

All plaster surfaces shall be thoroughly cleaned and shall receive 3 or more coats. The first coat shall be a prime coat. The second and third coats shall be of oil bound distemper of approved colour, shade, and quality, and shall be mixed in accordance with the manufacturer's recommendations.

After these operations, if the work is not to the satisfaction of the Engineer, one or more coats shall be applied without extra cost to the Employer until a smooth and even surface is achieved and approved by the Engineer.

♦ Distemping:

Distemper shall be dry distemper as approved by the Engineer. The distemper shall be mixed with clean water as recommended by the manufacturer and shall be stirred until the mixture attains an even consistency.

The surface shall be cleaned, cracks and holes repaired, all irregularities and inequalities sand papered smooth and wiped clean to present a fine smooth surface which shall be completely dry before distemping is started.

The mixture shall be applied evenly with a brush in long parallel strokes evenly so as not to leave any visible brush marks.

The surface of this first application shall be allowed to dry and harden. Then the second coat shall be applied on the first coat. If a uniform surface is not achieved, a third coat shall be applied.

♦ Plastic Emulsion Paint:

The surface shall be prepared as specified for oil paints. First, a priming coat of primer as specified by the manufacturer shall be applied.

The second and third coats of plastic emulsion paint of approved shade and manufacture shall be applied to achieve an even surface. If the finish is not to the satisfaction of the Engineer, more coats shall be applied at no cost to the Employer to achieve a smooth and even surface.

♦ Ready-mixed Enamel Paint:

Surfaces to be painted shall be dry, free from dust and dirt, and rubbed smooth by means of sand paper or pumice stone to the satisfaction of the Engineer.



The paint shall be ready-mixed synthetic enamel or oil paint of approved make and manufacture. The primary coat shall be applied evenly with a brush. After the primary coat is applied and perfectly dried, all holes, cracks etc. shall be filled with putty and the surfaces sand papered. A second coat of paint of approved shade and manufacture shall then be evenly applied and allowed to dry. The third coat shall be carefully applied as and when required, to achieve a smooth and even surface.

♦ French Polish:

The work shall be first cleaned and sandpapered thoroughly. It then will be painted with a 'filler', composed of ethylated spirit, and sandpapered.

A thin coat of French Polish shall then be applied and sand papered. Subsequent coats of French Polish shall be applied till the proper finishing is achieved to the satisfaction of the Engineer.

♦ Roofing

A water proofing coating on bare reinforced concrete roofs shall be bitumen based and shall be applied in two layers of primer and one layer of finishing coat in accordance with the manufacturer's instructions and recommendations.

Such coating shall be applied by brushing, spraying, or roller application and shall be placed on concrete which has been cured and has reached an age of not less than 3 months.

If not otherwise shown on the drawings or directed by the Engineer, the prime coats shall be applied at a rate of approximately 0.85 l/m<sup>2</sup> and the final coat at a rate of about 1.2 l/m<sup>2</sup>.

Care shall be taken in connection with drains, gutters, etc. to achieve proper flashing and lapping with the bitumen coating.

CGI roofing sheets shall be secured to the purlins firmly by using J-hooks, nuts, and bitumen washer. Side lap shall be half corrugation and the end lap shall be minimum 15 cm. Ridges of thickness same as of CGI sheets shall be fitted and fixed neatly same as of CGI sheets.

**(f) Tolerances**

The tolerances for flooring work shall be as those described for "Concrete", "Paintwork" and "Structural Steel" of Sections VI(B) and VI(C), as applicable, unless otherwise agreed between the Contractor and the Engineer prior to the commencement of the work.

**(4) Carpentry and Joinery Works**

**(a) Scope**

This specification covers the general construction requirements for timberwork,

carpentry and joinery, required in general building construction (e.g. guardhouse and operators quarters at reservoir sites).

**(b) Interpretations**

♦ Supporting Specifications:

The following specifications of the Section VI(b): Standard Specifications and Section VI(c): Special Provisions to the Standard Specifications shall, inter alias, form part of and shall be read in conjunction with this specification:

- ✓ Section 100: General
- ✓ Section 2000: Concrete
- ✓ Section 2500: Brickwork/Stonework

♦ Application:

This specification contains clauses that are generally applicable to timber works, carpentry and joinery for buildings and associated work.

**(c) Materials**

Timber for general purposes shall be approved hardwood of the best quality generally complying with IS 1326, Grade1, or similar and planed on all sides. The timbers shall be impregnated with an odorless wood preservative.

Unless specified elsewhere or otherwise directed, the frames, architraves, etc., of doors and windows, etc., shall be of well-seasoned wood free of knots, fissures, and decay. Local wood of equivalent quality shall be used whenever possible.

Door shutters shall be of chipboard or blackboard of approved quality having both sides faced with either commercial ply 5 mm thick or other approved veneering. Samples of such shutters shall be submitted for approval.

The fittings and fixtures like hinges, hooks, anchors, locks, handles, key plates, keys, doorstops, etc., shall be of brass and of best quality and manufacture. The Contractor shall submit samples of such fittings and fixtures well in advance for approval.

Timber and other wood material shall be straight, sound, bright, or mature growth, well-seasoned and conditioned to suit the particular purpose, for which it is to be used. The material shall be cleanly sawn, square edged, and free from injurious shakes, splits, warps, waness and knots, soft spots and rot, incipient decay and all other defects.

For the structural components which will be concealed after installation, e.g., in the case of built-in cupboards, wardrobes or wall linings, either the type of wood specified for the unconcealed structural components (spruce, fir, pine or a wood of at least equal quality) or an equally suitable material may be used at the Contractor's own choice, unless otherwise specified.

The timber shall be in a suitable condition so that the components made of it will neither crack, warp nor twist. The moisture content of timber assemblies when leaving the manufacturer's works shall be as follows (referred to the oven-dry weight):

- ✓ 8 to 12% for interior finish components
- ✓ 10 to 15% for structural parts in permanent connection with the outside air

Proof of this moisture content shall be furnished to the Engineer.

For plywood and wood chipboards, all surfaces to be veneered or seal coated shall be adequately closed.

Wooden fiberboards, veneers, coating slabs and coating foils of plastics shall be suitable for their intended applications.

Adhesives (glues) shall not cause any discoloration or other damage.

Sealing compounds shall be resistant to atmospheric influences, shall not harden and shall not be aggressive. All fittings such as hinges, hooks, anchors, locks, handles, key plates, keys, etc., shall be submitted to the Engineer in good time for approval.

All coating materials shall form a good bond with the base. Their surface shall be readily brushable and insensitive to wiping contact.

All polish (polishing varnish) shall be fast to light and unsuitable condition so that it provides a surface which is elastic to the greatest possible extent and resistant to scratches, water, acid and heat.

Wood preservatives shall be of an officially approved type. Where subsequent painting of the timber is required, the wood preservative shall be compatible with the paint. In interior applications, the wood preservative shall be odorless.

Treated lumber shall be accompanied by a certificate from a recognized lumber treating company, certifying the amount of treatment and the percentage of moisture after drying.

#### **(d) Construction Equipment**

Equipment, and tools for the execution of timber work, carpentry and joinery shall be sufficient in number and capacity, in good working order, and in accordance with the requirements of the applicable safety regulations.

#### **(e) Construction And Workmanship**

If not otherwise shown on the drawings, or directed by the Engineer, DIN 18334 shall be binding for the execution of the Works as well as the other DIN Standards as follow:

- ◆ DIN 1052 ..... Timber Structures
- ◆ DIN 68365 ..... Timber for Carpenters' Work, Quality Specifications
- ◆ DIN 4074 ..... Timber for Wood Building Components
- ◆ DIN 68800 ..... Timber Protection in Building Construction
- ◆ DIN 17440 ..... Stainless Steel; Quality Specification
- ◆ DIN 18202 ..... Dimensional Tolerances in Building Construction,

Timber as specified shall be jointed and erected in accordance with DIN 1052 and the drawings, including the required wind bracing. Posts shall be fixed to the concrete slab by means of bearing plates, straps and angles according to the structural calculations. Only non-rusting steel according to DIN 17440, Material No. 1.4571 shall be used for fixing components.

The Contractor shall supply to the Engineer shop drawings in accordance with the architectural design and Contractor's static analysis, which are subject to approval before any execution starts.

All structural components shall not warp or crack under any circumstances including stresses due to temperature and humidity that will have to be expected.

All timber connections and meters shall be accurately fitted. The surface exposed to view shall be trimmed, e.g. by planning and grinding. There shall be no plane cutting marks.

Solid timbers shall be joined in such a way that in the event of variations of air humidity, the wood is free to swell and shrink without affecting the joint.

Framing timbers shall not be butted. Dovetailing may be used subject to the Engineer's consent.

All edge surfaces of plywood, wood-chipboards and composite slabs exposed to view shall be veneered or provided with banding (insets or strips). On sealed, veneered and coated surfaces joints and irregularities of the base shall not show even after final drying.

All grained veneers shall be protected against tearing. All timbers ultimately in contact with outside air, or permanently in contact with particularly humid air, or connected to masonry or concrete, shall be treated on all sides with suitable wood preservative before being inserted. The manufacturer's instructions shall be observed.

#### **(f) Test and Acceptance**

A selection of samples for visual inspection and dimensional checks on material and fittings may be made by the Engineer. Supplier's material and test certificates pertaining to the material to be used shall be supplied to the Engineer by the Contractor. The Engineer shall have access at all reasonable times to all places where the work is being carried out and shall be provided with all the necessary facilities for inspection during all stages of manufacture or construction.

### **(5) Electrical Installations**

#### **(a) Scope**

This specification covers the general standards to be achieved when installing lighting and small power systems. i.e. guardhouse, operators quarters and site lighting. All materials and workmanship on the NEA power system shall be as per NEA practice.

## (b) Interpretations

### ♦ Supporting Specifications:

The following specifications of the Section VI(b): Standard Specifications and Section VI(c): Special Provisions to the Standard Specifications shall, inter alia, form part of and shall be read in conjunction with this specification:

- ✓ Section 100: General
- ✓ Section 900: Earthworks

### ♦ Application:

This specification contains clauses that are generally applicable to electrical installations and associated work.

## (c) Abbreviations

Wherever the following abbreviations are used they shall have the meanings below:

### Institutional:

- AIEE ..... American Institute of Electrical Engineers
- BSI ..... British Standards Institution
- DIN ..... Deutsches Industrie Normen
- IE ..... Indian Electricity Rules
- IEC ..... International Electro-technical Commission
- ISO ..... International Organisation for Standardisation
- ISI ..... Indian Standards Institute
- NEA ..... Nepal Electricity Authority
- NEC ..... US National Electrical Code
- NEMA ..... National Electrical Manufacturers' Association

### Technical :

- R ..... red phase
- Y ..... yellow phase
- B ..... blue phase
- ac ..... alternating current
- dc ..... direct current
- A ..... amp
- mA ..... milliamp
- V ..... volt
- HRC ..... High Rupturing Capacity
- kW ..... kilowatt
- kVA ..... kilovolt amp

- kWh .....kilowatt hour
- MVA..... mega volt amp
- Hz ..... hertz (cycles per second)
- SP.....single pole
- SPN.....single pole and neutral
- DP ..... double pole
- TP .....triple pole
- TPN.....triple pole and neutral
- SPSwN..... single pole and switched neutral
- TPSwN .....triple pole and switched neutral
- MCB ..... miniature circuit breaker
- MCCB.....moulded case circuit breaker
- RCD.....residual current device
- GES.....General Electric Standard

#### (d) Materials

##### ♦ Low Voltage Distribution Boards:

Low voltage distribution boards shall be of fabricated sheet metal construction, arranged for conduit and/or cable entry as required, fully rustproofed, painted to an approved finish and protected against ingress of solid foreign bodies and liquid according to IEC Recommendation 144 Degree IP 32. All boards shall be rated as required and shall conform in all respects with IS 13947. Exterior boards shall be protected to IP 65.

Low voltage distribution boards shall have banks of fuses or miniature circuit breakers which are easily removable and readily accessible for easy wiring. All boards shall have 25% spare ways fitted within the case. Incoming supplies to the distribution board shall enter by means of a lockable isolator, switch fuse, residual current device or molded case circuit breaker.

Boards which has feeders looped in or out at the busbars shall have double terminal blocks on each busbar.

All boards shall have insulating barriers installed between phases and between each phase and earth.

When required suitable holes/knockouts shall be provided to the top or bottom of the board to accommodate all incoming and outgoing cables through rubber washer glands.

Distribution boards shall be fitted with a permanent label giving details of fuses or miniature circuit breakers when their replacement by equipment of other makes or types would adversely affect the protection or discrimination provided.

♦ Fuses:

Fuses shall be categorised as AC 80, 660 volt to IS 13703. Fuse carriers and bases shall comply with IS 13703 Part 2.

♦ Miniature and Molded Case Circuit Breakers:

Miniature and molded case circuit breakers shall comply with IS 13032 and IS 13947 respectively. All breakers shall be selected in accordance with the Indian Standards with due regard to operating characteristics, current rating, calibration and discrimination. Adequate back-up protection by HRC fuses shall be provided.

Miniature circuit breakers shall be unconditionally rated at a category of duty M6 or higher. The effect of ambient temperatures, operating duty, and application shall be fully considered in applying de-rating factors for application at site.

Miniature and molded case circuit breakers shall have means for preventing any one pole of a multi pole circuit breaker being operated or tripping independently of the other poles.

Miniature and molded case circuit breakers shall have locking facilities and be supplied with all keys, or shall be enclosed in cases with locking facilities which shall be provided with keys.

Miniature and molded case circuit breakers shall be of the same type throughout the Contract.

♦ Residual Current Circuit Breakers:

Residual current operated devices are to be either 3 phase and neutral or 1 phase and neutral. Both types will be of the circuit current rating and rated tripping current as stated elsewhere in this Specification or on the drawings. Either type must isolate all poles and neutral and be complete with a test button marked 'PUSH TO TEST'. The unit must be of robust construction and be mounted in an enclosure of pressed steel.

Where residual current circuit breakers are used they shall be of the AC/DC current operated type complying with IS12640 when incorporated in fixed socket outlets, except that they shall be suitable for the service conditions as defined at site.

♦ Cables:

All cables shall be manufactured to Nepalese Standards:

- ✓ Low voltage (600/1 000 V grade) :PVC/SWA/PVC and XLPE/SWA/PVC multi-core cable. Installed direct in the ground, in ducts, on tray or clipped direct. Aluminium wire armouring shall be used for single core cables.
- ✓ Low voltage (600/1 000 V grade) :PVC/PVC multi-core cable to BS 6346. Installed in floor ducts, trunking or conduits.PVC single core non-sheathed (450/750 V grade). Installed in conduit or trunking PVC single core non-sheathed (600/1 000 V). Installed as internal wiring within switchgear and control assemblies.



- ✓ Instrumentation : PE/PSCR/OSCR/PE/SWA/PVC Plain annealed multi-stranded copper conductors, solid polyethylene insulation with aluminium-mylar pair screening including drain wire, with collective aluminium-mylar screen including drain wire, solid polyethylene bedded steel wire armour with an outer sheath of flame retardant PVC. PVC sheath to be blue colour for intrinsically safe circuits, black for ac and dc non-intrinsically safe circuits, 300/500 V grade.
- ✓ Control Digital :PE/OSCR/PE/SWA/PVC Plain annealed multi-stranded copper conductors, solid polyethylene insulation collective aluminiummylar screen including drain wire, solid polyethylene bedded steel wire armour with an outer sheath of flame retardant PVC. PVC sheath to be blue colour for intrinsically safe circuits, black for ac and dc non-intrinsically safe circuits, 300/500 V grade.

♦ Site Lighting:

Poles shall have:

- ✓ A weatherproof access door to the base compartment, fitted with tamper proof lock, to provide easy access to the equipment. The doors shall be interchangeable between poles without adaptation, and keys shall be supplied. Doors shall be provided with an earthing terminal for connection of an earth continuity conductor to the earth terminal block installed in the base compartment.
- ✓ A non-rusting earthing terminal bar near to the point of electrical supply and clearly marked 'earth'. This terminal shall be capable of accommodating an earth continuity conductor not less than 6 mm<sup>2</sup> nominal cross sectional area.
- ✓ Cable slot entries of not less than 150 mm long by 50 mm wide. The top of the slots shall be no more than 350 mm below ground level.
- ✓ A treated baseboard, within the compartment, of suitable size to accommodate all necessary control gear, cable terminations and looping type fuse service cut out. The baseboard shall be securely fixed within the pole.

Cutouts housed in the base compartments of lighting poles shall be designed primarily for use in street lighting poles and shall be suitable for termination or looping-in of the cables used. They shall consist of a substantial moulded plastic drip-proof enclosure with separate terminals for live, neutral and earth conductors, and incorporate a fuse carrier suitable for a fuse to IS 13703. Terminals shall be large enough to take the service cables used.

Three way type earth terminal block capable of accepting a cable size up to 6 mm<sup>2</sup>. shall be fixed to the base board adjacent to the cut-out. The terminal block may be incorporated within the cutout.

Ballast units shall comply with IS 1534 and shall be drip-proof, totally enclosed,



polyester filled, symmetrically wound type, silent in operation, and suitable for use on a 240 volt 50 Hz supply. Tapings shall be brought to suitable marked terminals to which lamp and supply connections can be made. Terminals shall be shrouded non-track type, and separate earth terminals shall be provided.

Capacitors shall comply with IS 1569 and shall be of the infused type, totally enclosed and proofed against condensation and climatic conditions, complete with discharge resistor, with sealed-in PVC insulated cable tails. Capacitors shall be suitable for working with the lamps and associated equipment specified and shall correct the power factor to not less than 0.85 lagging. The capacitors shall be marked with the manufacturer's name, capacitance and working voltage. Ballasts and capacitors shall carry the ISI mark.

Wiring between the terminal block in the lantern and the components in the base of the pole shall be PVC insulated, PVC sheathed cable of 1000 V grade having a copper conductor of not less than 2.5 mm<sup>2</sup> cross sectional area to IS 694. All cables shall be correctly colour coded. Unsupported lengths of wiring shall be kept to a minimum and taped such that they do not come into contact with components.

All metalwork other than current carrying parts shall be earthed.

Road lighting luminaries shall be die cast from aluminium alloy suitable for side entry spigot mounting. The luminaries shall be complete with polished aluminium reflector for use with the lamps and remotely mounted control gear. The impact-resisting bowl shall be sealed to provide a totally weatherproof unit and hinged to facilitate revamping.

Discharge lamps shall carry a 6000 hours guarantee, and shall be controlled by ballasts and capacitors, as recommended by the lamp manufacturer. High-pressure sodium discharge lamps shall be provided with an external ignitor unit.

♦ Lighting Luminaries

All 'discharge' luminaries shall be provided with a capacitor for the purpose of power factor correction to a value in excess of 0.85 lagging.

Breakjoint rings or 'biscuit' rings of approved colour shall be provided by the Contractor for all suspended luminaries and fluorescent batten luminaries where the batten is of insufficient width to completely cover the conduit box and its associated clearance hole in the finished ceiling.

Heat resisting cables shall be installed as the final connection to all tungsten luminaries.

All flexible cords to be used in conjunction with lighting luminaries shall be white 3 core circular 300/500 volt grade PVC insulated and sheathed manufactured to IS 694. Conductors smaller than 0.75 mm<sup>2</sup> cross sectional area shall not be used unless previously approved by the Engineer.

Fluorescent and incandescent luminaries shall be of the following types:

A. Tubular fluorescent luminaries:

- ✓ Reflection
- ✓ Diffuser

B. Incandescent type:

- ✓ Reflection/Shade
- ✓ Diffuser
- ✓ Water proof
- ✓ Bulk head

♦ Lamps

Tungsten lamps shall be coiled coil pattern to IS 418 and IS 6701. Fluorescent lamps shall be manufactured to IS 2418. High-pressure mercury lamps shall be manufactured to IS 9900. High - pressure sodium lamps shall be manufactured to IS 9974.

Incandescent lamps shall have IEC type B22d caps. Tubular fluorescent lamps shall have bi-pin caps. Discharge lamps shall have type ES 40 caps (GES).

♦ Lighting Switches:

Lighting switches for domestic and office purposes shall comply with IS 3854. They shall be of approved manufacture with shuttered outlets.

♦ Small Power Outlets:

For domestic and office applications, 13 amp socket outlets which comply with IS 1293 shall be used. These shall be switched unless otherwise indicated and supplied with a plug fitted with a fuse rated according to IS 13703. The fuse shall suit the apparatus served.

Where cooker control units are installed, double pole switches of suitable rating shall be installed without a socket outlet.

Fused spur units shall be of approved manufacture, of the same type and finish as socket outlets installed. Fuses to IS 13703 shall be sized to suit the connected load.

♦ Ceiling Fans:

Propeller fans of the non-ducted ceiling mounting type together with their associated control units shall comply with IS 374 and IS 3588.

♦ Conduits:

Rigid conduit shall be super high impact heavy gauge PVC conduit (HIP) and PVC accessories complying in all respects with IS 9537 and IS 3419. Each length of conduit shall bear the manufacturer's name or trademark and be smooth inside and out and free from imperfections.

20 mm diameter conduit shall have minimum 1.8 mm wall thickness; 25 mm diameter conduit shall have a minimum 1.9 mm wall thickness.

Flexible conduit shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings.

♦ Earth Electrodes:

Earth electrodes shall be 38 mm diameter galvanised iron rods made up in sections to the required length. Couplings joining rods shall be silicone bronze aluminium, counter bored and of sufficient length to cover the rod thread.

Earth plates shall be of a minimum size of 600 x 600 x 6 mm copper or galvanised iron.

♦ Standard Make:

The standard make of equipment, fixture, cables etc. shall be as per following or their equivalents:

MCCB	Seimens / Legrand /Terashaki
MCB	Seimen/Legra/Terashaki
Wiring cable	Nepalese cable with NS Mark
Light switch	Unbreakable - Legrand/ M
Switch socket	Unbreakable - Legrand/ MK
Fluorescent/CFL tube light fixture	Wipro / Philips
Outdoor light fixture/ Flood light fixture	Wipro / Philips
Incandescent light fixtures	Decon / Homedec
Power Cable	Poineer/Prakash/Trishakti/Janata
Lightening Arrestor (11 kV)	Japanese
Do-fuse	Japanese
Transformer	Crompton/ Alstom/ Ekrat
Diesel Generator	Cumins/ Perkins/ Kirloskar/Crompton &Greeves

**(e) Plant and Equipment**

Plant, equipment, and tools for the execution of electrical installations shall be sufficient in number and capacity, in good working order, and in accordance with the requirements of the applicable safety regulations.

**(f) Construction and Workmanship**

♦ Regulations and Standards:

The electrical installation shall comply with all relevant IS regulations, statutory instruments and regulations current at date of tender (unless otherwise indicated) some of which are listed within the detailed description in Appendix A.

The Contractor shall be responsible for complying with all local byelaws, supply

authority and local authority requirements. It shall be the Contractor's responsibility to determine the existence of these requirements and to comply with them.

♦ Cable Installation:

Cables to lighting and small power circuits shall be of one of the following sizes unless indicated otherwise:

- ✓ 1.5 mm<sup>2</sup> single core PVC for circuits loaded less than 1 kW.
- ✓ 2.5 mm<sup>2</sup> single core PVC for circuits loaded up to 3 kW.
- ✓ 4 mm<sup>2</sup>/6 mm<sup>2</sup> 2 core PVC for circuits loaded above 3 kW
- ✓ 1.0 mm<sup>2</sup> light duty multi-core PVC for control circuits.

Cables shall be segregated into the following categories:

- ✓ power (less than 1 000 V phase to phase)
- ✓ instrumentation/telemetry
- ✓ control
- ✓ telecommunications.

Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of equipment installed within the installation. As a general rule the following minimum clearances shall be adhered to wherever practical.

	HV power (mm)	MV/LV power (mm)	Instrumentation Telemetry Control(mm)	Telecommunications (mm)
HV power	-	-	-	-
MV/LV power	300	-	-	-
Instrumentation/telemetry/control	300	150	-	-
Telecommunications local area network	300	150	150	-

LV power cables may be bundled together where allowance is made for any derating factors.

Digital and analogue signals shall be segregated within junction boxes.

Cables shall be drawn into conduits simultaneously without twists. Cables bunched into circular groups shall have the appropriate de-rating factor applied in accordance with Appendix 9 of the IEE Regulations.

Cables shall be installed on the 'loop-in' principle, no joints or junction boxes being permitted. Single core cables in conduit shall have the line conductors looped at switches and the neutral conductors looped at lighting points. Multi-core cables shall have the line and neutral conductors looped at the lighting point.

Wiring shall not be looped at terminal blocks internal to lighting luminaries. For

fluorescent or similar luminaries having internal terminal blocks, the fixed wiring shall terminate at the conduit box with tails taken into the fitting. The arrangement shall be such that the fittings and tails may be removed without causing the other lighting luminaries on the circuit to be disconnected.

Wiring to 13 A socket outlet circuits shall be ring wired throughout. Spur circuits shall be used only where specified.

*(i) General*

Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.

Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.

*(ii) Direct in Ground*

Buried cable up to 600/1 000 V shall have a minimum cover of 500 mm measured to the top of the highest cable. On crossing roadways the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1 000 mm cover and encased on all sides by 150 mm of concrete.

The bottom of the cable trench shall be freed of sharp stones and such like and 75 mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above the cable.

Interlocking cable protective covers, minimum 1 m long x 150 mm wide, marked 'Danger -Electric Cable' in English, and Nepali shall be laid on top of the sieved sand. Covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm.

Warning tape shall be laid a minimum of 200 mm above the protective covers.

Cables are to be installed without tees or through joints unless otherwise approved by the Engineer. Single core cables are to be run in trefoil formation.

*(iii) In Underground Ducts*

Underground ducts shall be constructed of impact resistant PVC-U, glazed earthenware or concrete and laid at a minimum depth of 500 mm. Ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where they shall be 1 m deep and encased on all sides by concrete.

The Contractor shall ensure that sufficient draw-in points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required.

Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or other method approved by the

Engineer. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated.

*(iv) In Conduit*

Particular care shall be taken with the storage of conduit. A rack shall be provided for this purpose to ensure that the finish is not defaced. Conduit which is allowed to spread across the floor when stored so that the surface finish becomes damaged by being walked over or similar shall be rejected and removed from site.

All conduits shall be of sufficient size to permit the easy withdrawal and replacement of cables at a later date, no conduit smaller than 20 mm shall be used.

A space factor of 40% shall not be exceeded. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.

All bends shall be formed using bending springs in complete accordance with the manufacturer's instructions, and without alteration to the conduit section. Bends may be formed cold but in severe weather it may be necessary to warm the conduit slightly at the point where the bend is to be made. The inside radius of any bend shall not be less than 8 times of outside diameter of the conduit.

All conduit boxes on to which lighting fittings are to be affixed shall be capable of withstanding a dead weight of 10 kg and shall be fixed using two screws and washers. No weight shall be taken by any suspended ceiling.

For conduit boxes, couplers and all items of equipment that require adhesives, the manufacturer's recommended adhesive shall be used. Connection to square or rectangular boxes shall be made using female threaded sockets and male screwed bushes. On no account shall the conduit protrude into such items as switch boxes or socket boxes. Inspection bends, elbows, couplings and tees shall not be used.

Circular PVC boxes, having spout entries, shall be used at the termination of all lighting points and as draw-in boxes on long runs. For 20 mm conduits round boxes shall be used as draw-in points, but for 25 mm and larger conduits, rectangular boxes shall be used. In each case heavy quality lids shall be used and secured by brass screws.

Sufficient draw-in boxes shall be installed to permit the re-wiring of the installation and they shall be positioned to ensure that all boxes are in accessible positions. The Contractor shall check all proposed positions with the Engineer before installation. In the case of flush draw-in boxes the Contractor shall fit a joint ring or spacer ring to finished plaster level.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The whole of the installation shall be arranged for a loop-in type of system

with joints being carried out at switches, isolators, etc. Intermediate joints in the cable will only be allowed by arrangement with the Engineer. Where terminal blocks are necessary, they shall be of the porcelain type with brass pinching screws.

For entry into trunking and any item requiring holes to be cut, the method shall be by bell mouth bushes and sleeves. For entry into sheet metal boxes and any item complete with pre-cut holes, the method shall be by threaded female sockets and male screwed bushes.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement, etc. and covers, either temporary or permanent, shall be fitted on all boxes.

The conduits shall be completely assembled, fixed and swabbed out before wiring is commenced.

Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint. A total 150 mm movement shall be allowed.

The Contractor shall provide a typical installation method drawing for all conduit installations, when requested by the Engineer.

Where conduits are taken through walls and/or floors, the holes shall be made good with incombustible material.

All conduits to the telephone, TV and radio systems shall be installed with draw wires.

All conduits to lighting and small power systems shall be installed with a circuit protective conductor.

#### *(a) Surface Installation*

All surface work, work in ducts or ceiling voids, etc., shall be secured by means of heavy quality spacer bar saddles secured by screws driven into rawlplugs, or equivalent fibre, PVC, metal or compound types. The spacing of fixings shall not exceed 1.25 m for 20 mm, 25 mm and 32 mm conduit or less in hot temperatures. It should be noted that saddles are designed to be a sliding fit for PVC conduits and it is important to ensure that all fixings are sliding due to the requirement for expansion.

Due to the materials used in PVC conduits a rise in temperature of 25°C would cause an increase of approximately 6 mm in a 4 m length of conduit. Where long straight runs in excess of 4 m occur in conditions of varying temperature, expansion couplers must be used in accordance with the manufacturers installation instructions. A draw wire must be installed in runs where expansion couplings are used.

An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated. All surface conduit runs shall be marked out for approval by the Engineer before the installation is carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanised cable trunking.



*(b) Concealed Installation*

If the floor of any building is of solid concrete construction, conduits shall not be run in the screed rising to the outlets, etc., unless specifically instructed elsewhere in this Specification.

Where, due to the type of construction, it is necessary to cast conduits into concrete to serve lighting points, backed outlet boxes shall be used, using female threaded sockets and male screwed bushes, with the conduit installed in such a manner as to be self-draining in accordance with the IEE Regulations.

Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crampets or similar fixings shall be used for attaching the conduit to block work, etc. Building nails will not be accepted.

At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.

The conduit installation shall be inspected by the Engineer before the building operation conceals the work.

*(c) Flexible Conduit*

Flexible conduit shall be of the waterproof galvanised type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment. The earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc., will not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

*(v) Clipped Direct*

All cable hangers, clips, cleats and saddles shall be of an approved type and



appropriate to the type and size of cable installed.

Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

(vi) *In Internal Floor Trenches*

In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an approved manner.

Where the trench is shared by other services, cables shall be installed on the walls of the trench in an approved manner.

♦ *Distribution Boards*

Where boards are fixed on steelwork or concrete columns, reinforced concrete or brick walls, they shall be mounted on the surface with conduits and/or trunking rising vertically from them.

Where boards are fixed on plaster finished walls, they shall be surface mounted on the finished face of the plaster with an adaptable galvanised metal box (minimum size 150 x 150 x 75 mm), recessed into the wall at the back of each board.

The adaptable box and fuse board shall be electrically and mechanically linked together, but independently fixed on the wall by bolts and expansion shields.

♦ *Small Power Outlets*

Low voltage socket outlets for small power applications shall be fixed at a height of 300 mm from the finished floor level to the horizontal centre line of the switch.

Where recessed spur units control appliances such as incinerators, fans, water heaters, etc. a conduit shall be taken from the spur outlet box to an outlet box located immediately adjacent to the appliance in order to conceal the final connection to the appliances.

Wiring of spur units shall be carried out on 'ring' or 'radial' circuits as specified and shall conform to IEE Regulations.

♦ *Lighting Switches*

Lighting switches of a single pole type shall be connected to the phase conductor. Switches shall be fixed at a height of 1410 mm from the finished floor level to the horizontal centre line of the switch. Where grouped switches are used they shall be mounted in multi-gang boxes with plates.

All lighting switches shall be suitable for the power supply to which they are connected.

Lighting switches shall be mounted in separate boxes for separate circuits derived from different distribution boards.

Where multi-gang switches are supplied from opposite phases, phase barriers and warning labels shall be provided. Single gang switches connected to opposite phase polarity shall, in no case, be positioned less than 2 m apart.

♦ Lighting Luminaries

The Contractor shall check final positions of all lighting points with the Engineer and obtain his approval before installation commences.

All lighting luminaries shall be mounted and located in such positions as to be readily accessible for maintenance purposes from ladders or steps.

Fixing and suspension plates shall be suitable for direct connection to conduit boxes or as otherwise specified. Luminaries having conduit suspensions shall be provided with earthed pattern ball and socket back plates. The rigid type of backplate will not be accepted. Tubular fluorescent luminaries shall have at least two separate fixings at the manufacturers recommended spacings.

♦ Earthing and Bonding:

The earthing system shall comply with Clause 67 of the Indian Electricity Rules.

All low voltage systems shall be properly and efficiently earthed in accordance with BS/IS 3043.

The Contractor shall ensure that complete earth continuity exists throughout the system and that the resistance of the earth parts complies with the IEE Regulations.

Each control room building shall have a main earth bar consisting of a hard drawn high conductivity copper bar of at least 150 x 25 x 6 mm, mounted on stand-off insulators. Connections to this bar shall be by brass bolts, flat washers, nuts and locknuts.

The system neutral, where applicable, earth bars of all switchboards and all earthing terminals of all transformers shall be securely bonded to the main earth bar. For bonding purposes a galvanised iron earthing strip may be used, at least 25 x 6 mm in cross section.

Metal sheaths and armouring of all incoming, outgoing and interconnecting sub-station cables shall be securely bonded to the main earth bar. The sizes of bonding conductors shall be in accordance with IS 3043. Bonding conductors may be connected to the earth bar of the switchboard or other apparatus served.

All cables and conduits used throughout the installation shall be securely bonded to the associated equipment, and earthing straps shall be fitted. To facilitate such bonding, all cable glands shall be supplied with substantial armour clamps, having additional earthing lugs. Compression glands shall be fitted with earth tags and brass set screws.

Earthing terminals of every distribution boards, isolator or switchgear item or other apparatus shall be securely bonded through 14 SWG copper conductor or 25 x 6 mm

galvanised iron strip or by connecting the bonding conductors to the earth bar of the apparatus.

All electric motors and other items of electrical equipment within the Contract shall be bonded to earth by flexible copper cables, braids or conductors of not less than 6mm<sup>2</sup> equivalent size connected to the armouring of armoured cables unless stated otherwise.

All bonding of motors shall be to the stator frame of the motor. Bonding to end-shields, terminal boxes etc. is not acceptable.

Incoming gas, water, piped services and ducting shall be bonded in accordance with the requirements of IEE Regulation 413-2. The minimum size of the bonding conductor shall be 6mm<sup>2</sup>. Copper strip of green and yellow PVC insulated single core copper cables shall be used.

Earth clamps shall comply with IS 3043. In dry areas tinned brass clamps shall be installed. In areas where dampness is to be expected phosphor bronze clamps shall be used.

Where electrical components are mounted on custom built frames, each of the above earth bonds shall include the metalwork of the support structure. Conduit or trunking shall not be used as the sole circuit protective conductor.

♦ Earth Electrodes:

Where connections to the mass of earth are specified for lightning protection or system earthing the Contractor shall supply, install and test the connection in accordance with the following Clauses.

The Contractor shall, at the commencement of the Contract, carry out soil resistivity tests over the area of the Site indicated on the Drawings. A minimum of two tests of different spacings shall be carried out at each test location.

The results of these tests shall be used to determine the type and number of rods, plates or strips required.

The top end of rods shall be terminated at least 300 mm below finished ground level. Where rods are installed in areas accessible to persons or animals this depth shall be increased. The position of earth rods shall be indicated by pre-cast concrete inspection pits.

Where multiple earth rods are installed interconnections shall be made using bare galvanized iron strips. The strip shall be buried at a minimum of 600 mm below finished ground level.

The earth electrodes shall be connected to the main earth bar through test links. The earth electrode installation shall be tested in the presence of the Engineer when disconnected from the main system, using the method shown in Appendix 15 of the IEE Regulations.

Where the earth connection forms a link between a high voltage system and a low voltage system the earth connection resistance to earth when disconnected from the earth bar shall not exceed one ohm.

Where earth plates are required to carry a heavy system fault current these shall be buried at a depth of at least 2 m. Connection of copper tapes to earth plates shall be brazed and protected against corrosion.

Marker posts and plates shall be provided to mark the position of all electrodes and buried conductors.

♦ Site Lighting

The installation shall be in accordance with layouts with exact positions of control equipment, poles and lighting points determined on site to the approval of the Engineer, prior to starting erection.

The equipment shall be supplied in new and unused condition, having been tested in the course of manufacture and stored in weatherproof accommodation on site.

The Contractor shall carry out all unloading, slinging, stacking, erection and fixing of poles and brackets in accordance with the manufacturer's instructions.

Excavation for poles shall not be by mechanical means unless agreed by the Engineer. The bottom portion of pole shall be fixed in a solid precast concrete block not less than 450 mm square for the full depth of the block. Final adjustment shall be carried out using aluminium or hardwood wedges and the remaining annulus packed with sand. A cable duct shall pass through the concrete block into the column cable entry. Precast blocks shall be supplied and installed by the Contractor. The cable entry slot shall be temporarily plugged to ensure that it is maintained free from material during the backfilling process. The block shall be bedded on a 100 mm thick concrete base.

Poles shall be erected in a truly vertical position. The Contractor shall be responsible, until the expiry of the Defect Liability Period for correcting the alignment of any column which he has erected which has departed from the vertical position, excepting where it is established that such departure is due to an event outside the control of the Contractor.

Poles shall have their lanterns fixed and aligned in accordance with the manufacturer's instructions to prevent rotation in service. All joints shall be resistant to the ingress of moisture into the column and lantern.

**(g) Test and Acceptance**

Tests shall be carried out on site and witnessed by the Engineer or his representatives as follows for LV cables:

- ✓ Insulation resistance at 500 V dc shall not be less than 0.5 mega ohm.
- ✓ Earth continuity and earth resistance.
- ✓ Phasing and polarity (every fuse and single pole control and protective device

shall be connected in phase conductors only).

## 8005 DRAINAGE, PIPELINES AND RELATED ACTIVITIES

### (1) Pipe Trenches

#### (a) Scope

This specification covers earthworks for trenches for all types and sizes of pipes. It covers excavation, the preparation of a trench bottom, backfilling and the reinstatement of surfaces.

#### (b) Interpretations

##### ♦ Supporting Specifications:

The following specifications of the Section VI(b): Standard Specifications and Section VI(c): Special Provisions to the Standard Specifications shall, inter alia, form part of and shall be read in conjunction with this specification:

- ✓ Section 100: “General”
- ✓ Section 200: “Site Clearance”
- ✓ Section 900: “Earthworks”

##### ♦ Application:

This specification contains clauses that are applicable to earthworks for pipe trenches associated with the proposed sub-project.

##### ♦ Definitions

For the purpose of this specification (i.e. for Water Supply Works) the following definitions shall apply:

- ✓ Backfill - The approved filling material placed in a pipe trench after the pipe has been laid, bedded, and surrounded by the blanket that has been compacted at the sides and over the top of the pipe.
- ✓ Bedding - The material, and the operation of placing it, of the bedding cradle and blanket, up to the underside of the backfill.
- ✓ Blanket - The bedding zone in which material is placed and compacted on or from the top of the cradle up the sides and over the top of the pipe in such a manner that the barrel of the pipe is supported continuously and firmly on the sides and protected over the top by a dense cushion of material.
- ✓ Cradle - The bedding zone in which material is placed firmly and without voids under and up the sides of a pipe in such a manner that for all practical purposes the pipe cannot move or deflect.

#### (c) Materials

The excavation of material will, for purpose of measurement and payment, be classified as specified in Section 900: “Earthworks”.

For selected fill material, the requirements given in Sub-Clause 8005(2): “Pipe Bedding” shall apply.

Backfill material shall be material excavated from trenches, provided only that it contains no organic material, that it excludes stones of average dimension exceeding 150 mm, and that its moisture content will allow it to be compacted to 95% of the Modified Proctor Density to avoid significant settlement, and shall have a PI not exceeding 12. Backfill material in road or traffic areas shall in addition have a minimum CBR of 15% at specified density if placed in the upper 200 mm of the subgrade, and a minimum CBR of 7% if the backfill is to be placed lower in the subgrade. Material containing more than 10% of rock or hard fragments that are retained at a sieve of nominal aperture size 50 mm, and material containing large clay lumps that do not break up under the action of the compaction equipment being used, will be regarded as unsuitable for use in backfilling.

If the Contractor allows material which, when excavated was suitable for re-use, to become unsuitable when required for backfilling, he shall make good by running it to spoil and replacing with suitable material.

Where trenches cross or run along surfaced roads and paved areas of which the surfaces are ordered by the Engineer to be reinstated, the Contractor shall obtain prior approval for subbase and base materials that may be required to supplement such materials lost during excavation. Materials for bituminous or asphalt construction shall comply with the applicable standards of the Roads Department of the Ministry of Transport.

The Contractor is not required to use selective methods of excavation but may, if he so wishes, screen, wash or otherwise treat excavated material in order to produce material suitable for the bedding. He shall take positive steps to avoid burying or contaminating materials which otherwise would be suitable for use as different types of fill, topsoil, or road material, as applicable.

#### **(d) Construction Equipment**

The Contractor shall use trenching equipment that will excavate to a width such that the side allowance does not exceed the appropriate values specified herein for the “Minimum Base Width”, by more than 50 %.

The Contractor shall use appropriate techniques or provide equipment such as pumps, well points and sheeting or close timbering for keeping the trenches sufficiently free from water to enable him to lay pipes true to line and level and to bed them soundly.

The Contractor may use mechanical compaction equipment but he shall select such equipment and operate it in such a manner that the pipeline is not stressed or damaged. Machine compaction shall not be used directly above the pipe until sufficient backfill has been placed to ensure that machine compaction loads transmitted to the top of the pipe are not greater than would be imposed by normal road traffic over a pipeline with cover of depth 600 mm.

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(e) **Construction and Workmanship**

♦ Precautions:

- ✓ With regard dealing with water, the requirements of Section 900: “Earthworks” to be Kept Free of Water, shall apply in addition to the stipulations below.

In the case of a trench on sloping ground, the Contractor shall take approved measures (such as the construction of cross-embankments) to minimize erosion in the trench and adjacent ground.

With regard to accommodation of traffic and access to properties, the Contractor shall, in addition to the requirements for Traffic Control of Section 102: “Accommodation of Traffic” of SPSS (Section VI(C)), construct or put in order such bypass(es) as may be required to deviate traffic from portions of the road that are to be affected by the construction; or where half-width construction is ordered or approved, so arrange his work that the traffic will at all times have free one-lane access to at least half the width of the roadway; or ensure, wherever possible, that the whole road is open at night and left in a trafficable condition, complete with traffic signs and protection facilities as specified.

He shall also ensure, wherever possible, that the usable width of the road is at least 3.5m and he shall provide and allow reasonable access to persons occupying properties that fall within or adjoin the area over which he is working. If, for any reason, such access has to be closed during the construction period, the persons affected shall be given reasonable notice for each such period of closing.

With regard to existing services that intersect or adjoin trenches, the relevant requirements regarding to Existing Services, shall apply.

Special precautions may be necessary when buildings are close to the edge of the trench. Throughout the duration of such activities the Contractor will be fully responsible for the safety of all adjacent property. Wherever the minimum clearances cannot be complied with, e.g. in certain urban areas, the Contractor shall provide adequate temporary protective support by struts, bracing, etc. for adjacent structures and such support must be capable of safeguarding the buildings from structural damages resulting from the execution of the Works. Prior to installation the Contractor shall submit to the Engineer his proposed system of support for approval. Irrespective of the Engineer's approval sufficiency and suitability of the support will remain the sole responsibility of the Contractor. The support shall remain in place until such time as the Contractor is sufficiently convinced that there is no more imminent risk of damage of any kind to the adjacent buildings resulting from the activities. Upon removal of the support any damages caused by the attachment of the support itself shall be repaired to the satisfaction of the Engineer.

♦ Minimum Base Width:

Unless otherwise shown on the drawings, or as directed, the base width of a trench



shall be not less than the external diameter of the pipe barrels plus twice the side allowance as shown below:

- ✓ ND up to 600 mm ..... side allowance 300 mm
- ✓ ND over 600 mm up to 1000 mm ..... side allowance 400 mm
- ✓ ND over 1000 mm up to 2000 mm ..... side allowance 500 mm
- ✓ ND over 2000 mm ..... side allowance 600 mm

The minimum base width for pipes not exceeding 125 mm and laid at a depth not exceeding 1.5 m may be less than 600 mm for flexible continuous piping that, in terms of the specification or schedule, requires no bedding or jointing in the trench.

Where two or more pipes are to be placed in one trench, the base width of the trench shall be no less than the sum of the external diameters of the pipe barrels plus the side allowance for each outer pipe plus, between each pair of adjacent pipes, the average of the side allowance for each pipe.

♦ Site Clearance:

The Contractor shall clear the working strip, in accordance with Section 200: “Site Clearance” of the SPSS (Section VI(C)). The working strip shall be an area of sufficient width along the route of the pipeline to ensure that his construction operations are not hampered and damage to buildings and the environment is minimized.

♦ Excavation:

The length of pipe trench excavated by a gang shall not extend more than 200m beyond the start of excavation or the completed backfill unless approved by the Engineer. The width of the trench shall provide at least the appropriate side allowance (within trench supports, if any) as specified here above for the “Minimum Base Width”, and such that half of the base width is on either side of the designated centre-line of the pipe.

The sides of each trench from the bottom up shall be as nearly vertical as possible for at least the height of the bedding.

When cutting through bituminous surfaces, the edges of the existing bitumen base and/or wearing courses shall be cut back vertically to straight lines.

In densely built-up areas with restricted and confined space, such as in urban areas, the stockpiling of excavated material adjacent to the trench for use as backfill material may not always be possible. In such cases the Contractor transport such material to and stockpile it at a distance away from the point of excavation, at locations suitable and approved by the Engineer.

All trenches shall be braced and strutted to the satisfaction of the Engineer, if they are

- ✓ so close to a building or structure, that a line between the corner of the trench



bottom nearest to the building and the underside of the foundation of the building or structure would be steeper than 45°

- ✓ if the soil conditions are not providing sufficient stability to the side walls.

The Contractor will be responsible for any damage resulting from trench instability and insufficient bracing and strutting.

During the course of the Works the Contractor shall clean road surfaces and other paved areas used by his vehicles and employees to minimize disturbance to residents and road users, cleaning shall be to the satisfaction of the Engineer.

♦ Trench Bottom

Material that the Engineer considers to be unsuitable at the bottom of the trench shall be excavated to the depths directed and disposed of in the manner described. The resulting space shall be refilled, as ordered, with approved material and compacted as directed.

Where the bottom of the trench has been loosened during excavation, it shall be compacted at OMC to 90 % of modified AASHTO maximum density prior to bedding and pipelaying.

Bottoms of the excavated trenches shall be trimmed flat and levelled to provide an even base for the pipeline or pipe bedding; rocks, debris or other extraneous matter that may damage the pipes shall be removed.

Where pipes are to be laid on formation made in undisturbed ground (i.e. without bedding), the Contractor shall ensure that excavation in the first instance is stopped 75 mm above formation level and the trimming the formation shall be done by hand immediately prior to starting the laying of the pipes.

Where granular or concrete beddings are required, bottoms of trenches shall be excavated to a depth below the proposed level of the pipe over the full width of the trench as shown in the Drawings.

The depth of the trench shall be such that the depth of the cradle can be placed under the pipeline, and the trimming and grading of the bottom of the trench shall be such that the barrel of each length of pipe can be uniformly supported over its full length, free at the joints, and at the correct grades and levels.

The bottom of pipe trenches shall be sufficiently straight to enable the pipe to be laid without reduction of the side allowances given here above for the “Minimum Base Width”, and in conformity with the applicable tolerances specified.

♦ Backfilling

Backfilling of pipe trenches shall commence as soon as possible after the pipe has been laid and firmly bedded in the specified cradle and the blanket has been placed over the top of the pipe to the height of blanket cover specified.

Backfilling shall be carried out as described below and over the full extent of the

actual trench excavation and to original ground level, except where otherwise directed.

Unless the Contractor is authorized by the Engineer to use other material, the material for backfilling above the bedding (cradle and blanket) shall be obtained from trench excavations.

Unless prior approval has been obtained, no filling shall be placed in water.

Hard and rock material shall be incorporated in the backfill above the bedding only to the extent approved. Depending on the quality of the material, the Engineer may direct that it be suitably mixed with other backfill material.

Excavated material from the trench, which is unsuitable or has become surplus because of bulking, displacement by the pipe and importation, shall be disposed of as approved by the Engineer.

Any deficiency of backfill material from trench excavations because of removal of organic or other unsuitable material shall be made up from suitable surplus material from other excavations on the Site. If, insufficient or no suitable material is available for this purpose from such excavations, the Contractor shall import sufficient suitable material. The Contractor shall so arrange his work that the importation of backfill material is kept to a minimum.

The Contractor shall complete backfilling of trenches expeditiously and in reasonable lengths.

♦ Compaction

In normal areas backfill shall be in accordance with Section 700: “Pipe Drains, Pipe Culverts and Concrete Channels” of the SPSS (Section VI(C)).

In areas subject to traffic loads, trenches shall be backfilled with selected fill material in layers of thickness (after compaction) not exceeding 150 mm and the material shall be compacted to at least 95 % of modified AASHTO maximum density up to the top of the subgrade level.

♦ Reinstatement of Surfaces

In all cases, the Contractor shall, if ordered, reinstate surfaces over the full extent of the top of the actual excavation.

On private properties or other unsurfaced areas, the top 300 mm layer of each trench that will not be subject to road traffic loads shall be of such topsoil as is available in addition to soft material from excavations. The finished surface of backfilling that is left raised of the surrounding ground to allow for initial settlement shall be not more than 150 mm above the surrounding ground

In the case of gravel roads or similar surfaced areas, the Contractor shall, immediately after completion of the backfilling to the top of the subgrade level, reinstate the road surface by filling the remainder of the trench with a well-graded and approved hard-

wearing gravel surface of thickness at least 150 mm, and of quality equal to that of the existing road surface compacted to at least 95% modified AASHTO. The gravel layer shall be finished with a slight camber in order to allow for initial settlement but shall not be shaped such as to cause excessive jolting of any vehicle proceeding with normal speed.

If the surface of a road with a stabilized base has been disturbed, the base shall be replaced with crusher run base compacted with sufficient moisture to give a density of at least 98 % modified AASHTO maximum density.

Except if otherwise ordered by the Engineer, the surface of a bitumen road shall be reinstated with asphalt of at least the thickness used in the original state. The base material shall be graded to a level sufficiently below the final road surface to allow the bitumen surfacing to be accommodated, and the edges of the existing bitumen wearing course shall be cut back vertically to a straight line. Before the bituminous construction is commenced, all loose materials and dust shall have been removed and the surface shall have been approved and prime coated at 1.0 l/m<sup>2</sup> of MC30 cutback bitumen. The bituminous surface will have a tolerance of -0+6 mm after compaction.

The Contractor shall maintain the reinstated surfaces and shall make good, at his expense, any damage due to any subsidence, pothole or other unevenness immediately after it occurs during the period of the contract or during the defects liability period.

Where, during the execution of the activities, any road or paved surface adjacent to a trench has been damaged in any way whatsoever by the Contractor's equipment, he shall, at his own expense and as soon as is practicable, repair and restore such surface to a condition at least equivalent to that previously existing, and to the satisfaction of the Engineer and the concerned authority.

#### **(f) Tolerances**

##### ♦ Alignment and Grade:

The deviation from the specified level of the invert and the specified dimensions of a trench and (for a height equal to at least the diameter of the pipe) of the lower part of the sides of the trench shall be such that the pipe may be laid and bedded in the trench within the tolerances specified for the pipeline.

##### ♦ Moisture Content and Density:

The requirements for moisture content and density given in Clause 2.2.6 Tolerance in Positions, Dimensions, Levels, etc. shall apply.

#### **(g) Testing and Acceptance**

The Contractor shall prove: the optimum moisture content, the maximum dry density, the CBR, Marshall and the specified properties of reinstatement and backfill materials before use at a rate of one test per 200 m<sup>3</sup> of material. In-situ density test of non-bituminous materials, and Marshall compaction/in-situ coring of bituminous materials will be carried out on each layer for every 200 linear meter of trench or part thereof

by the Contractor in the presence of the Engineer, or by an independent laboratory approved by the Engineer. The cost of all testing will be included in the Contractor's rates. In the event of failure results, the Engineer will order any necessary re-testing and remedial works at the Contractor's expense.

## (2) Pipe Bedding

### (a) Scope

This specification covers the bedding, consisting of the bedding cradle and the selected fill blanket, for buried pipes for carrying fluids under pressure or gravity.

### (b) Interpretations

#### ♦ Supporting Specifications:

The following specifications of the Section VI(b): Standard Specifications and Section VI(c): Special Provisions to the Standard Specifications shall, inter alia, form part of and shall be read in conjunction with this specification:

- ✓ Section 100: "General"
- ✓ Section 200: "Site Clearance"
- ✓ Section 900: "Earthworks"
- ✓ Section 700: "Pipe Drains, Pipe Culverts and Concrete Channels"

#### ♦ Application:

This specification contains clauses that are generally applicable to the bedding of pipes.

#### ♦ Definitions:

For the purpose of this specification the following definitions shall apply:

- ✓ Bedding - The material in the bedding cradle and fill blanket up to the underside of the main fill, and the operation of placing and compacting bedding in the manner specified.
- ✓ Bedding cradle - The zone in which bedding is placed firmly and without voids under and up the sides of a pipe in such a manner that for all practical purposes the pipe cannot move or deflect.
- ✓ Expansion joint - A joint in concrete bedding in which two concrete surfaces are separated by resilient filler of thickness at least 15 mm.
- ✓ Flexible pipe –A pipe whose properties are such that the first limit state reached is either excessive deformation, or buckling collapse. Plastic pipes, UPVC etc., are examples of flexible pipes.
- ✓ Joint hole - A depression formed in the bedding cradle to accommodate a joint in a pipeline.
- ✓ Main fill - The approved filling material placed in a pipe trench after the pipe has been laid, bedded, and surrounded by selected fill blanket up to 300 mm

cover above the top of the pipe.

- ✓ Rigid pipe – A pipe whose properties are such that the first limit state reached is fracture of the pipe walls due to bending stress. Concrete pipes are an example of rigid pipes.
- ✓ Selected fill blanket - Material placed and compacted to form a blanket on or from the top of the bedding cradle up the sides and over the top of the pipe in such a manner that the barrel of the pipe is supported continuously and firmly on the sides and is protected over the top by a dense cushion of material.
- ✓ Selected fill material - Material that complies with the requirements described here below for “Selected Fill Material”.
- ✓ Selected granular material - Material that complies with the requirements described here below for “Selected Granular Material”.
- ✓ Semi-rigid pipe - A pipe that can deform enough to redistribute some of the overburden pressure to the side-fills, but which is stiff enough to rule out the possibility of buckling. The first limit state reached may be either excessive deformation, or excessive wall bending stresses. Ductile iron pipes are considered semi-rigid.

(c) **Materials**

♦ Selected Granular Material:

Selected granular material shall be material of a granular, non-cohesive nature, free draining, a pH > 6 and the following grading.

Sieve Size (mm)	% Passing Sieve
40	100
20	80-100
5	40-100
2.5	20-80
0.6	
0.315	0-20
0.075	0-5

♦ Selected Fill Material

Selected fill material shall be material that has a pH > 6 and the following grading.

Sieve Size (mm)	% Passing Sieve
40	100
20	80-100
5	40-100
2.5	20-100
0.6	5-100
0.315	0-70
0.075	0-10

♦ Bedding

*Rigid Pipes:*

Bedding for rigid pipes shall be of Class A, B, or C. The bedding cradle for Class A bedding shall be concrete. Bedding cradles for Class B and C bedding shall be of selected granular material. The material for the selected fill blanket shall be selected fill material.

*Flexible and Semi-rigid Pipes:*

Bedding for flexible and semi-rigid pipes shall be of Class S or B. The bedding and blanket for Class S shall be selected fill material. Bedding cradles for Class B bedding shall be of selected granular material and blanket shall be selected fill material.

♦ Selection

The Contractor may screen, wash, or otherwise treat excavated material from pipe trenches or other excavations in order to produce material suitable for bedding or covering the pipeline. The Contractor shall take every reasonable precaution to avoid burying or contaminating material that is suitable and is required for bedding or covering the pipeline.

When material suitable for use as selected fill material or selected granular material is not readily available from trench or other excavation within a reasonable distance, the Contractor shall, subject to the Engineer's approval for each material, obtain suitable material to replace the shortfall by opening up borrow pits at approved areas located at intervals along the route of the pipeline or by importing from commercial or other sources.

**(d) Construction Equipment**

Adequate equipment shall be provided by the Contractor for the placing and compacting of bedding as specified here below.

The Contractor shall also provide the necessary test equipment for performing on Site the tests referred here below for "Testing and Acceptance".

**(e) Construction and Workmanship**

♦ General

No bedding shall be laid until the Engineer has approved the trench, measured the depth if necessary, and authorized pipelaying to proceed.

The anchoring of pressure pipes shall be as shown in the Drawings.

The bedding criteria for ductile iron is given in the following table.

Pipe Diameter	Bedding Type	
	Class S	Class B
	Pipe cover	
1400	> 4.0m	>4.0m
1100	>4.1m	>4.1m
1000	>4.3m	>4.3m
900	>4.7m	>4.7m
800	>5.1m	>5.1m

700	>5.8m	>5.8m
<600	>6.0m	>6.0m

A cavity of adequate size shall be excavated in the sides and bottom of the trench or left in the pipe bed at each joint and at each sling position.

The preparation of the trench bottom or surface of the bed shall be completed for at least one full pipe length in advance of the pipe laying, except where in exceptional circumstances another arrangement is approved.

No bedding material shall be placed in trenches containing water.

Where bedding other than concrete is to be used, stones, bricks, or similar materials shall not be used below or against the pipes to locate them in position in the trench or to level the pipes.

Except in the case of Class A bedding and concrete surround, the joint holes shall be refilled with fine granular material and lightly compacted to prevent the migration of adjacent pipe bedding material into the holes and to obviate the forming of hard spots under joints.

In the placing of bedding, all voids under the overhang of the pipes shall be filled and the compaction shall be carried out uniformly on each side of the pipes so as not to cause any lateral or vertical displacement of the pipe.

Bedding shall be carried out as pipelaying proceeds, and shall be completed before the acceptance test is carried out.

The degree of compaction attained for bedding (other than concrete) shall be 90% modified AASHTO maximum density.

♦ Placing and Compacting of Bedding for Rigid Pipes

In addition to complying with the requirements listed above, the Contractor shall construct the bedding for rigid pipes in accordance with the following requirements:

- ✓ Class A: The pipes shall be supported on a continuous cradle of concrete having a 28 days compressive strength of at least 20 MPa. During pipelaying and before the placing of the concrete bedding, the pipes shall be suitably supported. Care shall be taken during the placing of the concrete to prevent movement or flotation of the pipes. In the case of pipes with flexible joints, concrete shall not be allowed to enter the joints during casting of the bedding and a positive vertical expansion joint in the bedding cradle shall be formed at each pipe joint. The selected fill blanket shall not be placed in any section until a period of 24hr has elapsed after placement of the bedding cradle in that section.

The main fill shall not be placed in any section until the bedding cradle in that section has achieved a compressive strength of at least 15 MPa.

- ✓ Class B: The pipes shall be bedded on a continuous bed of selected granular



material, the material being placed in accordance with the details, as relevant, and the bedding constructed in the manner shown, as relevant. To ensure that each pipe will be fully supported throughout the length of its barrel on the bedding cradle, joint holes shall be formed in the bedding cradle for pipe sockets and couplings.

- ✓ Class C: The pipes shall be placed directly on the trench bottom after this has been hand-trimmed to ensure that each pipe will be fully supported throughout the length of its barrel. Joint holes shall be formed in the trench bottom for slings, pipe sockets, and couplings.

Any material that is used to support a pipeline temporarily during construction or does not comply with the requirements for bedding cradle shall be removed before the selected fill for Class B or C is placed.

After the pipes have been laid and tested, selected fill material shall be carefully placed into the spaces between the pipe and the sides of the trench to the level of the crown of the pipe. The material shall be thoroughly packed and rammed by careful hand tamping in layer 100 mm thick before compaction to the density specified here above in Clause General.

Placing and tamping shall proceed equally on both sides of the pipe. A further layer of the same material at least 300 mm thick after compaction and the full width of the trench shall be placed over the crown of the pipe in equal layers, each layer being compacted to the density specified here above in Clause General.

- ♦ Placing and Compacting of Bedding for Flexible and Semi-Rigid Pipes

In addition to complying with the above described general requirements, the Contractor shall construct the bedding for flexible and semi-rigid pipes in accordance with the following requirements:

- ✓ Class B: Flexible and semi-rigid pipes shall be supported on a cradle as indicated on the engineer's drawings. Initially continuous bed of selected granular material of compacted depth indicated shall be placed in 100 mm layers and covering the full width of the trench. The granular material shall be compacted to the density specified here above as General requirements. After laying of the pipeline, additional selected granular material shall than be placed carefully and evenly between the sides of the trench and the pipeline, in layers of un-compacted thickness approximately 100 mm and in accordance with the construction details. Each layer shall be compacted individually to the density specified here above as General requirements.

After completion of the bedding cradle, selected fill blanket shall be placed carefully in layers of 100 mm un-compacted thickness over the full width of the trench and shall be compacted to the density specified here above as General requirements up to a height of at least 300 mm above the crown of the pipeline.



- ✓ *Class S*: Flexible and semi-rigid pipes shall be supported on a cradle as indicated on the engineer's drawings. Initially continuous bed of selected fill material of compacted depth indicated shall be placed in 100 mm layers and covering the full width of the trench. The fill material shall be compacted to the density specified here above as General requirements. After laying of the pipeline, additional selected fill material shall than be placed carefully and evenly between the sides of the trench and the pipeline, in layers of un-compacted thickness approximately 100 mm and in accordance with the construction details. Each layer shall be compacted individually to the density specified here above as General requirements.
- ✓ After completion of the bedding cradle, selected fill blanket shall be placed carefully in layers of 100 mm un-compacted thickness over the full width of the trench and shall be compacted to the density specified in here above as General requirements, up to a height of at least 300 mm above the crown of the pipeline.

When placing and compacting the bedding particular care shall be exercised to prevent damage, deflection, or displacement of the pipeline and the polyethylene sleeving.

♦ *Concrete Surround for Flexible and Semi-Rigid Pipes:*

In special cases, and where ordered by the Engineer, pipes shall be surrounded in concrete of the specified grade, generally of at least 20 MPa. The lower part of the encasement shall be constructed in the manner specified for Class A bedding. Once the pipeline has been tested and approved, the pipes shall be covered with concrete to the specified depth and expansion joints shall be cut or constructed in the upper part to coincide with those in the lower part. No earth filling over the concrete shall be commenced until at least 5 days after the concrete has been placed or until the concrete has attained a strength of at least 15 MPa.

**(f) Tolerances**

The permissible deviations shall be as follows:

- ♦ Moisture Content in field during compaction ..... OMC -2, +1 %
- ♦ Density when bedding rigid pipes ..... -0, +5 %
- ♦ Density when bedding flexible and semi-rigid pipes ..... -0, +3 %

**(g) Testing And Acceptance**

The Engineer may order density tests to be carried out to determine the density and grading of the bedding. Tests will be carried out for every 200 linear meter of trench or part thereof by the Contractor in the presence of the Engineer, or by an independent laboratory approved by the Engineer. The cost of all testing will be included in the Contractor's rates. If the density is found to be below the specified value, the Engineer may order removal and re-compaction at the Contractor's expense, and the cost of

retesting shall be borne by the Contractor.

The tests may be carried out by the sand replacement method or, where the grading of the bedding is such that the particle size is not less than 0.075 and not more than 2 mm, by use of a dynamic cone penetrometer.

### (3) Pressure Pipelines

#### (a) Scope

This specification covers the transportation to Site, installation and testing of ductile iron pipe, valves, fittings and plastic sleeving supplied by the Employer.

It also covers the construction of valve chamber, thrust blocks and other structures required for the operation of the bulk distribution mains.

#### (b) Interpretations

##### ♦ Supporting Specifications:

The following specifications of the Section VI(b): Standard Specifications and Section VI(c): Special Provisions to the Standard Specifications shall, inter alia, form part of and shall be read in conjunction with this specification:

- ✓ Section 100: “General”
- ✓ Section 200: “Site Clearance”
- ✓ Section 900: “Earthworks”
- ✓ Section 700: “Pipe Drains, Pipe Culverts and Concrete Channels”
- ✓ Section 2000: “Concrete for Structures”
- ✓ Section 2500: “Brickworks for Structures”

##### ♦ Application:

This specification contains clauses that are generally applicable to the construction of ductile iron pipelines and appurtenances.

##### ♦ Definitions

For the purpose of this specification the following definitions shall apply:

- ✓ Fitting - A special or a valve, or a process of jointing (except welding) straight pipes to one another and to specials and valves.
- ✓ Pressure Pipelines – A pipeline in which the normal internal working pressure exceeds 3 metres of water (0.3Bar) and such other pipework as may be so designated
- ✓ Special - Any pipe other than straight pipe, such as bends, tees, reducers, etc.
- ✓ Straight pipe - A straight pipe of uniform bore and of standard or non-standard length.

##### ♦ Abbreviations:

For the purpose of this specification the following abbreviations shall apply:

- DI.....Ductile iron
- IRHD ..... International rubber hardness degree
- PTFE..... Polytetrafluor ethylene

**(c) Materials**

Ductile cast iron pipes, specials, polyethylene sleeving and valves, shall comply with the specification as mentioned herein for “Ductile Cast Iron Pipe”. They shall be capable of withstanding the applicable test pressure specified here below as per the general requirements. All pipes and fittings shall be supplied complete with couplings and jointing material.

Satisfactory temporary end covers shall be provided by the contractor for the protection of threads, flanges, and prepared ends of plain-ended pipes and fittings, and to prevent damage to internal lining during transportation and during handling on Site.

The Contractor shall supply a mastic putty, and a wrapping tape, to protect all buried nuts and bolts from corrosion

The Contractor shall supply protective wrapping tape to be used to protect the pipe and joints from corrosion in the locations indicated on the Drawings. The primer used before application shall consist of xylene and bituminous material and shall be supplied by the tape manufacturer. The tape shall be black in colour and consist of a PVC backing bonded to a self-adhesive bituminous rubber compound with a total thickness of 1.65mm. The PVC backing shall be extruded (non-calendered) and have an average thickness of 0.75mm. The tape shall be supplied on a high quality over width silicone release paper, extending some 12.5mm wider than the tape.

Pipeline materials shall be so transported, stored, and handled that pipes are not overstressed at any time and fittings are not damaged in any way. Pipes damaged or cracked in any way shall be removed from the Site and replaced at the Contractor’s expense.

Materials for manhole covers and surface boxes shall be as specified herein for “Covers for Chambers”.

**(d) Construction Equipment**

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturer’s recommendations.

The equipment and rigging equipment used by the Contractor for the handling and placing of pipes shall be in accordance with the manufacturer’s recommendations and shall be such that no pipe is overstressed during any operation covered by the specification.

The Contractor shall provide all tools and equipment used for the cutting, jointing and laying of pipes, fittings and valves.

The Contractor may use any acceptable device, including one incorporating a laser beam, to control the alignment and laying of the pipeline subject to the approval of the Engineer.

The Contractor shall provide all equipment and tools required for installation of polyethylene sheeting, mastic putty and all types of wrapping tape.

The Contractor shall provide all equipment, materials, tools and fittings required for the cleaning and swabbing of the pipeline.

The Contractor shall provide all the equipment, materials, tools, and fittings required for the performance of the tests given in Sub-section 3.3.7 below. Test gauges shall be of approved manufacturer having dials at least 200 mm diameter, graduated such that the test pressure is at least 75% of the gauge reading. If necessary different gauges shall be supplied for different pipeline sections. Two gauges of each type shall be provided for the sole use of the Engineer and shall remain in the Engineer's possession for the duration of the Contract.

All gauges shall be dead weight tested and proved at the commencement of use and at regular intervals thereafter as required by the Engineer.

All equipment and methods shall be subject to the approval by the Engineer

**(e) Construction and Workmanship**

♦ Handling of Pipes and Fittings:

Coated pipes shall be transported on trucks or trailers fitted with approved padded timber cradles shaped to fit the curvature of the pipes and of adequate dimensions so as to prevent any damage to the pipe coating. Successive tiers of coated pipes shall be separated by similar suitable shaped timber cradles when more than one tier of pipes is being transported. Pillows shall be provided between securing chains or lashings when loads are being transported.

Particular care shall be taken during unloading, loading, handling and transportation to avoid distortion, flattening, denting, scoring or any other damage to the pipes, fittings and any damage to the external or internal coating or lining of the pipes, fittings etc. Under no circumstances shall pipes be dropped, be allowed to strike on another, be rolled freely or dragged along the ground.

Loading, unloading and handling shall be carried out using special hooks, well padded, with a curved plate to fit the curvature of the pipes or webbing slings not less than 30 cm wide or other means approved by the Engineer. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum. Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Engineer may cause damage to the pipes shall be discarded.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

Care shall be taken during loading, transporting, and unloading to prevent damage to the pipes, fittings or coatings. When loading pipes in the stockyard the Contractor will be responsible for any damage to pipes and fittings which shall be noted and reported to the Engineer. After unloading all pipes or fittings will be examined and any defects or damage shall be noted and reported to the Engineer. Any damage shall be repaired in a manner recommended by the Manufacturer with the approval of the Engineer. Any pipe not considered by the Engineer to be of an acceptable quality after repair will not be accepted and the Contractor will be required to compensate the Employer.

When materials are temporarily stored at the edge of the wayleave they shall be stored clear of the ground and positioned to avoid damage by passing traffic in a manner approved by the Engineer.

♦ Laying:

To ensure that his supervisors and operators are familiar with the manufacturer's instructions/pipeline construction manuals for the laying and jointing of pipes and that these instructions are strictly adhered to, the Contractor shall employ the manufacturer to demonstrate laying and jointing. The demonstration shall also include the cutting of pipes and the repair of damaged pipes.

Pipe laying shall not commence until the bottom of the trench and the pipe bed have been approved by the Engineer's representative.

The trench bottom shall be prepared as specified in Clause. 8005(1): "Pipe Trenches". Trenches shall be kept dry to allow proper and safe bedding, laying, jointing of pipes and construction of the selected fill blanket over the pipes.

The pipeline shall be tape wrapped or sheathed in polythene sleeve for protection. The use of the type of protection shall be based on ground conditions in accordance with the following table or as directed. The Contractor shall measure soil resistivity and pH at 100 m intervals.

Soil Corrosivity	Ground Condition	Protection System
Aggressive	<ul style="list-style-type: none"> <li>Natural soils with resistivity between 15 and 25 <math>\Omega</math>m with seasonal water table or permanent water logging.</li> <li>Natural soils with a pH range <math>5 &lt; \text{pH} &lt; 6</math> without water table.</li> </ul>	Standard pipe coating plus PE sleeving
Highly Aggressive	<ul style="list-style-type: none"> <li>Natural soils with resistivity below 15 <math>\Omega</math>m with seasonal water table or permanent water logging.</li> <li>Natural Soils with a pH range <math>5 &lt; \text{pH} &lt; 6</math> with seasonal water table or permanent water logging.</li> </ul>	Standard pipe coating plus 25 mm overlap
	<ul style="list-style-type: none"> <li>Made up ground with heavy chemical contamination</li> </ul>	Standard pipe coating plus tape wrap 55% only.

The protected pipeline shall be laid and bedded to even grades and to levels and alignments shown on the drawings or as directed. It shall be laid centrally in the trench and with the manufacturer's class and quality identification marks visible from the top of the trench, if possible. Control of laying and bedding shall be by means of boning rods and sight rails or an acceptable laser beam device. Sight rails shall be painted black and white and shall be fixed securely and accurately.

Pipes shall be brought to the correct alignment and inclination, concentric with the pipes already laid. Adjustments to line and grade should be made by scraping away or adding adequately compacted foundation material under the pipe and not using wedges and blocks or beating on the pipe.

Pipes shall be handled in manner which eliminates any possibility of high impact or point loading, taking care to protect the joint elements.

Every reasonable precaution shall be taken to prevent the entry of foreign matter and water into the pipeline. At the close of each day's work or at any time when work is suspended for a significant period, the last laid pipe shall be plugged, capped, or otherwise tightly closed until laying is recommenced.

Where so required, the cover or the alignment of a pipeline may change gradually by deflection at pipe joints, but this deflection shall not be greater than half the deflection permitted by the manufacturer of the pipe.

The minimum clearance between the outside of a pipeline being laid and the outside of any other pipe that it crosses shall be 150 mm. Where this requirement conflicts with the requirements for cover over the pipeline the Contractor shall ask the Engineer for written instructions and shall carry out the work in accordance with those instructions.

♦ Jointing:

All pipelines shall be jointed in accordance with the manufacturer's instructions and to the approval of the Engineer.

Until required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Spigots and sockets of pipes being jointed shall be thoroughly cleaned by brushing and wiping immediately before being jointed. All rubber rings and seals shall be carefully inspected after being placed in position and before the joint is closed, to ensure that they have not suffered any cuts, tears, or other damage, and are not in any way defective.

All pipes with flexible joints shall be accurately marked prior to laying to ensure that the correct gap is left in the joint.

For push-fit and bolted gland joints only lubricants recommended by the manufacturer

shall be used in connection with rubber rings and these lubricants shall not contain any constituent soluble in water conveyed in the pipe. They shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

For bolted gland joints the joints ring shall be pushed into place by the gland ring using only hand pressure, fixing nuts and bolts should then be fitted and first tightened to finger pressure. Thereafter tightening shall be in the sequence proposed by the manufacturer and to the torque recommended.

In the jointing of pipes with flanges, special care shall be taken to align, grade, and level the pipes, specials, and valves to avoid straining of the flanges. All bitumen and paint shall be removed from the mating face of each flange immediately before jointing. Bolts shall be tightened up evenly in opposite pairs to ensure uniform bearing, the final tightening shall be to the torque specified by the manufacturer.

For flanged joints the gasket shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using only standard spanners of a type approved by the Engineer.

Graphite grease shall be applied to the threads of bolts before joints are made. All joints containing nuts and bolts which are buried shall be protected with anticorrosive mastic and wrapping tape, applied in accordance with the manufacturer's recommendations.

Care shall be taken to avoid damage to the internal surface of the pipes during assembly of the pipeline.

Once joints are made they shall be protected to a level appropriate for the pipe by: polyethylene sleeving, muffs, or with molding putty and tape wrapping.

♦ Setting of Valves, Specials and Fittings

Unless otherwise shown on the drawings, or directed by the Engineer, gate valves shall be set upright and butterfly valves shall be set with the main shafts horizontal. All valves, specials, and fittings shall be located in the exact positions shown on the drawings or otherwise directed. All bolts and flanges which are to be buried shall be covered with a corrosion inhibiting mastic putty or molding compound to produce smooth contours, the prepared fitting shall then be wrapped in protective tape.

♦ Cutting of Pipes

Pipes shall be cut by a method, which provides a clean square cut of the pipe and of the lining, without damage to pipe or lining. All cut or trimmed ends and the parts of any pipe on which the coating may have suffered damage shall be re-coated as specified before the pipes are laid.

The external area at cut spigot ends of ductile iron pipes shall be ground smooth for a distance of at least 125 mm, and then chamfered or otherwise made suitable for jointing as recommended by the pipe manufacturer.



♦ Anchor/Thrust Blocks and Pedestals

At tees, bends, terminal valves, end caps, and where otherwise directed, anchor/thrust blocks shall be constructed to dimensions ordered or shown on the drawings. Unless otherwise indicated on the drawings, anchor/thrust blocks and pedestals shall be constructed with concrete Type D (M20/20) (refer to Section 2000 of the SPSS of Section VI(c)). The concrete shall be well punned around the pipe, if in trenches, against the undisturbed faces and bottom of the trench. Backfilling behind or under thrust faces will not be permitted. Excess excavation shall be replaced with the prescribed mix concrete given above at the Contractor's expense.

Care shall be taken to leave all joints accessible. No anchor/thrust block and pedestals shall be concreted before the approval of the Engineer has been obtained.

♦ Valve Chambers

All washout valves, pressure reducing valves, and air valves in pipelines shall be housed in a chamber as shown on the drawings or directed by the Engineer.

♦ Covers for Chambers

All covers and frames shall be manufactured, from cast grey or ductile iron, and be coated to the approval of the Engineer. Covers and frames shall conform to NS 104/2042.

All covers shall be fitted to the frames and tested at the manufacturer's works, and covers and frames shall be similarly numbered in a legible and permanent manner in a position which will not be visible when fitted in place, and shall be of such construction as to minimize the ingress of sand.

The Contractor shall ensure that the covers are fitted to the appropriately numbered frames after the frames have been fitted.

The name of the Employer and year of manufacture shall be embossed in all covers.

♦ Interface Points

✓ General: Where the interface is a pipe flange, the Contractor may be instructed by the Engineer either to install a blank flange, backfill and mark the interface, or to expose and connect to a flange installed by another contractor and backfill on completion. The rate included in the Bill of Quantities shall cover the cost of either operation.

✓ Installation of Flanged Connection Point: The connection point shall be provided at the location specified. The flange shall be installed so that it is vertically plumb and its face is perpendicular to the axis of the pipeline. The flange shall be covered by a PN 16 blank flange, the flange shall be installed in the specified manner. The flange shall be backfilled and the location marked with a marker post.

✓ Connection to Flanged Connection Point: The connection point shall be at the



location specified and indicated on Site by a temporary marker post. The Contractor shall excavate to expose the flange, remove and dispose of the blank flange and water contained in the pipe and make the flange joint in accordance with the Specification, including the provision of all jointing materials.

♦ Permanent Pipeline Markers

Permanent pipeline marker posts shall be installed at all changes of horizontal alignment, and at 200m intervals along the straight lengths of pipe. Marker posts shall be positioned as close as possible to a 2 m offset from the pipe centre line. In the case of twin pipelines the marker posts shall be installed along the centre line of the twin pipes.

Permanent marker posts shall be of precast concrete Type B (M30/20) (refer to Section 2000 of the SPSS of Section VI(c)) to the dimension shown on the Drawings

♦ Internal Pipe Cleaning

Pipelines of 750 mm diameter and larger shall be manually cleaned internally of all debris, stones and sand prior to testing.

All pipelines less than DN 750 shall be cleaned by the passing through of a foam swab before the hydraulic test on completion. Swabbing shall be carried out successively between adjacent temporary swabbing points installed by the contractor.

The foam swab shall comply with the following:

Size:

- ✓ Main up to DN 300 : swab diameter = pipe diameter + 25%
- ✓ Main over to DN 300 : swab diameter = pipe diameter + 75 mm

Quality:

- ✓ Hard: Where restrictions in the main do not reduce the diameter of the pipeline to less than two thirds of the swab diameter.
- ✓ Soft: Where restrictions in the main are in excess of the above but do not reduce the diameter of the pipeline to less than one half of the swab diameter.

♦ Disinfection of Potable Water Pipelines

- ✓ The internal surfaces of all pipelines and pipework including all equipment incorporated in a pipeline or pipework through which water will pass shall be disinfected after they have been cleaned to the satisfaction of the Engineer.
- ✓ Disinfection shall be effected by filling the pipeline with water heavily dosed with chlorine, and shall be carried out when filling the pipeline with water for carrying out the hydraulic test on completion. Alternative methods may be adopted with the approval of the Engineer.

- ✓ The level of the chlorine dosing shall be such as to make available 50 mg/l of free chlorine throughout the pipeline.
- ✓ The water, heavily dosed with chlorine, shall stand in the pipeline for a period of 24 hours or for such longer period as the Engineer shall require and all valves in the system shall be operated at least once during this period.
- ✓ At the termination of the required period, chlorine residual tests shall be taken at the end of the pipeline farthest from the point of injection and the test shall be repeated if necessary until the residual is not less than 10 mg/l.

The Contractor shall obtain the Engineer's approval to the method to be adopted for disposing of the chlorinated water and the time when such disposal shall take place on completion of disinfection. The Contractor shall neutralize the chlorine by the use of sodium thiosulphate prior to disposal.

♦ Training of the Operation and Maintenance Staff

The Contractor shall train the staff identified by the Employer who will be responsible for the operation and maintenance of the bulk distribution system. The training shall include but not be limited to, cutting pipes of all diameters, installation of polyethylene sleeves, tape wrapping of pipes and fittings, repair of coatings, jointing of pipes of all diameters with all types of joint, installation of valves and fittings and maintenance of valves and fittings.

**(f) Tolerances**

♦ General

No deviation will be permitted from the minimum cover specified or as shown on the drawings.

The criteria for the level and gradient to which pressure pipelines shall be laid are as follows:

- ✓ the cover above the crown of the pipe to ground level shall be as shown on the Drawings, but in no event shall be less than 1000 mm in green areas, 1200 in the verge or carriageway of roads and 1500 mm where crossing roads.
- ✓ The upward gradient shall be steeper than 1 in 500 with flow, or steeper than 1 in 250 against the flow except where expressly shown in the Drawings.

♦ Control Points

For the purpose of this specification valves set on the centre line of the pipeline, designated changes in gradient and designated changes in horizontal alignment, shall be regarded as control points and shall be located with a permissible deviation of + 100 mm on the centre line. The same deviation will be permissible laterally except where the Contractor is required to lay the pipeline to a curve or at a designated distance from a boundary, kerb line, or fence line, in which case the permissible deviation shall be +30mm. Unless otherwise directed and subject to a permissible

deviation (measured along the centre line) of +5m, scour valves shall be located at the lowest points in pipelines and air valves at the highest points.

♦ Alignment (Plan and Level)

Unless otherwise directed, the permissible deviation in alignment between control points from a straight line joining the control points, when measured on the top centre of the pipeline, shall be +100mm or +20% of the nominal diameter, whichever is the larger, and the permissible deviation per pipe length shall be +30mm. The permissible deviation from the designated level at any point on the invert of the pipeline shall be +50mm or +10% of the nominal diameter of the pipe, whichever is the larger.

Each pipe shall be laid to the required gradient such that the end of the pipe is +5mm of the required level relative to the other end of the pipe.

♦ Valve Chambers, Manholes, etc.

Valve chambers, manholes, and the like shall be constructed centrally on the control points and, with the exception of tolerances that affect access to bolts, nuts, etc., with a permissible deviation of +50mm on all clearance dimensions. The clearance dimension between the outside of each nut and bolt-head and the inside face of the wall of a structure or any other fitting shall generally be not less than 150 mm.

♦ Pipe Protective Coatings, etc.

No air must be trapped underneath the wrapping tape. Unsatisfactory pipes shall be cleaned, prepared and rewrapped.

All damage to protective coatings must be repaired. In the following manner;

- ✓ Bitumen Coating: Damage to bitumen coating will be repaired by preparing and repainting the damaged area in accordance with the pipe manufacturer's instructions.
- ✓ Polyethylene Sleeving: Minor damage, small holes etc, to polyethylene sleeving may be repaired by sticking adhesive tape over the damaged point. Larger damage shall be repaired by replacing the sleeve or by sticking a large patch of the sleeving material over the damaged area.
- ✓ Tape Wrapping: Minor damage, small holes etc, to wrapping may be repaired by sticking adhesive tape over the damage after cleaning and preparing the damaged point. Larger damage shall be repaired by cleaning and rewinding the damaged area.

**(g) Testing And Acceptance**

♦ General

Except where otherwise specified pipelines and pipework shall be subjected to hydraulic pressure tests in the presence of the Engineer which shall comply with BS8010 or CP312.

Testing shall be carried out in two stages:

- ✓ test of sections as construction proceeds;
- ✓ a final test of the whole of the pipework or pipeline on completion.

The Contractor shall submit to the Engineer, in advance of the time for tests, details of his proposals. The proposals shall include details of temporary works to resist test pressures and methods for carrying out the test. Proposals for testing where thrusts on structures are involved, even where thrust collars on the piping are installed, shall be submitted, with the calculations of the forces to be carried, to the Engineer for approval. The proposal shall include details for transporting the test water from the point of supply to the pipeline to be tested. No connections to the pipeline or pipework which would involve cutting, tapping or otherwise permanently altering the Permanent Works, will be allowed.

♦ Procedure

Each section of the pipeline or pipework to be tested shall be capped or blanked off at each end and securely strutted or restrained to withstand the considerable forces that will be exerted when the test pressure is applied. Testing against closed valves will not be permitted. Hydrants, washout valves and isolation valves shall be fitted with blank flanges and these together with in-line valves shall be left open. Air valves already fitted shall be permitted to function during the test. The air valve manufacturer's confirmation shall be obtained that the valves are capable of withstanding the test pressure involved.

The section under test shall be filled making certain that all air is displaced through an air valve installed at the high end of the line. The section shall then remain under constant moderate pressure – 10 to 20 m head of water – for a period of several hours until the pressure can be maintained without additional pumping. Pipes of materials liable to absorb water, eg concrete and asbestos cement, shall be allowed to become saturated under this moderate pressure for 24 hours.

The pressure shall then be slowly increased to the full test pressure and pumping discontinued for 3 hours or until the pressure has dropped by 10 m, whichever occurs earlier. Thereafter pumping shall be resumed and continued until the test pressure has been restored. The quantity of water pumped to restore the pressure shall be the measure of leakage from discontinuation of pumping until its resumption.

The pipe section shall be considered as having passed the test if the leakage is not more than 0.365 l/mm of pipe diameter per kilometre per 24 hours for each 100 m head of pressure applied.

Notwithstanding the satisfactory completion of the hydraulic test, if there is any discernible leakage of water from any pipe or joint the Contractor shall, replace the pipe, repair the pipe or re-make the joint and repeat the hydraulic test all at his own cost.

No line shall be accepted until and unless the leakage of any section of the lines tested is not more than the rate of leakage specified above. All activities required to locate leaks and their repair and the repeat of the hydraulic test shall be at the Contractor's expense.

Pipelines shall be tested as above except where the Engineer issues such instructions as are necessary for testing parts of the Works that have been designed for stresses limited by considerations other than those applying to the pipeline systems.

♦ Test Pressures

Test pressures are to be measured at the centre of the blank flange situated at the lowest end of the pipeline under test. All pipelines shall be tested to a pressure corresponding to a hydraulic grade of 1452 masl.

The contractor shall submit a schedule of pipeline test pressures to the Engineer for approval prior to commencing testing.

♦ Sectional Hydraulic Test

The Sectional Hydraulic Test shall be carried out after the pipeline or pipework section to be tested has been laid, jointed and backfilled to a depth sufficient to prevent flotation of the pipeline. The sections to be tested shall be to the approval of the Engineer and shall be no longer than 2,000 m or 500 m when either the pipeline is laid adjacent to or underneath the carriageway.

In addition to the above requirements the Contractor shall perform a hydraulic test on the first 200 m length of pipeline of each diameter to be laid under the Contract. This test shall be undertaken within one month of the Contractor commencing the laying of pipes. Should the pipeline fail the test or the Contractor fail to undertake the test, all laying work for that diameter shall come to halt until that section of pipeline passes the hydraulic test.

♦ Hydraulic Test on Completion

The test on completion shall be carried out after all the pipeline sections have been joined together on completion of sectional testing. The joints between sections shall be backfilled once the test is satisfactorily completed.

**(4) Sewers And Stormwater Drainage**

**(a) Scope**

This specification covers the general construction requirements for sewerage and stormwater drainage systems including connecting sewers, manholes, and the like, but excluding sewer pressure mains, pump stations, treatment works, and ancillary works.

**(b) Interpretations**

♦ Supporting Specifications

The following specifications of the Section VI(b): Standard Specifications and

Section VI(c): Special Provisions to the Standard Specifications shall, inter alia, form part of and shall be read in conjunction with this specification:

- ✓ Section 100: “General”
- ✓ Section 200: “Site Clearance”
- ✓ Section 900: “Earthworks”
- ✓ Section 700: “Pipe Drains, Pipe Culverts and Concrete Channels”
- ✓ Section 2000: “Concrete for Structures”
- ✓ Section 2500: “Brickworks for Structures”

♦ Application

This specification contains clauses that are generally applicable to sewer and stormwater drainage construction.

♦ Definitions

For the purpose of this specification the following definitions shall apply:

- ✓ Expansion pipe joint - A pipe joint that allows relative longitudinal movement between adjacent pipes without the occurrence of fracture or leakage.
- ✓ Flexible pipe joint - A pipe joint that allows relative angular (radial) and longitudinal movements between adjacent pipes without the occurrence of fracture or leakage.
- ✓ Geofabric blanket - A blanket so woven from synthetic fibres that it is capable of acting as a filter that retains some or all of the solid particles carried by a fluid but, with varying degrees of restriction, allows the passage of the fluid.
- ✓ Invert slab - The slab, normally of concrete, that forms the bottom of the culvert.
- ✓ Prefabricated culvert units - Portal or rectangular culvert units that have been prefabricated from reinforced concrete.
- ✓ Rigid pipe joint - A pipe joint that allows no relative movement between adjacent pipes without the occurrence of fracture or leakage.

♦ Abbreviations

For the purpose of this specification the following abbreviations shall apply:

- AC: ..... Asbestos cement
- CI: ..... Cast iron
- CID, DN ..... Constant inside diameter
- COD ..... Constant outside diameter
- PVC ..... Polyvinyl chloride
- uPVC ..... Unplasticized polyvinyl chloride
- CP ..... Machine made concrete pipe

- RCP.....Reinforced concrete pipe

(c) **Material**

♦ Pipes, Fittings and Pipe Joints

For drainage and sewerage prefabricated concrete pipes NP2 or NP3, built according to provisions of NS80/2042 or equivalent shall be used.

The concrete pipes shall have circular cross-section and jointed using a collar. The concrete pipes must be of uniform condition. They must not exhibit any damage or be affected in any way likely to impair their serviceability, their strength, water tightness and service life.

All the pipe used in the Works will be from the same manufacturer. The manufacturer must be a nationally recognized and specialized concrete pipes manufacturer. On first starting production the manufacturing plant must demonstrate, prior to delivering concrete pipes that the pipes comply with the requirements of NS 80/2042. The tests necessary for this purpose must be carried out by an accredited testing agency having suitable testing equipment at its disposal.

The collars must be matched to the dimensions of the pipes and must be included in the delivery of the pipe. The dimensions of the collars must comply with NS 80/2042 or equivalent.

♦ Alternative Materials

Should the Contractor proposes to use pipes and fittings of material other than those referred to above, he shall submit for approval detailed specifications including full details of the type of joints and specials he proposes to use with such pipes and fittings. The Contractor shall not use such pipes or fittings until he has obtained approval for their use from the Engineer.

♦ Bedding

The requirements for bedding of specification Section 700: “Pipe Drains, Pipe Culverts and Concrete Channels” of Section VI(b) and Section VI(c) shall apply.

♦ Culvert Units and Pipes

Prefabricated culvert units and pipes shall be either precast concrete pipes, or portal and rectangular precast concrete culvert units, as applicable.

♦ Concrete

Concrete, cast-in-situ or precast concrete, shall comply with the relevant requirements of specification Section 2000: “Concrete for Structures” of Section VI(b) and Section VI(c) shall apply.

♦ Manholes, Catchpits and Accessories

Bricks and mortar shall comply with the relevant requirements of specification



Section 2500: “Brickworks for Structures” of Section VI(b) and Section VI(c) shall apply.

Prefabricated manhole sections may be of spun concrete, asbestos cement, glass-reinforced polyester, PVC, or such other material as are approved by the Engineer. Covers and frames for manholes and grid inlets shall be supplied in matching sets, each set bearing a serial number to enable it to be identified.

Step irons shall comply with the applicable requirements of BS1247 or equal approved and shall be of suitable length for the wall of the manhole into which they are to be built.

♦ Geofabric Blanket

The synthetic fibres of a geofabric blanket shall consist of at least 85% by mass of polyester, polyethylene, or polypropylene, or a combination of these polymers, and shall contain such additives as are necessary to render the geofabric blankets resistant to the effects of ultra-violet radiation and heat.

The Engineer's approval of the make and grade of the geofabric shall be obtained by the Contractor before he orders any geofabric or uses it on the Works.

For normal application, and if not otherwise directed by the Engineer or specified in the Particular Specification, geofabric blankets shall be of the non-woven, needle-punched type with a specific weight of approximately 270 g/m<sup>2</sup>.

**(d) Construction Equipment**

The equipment and rigging equipment used by the Contractor for the handling and placing of pipes shall be of the type recommended by the pipe manufacturer and subject to the approval by the Engineer and shall be such that no pipe is overstressed during any operation covered by the specification.

The Contractor may use any acceptable device, including one incorporating a laser beam, to control the alignment and laying of the pipeline.

The Contractor shall provide all the equipment, materials, tools, and fittings required for the performance of the tests here below specified for “Testing and Acceptance”, and shall provide suitable equipment for the location of faults up to the date of issue of the final certificate.

**(e) Construction and Workmanship**

♦ Trench Bottom

The trench bottom shall be prepared as specified in Section 700: “Pipe Drains, Pipe Culverts and Concrete Channels” of Section VI(b) and Section VI(c). Trenches shall be kept sufficiently dry to allow proper and safe bedding, laying, and jointing of pipes and kept dry until the pipeline has passed the required tests and construction of the selected fill blanket over the pipes has been completed.

For the laying of culvert elements, the trench bottom shall be excavated to a depth of



75mm in soil, or 200mm in rock, or such other depth as may be shown on the drawings, below the level of the underside of the precast invert slab or to the level of the underside of the cast-in-situ invert slab, as applicable, and this space shall be filled with granular material, compacted, and shaped to enable the culvert units to be bedded properly.

Where, because soft, soggy, spongy, or otherwise unsuitable material is encountered, the bottom of the trench as excavated does not provide a suitable firm foundation for the culvert, the unsuitable material shall be excavated to a depth below the bottom of the culvert indicated by the Engineer and replaced with gravel or other approved granular material compacted to at least 90% of modified AASHTO maximum density. When so ordered, the Contractor shall construct a layer of concrete blinding, at least 75 mm thick, to provide a suitable working floor.

♦ *Bedding, Laying and Backfilling*

Each pipe and fitting shall be thoroughly cleaned out and carefully examined for damage immediately before laying. The onus of detecting damaged pipes and fittings before installation shall be on the Contractor. Should any damaged pipe or fitting be found in the sewer after it has been laid, the damaged item shall be removed and replaced at the Contractor's expense.

Pipes shall be laid on the specified bedding cradle true to designated line and level, and the bedding shall be placed and compacted in accordance with the applicable requirements of Construction and Workmanship. Designated invert levels shall take precedence over design depths shown on drawings.

The completed sewer or stormwater drain shall have no bends or undulations except where directed. Should pipes be allowed to have any deviation from straightness, they shall be so laid that preference is given to level over line.

The method of laying and bedding shall be such that barrels of pipes bear evenly on the bedding for their full length, that no packing is used under the barrels, and that no socket or coupling bears on the bedding. Where the slope of a pipe is greater than 1 in 10, anchor blocks shall be constructed according to the details provided.

Pipes shall be so cut as to obtain a clean and square end, and, where pipes and fittings of different material shall be jointed, shall be so only with special adaptors recommended by the pipe manufacturer(s).

All pipe openings shall be sealed by the Contractor to ensure that no water, stones, or other foreign matter enters the sewer during or after laying.

The sewer or stormwater drains shall be so jointed to the pipes built into the manholes that there is a flexible joint positioned as close as possible to the manhole.

Precast units shall be lifted and handled only by means of lifting devices approved by the manufacturer.

The Contractor shall exercise due care not to damage, overstress, or displace any

culverts by the imposition of any loads such as may be caused by the movement of his own vehicles or compaction equipment. Where superimposed moving loads in excess of those prescribed in the applicable road traffic ordinance are, during the construction of the Works, likely to pass over completed culverts, the Contractor shall provide sufficient additional cover over the culverts to ensure that the design stresses on the culverts are not exceeded.

Any units that become deformed or cracked, or that are not constructed to the required lines, levels, and grades, or that become displaced in the course of the work, shall be removed and replaced by the Contractor at his own expense.

Cast-in-situ invert slabs for portal or rectangular culverts shall be constructed to the dimensions and at the locations shown on the drawings or as directed. They shall be reinforced as detailed on the drawings. The units of the upper portion of precast portal culverts shall be placed accurately on the invert slabs, with a thin layer of 1:3 cement: sand mortar between the horizontal contact surfaces to ensure a firm and uniform support. The units of the upper portion shall be butt-jointed end to end and each joint shall be covered with geofabric blanket placed symmetrically over the joint.

Pipe culverts shall be laid and bedded to the level and alignment shown on the drawings or as directed. They shall be laid hard up against each other longitudinally to obtain tight joints and they shall be supported evenly throughout the barrel length. Holes or grooves of adequate size to allow for jointing and for bedding thickness under joints, shall be cut in the bottom of the trench. Pipes shall be laid centrally in the trench in such a manner that the side allowances are available as working space for the proper bedding of the pipes. For ease of inspection pipes shall be laid with the manufacturer's class and quality identification marks visible from the top of the trench unless, in the case of larger pipes, the position of lifting eyes renders this impractical.

Each pipe shall be cleaned out and carefully examined for possible damage immediately before laying. The onus on detecting damage shall rest on the Contractor. Should any damaged pipe be laid, it shall be removed and replaced at the Contractor's expense and to the satisfaction of the Engineer.

Joints of butt-ended pipes shall be externally wrapped with either 2 layers of 0.5 mm thick plastics damp course or one layer of geofabric blanket. The wrapping shall be at least 200 mm wide and be centrally placed over each joint.

Ogee type pipes need not be wrapped but shall be laid with the spigot ends pointing downstream.

Spigot and socket pipes with rubber ring joints shall, unless another method is directed or approved by the Engineer, be jointed in accordance with the manufacturer's instructions.

Backfilling of pipes and pipe culverts shall comply with the applicable requirements of specification Section 700: "Pipe Drains, Pipe Culverts and Concrete Channels" of Section VI(b) and Section VI(c)..

Material for backfilling of portal or rectangular culverts shall comply with the requirements herein specified for “Materials”, and shall be obtained by the Contractor from approved borrow pits, if necessary.

Backfill alongside the walls and over the top of culverts shall be watered, mixed, placed, and compacted in layers not exceeding 150 mm after compaction, to a density at least equal to that required for the material in the adjoining layers of fill, subgrade, and subbase, as applicable, or to at least 90 % of modified AASHTO maximum density in the case of excavation made in natural ground.

Backfilling shall be carried out simultaneously and equally on both sides of the structure to avoid unequal lateral forces.

♦ Manholes, Inspection Chambers, Catchpits etc.

Manholes, inspection chambers, catchpits, inlets, outlet structures etc., shall be constructed of cast-in-situ concrete, precast concrete, brickwork, as shown on the drawings or as directed by the Engineer.

Manholes shall be provided in following situations:

- ✓ changing of direction,
- ✓ changing of slope,
- ✓ changing of diameter
- ✓ interception of secondary lines,
- ✓ interception of house connections,
- ✓ on main lines at a distance of max. 80 m.

Manholes shall comply with the requirements of NS 80/2042.

The incoming and outgoing pipes shall be fixed in position as detailed before concreting. The concrete surrounding these pipes shall be placed in a single operation and particular care shall be taken to ensure that it fills the whole space beneath and around the pipe.

Benching shall be left completely smooth to the satisfaction of the Engineer. The concrete surround shall be formed using properly constructed formwork.

Selected material shall be carefully filled in and compacted behind the concrete and made solid after the concrete has hardened sufficiently and the protective coating has cured and been properly protected.

Cover slabs shall not be placed until 24 hours after the placing of the concrete manhole surround. This time may be increased or decreased to the discretion of the Engineer.

♦ Step Irons

Step Irons shall be of cast iron or mild steel and they will be built into concrete as the work proceeds at 300 mm apart vertically.

The entire steps shall be corrosion protected as specified to the approval of the Engineer

♦ Manhole and Chamber Covers

All covers and frames shall comply with “Covers for Chambers”.

♦ Concrete Casing to pipes

In special cases, and where ordered by the Engineer, pipes shall be encased in concrete of the specified grade, generally of at least 15 MPa. The lower part of the encasement shall be constructed in the manner specified for Class A bedding. Once the sewer or stormwater drain has been tested and approved, the pipes shall be surrounded with concrete to the specified depth and expansion joints shall be cut or constructed in the upper part to coincide with those in the lower part. Use shall be made of poker vibrators to ensure proper filling with concrete of all spaces under and around the pipe, and displacement or flotation, or both, shall be prevented. All temporary supports provided for the pipes shall be removed as concreting progresses. No earth filling over the concrete shall be commenced until at least 5 days after the concrete has been placed or until the concrete has attained a strength of at least 10MPa.

♦ Raising or Lowering of Existing Manholes

Where an existing manhole is required to be raised or lowered, the work shall be so carried out that the finished manhole complies with the applicable requirements here above specified for “Jointing”. Where practicable, the same cover shall be used, which shall, on completion of a manhole be flush with the surface of the finished road, shoulder, or sidewalk, as the case may be.

♦ Connecting Pipes

Connecting sewers or stormwater drains shall be laid from junctions provided in the main lines to the positions and depths as shown on the drawings or as directed.

The Contractor shall record all relevant data (e.g. street name, number of plot, location measurements and distances in relation to boundary peg(s), size of connection, depths of invert at connecting point and end of connection etc.) for the preparation of "as-built" drawings, and shall make these records available to the Engineer.

♦ Action to be Taken During and After Testing

The Contractor shall make good any defects that may be found while the pipeline is under test and after that the tests shall be repeated at his expense until the pipeline is found to comply with the specification.

After the sewer or stormwater drain has passed the tests all access lids shall be properly sealed with bitumen or by any other approved method in watertight manner.

♦ Reinstatements of Existing Drains

The existing drains damaged by the works shall be relocated and connected into new

drains as required. Existing drains shall be cleaned out from the new drain trench face and any disturbed pipe re-laid to ensure a free discharge into the new drain. The disused end of the intercepted drains shall be sealed with puddle clay or other approved materials.

Where an existing land drain is exposed and temporarily severed by trench excavation, the position of the drain shall immediately be marked and recorded. The normal functioning of the drain until permanent restoration is made shall be maintained by the construction of a watertight conduit adequately supported across the trench.

Without limiting the Contractor's liability for restoration of damage, the Contractor shall notify the Engineer of any drain which is blocked or is otherwise defective when the drain is first exposed.

When the line of an existing drain interferes with a pipeline, the Contractor shall deal with the drain as directed. Drains shall be reinstated on their original line, unless the Engineer orders otherwise.

When backfilling is being done the temporary conduit shall be removed and the ground below the line of the drain shall be compacted. The positions of the ends of the drains shall be marked and the trench reinstatement completed. The trench for the drain shall be re-excavated and the drain reinstated with approved material laid on supports. The line, level and grade of the original drain shall be maintained.

The supports shall be of durable material and shall be bedded firmly at 500 mm into the undisturbed ground on the trench sides. The supports shall be of suitable timber having a cross section not less than 150 x 65 mm or such section as would be required to permit the laying of the new drain without deflection.

**(f) Tolerances**

♦ General

Tolerances will be determined on the basis of permissible deviations from designated location, alignment, grades, and levels. The Contractor shall construct each of the various parts within the limits set out below.

♦ Manhole and Catchpit Locations

The permissible deviation of the location of manholes and catchpits (other than kerb-side catchpits) in plan of the designated position shall be half the pipe length longitudinally and  $\pm 200$  mm laterally, except where locations are dimensioned from fixtures such as fences, kerbs, and the like, in which event the permissible deviation in each direction will be  $\pm 50$  mm.

Such manholes or chambers shall be constructed at the meeting points of intersecting pipelines subject only to such deviations as can be tolerated by the junction channels or specials.

♦ Invert Levels

The permissible deviation from the designated level of the invert at each manhole shall be  $\pm 50$  mm but, should the fall between any two successive manholes be less than 90 % of that specified, the said permissible deviation shall be reduced to a value such that the fall is at least 90 % of that specified.

The permissible deviation of the level of the invert of a culvert from the designated level shall be  $\pm 25$  mm.

♦ Alignment and Grade

Subject to the permitted manufacturing tolerances applicable to the pipes being laid, the line of the pipe invert shall at no point between successive manholes deviate from a straight line by more than 5 % of the nominal diameter of the pipe, or be lower than at any other place closer to the lower manhole.

The permissible deviation of the alignment and grade of each culvert shall be  $\pm 25$  mm from the designated line and level, when measured over any 6 m length, and all such deviations shall be gradual.

♦ Manholes and Chamber Structures

The dimensions of walls and roofs of manholes and chambers shall conform to the dimensions specified, subject to the allowable tolerances laid down for concrete structures (see Clause 2.3)

♦ Kerbside Catchpits, Kerb Inlets or Grid Inlets

The permissible deviations of the longitudinal location shall be half a kerb length or 0.5 m, whichever is the greater and the permissible deviations of the lateral location from the designated distance from the centre line of the road shall be  $\pm 25$  mm, except that any open grid or grid frame shall be truly parallel to and within 5 mm of the face of the kerb.

**(g) Testing and Acceptance**

♦ General

Tests described below apply to sewers and stormwater drain and references to a sewer apply equally to a drain.

All acceptance tests shall be carried out in the presence of the Engineer and at such times and in such manner as the Engineer may direct.

No pipe joint or fitting shall be covered until the tests applicable have been completed and the Engineer has authorized such covering.

The sewer or any section of it shall be inspected by the Contractor who, if he deems it ready to be tested, shall advise the Engineer of his intention to subject the sewer or the said section of it to the appropriate tests.

The sewer shall be tested in sections between manholes or chambers, as applicable, the section being tested being isolated from other sections by means of suitable plugs

or stoppers that have been braced adequately.

Notwithstanding any authorization by the Engineer as described above, the Engineer may, after backfilling and compaction have been completed, order that the sewer be retested to check that it has not been disturbed or damaged during backfilling.

The Engineer may order one of the following to be carried out on the sewer or any section of it:

- ✓ an air test on pipes, other than concrete pipes, of all sizes; or in the case of pipes, other than concrete pipes, of diameter up to 600 mm, an air test followed by a water test
- ✓ a water test in the case of pipes of diameter up to 750 mm
- ✓ a visual internal inspection in the case of pipes of diameter greater than 750 mm.

The Contractor shall provide all labour and apparatus (including expandable plugs and flexible bag stoppers) that may be required for carrying out the tests.

All test results shall be recorded in the manner directed, whether or not the pipeline or section of pipeline has passed the test.

◆ Tests and Acceptance/Rejection Criteria

- ✓ Air test: An approved air testing machine shall be used to raise the gauge pressure in the section of the pipeline under test first to 3.75 kPa. After a 2 min stabilization period the pressure shall be reduced to 2.5 kPa. The machine shall then be switched off and the time taken for the pressure to drop from 2.5 to 1.25 kPa shall be measured. The time taken shall be at least 2 min for ND 100, 3 min for ND 150, 4 min for ND 200, 4.5 min for ND 250, 6 min for ND 300, 8 min for ND 400, 10 min for ND 500, 12 min for ND 600, and 14 min for ND 700. Times applicable for other diameters may be interpolated.
- ✓ Water test: The section of the pipeline under test and the manhole at the upper end of the said section shall be filled with water to such depth that every portion of the pipeline is subjected to a pressure of not less than 12 kPa and not more than 60 kPa. During the test there shall be no discernible leakage of water. An appropriate period, which shall be at least 12 min, shall be allowed for initial absorption, and the loss of water over the next 30 min shall be noted. The amount lost, in litres, per 100 m of pipeline per hour, shall not exceed the following values: 6 for ND 100, 9 for ND 150, 12 for ND 200, 15 for ND 250, 18 for ND 300, 23 for ND 400, 29 for ND 500, 36 for ND 600, and 44 for ND 700. Amounts applicable for other diameters may be interpolated.
- ✓ Tests on existing pipes shall be carried out in accordance with the above unless directed otherwise by the Engineer.

Should any section of the pipeline fail to pass the water test, a re-test will be permitted and, in such case, acceptance or rejection of the section will be determined on the



result of the re-test.

♦ Rejection

In the case of AC, vitrified clay, and fibre pipes, failure under the air test will be deemed to be cause for rejection. After such rejection the Contractor may apply a water test to locate the source of failure, rectify the pipeline, and re-apply the air test. In the case of concrete, failure under the water test will be deemed to be cause for rejection.

♦ Testing of Connecting Sewers

Each connecting sewer shall be tested between its upper end and the junction at the main sewer. The upper end of the connection shall be kept securely closed with expanding plugs during the test. Where practicable the Contractor may test the main and connections simultaneously if he so wishes. On completion of the test, the upper end of the connection shall be permanently sealed by means of a plug stopper suitable for the type of pipe.

## **8006 ELECTRO-MECHANICAL EQUIPMENT AND REALETED WORKS**

### **(1) Transformer**

The transformer shall be manufactured and tested in accordance with international code IEC-60076.

#### **(a) Tank**

The transformer tank shall be of robust construction, which shall be oil tight and silica-gel breathing system. The tank cover shall be bolted and grounding pads complete with clamp type terminal connector shall be provided on the tank wall near the base.

#### **(b) Core**

The transformer core shall be constructed of high quality, non-aging, high permeability sitcom steel. The steel shall be clamped with positive locking devices to ensure adequate mechanical strength to support the windings and reduce vibrations to a minimum during operation.

#### **(c) Windings**

The windings of the transformer shall be of copper such that the completed assembly of core and coils give efficient performance during operation. The core and coils assembly shall be dried in a vacuum for ensuring complete elimination of air and ingress of moisture within the insulating materials. After the drying process, the assembly shall be immediately impregnated with dry oil. The transformer shall be provided with a oil conservator tank.

#### **(d) Short Circuit Capacity**

The transformer shall be able to withstand the mechanical and thermal stress produced



due to short circuit current which should be limited by the impedance of the transformer.

**(e) Tap Changer**

The transformer shall be furnished with an externally operational tap changer at no load. The tap changer shall have an operating handle, visible indication of tap position and lockable.

**(f) Insulating Oil**

The insulating oil shall be refined mineral oil and the transformer shall be supplied with first filling of the oil.

**(g) Bushings**

The bushings shall be made of porcelain. The H.T., L.T. and neutral bushings shall have bolted terminal lugs suitable for terminating 10–35 sq. mm. aluminum conductor.

**(h) Temperature Rise**

The average winding temperature rise above the maximum ambient temperature of 45°C while carrying maximum continuous rated kVS shall not exceed 55°C.

**(i) Accessories**

The transformer shall be equipped with the following accessories:

- ✓ Lifting lug
- ✓ Name plate
- ✓ Tank grounding terminal connector
- ✓ Conservator tank
- ✓ Silicagel breather
- ✓ Silicagel vent
- ✓ Tap changer
- ✓ Oil drain valve
- ✓ Upper oil sampling valve

**(2) Diesel Generator**

**(a) Technical Requirements**

The diesel generator (DG) shall be installed at appropriate location as instructed by the Engineer for power supply in case of NEA, 11/0.4 kv mains failure. This standby diesel generator shall supply the pump load, which is normally operational from 14 hours a day. The generator in-feed circuit breaker can be closed if and only if the mains incoming breaker is open and vice-versa.

The diesel generator shall be for instantaneous starting and loading in cold condition through an electric starter motor. The loadability of the DG set after cold start shall be immediately 75%, after 30 seconds, 90% and after 5 min 100%.

The speed controlling device of the set shall be automatic with a setting range of +10% of rated speed. For stop of the engine a closed magnetic fuel valve and manual fuel valve shall be used.

**(b) The Fuel System**

A standard storage fuel oil tank shall include a filling and supply piping with valves, level indicator and low level alarm device. The day capacity tank shall be of at least 14 hours operation of the engine at rated load.

The diesel engine shall have a complete lubrication system low lub-oil pressure trip device. The combustion air intake shall be through an air filter. The exhaust system shall have the necessary silencer piping, heat insulation and flexible joint to absorb vibration.

The engine shall be closed loop water-cooled type with a radiator and a mechanically driven fan behind it. The starting system shall include, an electric started motor, a started battery 24 V DC, a battery charger and a low voltage alarm relay for battery voltage.

**(c) Generator**

The generator shall be rated as specified in the BOQ or Particular specification with star connected synchronous machine for three phase 400 v, 50 Hz supply at 0.8 power factor. The neutral point shall be of easy bolting type.

**(d) Exciter and Voltage Regulator**

The generator shall have a rotating brush-less exciter and a static voltage regulator. The output voltage from the regulator shall not deviate more than +2.5% of the nominal value in any loading conditions and voltage settings shall be +10%.

**(e) Control Cabinet**

The diesel generator set shall have complete equipment for automatic start and stop sequences in case of mains supply break and return. The automatic starting equipment shall make three consecutive starting attempts and alarm after the third unsuccessful attempt.

A time-lag relay shall be included to delay the start from 1 to 10 sec. (adjustable) in order to prevent unnecessary starts during short mains failure.

The automatic switching over from mains and back shall be made by the generator circuit breaker and mains circuit breaker, which are electrically interlocked. The switchover back to mains shall be made after 1 minute once the mains have recovered. After switchover back to mains the set shall run on no-load long enough to prevent damage due to post heat for about 5 minutes.

Manual start / stop equipment and an OFF / MANUAL / AUTO switch shall be included.

### **(3) Submersible Pumpset with Accessories**

#### **(a) General**

Unless otherwise mentioned in the BOQ the Work shall consist of installation of one unit of submersible pump set for each bore-hole, and one unit of submersible pump will be kept as standby unit.

#### **(b) Selection of Submersible Pumpset**

Submersible pump set installed horizontally in the sump well have been selected because in this case separate pumphouse need not be constructed, and priming of the pump is not necessary as the pump set is already submerged in water. This arrangement also makes the provision of suction pipe, valve and fittings unnecessary.

Submersible pumpset shall consist of a centrifugal pump directly completed to a submersible motor, complete with all necessary accessories and suitable for the horizontal installation of the submersible pumpset inside the sump well/water reservoir. The pumpset shall be suitable in all respects for pumping drinking water.

#### **(c) Operating Technical Parameters**

Operating technical parameters such as rated discharge capacity of the submersible pumpset; Capacity of motor, Combined / overall efficiency at rated duty point, etc shall be as described in the supplementary specification or as described in the BOQ.

Submersible pumpset shall have ISI making and fully conform to IS8034 – 89 in all respects.

The manufacturers of the submersible pumpset shall be an 950, 9001 or 9002 certified Company.

#### **(d) Pump Design**

The pump shall be a multistage centrifugal pump with dynamically balanced impellers of radical/mixed flow design. A non-return valve shall be located at the pump discharge point.

The submersible motor shall be capable of withstanding heavy demands made on it in respect of reliable insulation and bearing loads. It shall consist of water filled, required cage type induction motor, sealed by radial seal rings to avoid mixing of well water and the fill water.

The pump shall be provided with sleeve bearings and the motor with sleeve and thrust bearing. All the bearings shall be water lubricated and protected against structural elements. Mitchell type thrust bearing shall Mitchell type trust bearing shall be provided to withstand axial thrust loads; and a suitable reflex pressure compensating device shall be incorporated the overpressure, which may arise as a result of the thermal expansion of the fill water when the temperature of the windings rises. Power

shall be supplied through a special cable passing through a watertight sealing gland, protected by means of metal sheath along the length of the pumpset shall be suitably chemically treated to protect them from water corrosion.

The design and operating conditions which shall govern in the selection of pumps are based on the actual improved yield achieved after the drilling of deep tubewells. Complete equipment shall be suitable for the condition of submergence in liquid. Pump characteristic curve allowable tolerances shall be in accordance with the Hydraulic Institute Standard. Shutoff head allowable tolerance shall not exceed 3 percent. Negative tolerances in design head and efficiency are not permissible. The final head curve for all pumps shall rise steadily and at a slope rate from the design point to pump shutoff.

Engineer reserves the right to change the pump design TDH within +5 percent prior to fabrication without any price increase, as long as TDH remains a function of impeller size. All pumps shall be designed to withstand 1.5 times of the pump shutoff pressure. All pumps supplied under this specification shall be capable of both intermittent (start-stop) and continuous operation under the operating conditions from minimum flow to runout condition.

Design and construction of each pump shall permit full voltage starting of driving motor. Shaft's critical speeds shall be at least 10 % higher than the max. operating speed. The maximum limits for vibration shall be kept without those limits stated in the HIS standard. Normal and maximum permissible operating vibration amplitude limits shall be provided by Contractor/Manufacturer, and if required, the Contractor shall provide the vibration detector with switch monitoring shall be carried out.

**(e) Materials of Construction**

Materials of construction of pumpset shall be as given below:

S. No.	Part	Materials
1.	Suction Casing	Cast Iron
2.	Bowl / Stage Casing	Cast Iron
3.	Impeller	Zinc Free Bronze
4.	Pump-shaft	Stainless Steel
5.	Water lubricant Bearing	Bronze
6.	Thrust Bearing Plate	Bronze

Submersible type pumping equipment shall be single stage, non-clog centrifugal pump capable of pumping continuously the liquids identified previously and conforming to the specified pumping heads and flows. Pump casing shall be manufactured II- 13% chrome iron ASTM A532 class III type A, heat treated to a hardness of 400 Brinell. The casting shall have ample thickness, capable of prolonged resistance to the abrasive actions of solids or foreign matter contained in the liquid passing through the pump. The pump casing shall be hydrostatically tested under a hydrostatic head of at least 50 meters of water. Discharge flange connection shall have the appropriate size in accordance with the pump, flat faced and drilled according to ANSI B 16.5.

Each pump & motor shaft shall be made of stainless steel with ample provision to compensate for pump thrust and for the overhand load on the impeller.

Impeller shall be 11-13% chrome iron head treated to a hardness of 400 Brinell, nonclog, symmetrical, balanced type with a minimum of vanes or blades having a wide suction, Impeller vanes shall be free from sharp edges and waterways with smooth contours and well-rounded entrances. The impeller shall not have port for reduction of thrust on impeller. The impeller shall be held securely to shaft method permitting easy removal of impeller. The impeller shall be capable of holding securely in event of pump reversal to full runways speed.

The electric motors shall be squirrel cage induction type suitable for full voltage starting designed for a Class I. Groups C and D. Division I hazardous location in air or submerged in liquid rated for continuous duty in the liquid or in air. Power supply shall be 400 volt or as required, 3 phase 50 hertz.

All electrical parts shall be housed in a cast-iron, watertight enclosure. The cable leads shall be epoxy sealed. Cable leads shall be a minimum 15 meters long. Lifting eyes shall be cast into the motor housing and shall be of adequate strength to lift the entire pump motor assembly. Lifting chains shall be provided for each submersible type of pumping unit.

Length of each chain shall be minimum 15 meters. The motors shall be supplied with dandem mechanical seals. The upper seals shall have carbon rotating faces, ceramic stationary faces with Buna N elastomers or better. The lower seals shall have solid tungsten carbide rotating and stationary faces with viton elastomers or better.

Electric motors shall be tested for the following characteristics prior to shipping and certified copies of the test report shall be forwarded to the engineer for review:

- ✓ Full load heat run
- ✓ Percent slip
- ✓ No load current
- ✓ Locket rotor current
- ✓ Starting torque
- ✓ Efficiency at 100%, 75% and 50% of full load nameplate rating
- ✓ Power factor at 100%, 75% and 50% of full load nameplate rating
- ✓ Winding resistance
- ✓ High post-dental
- ✓ Bearing inspection

Each submersible type of pumping unit will be equipped with two float type level switches which shall control the operation of the pumping unit's electric motor at high liquid level and stop the motor at low liquid level.

**(f) Standard Accessories**

Standard accessories supplied along with the submersible pumpset shall include, but not limited to, the following matching items as recommended/ supplied by the manufacturer of the pumping set:

- ✓ Bearing pedestals
- ✓ 2 Nos. of water reservoir for use in horizontal installation of pumpset
- ✓ Suitable expansion joint
- ✓ Suitable bend
- ✓ Submersible cable of sufficient length, flat type, continuous without any splices
- ✓ Suitable pressure gauge with isolating valve
- ✓ Dry run cut out electrode with cables
- ✓ Motor started panel as mentioned in the Tender Document.

**(g) Technical Documents**

◆ Drawings and Documentation to be submitted with Proposal:

Tenderer shall submit with proposal the following drawings and documentations in addition to the information required by other section of this specification. The drawings where applicable, shall show the terminal points of Contractor's scope of supply.

Technical Data:

All blank space in the technical data sheets in other section of specification, shall be completely filled in with the required information or where not applicable to Contractor's, offer a horizontal line shall be drawn and if any more necessary shall be added.

Drawings and Document:

- ✓ Outline drawings showing dimension, for pump, motor, instrument panel, if any.
- ✓ Sectional drawings of major equipment
- ✓ P&I diagrams including terminal points, if sealing, cooling or lubricating are required.
- ✓ Loading diagrams for civil work
- ✓ Characteristic curves
- ✓ Recommended operating logic diagrams
- ✓ Available delivery schedule

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- ✓ Test and inspection schedule
  - ✓ Spare part list
  - ✓ Special tool list
  - ✓ Motor (or electrical power consumption) list.
  - ✓ Instrument and set-point list
  - ✓ Experience or reference list
  - ✓ Manufacturer's catalogues and literature to supplement the drawings and illustrate the equipment, instrument, fitting, furnishing, etc.
  - ✓ Control schematic and wiring diagram if required.
  - ✓ Any other drawings or data not specifically called for, but necessary to fully describe the offer.
- ◆ Drawings and Documents to be Submitted After Contract
- ✓ Contractor shall furnish for approval the indicated drawings and data within the time limit set forth in the purchase order.
  - ✓ Drawings and documents called for below, shall be a guideline of drawings and documents to be provided by Contractor.
  - ✓ Contractor shall resubmit all data and drawings, which were submitted with proposal, for approval after contract.
  - ✓ Contractor shall submit the technical data and drawings for electric motor as per specification of electric motors.
  - ✓ Lists and schedules
  - ✓ Master drawing list showing the submission schedule
  - ✓ Spare part list with sectional and/or outline drawing
  - ✓ Special tool list with sectional and/or outline drawings
  - ✓ Clearance and tolerance list
- ◆ Detail drawings:
- ✓ Assembly drawings of all equipment
  - ✓ Dismantling drawings
  - ✓ Detail drawings showing construction of all valve type and dimensions for all size.
- ◆ Procedures and manuals:
- ✓ Test and inspection procedure
  - ✓ Installation manual

- ✓ Initial start-up procedure including check list and typical format
  - ✓ Optical manual
  - ✓ Maintenance manual
  - ✓ Test and Inspections Reports
  - ✓ As-Built Drawings
- ◆ As Built Drawing:
- Contractor shall submit to the Engineer as-built drawings, which were submitted for approval and for construction.

#### **(h) Engineer's Pre-Approval**

The Contractor must obtain the pre-approval of the Engineer regarding the make/model, capacity, quantity of the submersible pumpset and related accessories to be procured / supplied by the Contractor; and also for the planned installation and erection work of the submersible pumpset along with the necessary accessories.

#### **(i) Site Visit**

Before testing the submersible pumpset Service Engineer/Expert of the manufacturer shall visit the manufacturer shall visit the installation site to check for the correct installation and operation of correct installation and operation for the pumpset; and shall issue a formal letter to this effect to the Engineer. The total cost for this job shall be fully borne by the Contractor only.

#### **(j) Cleaning and Painting**

All manufacturing waster, such as metal chips and filings, welding rods and studs, waster, rags-debris etc; shall be removed from the interior of each component. All loose mail scale, rust, oil grease, chalk, crayon, paint marks, and other deleterious material shall be removed from interior and exterior surfaces. At time of shipment, product shall be clean inside and outside.

All centrifugal pumps and accessories shall be thoroughly cleaned and shop painted in accordance with the following cleaning procedure and painting system(s). All centrifugal pumps and accessories installed outdoors shall be prepared for priming in accordance with SSPC-SP 10 near white blast cleaning. Stainless steel of galvanized steel surface shall not be painted. Interior and exterior surface shall be painted in accordance with general technical requirements.

#### **(k) Tagging of Equipment**

A corrosion-resistant nameplate shall be securely attached to each completely assembled piece of equipment, at an easily accessible point of each pump and shall contain the following data: Manufacturer's name, serial number, shop order number, project identification number, type of equipment, tag number, rated horsepower, speed, total head, capacity and direction of rotation.



Name plate shall be chromium plated bronze unless otherwise. Description on the plates shall be engraved with black filled lettering in English. The armatures shall be fitted with circular stainless steel name plates, having engraved back letting in English for which the armature is intended and giving the armature number.

**(l) Spare Parts, Tools and Consumable**

Contractor shall provide in the manner and within the time limits as set forth in the purchase order, its list of spare parts and special tools if necessary for installation, operation and maintenance for three (3) years operation of pump set and accessories furnished by him.

Unless otherwise, recommended spare parts shall be accompanied by Manufacturer's expected lifetime of wearing parts and description sufficiently detailed to identify the spare parts and the specific item or items for which it applies. Manufacturer shall indicate the minimum recommended inventory for routine maintenance and installation, start-up and continuous operation. Contractor shall indicate whether the recommended spare is a stock item or special item, location of nearest supply point and approximate lead time required for shipment.

The list of special tools shall be accompanied by description sufficiently detailed to identify the function of the tool and the specific item or items for which it applies, Contractor / Seller shall indicate whether the tool is required for installation, and prepared by suitable means for storage by greasing or storage. The spare parts ordered shall be delivered with the main equipment but in separate boxes clearly marked "SPARE PART".

The contractor shall submit a priced list of each Spare Parts for the Engineer's approval. For approval and supplied Spare Parts the contractor be paid from the provisional sum.

Contractor shall submit sectional and / or outline drawings for spare parts and special tools at the time of shipment of the spare parts and special tools. The number of copies and reproducible of each drawing to be submitted shall be in accordance with general technical requirements.

Contractor is required to supply the lubricating oil for first fill.

Contractor shall provide a specification for the lubrication of the equipment. The number of different oils and grease recommended should be kept at a minimum. The types or nipples should be reduced to a minimum.

**(m) Test and Inspection**

♦ General

Equipment testing shall be within the guideline of the approved test code and to the standard for centrifugal pumps to the satisfaction of employer / engineer.

♦ Material Tests

Certified mill test reports for pressure retaining parts shall be provided in accordance with relevant material specifications and shall include mechanical and chemical properties.

♦ Shop Tests

- ✓ Hydrostatic tests: Pressure retaining parts, shall be hydrostatically stated at 150 % of shut-off pressure at design speed. The test pressure shall be held for a minimum 5 minutes.
- ✓ Performance tests: Each pump shall be performance-tested at design speed and rated suction conditions.

The final performance curve shall be based on not fewer than five (5) test points at rated speed. The specified guarantee point, the runout point, and the shut off point are three (3) mandatory test points. The remaining two (2) point shall be evenly distributed between the guarantee point and the shut off point.

- ✓ Test reports: Certified test reports shall be prepared and submitted to Engineer shall include test arrangement, instrumentation and calibration data, test data.

Result of the performance tests shall be summarized in curve form with total generated pressure, efficiency, and power absorbed. The guaranteed design performance, maximum run-out operation, and test water temperature shall be stated on the curve.

- ✓ Field Tests: Acceptance field tests, after equipment is completely installed, may be performed by Contractor to demonstrate performance requirements. If specially requested by the Engineer.

When the adjusting is terminated, new tests shall be carried out at the Contractor's expenses, except expenses of fuels, electric power and water in case of the Engineers field test.

- ✓ Criteria for Rejection: At design point, deviation from guarantee values by more than:

- Delivery rate %: +10/-0
- Delivery head, % : +5/-0
- Efficiency, % :-0

On completion of the installation and erection of the submersible pumpset with accessories and after the required initial setting of the electro-mechanical works the Contractor shall notify the Engineer at least 7 days in advance about his readiness to demonstrate and commission the submersible pumpset along with the transformer, stand-by diesel generating set and the pipeline works with valves and fittings. This demonstration work shall show that the electro-mechanical items / systems meet the specified specifications and performance criteria as mentioned in the Contract Document.

For carrying out the testing and commissioning works the Contractor shall provide the following items fully at his own cost.

- All skilled and qualified staff and labour as required.
- Provision and disposal of all services and consumables, e.g. lubricants, fuels, electricity, water, etc.
- All measuring and testing instruments (e.g. gauges, flow-meters, multi-meter), hand tools, etc) required to demonstrate that the items / system are operating to the required performance criteria.

**(n) Acceptance Certificate**

Only upon successful testing and commissioning of the electro-mechanical works an acceptance certificate shall be issued by the Employer / Engineer.

**(o) Warranty Period**

The Contractor shall provide warranty for the installed distribution transformer, standby diesel generator set, submersible pumpset, motor control panels, change over switch, etc. and for their relevant accessories to be free from defects in design, quality of material and workmanship under the normal use and service for a period of one year from the date of issue of Acceptance Certificate. Any fault arising due to defects in design or quality of material or workmanship during the Warranty period shall be promptly made good by the Contractor fully at his own cost, failing which the Performance Bond of the Contractor shall be forfeited.

**(p) Training**

After the successful testing and commissioning of the electro-mechanical works the Contractor shall provide training to the 4 personnel of the Employer for a period of 7 days. Suitable training shall be given by approved Experts at project site regarding the proper operation, maintenance and repair of the stand-by diesel generator set, submersible pump sets, motor control panels, change-over switch, valves and gauges of the pipeline works, etc. The cost of this training shall be fully borne by the Contractor.

## **8007 PIPES, FITTING AND RELATED ACCESSORIES**

**(1) General**

**(a) Materials**

The term materials shall mean all materials and articles of every kind, raw, processed or manufactured, which are used in the manufacture of goods to be used under the Contract.

All materials shall be new and of the kinds and qualities described in the clauses hereof appropriate to the particular item and shall be at least equal to approved

samples except that alternative materials may be accepted provided the Contractor has at the time of tendering :

- ✓ Drawn particular attention to the deviation from the Specification in his bid and provided particulars of the alternative material offered at the time of tendering, and
- ✓ Substantiated, to the satisfaction of the Engineer, that the material offered is equal or superior to the material specified for the use to which it is to be put and has obtained from the Engineer's approval in writing to its use. Where materials to be used for any component have not been laid down in the Specification the Contractor shall use only those materials in such compositions as have been proven in actual service to be the most suitable for the particular purpose.

All pipes and assembling parts selected under this Contract must be of first quality, truly circular, of a uniform thickness, free from scale, lamination, honeycombs, and other defects, and shall be designed to withstand the stated pressures and temperatures. They shall be of service proved products of specialized manufacturers.

Each pipe length should be as long as indicated in the drawings. When not indicated, the length should be as long as practicable to keep the number of joints to a minimum.

Where the coating of pipes is damaged, the surface shall be cleaned and dried and the Contractor shall paint the damaged area with a minimum of three coats of paint and to the full thickness and specification as the original coating.

#### **(b) Equivalency of Standards and Codes**

Wherever reference is made in the Contract to specific standards and codes to be met by the goods and materials to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly stated in the Contract. Where such standards and codes are national, or relate to a particular country or region, other authoritative standards which ensure an equal or higher quality than the standards and codes specified will be accepted subject to the Engineer's prior review and written approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's approval.

In the event the Engineer determines that such proposed deviations do not ensure equal or higher quality, the Contractor shall comply with the standards specified in the documents.

#### **(c) Standards and Codes**

All workmanship, materials and components throughout shall, where applicable and unless otherwise stated in the Contract, comply either (a) with the relevant

International Standard ISO, (b) with the relevant British Standard or Code of Practice current on the date fixed for receipt of tender, (c) comparable Indian Standards, (d) with the relevant Nepal Standard or as per Engineer's approval.

The following is a list of some nationally and internationally accepted standards and codes and some associations concerned with the standardization of products and abbreviations below will be used in the following text.

**(d) Test Certificates**

Certificates in triplicate shall be provided by the Contractor for each material such as valve, pipe, and fitting giving the process of manufacture and the results of the specified tests.

Similar certificates in triplicate shall be provided by the Contractor in respect of materials to be used in the manufacture of the valves, pipes and fittings giving the process of manufacture, chemical analysis (where relevant) and the results of specified tests.

The materials shall be suitably marked to enable them to be identified from references on the certificates.

**(e) Samples of Materials and Tests on Samples**

The Contractor shall provide to the Engineer three copies of the results of any routine analyses or tests carried out by him or his manufacturer on materials used in the manufacture of the Goods.

In addition, when and if required by the Engineer, the Contractor shall provide samples of all or any materials used in the manufacture of the Goods and shall carry out any specified test on the said materials as may be required the Engineer at the place of manufacture or at a laboratory approved by the Engineer and shall provide to the Engineer within seven days of each such test three certified copies of the results of the analysis or test.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer. The Contractor or his manufacturer shall prepare the necessary test pieces and supply all labour, appliances, testing apparatus and everything necessary for carrying out all specified tests.

The Contractor shall give the Engineer 14 days notice in writing of the date on which any of the samples will be ready for testing or inspection and unless the Engineer shall attend at the appointed place within the said 14 days, the test may proceed in his absence.

Approval by the Engineer as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer's rights under the Contract.

**(f) Independent and Local Tests**

The Engineer reserves the right to carry out any independent or local tests he may

deem fit on the completed pipes and fittings or on any material provided under the Contract at any stage during the Contract. In addition to any relevant clause in the General Conditions of Contract any materials, workmanship or completed pipes and fittings which are shown by such independent tests not to be in accordance with the Specification shall be rejected notwithstanding any previous certificate which may have been provided.

Any pipes and fittings, which have been rejected, shall be marked in a distinctive manner, which shall preclude any possibility of their use for the purpose for which they were supplied. Such pipes and fittings may be submitted for re-test following the correction of any defects, where such corrections are permitted by the Engineer

**(g) Rejected Goods**

Any Goods delivered to the site which have been rejected by the Engineer shall immediately be removed from the site. Replacement of rejected Goods shall be made as soon as possible but in no case exceeding thirty (30) days from the time of rejection.

Any pipes which have been rejected shall be marked in a distinctive manner which shall preclude any possibility of their use for the purpose for which they were supplied. Such pipes may be submitted for retest following the correction of any defects, where such correction is permitted by the Engineer.

**(2) Ductile Pipes and Fitting Valves**

**(a) Ductile Cast Iron Pipe**

♦ General:

Ductile cast iron pipe shall conform to ISO 2531/DIN 28614, with flanges to ISO 2531/DIN 2532, PN 10 unless otherwise specified. DI fitting shall be preferably of same manufacturer as of DI pipes.

Non-standard specials shall be avoided. If non-standard specials (e.g. flexible couplings) shall have to be used, the Contractor shall submit full details to the Engineer for approval.

♦ Composition:

The metallurgical composition of the ductile cast iron shall conform with the following requirements:

- ✓ 1,7 % to 5 % Carbon,
- ✓ 1,5 % to 3 % Silicon,
- ✓ minimum tensile strength 420 (MPa) for pipes, 400 (MPa) for fittings,
- ✓ minimum elastic limits 300 (MPa) for pipes and fittings,
- ✓ minimum elongation at failure 10 % for pipes, 5 % for fittings,

- ✓ maximum hardness 230 (HB) for pipes, 250 (HB) for fittings.

◆ Pipes:

Ductile cast iron socket and spigot pipes, and accessories shall be centrifugally casted in accordance with ISO 2531 (1991) Class K9, including the latest relevant revisions, if any, or other internationally accepted standards which ensure an equal or higher quality performance. All spun iron pipes and cast iron specials shall be ductile iron unless otherwise described. Water-tightness shall be ensured by the push-on joint for the pipes.

The pipes of class K9 shall be subject to a hydrostatic pressure test in the factory as follows:

- DN80 to DN300 ..... :60 bar,
- DN350 to DN600 ..... :50 bar,

◆ Fittings:

Ductile iron fittings shall be sand casted in accordance with ISO 2531 class K12 for fittings not including tees, class K14 for tees, and shall be manufactured with spigot and socket ends in which the seal is achieved by means of a suitable retained rubber gasket such as push-on or mechanical joints, unless otherwise specified. The gasket shall be of such size and scope that, when joined in accordance with manufacturer's instructions, it shall prove a positive seal within the manufacturer's range of maximum joint deflection and slip under all combinations of joints and gaskets dimensional tolerances and in the range of pressures specified.

The water-tightness of the fittings for the Project shall be ensured by the following types of joints: push-on joint, flanged joint 150 PN 10.

The flanged joint is either a joint with mobile flanges or a joint with fixed flanges depending on the fittings and the nominal diameters. The fittings shall be of the same pressure class as that of the DCI pipes. Drilling details and designed maximum pressure shall comply with ISO 2531 PN 10. The fittings shall be subject to a leak-tightness test carried out in the factory under 1 bar air pressure in accordance with ISO 2531.

◆ Joint Accessories:

The gaskets for the joint shall be made of elastomer rubber.

- ✓ natural rubber,
- ✓ EPDM (eddyline propylene diene monomer) as per ISO 4633/EN681
- ✓ or equivalent elastomer.

The gaskets shall be stored strictly in accordance with ISO 2531.

Bolts, nuts, and washers shall be made of steel with hot dipped cadmium coating or equivalent protection. The supply shall include for repair sets of epoxy cement mortar



for the internal lining and external coating (primer and final) including material, tools, and application manuals.

♦ Internal Lining- Pipes:

The pipes shall be internally lined in the factory with a sulphate resisting blast furnace cement mortar. The thickness and the lining shall be in accordance with ISO 4179 (1985). Prior to application of the lining the internal surfaces shall be shot blast cleaned to acceptable standard. The lining shall be applied centrifugally. The cement composition shall conform to BS 4027. The Colebrook roughness coefficient of the lining shall be less than 0.03 mm.

♦ Internal Lining – Fittings:

The fittings shall be internally lined in the factory with an epoxy coat suitable for potable water by test certificate from an international health institute, shall be abrasion resistant, and shall be subject to the approval of the Engineer. The thickness of the lining shall be not less than 0.3 mm. Prior to application of the lining the internal surfaces shall be shot blast cleaned to acceptable standard. The lining shall be applied in layers by spraying method. The Colebrook roughness coefficient of the lining shall be 0.01 mm.

♦ External Coating - Pipes & Fittings:

The pipes and fittings shall be externally coated in the factory with a metallic zinc coat as primer and a black bituminous or black coal tar based anticorrosive varnish in accordance with ISO 8179 or latest or synthetic resin or equivalent approved external surfaces to be applied with coatings shall be thoroughly cleaned and prepared immediately prior to the application of the primer paint. After the prime coat application, tests shall be carried out for misses or pinholes on the painted surface. The zinc for the coat shall be an electrolytic pure zinc of more than 99.9%. The zinc coat shall be applied by arc gun and the bituminous/tar based coat by an airless gun in at least 2 layers.

♦ Shop Testing and Inspection:

The inspection of pipes, fittings, valves and accessories shall be done by the contractor on the manufacturer's premises to assure himself of that the materials are of required design and specification prior to forwarding the materials to the site. The Contractor shall arrange for the testing equipment, the needed material, the checking devices and necessary trained personnel for the work.

The independent inspector(s) responsible for the acceptance being appointed by the Employer shall be informed three weeks in advance by writing before the demonstration procedure will take place.

The Contractor has to arrange the number of shipment of the DI pipe in three lots for delivery up to 5000m and for more than 5000m the number of shipment should be not more than five.



Inspection of external appearance, shape, dimensions and weight shall be carried out for each pipe and fitting. Pipes and fittings will be straight and shall be stripped with care to avoid warping. All pipes and fittings shall be sound and free from surface defects.

Each pipe and fitting shall be subjected to an approved hydrostatic pressure test. Any pipe or fitting that does not withstand the test pressure shall be rejected. Mechanical tests for hardness, tensile strength and elongation shall be performed on test pipes selected at random out of batches grouped in lots. Each lot shall be made up of pipes cast successively as follows:

- up to 300 mm Dia. ....: 100 pipes,
- 350 - 600 mm .....: 50 pipes

Inspection and weight check of pipes, fittings valves and accessories may be done after coating. Pieces of which the deviations from standard dimensions exceed the tolerances shall be rejected. The pipes, fittings, valves and accessories which show in the opinion of the inspector(s) minor imperfections unavoidable occurring during manufacturing and not disadvantageous for their use, shall not be rejected and the Contractor may under his own responsibility decide the method of removing such small visual superficial imperfections. He may also after approval of the Engineer repair certain defaults by any method other than welding.

- ✓ All pieces shall be weighed. Pipes and fittings of nominal diameter of 300 mm or more must be weighed separately. Those of smaller diameter shall be weighed in consignments up to 2,000 kg.
- ✓ The pieces of which the weight appears less than the normal weight (after deduction of the tolerance) can be accepted by the Engineer at his own discretion who shall decide, in each case and under the condition that they comply with all other requirements. Pieces of which the weight exceeds the normal weight are accepted.
- ✓ For each lot a tensile test and a hardness test shall be done on a sample. The tensile test is executed on a sample selected from the pieces forming the respective lot. If the test results comply with the requirements, all pieces of the lot shall be accepted under the condition that they satisfy all other conditions; if during the tests the tensile test shall be repeated on 3 test samples taken from other parts of the lot. In this case the lot is accepted if the average result does fulfill requirements under the condition that none of the tested samples shows a result less than 10% of the required demand.
- ✓ For each lot an inspection report shall be written which shall be signed by the parties present. Each piece weighed separately shall appear on this report with the indication of its mass and number.
- ✓ Each group of pieces weighed together shall be indicated by the number and the total weight of the consignment.

- ✓ All certificates of tests carried out during manufacture
  - shall be attached to the inspection report.
  - the inspections reports and certificates form an integral part of the documents.

♦ Handling and Storing:

Pipes and fittings shall be unloaded and stocked by the Contractor at the place approved by the Engineer and in piles only up to such height which prevents the lower layers from deformation or other damages.

The first layer will be placed on beams, large enough to give sufficient isolation from the ground, and the pipes will be secured by wedges. Each layer will be separated from the next by an adequate number of beams (at least two).

Care shall be taken during loading, transporting, and unloading to prevent damage to the pipes, fittings or coatings. Under no circumstances will pipes or fittings shall be examined and no piece shall be accepted which is found to be defective. Any damage to the pipe coating shall be repaired as directed by the Engineer. Special handling of pipes and fittings shall be in accordance with the manufacturer's instructions.

All pipes shall be bundled or packed in such a manner as to provide adequate protection for the ends, threaded or plain, during transportation.

Loading, unloading and handling shall be carried out using special hooks with a curved plate to fit the curvature of the pipes or webbing slings not less than 30 cm wide or other means approved by the Engineer. Coated pipes shall be transported on trucks or trailers fitted with approved padded timber cradles shaped to fit the curvature of the pipes and of adequate dimensions so as to prevent any damage to the pipe coating. Successive tiers of coated pipes shall be separated by similar suitable shaped timber cradles when more than one tier of pipes is being transported. Pillows shall be provided between securing chains or lashings when load are being transported.

Particular care shall be taken during unloading, loading, handling and transportation to avoid distortion, flattening, denting, scoring or any other damage to the pipes, fittings and any damage to the external or internal coating or lining of the pipes, fittings etc. Fittings shall not be stacked more than one tier high and shall be adequately supported clear of the ground on timbers all to the Engineers approval.

The Contractor shall provide appropriate packing for all transport to site. The packing must be specifically suited to the proposed pipes.

All components shall be packaged, finished or otherwise prepared such that they may safely be stored outdoors for an extended period in the project environment. Prior to shipment all unpainted surfaces, including bolts and nuts, machined surfaces, tapped holes and studs, and all other exposed ferrous surfaces, shall be protected with a heavy coat of suitable grease or other easily- removed corrosion-protective material.

All rubber gaskets and glands, and other components which are subject to

deterioration by ultraviolet light shall be packed so as to exclude sunlight.

Any materials which, in the opinion of the Engineer are delivered damaged or are damaged by the Contractor in the process of stockpiling at the delivery site shall be promptly removed from the site. The Contractor shall receive no compensation for the damaged material or its removal until it is either repaired to the satisfaction of the Engineer or replaced.

Crated small items shall be delivered and stored in their original containers. Each crate, box and other packing shall be clearly labeled with weatherproof marking identifying the quantity and exact nature of the contents thereof, such that materials may be readily identified without opening of the crates.

The Contractor will be responsible for making of the materials to be supplied as directed by the Engineer.

The pipes and fittings shall bear readable and indelible marks as follows in the English language.

- ✓ manufacturing mark
- ✓ last two digits of year of manufacture
- ✓ nominal diameter
- ✓ nominal pressure
- ✓ confirming standards

Spigot ends will show control marks for ease in connection.

The Contractor shall take all the precautions to avoid any corrosion or deterioration of the outside coating and shall protect the pipes from sunlight, dew, wind and other inclement of the weather.

#### Cutting of Pipes

- ✓ All pipes, and in particular pipes with internal and external coatings should only be cut, if the site conditions do not allow for any other solution. In this respect, the trace given on Drawings is only indicative and shall be adapted on Site in such a way, as to avoid the cutting of full length pipes.
- ✓ Should cutting of a pipe become necessary then the cut shall be made with an approved mechanical pipe cutter. The edges of the cut shall be clean, true and square.
- ✓ The Contractor shall be responsible for the provision of all equipment necessary for cutting and turning of pipes.
- ✓ The Contractor shall repair the damaged portions in the internal and external lining of the pipe work after the cutting in accordance with the manufacturer's instructions and shall make the cut metal portions smooth by grinding and filing.

## (b) Accessories

### ♦ Dismantling Pieces:

Adapting pieces shall be provided to all valves, and where necessary, to ensure a simple dismantling of the pipe work. They shall be lockable in position.

Dismantling pieces shall be flanged according to DIN 2501 and shall comply with the requirements of the DIN 2631, 2632, 2633 in accordance with the required pressure of the pipe. The materials of the dismantling pieces shall be the same, as it is of pipe, where they are to be built in.

### ♦ Rubber Compensators:

Rubber compensators shall be provided, if indicated in the drawings to the pipework, at the connected access to machines, like blowers and pumps.

Rubber compensators shall be capable of balancing thermal expansions, discrepancies in assembling, vibrations of machinery and settlement in a range of:

DN	Axial mm	Compression mm	Lateral mm	Angular
80	10	35	15	20°
100	10	35	15	15°
150	10	35	12	12°
200	15	45	15	8°
250	15	45	15	7°
400	15	45	15	6.9°
500	30	50	30	4.9°
600	30	50	30	4.9°

Rubber compensators shall be flanged according to DIN2501 and provided with guide tubes in order to reduce friction losses. Screws shall not protrude in the direction of the rubber. Rubber parts shall not be painted.

On suction side the compensators must be steel wire armored.

### ♦ Branches and Type of Fittings:

Branches shall be formed in accordance with the relevant DIN standards and welded before the pipe is erected.

All bends made from pipes shall be formed so that at any point along the bend ovality will not reduce the bore by more than 2.5%. Radius of bends for all pipes shall be not less than 1.5 times the outside diameter, in accordance with DIN 2605, if not indicated otherwise.

## (c) Valves and Gates

### ♦ General:

All valves shall be flanged if not specified otherwise. All flanges of the valve shall be according to DIN 2501 and in accordance with the required test pressure of DIN 3230 and shall satisfy the requirements stated in these DIN standards. The leakage rate has

to be in accordance with DIN 3230, Degree 1.

The face-to-face dimensions of all flanged valves shall comply with the DIN 3202 Part 1.

All valves shall belong to a class which can withstand the maximum pressure they will attain in service including any surge pressures, but all valves shall be tested at not less than their Nominal Pressure Rate.

Valves shall be capable of withstanding the same test pressures as the pipe line on which they operate. All nuts and studs subjected to vibration shall be fitted with spring washers or locking taps.

Valves shall carry identification marks and/or plates in accordance with DIN EN 19.

All materials used in the manufacture of the valves shall conform to the following minimum standards:

- Cast Iron .....DIN 1691 Mat. No. 0.6025
- Gunmetal .....DIN 1705 Mat. No. 2.1096.01
- Aluminium Bronze ..... DIN 1725
- Stainless Steel .....DIN 17440 Mat. No. 1.4571

Extended spindles and headstocks shall be provided where necessary and where indicated in the drawings. Valves above 100 mm bore except non return check valve shall be fitted with indicators so that it may be clearly seen whether the valves are open or shut. In the case of those valves fitted with extended spindles indicators shall be fitted body to the extended spindles and to the valve.

♦ Sluice Valves:

Sluice valves provided for the distribution network system shall be of the flat-body type, double flanged, with ductile iron bodies, and shall comply with the requirements of DIN 3352. They shall be of the inside screw non-rising stem type. The direction of closing shall be clockwise.

Sluice valves up to 400 mm bore shall have resilient seats.

Sluice valves over 400 mm bore shall have renewable gun metal faces on bodies and wedges.

Valve stems shall be, forged aluminium bronze, machined all over and have a strong trapezoidal or square formed thread, operating in a gunmetal nut. Stems in chromium steel (Material No. 1.4021) will also be permitted.

Stems shall be sealed with two O-rings, arranged for easy replacement of the packing and shall be accessible for maintenance without removal of the valve from the pipe line.

All valves shall be supplied with either hand wheel or extension spindle sockets. Extension spindle sockets shall be drilled and each provided with a nut and bolt for

searing of the stem which shall also be drilled.

Extended spindle installation shall include all necessary brackets, intermediate supports etc and provisions shall be made for adequate lubrication.

Handwheel dimensions are designed for easy operation, according to API 600. They are made in cupola malleable iron (to ASTM A 197) to external dimension 560 mm and in cast steel over.

♦ Non-return Valves:

Non-return valves shall comply with DIN 3202 and be of double flanged cast iron type, unless otherwise specified.

They shall be of the quick acting single door type, designed to minimize the losses at the event of pump shut down, and shall have gunmetal flaps and seating faces, and be fitted with external levers for back flushing, the levers so arranged, as to assist in the closing by the addition of weights if necessary.

The door hinge pins shall be of stainless steel and preferably square in section to ensure, positively, location of the doors and back flushing levers, and the hinge pins shall be extended through a sealing gland located at the side of the bodies.

The flaps and external weights shall be positively and securely fixed (grub screws, pins or clamps are not acceptable). All internal fixing devices shall be of stainless steel.

All reflux valves shall be suitable for operating in the vertical plane unless otherwise specified.

Covers shall be provided to allow ample access for cleaning and service and shall be supplied complete with tapped boss fitted with air release cocks.

The design of the valve bodies shall be such that there is adequate clearance around and at the back of the doors to minimize jamming by rags, etc. Stops shall be provided to limit the back lift of the doors and in such a position to prevent fouling by rags.

♦ Air Valves:

Air relief valves shall be rated for a minimum pressure of 10 bars having bodies of ductile iron, and shall be complete with isolating gate valves.

The valve shall have a nominal diameter of 100 mm, and shall include a calibrated air release nozzle. The valve closure device will consist of a rubber coated, spherical, perfectly calibrated float, guided in the body. The air relief valves shall be double type body.

♦ Sluice Gates (Manual):

The gate shall consist of frame, disc, wedge, stem and manually operated handwheel. Frame shall be of cast iron flat type.

Disc shall be of cast iron single piece construction with stiffening ribs and reinforced section. Disc shall have an opening for weir with weir plate made of stainless steel.

Seat shall be stainless steel, and bronze casting firmly fixed on the surfaces of the frame and disc by means of sufficient numbers and size of nut bolts.

The stem shall be of outside screw type and made of stainless steel.

Manually operated handwheel shall have a lift nut of cast bronze, threaded to fit the operating stem.

The direction of wheel rotation to open the gate shall be indicated on the wheel. The position indicator shall be attached to the manually operated handwheel.

♦ *Gear Operated Valves (Manual):*

Gear Operated valves for the water treatment plant shall be fitted with hand operated gear.

The valves shall be manufactured in accordance with the sluice valves specified herein for "Sluice Valves".

Special attention shall be given to the operating mechanism for the valves in order that quick and easy operation is obtained and maintenance is kept to a minimum.

Valves shall be supplied with either, bevel or spur gear operators.

♦ *(Pressure Reducing Valves:*

The pressure reducing valve shall function to maintain a uniform downstream pressure as pre-adjusted on the control pilot handwheel or adjusting screw.

The control pilot shall be capable of field adjustments from near zero PSI to 10% above 5Kg/cm<sup>2</sup> of factory preset pressure. The valve shall be completely piped ready for installation.

Throttling shall be done by the valve Vee ports and not the valve seating surfaces. The valve shall be capable of operating in any position and shall incorporate only one Hanged cover at the valve top from which all internal parts shall be accessible. There shall be no stems, stem guides, or spokes within the waterway. There shall be no springs to assist the valve operation.

The valve body shall be of cast iron ASTM A126 with flanges conforming to the latest ANSI Standards. The valve shall be extra heavy construction throughout. The valve interior trim shall be bronze B-62 as well as the main valve operation.

The valve seals shall be easily renewable while no diaphragm shall be permitted within the main valve body.

All controls and piping shall be of non-corrosive construction.

A visual valve position indicator shall be provided for observing the valve piston position at any time.



The valve shall be factory tested and set for the 5 bars of delivery pressure but field adjustments should be easily made.

**(d) Flowmeters(Bulk-meters)**

The flowmeters shall be supplied and installed on the discharge pipes of each well and high service pump station as shown in the drawings. Each flow meter shall be a self-contained volumetric measuring instrument with a magnetically coupled propeller and register, eliminating the stuffing box, packing glands and resultant friction load. All internal parts shall be protected against the adverse effects of moisture, corrosion and other harmful external influences. The sealed oil-filled gear housing shall exclude water borne contaminants. The register shall be hermetically sealed.

The flowmeter shall have a maximum allowable error of 2 percent within a range of flow varying from 20 percent to 120 percent of the design flow rate. Each flowmeter shall be provided with a calibration certificate. The meter shall be suitable for the pump shutoff head, and the contractor shall ensure that the flanges are drilled to suit the adjoining components or piping. Straightening vanes shall be provided directly upstream of the meter to ensure stream line flow. The meter tube shall have a uniform internal diameter not less than the nominal size of meter required.

Construction material shall be close grained cast iron up to 300 mm sizes and fabricated steel for larger sizes. The flow tube shall have a stainless steel liner and straightening vanes up to 300 nun dia and epoxy coated steel vanes and liners for larger sizes. The integral drop pipe and gear box shall be of cast bronze and the propeller of high density plastic or polypropylene. The propeller and magnet assembly shall be carried on graphite (or other approved material) bearing turning on hardened and polished stainless steel. The thrust load shall be carried by bearing of approved composition such as graphite-carbide. The internal parts shall he sealed, making field maintenance unnecessary.

A hermetically sealed rate indicator/totalizer with easily decipherable numerals etched on metal shall be provided in a integral case mounted enclosure on each meter, complete with case cover and hasp for locking. The meter head shall have a 6-digit, straight reading type Totalizator registering in 100 cu. m. units and a 75 mm dia. rate of flow dial with linear gradations in units of cu.m./hour. The seals shall be suitably sub-divided for the specified flow ranges.

Two (2) times of calibration tests shall be carried out by the supplier during commissioning period, and rectify and in accuracies discovered. The cost of this follow-up action shall be deemed to be included in the equipment price.

**(e) Pressure and Vacuum Gauges**

The pressure gauges shall be installed to the well head fittings by factory in connection with a ½" water sample tap. Gauges shall be provided for all pumps as detailed in the Specification and for all other equipment where necessary.

Pressure and compound gauges of approved manufacture shall be provided and fixed



directly to, and at the same level as the pressure and suction branches of, each dry well pump.

The gauges shall be fitted with diaphragm type isolating valves, but siphon pipes will not be required. Gauges shall not be connected to air release or auxiliary suction pipes.

The gauge mechanism shall be of the bourdon tube type with diameter DN 100 mm having stainless steel movements and shall comply and be tested in accordance with DIN 16064. Gauge graduations shall be such that the gauge is never used continuously beyond 60% the max graduations. Pressure gauges shall be graduated in the bars or millibars.

The face of the dial shall have a warning label marked in red attached thereto reading "IMPORTANT: TURN OFF WHEN NOT IN USE" in Nepali and English languages.

All gauges shall be proved with glycerin filling to dampen pressure pulsation. All gauges shall be installed vibration free.

**(f) Labels**

The Contractor shall arrange for the supply and fitting of engraved identification labels to all items of plant and all valves throughout the plant.

The Contractor shall also arrange for the supply and fitting of warning labels for machinery that is operated under automatic control.

All labels shall, in design, conform with the labels specified for control panels. All identification and warning labels shall be in the Nepali language.

**(3) HDPE Pipes and Fittings**

**(a) General Requirements**

♦ Materials:

The term "materials" shall mean all materials and articles of every kind whether raw, processed or manufactured which are used in the manufacture of the Goods to be supplied under the Contract.

♦ Composition:

The pipes shall be extruded from HOSTALIN GM 5020 T.2 or equivalent approved compound consisting of virgin polythene in which carbon black and a suitable non-toxic anti-oxidant are evenly dispersed.

All materials shall be new and of the kinds and qualities described in the clauses hereof appropriate to the particular item and shall be at least equal to approved samples except that alternative materials may be accepted provided the Contractor has at the time of tendering:

- ✓ drawn particular attention to the deviation from the Specification in his tender and provided particulars of the alternative material offered at the time of tendering; and

- ✓ substantiated to the satisfaction of the Engineer that the material offered is equal or superior to the material specified for the use to which it is to be put and has obtained from the Engineer approval in writing to its use.

Where materials to be used for any component have not been laid down in the Specification, the manufacturer shall use only those materials in such compositions as have been proven in actual service to be the most suitable for the particular purpose. All pipes shall be smooth, clean and free from all defects.

- ◆ Samples of Materials and Tests on Samples:

The Contractor shall provide to the Engineer three certified copies of the results of any routine analyses or tests carried out by him or his manufacturer on materials used in the manufacture of the Goods when and if asked by the Engineer.

In addition, when and if required by the Engineer, the Contractor shall provide samples of all or any materials used in the manufacture of the Goods and shall carry out any specified test on the said materials as may be required the Engineer at the place of manufacture or at a laboratory approved by the Engineer and shall provide to the Engineer within seven days of each such test three certified copies of the results of the analysis or test.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer. The Contractor or his manufacturer shall prepare the necessary test pieces and supply all labour, appliances, testing apparatus and everything necessary for carrying out all specified tests.

The Contractor shall give the Engineer 14 days' notice in writing of the date on which any of the samples will be ready for testing or inspection and unless the Engineer shall attend at the appointed place within the said 14 days, the test may proceed in his absence. Approval by the Engineer as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer's rights under the Contract.

- ◆ Test Certificates:

Test certificates in triplicate shall be provided by the Contractor for each consignment of pipe supplied, giving the process of manufacture and the results of the specified tests.

Similar certificates in triplicate shall be provided by the Contractor in respect of materials to be used in the manufacture of the pipes giving the process of manufacture, chemical analysis (where relevant) and the results of the specified tests. The material shall be suitably marked to enable it to be identified from references on the certificates.

Any materials subject to test incorporated in the manufacture of the pipes and fittings before the Engineer has received a satisfactory Test Certificate shall be at the Contractor's risk.

- ◆ Independent Tests:

The Engineer reserves the right to carry out any independent tests he may deem fit on the completed pipes or on any material to be used in the Contract at any stage of manufacture or delivery, in addition to those tests specified to be made by the manufacturer.

Any samples of materials which may be required for such tests shall be provided by the Contractor at no extra cost to the Engineer.

The cost of making any such independent tests shall be borne by the Contractor, unless it is shown that the workmanship or materials under test are not in accordance with the Specification.

Any materials, workmanship or completed pipes, which are shown by such independent tests not to be in accordance with the Specification shall be rejected, notwithstanding any previous certificate which may have been provided.

♦ Rejected Goods:

Any Goods delivered to the Site which have been rejected by the Engineer shall immediately remove from the Site by, the Contractor, free of cost. Replacement of rejected Goods shall be made as soon as possible but in no case exceeding forty five (45) days from the time of rejection.

Any goods which have been rejected shall be marked in a distinctive manner which shall preclude any possibility of their use for the purpose for which they were supplied. Such goods may be submitted for retest following the correction of any defects, where such correction is permitted by the Engineer.

♦ Standards:

All materials, workmanship and components shall, where applicable and unless otherwise stated in the Contract, comply with either:

- ✓ a relevant Nepal, Indian, British or American Standard current on the date fixed for receipt of tenders, or
- ✓ any other internationally accepted equivalent standards which, in the opinion of the Engineer, are equal or better than the specified standards.
- Nepal Standard NS : 40 - 2040 published by Nepal Bureau of Standards and Metrology;
- Indian Standards IS : 4984 - 1978 published by Bureau of Indian Standards, Manak Bhavan, New Delhi, India;
- British Standards BS 3284 : 1967 published by British Standards Institution (BS), British Standards House, London W1, England.

The acceptance of a tender based upon a Standard or Code of Practice proposed by the Contractor shall only signify the Engineer's general approval to the use of such Standard or Code of Practice and shall not signify acceptance by the Engineer of any materials or workmanship subsequently found to be inferior to that specified in the

corresponding Standard or Code of Practice.

♦ Supply and Marking of Pipes:

The Pipes shall be supplied either as coils with a minimum inner diameter of 25 times the OD of the pipes (except 2, 2.5, and 4 Kg/Sq.cm. pressure ratings), as given below or in lengths of five meters. The pipes may also be supplied in other lengths where so agreed between the Contractor and the Engineer. The ends shall be cut at right angles to the pipe axis and shall be plugged or covered.

A continuous line between 2mm to 5mm wide must be indelibly and clearly marked along the pipe surface according to the following code:

- 2.5 kg/cm<sup>2</sup> working pressure - Red line
- 4.0 kg/cm<sup>2</sup> working pressure - Blueline
- 6.0 kg/cm<sup>2</sup> working pressure - Green line
- 10.0 kg/cm<sup>2</sup> working pressure - Yellow line

Each pipe shall also have the following information marked on it at every 1m interval:

Name of project, i.e. TSTWSSSP, Pipe size - outer diameter; Series in Kg/cm<sup>2</sup>; Weight; Length; ISO, NS, IS, BS, etc. or relevant authoritative Standards mark.

The method of marking shall be such as to ensure that all of the information will remain legible after shipping, local haulage and storage in the open.

♦ Drawings:

Before manufacture is commenced, the Contractor shall submit to the Engineer for approval six copies of drawings of all pipes to be supplied which do not comply with relevant accepted Standards, showing all dimensions in metric units. The Contractor shall supply the Engineer without charge two copies of all drawings subsequently approved.

**(b) Testing of Pipes Before Shipment**

♦ Tests:

At the place of manufacture; hydraulic tests, reversion tests and internal pressure creep tests shall be carried out on ten random samples from each pipe series and diameter spaced throughout the manufacturing period.

This requirement may be reduced where a small length of a particular pipe diameter and series is to be supplied.

The working pressures for the various pipe series shall be:

- ✓ Series II 2.5 kgf/cm<sup>2</sup>,
- ✓ Series III 4kgf/cm<sup>2</sup>,
- ✓ Series IV 6kgf/cm<sup>2</sup>,

✓ Series V10 kgf/cm<sup>2</sup>.

Tests shall be witnessed by an independent inspection agent, to be appointed by the Engineer, who shall approve the tests on behalf of the Engineer.

♦ Site Inspection and Testing:

All Goods will be inspected after delivery to site and the Engineer will reject any item which is damaged or not complying with the specification.

**(c) HDP Fittings**

All HDP fittings shall be manufactured by Injection Moulding Process in accordance with IS: 8008 (Part I-VII) - 1976 or equivalent to join HDP pipes to IS: 4984 - 1978 or equivalent. All fittings shall be moulded from a compound consisting of virgin polyethylene in which carbon black and suitable non-toxic anti-oxidant are evenly dispersed and shall be suitable for butt - welding at fusion temperature 200°C - 220°C. All HDP fittings shall conform corresponding to working pressure rating of 10 kg/cm<sup>2</sup>. Fittings supplied must have a clear marking indicating the relevant pipe size(s) indelibly on each item.

**(d) Jointing**

All HDP pipes and fittings shall be jointed with the automatic butt-welding fusion machine at fusion temperature of 200°C - 220°C. The welding shall be as specified by the welding machine and as per manufacturer's specification.

Before joining it has to be ensured that equipment is clean, in good condition, regularly maintained and within required calibration/service. The cutter/blades and scrapers should be clean and in good condition. Mechanical Scrapers must be used wherever possible and the restraining clamps should be in good condition. Clean and dry place to place tools and equipment should be checked before during electro fusion process. The joining process should not be started unless it can be completed in one go.

Shelter and ground sheet, both in dry and wet condition should be used in order to minimize contaminations. Clamps should be used for alignment/restraining/re-rounding. Voltage should be ensured compatible with fittings.

**(4) Galvanized Mild Steel Pipes and Fittings**

**(a) Materials**

The term materials shall mean all materials and articles of every kind, raw, processed or manufactured, which are used in the manufacture of goods to be supplied under the Contract.

All materials shall be new and of the kinds and qualities described in the clauses hereof appropriate to the particular item and shall be at least equal to approved samples except that alternative materials may be accepted provided the Supplier has at the time of tendering:-

- ✓ Drawn particular attention to the deviation from the Specification in his tender and provided particulars of the alternative material offered at the time of tendering, and
- ✓ Substantiated, to the satisfaction of the Engineer, that the material offered is equal or superior to the material specified for the use to which it is to be put and has obtained from the Engineer approval in writing to its use. Where materials to be used for any component have not been laid down in the Specification the Supplier shall use only those materials in such compositions as have been proven in actual service to be the most suitable for the particular purpose.

**(b) Standards**

All workmanship, materials and components throughout shall, where applicable and unless otherwise stated in the Contract, comply either

- ✓ with the relevant Nepal, Indian or British Standards or Code of Practice current on the date fixed for receipt of tenders, or
- ✓ with other internationally accepted equivalent Standards or Codes of Practice which are equal or superior than the specification.

The acceptance of a tender based upon a Standard or Code proposed by the Supplier shall only signify the Engineer's general approval to the use of such Standards or Codes and shall not make the Engineer liable to accept a Standard or Code subsequently found to be inferior to that specified in the corresponding Standard or Code of Practice.

**(c) Test Certificates**

Certificates in triplicate shall be provided by the Supplier for each valve, pipe and fitting supplied giving the process of manufacture and the results of the specified tests.

Similar certificates in triplicate shall be provided by the Supplier in respect of materials to be used in the manufacture of the valves, pipes and fittings giving the process of manufacture, chemical analysis (where relevant) and the results of specified tests.

The materials shall be suitably marked to enable them to be identified from references on the certificates.

**(d) Independent and Local Tests**

The Engineer reserves the right to carry out any independent or local tests he may deem fit on the completed goods or on any material provided under the Contract at any stage during the Contract including the guarantee period. In addition to any relevant clause in the General Conditions of Contract any materials, workmanship or completed pipes and fittings which are shown by such independent tests not to be in accordance with the Specification shall be rejected notwithstanding any previous certificate which may have been provided.

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**(e) Rejected Materials**

Any goods delivered to site, which are rejected by the Engineer, shall be immediately removed from site by the Supplier free of costs.

Any pipes and fittings, which have been rejected, shall be marked in a distinctive manner, which shall preclude any possibility of their use for the purpose for which they were supplied. Such pipes and fittings may be submitted for re-test following the correction of any defects, where such corrections are permitted by the Engineer.

**(f) Manufacture and Testing**

Tube shall be made from tested quality steel manufactured by any approved process.

The manufacture and testing of all galvanized steel pipes and fittings shall comply with the current edition of NS, IS, BS or equivalent. Galvanized steel pipe shall be of the class specified in the Bills of Quantities.

Ends of pipes shall generally be screwed at both ends as per IS 554 - 1975, BS 21 threads or equivalent or as requested by the Engineer. Ends of pipe specials and fittings shall be screw socketed suitable for screwing to IS : 554 - 1975 or BS : 27 threads or equivalent pipe threads. Where flanged pipe work is specified this shall be suitable for jointing with other flanged pipe work and valves.

**(g) Process of Manufacture**

"Medium" and "Heavy" duty galvanized steel pipes and sockets shall be either welded or seamless as agreed to between the Engineer and the manufacturer.

**(h) Standard and Non Standard Lengths**

The pipe shall be supplied in standard lengths of 6 metres each. Each pipe shall be provided with a corresponding size of one socket at one end and a plastic ring (cover) at the other end for protection of the threads of the pipes.

Nonstandard lengths shall be approximately 3 metres in length or as required by the Engineer. One socket to be provided with each pipe at one end and a plastic ring on the other end as mentioned above.

In both the cases, the total lengths for each class and diameter shall be the sum of the pipe lengths measured excluding the sockets.

**(i) Pipe Dimensions and Tolerances**

The pipe wall thickness and outside diameter of the pipes shall comply with Section 2.4 of BS 1387 or equivalent.

The weights per metre in Kgs. of Screwed and Socketed Galvanized Mild Steel Tubes (including sockets) shall not be less than:-



Diameter (mm)	Heavy Duty Kg/m	Medium Duty Kg/m	Light Duty Kg/m
15	1.51	1.28	1.02
20	1.97	1.65	1.48
25	3.07	2.54	2.11
32	3.97	3.27	2.72
40	4.59	3.77	3.41
50	6.39	5.32	4.33
65	8.21	6.82	6.11
80	10.52	8.87	7.21
100	-	12.69	10.49

**(j) Hydraulic Tests**

Each pipe and fitting shall be tested at the place of manufacture to a hydraulic test pressure of 50 bar without showing defects of any kinds, the pressure being maintained sufficiently long (in any case not less than three minutes) for proof and inspection.

**(k) Galvanizing**

After hydraulic testing of each item has been completed, pipes, fittings and flanges shall be thoroughly descaled, washed as required and then dipped in a bath of molten zinc, containing not less than 98.5% by weight of zinc at a temperature suitable to produce a complete and uniformly adherent coating of zinc. Where tubes are required to be galvanized, the zinc coating on the tubes shall be in accordance with IS4736 - 1968 or equivalent. Pipes and fittings which are to be screwed shall be screwed after galvanizing has been completed.

**(l) Tests on Finished Pipes**

The Supplier shall arrange and carry out tests on the galvanizing in accordance with Appendix A of BS1387 or equivalent. One pipe per batch of 500 pipes shall be sampled for this test.

The Supplier shall also arrange and carry out bending and flattening tests on pipes above 50 mm nominal diameter in accordance with Section 2.9 of BS 1387 or Section 14 of IS: 1239 (Part I) - 1979. Two pipes per batch of 500 pipes shall be subjected to these tests.

**(m) Pipe Specials and Fittings**

Galvanized mild steel pipe specials and fittings shall conform to the appropriate dimensions given either in BS 1387 or BS 1740 or IS: 1879 - 1987 or equivalent. The material used for the manufacture of malleable cast iron fittings shall conform to any of the grade specified in IS: 2107- 1977 or IS: 2108 - 1977 or equivalent. Outlets of fittings shall be threaded to dimensions and the tolerances as specified in IS: 554 - 1975 or equivalent. Fittings shall be galvanized to meet the requirements of IS: 4759 - 1985 or equivalent. Pressure test shall be as per section 13 of IS : 1879 - 1987 or equivalent. The dimension and weight of all fittings shall be as per the corresponding section of standards e.g. IS : 1879 - 1987 or equivalent. The ends of all pipe specials



shall generally be screw socketed. If the supplier offers screw spigot ended pipe specials, a matching screw socket shall be provided for each end of the pipe specials. All standard lengths shall be supplied with one coupling and the price quoted shall include for this.

**(n) Flanged Joints**

Flanges shall be the boss screwed type in accordance with BS 4504 Table 16/4 or equivalent suitable for screwing to BS : 21 pipe threads or equivalent. Each flange to be supplied with one set of jointing materials.

Each set of flange jointing materials shall be supplied complete with nuts, bolts, washers and joint rings with an additional 10% as spares. Body bolts and nuts shall be galvanized, joint rings shall be of flat section 3 mm thick, medium rubber reinforced with two-ply flax fabric and complying with BS 5292 or equivalent and shall not extend beyond the bolt circle. Bolts and nuts shall be hexagonal and shall be in accordance with BS 4190 or equivalent.

**(o) Markings**

Each standard length Medium Class galvanized pipe shall be marked with two blue bands 50 mm wide (one band at each end of the pipe) the nominal diameter, the length of pipe and the relevant manufacturing standard. Similarly for light class pipes except that the band colour shall be brown or yellow and that for heavy class red bands colour.

**(p) Protection Against Damage in Transit**

Pipes and specials shall be protected with a suitable varnish throughout their entire length. Straight pipes shall be bundled together into convenient lots (for transport) by rope or 105 WC wire or other suitable material in at least three places. Sockets and other small fittings shall be packed in strong wooden boxes.

The threads of all pipes shall be effectively covered with a good quality grease or other suitable compound and each pipe above 50 mm diameter shall have a protecting ring affixed to the screwed spigot end. Rates should include for all packaging.

**(5) Valves, Stop Cocks and Ferrules**

**(a) General**

All valves shall be manufactured to an internationally recognized standard and full details concerning such standards shall be provided by the manufacturer for approval before manufacture commences. Where British or Indian Standards are quoted in this specification an equivalent internationally recognized standard is acceptable.

Cast iron shall have properties not inferior to those specified for Grade 14 of BS 1452 or equivalent and shall withstand the test pressure specified. All castings shall be carefully cleaned and dressed off. No stopping or plugging will be permitted in the case of holes or flaws appearing therein, and casting shall be made from first running.

Gunmetal and bronze shall be of such compositions as have been proved in actual service to be the most suitable for the particular purpose. If any casting, forging, bearing or other part should prove to be defective, the Engineer shall have the power to reject it and the Supplier shall replace it at no extra expense to the Engineer.

**(b) Interchangeable Components**

All similar equipment shall be strictly interchangeable as a whole and as regards their component parts.

**(c) Protection Against Climatic Conditions**

Valves supplied shall be of the appropriate grade and quality for and shall be adequately protected against the tropical climatic conditions. The supplier shall take those conditions into account in deciding what grade, quality and protection is required. Cast iron and steel surfaces of all valves, hydrants, and fittings shall be painted with at least two coats of approved bituminous paint. Failure to comply with the requirements of the above will result in rejection by the Engineer. Valve bodies, protecting tubes, surface boxes and all other casting shall be coated in accordance with BS 5163 or equivalent, for tropical conditions. Where this is not applicable, they shall be thoroughly cleaned and given one coat of bituminous paint. Machined surfaces shall be covered by a suitable rust inhibitor, such as a high melting point grease of approved quality.

All submerged moving parts of the valves, or the pins and spindles etc of submerged moving parts, or faces etc. in contact with them shall be of non-corrodible materials. Any parts that show signs of corrosion or wear during the Period of Liability shall be replaced by non-corrodible material of special quality for the purpose at no extra expense to the Engineer. Care shall be exercised in the choice of metals for use in the valves to reduce the effects of bi-metallic corrosion to a minimum. The foregoing shall apply also to the moving parts of valves exposed to the weather.

**(d) Works Tests**

All valves shall be hydrostatically tested at the place of manufacture to the pressures specified and valves shall satisfactorily pass the specified tests before they are packed for delivery.

All valves shall be body tested to twice the working pressure stated in the Bill of Quantities. Seat tests to the working pressure stated in the Bill of Quantities shall be carried out on all sluice valves and stop valves.

All sluice valves and stop valves shall be subjected to "open end" test in accordance with BS 1218 or equivalent and each valve shall be subjected to three separate hydrostatic tests as follows:

♦ Seat Tests:

- ✓ The tightness of seats shall be tested as follows: with the wedge closed and with the valve fixed at one end only the test pressure shall be applied to one

face of the wedge, the other face being at atmospheric pressure. There shall be no visible leakage past the wedge at the hydrostatic test pressure (gauge) specified;

- ✓ The above procedure shall be repeated but with the valve fixed at the other end and with the pressure applied to that end of the valve.

♦ Body Test:

- ✓ With the wedge open the test pressure (gauge) specified shall be applied to the whole body of the valve. There shall be no visible leakage. The test durations for all tests shall be as in the table below:

Nominal Diameter mm	Minimum Test Duration (minutes) for	
	Body	Seat (if applicable)
50 and under	0.25	0.25
65 to 150	1	1
200 to 300	2	2

All valves shall be marked with cast-on or stamped lettering stating the body test pressure in meters head of water. The cost of testing shall be included in the contract rates.

**(e) Valves Generally**

Valves shall have adequate provision for lubrication, shall cause the minimum of head loss in the open position and shall seal the water passage completely when shut.

All valves shall be closed in a clockwise direction unless otherwise specified. Direction of closing to be shown on the hand wheel.

All valves shall be suitable for use with water in the temperature range -10°C to 70°C and for working pressure of 10 bar or as otherwise specified.

Each flanged valve shall be supplied complete with nuts, bolts, washers, and joint rings. Joint rings shall be of that section complying with BS 4190 or equivalent and shall not extend beyond the inner edges of the bolt holes. Bolts and nuts shall be hexagonal complying with BS 4190 or equivalent.

All materials which may come in contact with raw or potable water shall be free from toxic substances and shall not foster microbiological growth or give rise to taste, cloudiness or discoloration of the water with which they are or could be in contact.

Rubber used in valves shall be ethylene propylene rubber (EPDM or EPM) or styrene butadiene rubber (SBR), which complies with the above requirements, and is suitable for making a long term flexible seal and is resistant to mechanical, chemical, or bacteriological attack leading to deterioration of the flexible seal.

**(f) Flanges**

Flanges for pipe work connections shall in all respects be in accordance with BS 4504 PN 16 or equivalent unless otherwise specified.

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**(g) Bib Cocks**

Bib cocks shall be of brass and shall be nominal 15 mm diameter conforming to BS 1020 or IS : 781 - 1984 or equivalent. Inlets shall be male screwed suitable for joining to 15 mm GI socket. Outlet shall be plain ended. Top shall be round turned crutch.

**(h) Globe Valves**

Globe valves shall be gunmetal, rising stem, hand-wheel operated with screwed female ends; conforming to IS: 778 - 1984 Class 1 or equivalent.

**(i) Gate Valves**

Stop valves shall be gunmetal wedge gate valves, rising stem, hand-wheel operated with screwed female ends; conforming to IS : 778 - 1984 Class 1 or equivalent.

**(j) Ferrule Cocks**

Ferrule cocks shall be of gunmetal square head of 15 mm internal diameter swivel balancing screw down ferrules with male inlet and single male outlet; conforming to IS: 2692 - 1984 or equivalent.

**(k) Air Valves**

Single orifice air valves shall be of cast iron body, reliable in action and shall operate in such a manner that the balls of the valves cannot be held against the orifice by air pressure alone. Each air valve shall be supplied with an approved isolating device. The inlet shall be male screwed 15 mm diameter suitable for connection to a GMS riser pipe. Maximum operating pressure will be 100 meters head of water.

**(l) Marking and Packing**

Each valve shall be indelibly marked with the diameter, weight and pressure rating and shall in addition carry a unique reference number to enable each item to be clearly identified to works fabrication records, works test certificates, delivery notes and the like.

All valves shall bear the authorized Standard mark cast on showing to which Standard specification they have been manufactured.

Whenever possible the identification marks except for the "Standard mark" shall be painted on the outside of the item but where there is insufficient smooth surface area to accommodate the identification marks they shall be put on rust proofed metal tags secured to the item with galvanized wire.

Flanges shall be protected with wooden discs attached by service bolts or other approved means. Service bolts shall not be incorporated in the works.

All items shall be properly prepared and packed for delivery and shipping. In particular, small items such as small valves, parts of operating gear, bolts, nuts, gaskets, and other joint components shall be crated for delivery. Each crate shall contain a detailed packing list in a waterproof envelope. The outside of the crate shall

bear a general description of the contents and identification mark relating it to the detailed packing list.

All valves and fittings shall be securely packed in crates or boxes for protection against damage during transit. The costs of packing shall be included in the contract rates. None of the packing will be returnable.

**(m) Unions**

Unions shall either be brass or galvanized malleable iron, as specified in bill of quantities, manufactured in accordance with a recognized international standard. The manufacturer shall produce full details concerning the standards to which his goods are produced. All unions shall be suitable for joining GMS pipes manufactured to BS 1387 or IS: 1239(part 1) - 1990 or equivalent with threads to BS 21 or equivalent.

**(n) Flexible/Detachable Couplings**

Flexible/detachable joints are required for repairs to existing GMS pipes of medium class manufactured to BS 1387 or equivalent specification. They shall be similar to 'Viking Johnson Couplings' without central register and shall be capable of withstanding a pressure of 250m head of water. They shall be supplied complete with all bolts and gaskets and shall be suitably protected against corrosion by an approved coating. Sizes required in the range of pipe sizes ND50 to ND100. Full details to be supplied for approval before manufacture.

**(o) Others**

♦ Float Valve:

Float valve shall be of heavy duty type for break pressure chamber and conforming to standard IS: 1703- 1977 (horizontal plunger type or equivalent. The pressure rating shall be 14 Kg/m<sup>2</sup> and male thread shall be as per corresponding standard.

♦ Nipples:

Nipple of various length as required by the Engineer shall be manufactured of Medium/Heavy duty galvanized mild steel pipes conforming to IS : 1239 (Part I) - 1990 or equivalent. Threads to conform with IS : 554 - 1975 or equivalent. The standard lengths are :

- 100 mm up to 25mm nominal bore
- 150 mm for 32 mm & 65 mm nominal bore
- 200 mm for 80 mm & 100 mm nominal bore

♦ Brass Union

Brass union shall be used to join HDP pipe and equivalent G.I. Pipe. Dimensions for HDP pipes are as per IS : 4987 - 1979 equivalent and GI pipes as per IS : 1239 (Part I)- 1990 or BS : 1387 - 1967 make threads or equivalent. Type of joint : Expansion joint consisting of:

- union body

- brass ring
- brass expansion plunge (for insertion into the HDP pipe)
- neoprene ring for insertion into union body &
- flat rubber coaster. Each set to be supplied assembled.

♦ Flange Set (For HDP - GI Jointing):

Flange set to join HDP pipe as per IS : 4984 - 1978 or equivalent to IS : 1239 (Part I) - 1990 or BS : 1387 - 1967 GI pipe (make threads) shall consist of :

- female threaded flange
- plain unthreaded flange
- HDP flange adaptor
- duty rubber gasket and
- nuts, bolts and washers (adequately lightened)

♦ GI Flange:

Flanges shall be female threaded to join GI pipe and valves etc and shall be drilled in accordance with BS: 4504 PN 16 or equivalent. The supply shall be complete with nuts, bolts and washers, all adequately tightened.

♦ GI Valve Box:

GI Pipe Boxes shall be manufactured according to sample made available or the Drawing and GI pipe used must be medium duty conforming to NS: 199 -2046 or IS: 1239 (part) - 1990 or equivalent. As shown in the drawing one end of the GI pipe shall be fitted with one set of GI flange and GI blank flange complete with nuts and bolts. The bottom of the GI pipe shall be slotted to allow it to slip over the pipeline and locked into place with 300 mm long M.S. bar by passing through two 10 mm holes drilled near the base.

♦ GI Valve Key:

The Valve Box Keys shall be manufactured according to sample or drawing made available to the manufacturer. Valve Boxes Keys to be manufactured of light duty pipe conforming to Nepal Standard NS: 199 - 2046 or Indian Standard IS: 1239 (Part I) - 1990 or equivalent. Other required reducers shall conform to IS: 1879 - 1987 or equivalent.

♦ CI Manhole Cover and Frame:

CI Manhole cover and frame shall be manufactured as per drawing or samples made available to the manufacturer conforming to NS: 104 – 2042 or IS: 1726 of latest edition or equivalent.

CI manhole covers and frames are to be provided and fixed on the top RCC slab as per drawing with minimum 100mm thick M150 RCC.

The CI manhole cover shall be laid as such so that top of the manhole cover should be the same of the top of the road surface or finished level of Manhole shall match

with the finished level of surrounding structure.

The CI manhole cover shall be measured in numbers unless otherwise mentioned in the BOQ.

The rate shall include cost of material, transportation, laying, fixing and other necessary associated parts including necessary form works, PCC, reinforcement, curing, etc. as instructed by the Engineer.

**(6) Household Connection Water Meters**

**(a) General**

All meters to be supplied under this Contract shall be service proved products of specialized manufacturer's.

The Suppliers will be deemed to have obtained manufacturer's complete instructions with respect to the products to be supplied under this Contract. He shall adhere carefully to such instructions and shall wherever necessary employ manufacturer's specialist assistance in the performance of the works.

The provisions of this article shall not be construed as releasing the Supplier from his responsibility under the Contract.

**(b) Warranties and Certificates**

The Supplier shall guarantee all materials and equipment furnished under this Contract in conformity with the stipulations in the Agreement, the General Conditions and these Specifications.

Before shipment of any consignment, the Supplier shall submit manufacturing certificates and third party inspector's showing the materials, workmanship, functions and performance to be in accordance with the reference standard and more specifically with the requirements of this Contract. Any form of certificates of the manufacturer or recognized agency may be submitted.

The certificates shall be accomplished by the manufacture/s design calculations and of the required test.

Factory Warranty of the meter shall be at least 1 year after successful delivery

**(c) Materials**

Only the best quality and type of materials shall be used, which shall be suitable for the purpose intended. Unless otherwise specified, materials shall be selected by the Supplier. The materials shall be appropriate both mechanically and chemically to the operating conditions. In connecting units they shall be mechanically, chemically and electrochemically compatible with one another and with the environment.

Materials shall be selected to the adequate resistance against abrasion and corrosion. Where necessary protective coating and lining shall be applied.

Materials in contact with the water shall be non-toxic and shall not affect the quality



of the water.

**(d) Design and Construction**

Meters shall be designed for use in tropical climate and for measuring the water described in Project Information with temperatures up to 50°C, and shall comply to the requirements of ISO 4064 or equivalent.

Meter shall have a modular design, consisting of an inlet case and separate measuring chamber. The measuring chamber shall be removable and rapidly exchangeable without removing the body.

Registration shall be by direct reading digital counter, with a display to show the smallest measurements.

Registration shall be in cubic meters. For ease and accuracy of calibration and adjustment, dials shall register or as to permit accurate readings of 0.05% of the nominal discharge.

Meters shall have a means of adjustment by a by-pass chamber side screw which adjusts the cross-section of the chamber. The adjustment screw shall be operable from outside the meter and shall be protected by a screw in sealed plug.

All meters shall be provided with wire and lead seals, both to the register and to the plug covering the adjustment screws.

All parts in contact with the rotor shall have smooth surfaces, protected where necessary to prevent encrustation.

A strainer shall be fitted to the inlet of each water meter. The strainer screen shall be rigid, fit snugly, be easily removable and have an effective straining area at least double that of the inlet.

Water meters shall be designed for a lifetime of 10 years under normal operating conditions.

**(e) Markings**

The following markings shall be provided on the meters:

- ✓ at least one arrow cast onto the body indicating direction of flow.
- ✓ nominal size cast on the body.
- ✓ model identification, individual serial number, year of manufacture, engraved on the housing or indelibly marked on the dial.
- ✓ manufacturer's name and serial number, engraved on the lid or otherwise suitably marked.

**(f) Meter Performance**

General Performance and accuracy shall be as indicated below. The range of measured flow rates is sub-divided into 3 reaches, the limits being defined by the following flow



rates:

$Q_s$  = starting flow rate.

Below this flow rate the register will not show any reactions.

$Q_m$  = minimum flow rate for reliable registration. The error shall not exceed plus minus 5%.

$Q_1$  = limiting flow rate for increased accuracy of registration. For flow rates above  $Q_1$ , the error shall not exceed plus minus 2%.

$Q_n$  = nominal flow rate for continuous or intermittent function of the water meter. The error at  $Q_n$  shall not exceed plus minus 2%,

$Q_{max}$  = maximum flow rate at which the meter may function for limited time without exceeding a metering error of plus minus 2% and without exceeding permissible head loss.

For domestic type water meter  $Q_{max}$  should be  $2 \times Q_n$ .

The Supplier shall include with his Bid the information in a format set out in the Technical Data Sheets regarding the above performance.

#### **(g) Specifications**

Water meters in this category shall be of 112" (15mm) size or their nearest metric equivalent.

They shall be the Rotary Piston Type with completely waterproof encased gear train, magnetic couplings and register. The inlet and outlet shall have a common axis.

The meters shall have the following minimum performance characteristics:

- Approx. nominal flow rate  $Q_n$  (m<sup>3</sup>/h) ..... 1.5
- Minimum capacity of register (m<sup>3</sup>/h) ..... 104
- Minimum readable quantity (litres) ..... 1

Otherwise they should comply to Class C EEC or ISO standard.

Domestic water meters shall have a non-return valve on the outlet end to prevent back flow.

Domestic water meters shall have water tight dismantling coupling on each side to allow easy removal of the unit from the pipe work.

Their design and materials shall afford reasonable safeguards against destruction. Attention in this regard shall be given to the strength of the glass and the lid.

The pressure rating of domestic water meters shall be PN 10 (10 bar).

The meter housing (body) shall be manufactured from brass metal with minimum weight of each meter shall be 1.0 kg without connectors and 1.2 kg with connectors.

Domestic water meters shall be suitable for mounting in both the horizontal and in the

vertical positions.

#### **(h) Testing**

It is required that the quality and the compliance with these specifications shall be demonstrated for all materials and equipment by appropriate tests performed during the various phases of the Work of production.

The minimum test pressure shall be the specified nominal pressure plus 50%. This pressure shall be applied increasing from 0 to maximum event over 15 minutes.

The test pressure shall be held without pressure drop for at least half an hour without any sign of leakage.

The measuring devices used in ship testing shall afford the following accuracy:

- Capacity: ..... plus minus 0.1%
- Differential head ..... plus minus 1 %
- Time measurement: ..... plus minus 0.03 %

Shop testing shall be run with water of not more than 40°C and not less than 10°C temperature. Shop testing shall sufficiently cover the entire range of the capacity to demonstrate that the characteristics are stable.

Each point shall have at least 3 (three) reading sand the arithmetic means shall be considered the proven value.

None of the individual readings shall differ from the specified limits more that in admissible by accuracy of measurement as defined above.

The arithmetic mean of all readings for one performance point shall be within the specified limits.

#### **(i) Spare Parts**

The Supplier shall submit a fully detailed list of the spare parts of the meters to be offered.

Assembly Drawings, Operation and Repair Manuals for Water Meters

The Supplier shall submit assembly drawings and other related information of meters. The assembly drawings shall contain all necessary information and construction. The assembly drawings shall be accompanied by instruction manuals and any other information which may assist in interpretation of the drawings and forming an appreciation of the materials offered.

The Supplier shall submit the operation and repair manual in 2 (two) copies in English Language.

## **8008 BORE-HOLE DRILLING**

### **(1) General**

These specifications shall be read supplementary to the specifications of Standard Specifications (Section VI-B), the Special Provisions (Section VI-C). In case of ambiguities or discrepancies, the specifications of Sections VI(B) and VI(C) shall prevail. If necessary, clarification by the Engineer shall be requested.

**(a) Description of the Works**

As per BOQ

**(b) Requirements, Specification, Standards and Brand Names**

The Contractor shall fulfill all requirements and obligations under all relevant specifications for construction work of Section VI(b): “Standard Specifications” and Section VI(c): “Special Provisions to the Standard Specifications. Neither the following Clauses of these specifications, the detailed description therein nor the quantities shall limit or exempt the obligations of the Contractor.

Where items are not included in Bill of Quantities for any such requirements or obligations, the cost of such requirements or obligations shall be deemed to be spread over all the items of the Bill of Quantities.

All the standards mentioned herein shall be deemed to form part of this specification. All references to such standards shall be to the latest edition or revision thereof unless otherwise stated. Where a specific standard is referred to in this specification another standard will be acceptable, provided that it ensures an equal or higher quality of materials and workmanship than the standards referred to. If the contractor intends to use such alternative standard, he shall notify the Engineer thereof, submitting with his notice of the proposed standard, and shall not order any material or perform any work unless and until he has obtained the Engineer’s approval of such standard. Brands name where used in the specification is only intended to define a standard of quantity and performance and the contractor may use other equivalent products approved by the Engineer.

**(c) Contractor’s Work Program**

The Programme for the Water Supply works shall be in accordance with the main programme of the Project described in Section VI(c), Sub-Section 116: “Programme”.

Work program for the drilling and installation of deep tubewell, purchase of casing and well screens, development and pumping test, etc. showing all the stages proposed by the Contractor must be submitted at the time of agreement.

**(2) Materials**

**(a) General**

The Contractor shall provide all the required material for the construction of tubewell completely. Materials provided and used in the works shall be new and conforming to the qualities and kinds specified herein and or equal to approve samples. In respect of all materials used in the works currently practiced relevant standard specifications

such as British standard specification (or other equivalent standard specification) shall be generally applicable.

**(b) Inspection and Testing**

All materials used in the works shall be subject to inspection and tests as the Engineer may direct from time to time as the work proceeds. Only materials which are considered satisfactory by the Engineer shall be used and materials condemned or not approved by the Engineer shall be removed from the works at the Contractor's cost.

**(c) Standard Specifications**

Where in this specifications any material or work is required to be supplied or done in accordance with a certain standard specification, the Contractor will be permitted to supply such material or to do such work in accordance with an alternative standard upon the review and approval by the Engineer. The Contractor shall not order any material or perform any work unless and until he has obtained the Engineer's approval of such standard.

**(3) Housing, Casing and Slotted Pipes**

Unless and otherwise mentioned in BOQ, the size of housing pipe shall be of mild steel (heavy class) of thickness 7.0 mm with pipe lengths of 6 m. the Pipe shall be plain/ beveled ends or mild steel socketed end suitable for welding. The housing pipe shall project a distance of 400 - 600 mm above the ground level during installation. The top of the housing pipe shall have a flange welded on to which a blank flange shall bolted on at all time when the well is not attended by the Contractor.

The size of casing pipe shall be as specified in the bill of quantities and of mild steel (heavy class) of thickness 7.0 mm with pipe length 3 to 6 m. having plain/ beveled ends or mild steel socketed end suitable for welding.

The housing pipe and casing pipe shall be joined by electric arc welding with MS collar/reducer of one size bigger size pipe.

The housing pipe shall be 300mm diameter and 7 mm thick and 200 mm dia and 7.0 mm thick for casing pipe. Mild steel pipe with mild steel socketted ends suitable for welding. The housing pipe shall project a distance of 500 mm above the ground level. The top of the housing pipe shall have a flange welded on to which a blank flange shall be bolted.

The well screen shall be of the continuous slot wedge wire design, Johnson type, fabricated of special-shaped, manufactured in the all welded to support rod construction with electronically controlled welding system, ensuring greater fusion strength between the profile wire and support rod maintaining accurate slot opening tolerance. The wire and rods shall be of the identical material. The material shall be of SS 304 stainless steel conforming to the requirements of AISI.

The well screen shall have adequate strength to resist the external forces to which it will be subjected during and after installation. Screen openings shall be V-shaped, widening inwardly to avoid clogging during the development of the well.

The well screen shall be of heavy construction strength to set in the 200m depth. The screen shall be pipe size. Overall length shall be 3 m, end fitting shall be weld/rings, inside diameter of screen shall be 205mm, outside dia. 219 mm, slot opening aperture shall be 1.3mm to 1.5mm continuous slots SS 304 stainless steel material, the percentage of slot opening shall be minimum 25 percent, wrap wire size 2.3mm x 3.5mm, supports rod size 3.8mm/42nos.

There must be a minimum length of 2 m to 6 m of 200 mm dia. casing pipe below the lowest screen pipe as a sand trap and this must be fitted with welded on conical steel plug with a solid point.

All pipes and screens shall be of the best quality and the contractor shall submit full detail concerning the specifications and sources of supply of these for approval before bringing the materials on site,

All housing and casing pipes shall be thoroughly cleaned or descaled before assembly lowering and shall be painted internally and externally with one priming coat and one top coat of an approved nontoxic corrosion inhibiting paint.

All welds shall be allowed to cool before applying the necessary paint to the joints. The paint must dry before lowering the well assembly down the bore hole.

#### **(4) Tube-well Construction**

##### **(a) GENERAL**

The Contractor shall drill and install the required numbers of tube-well at the site defined by the Engineer. The drilling point will be assigned by the Engineer. The Contractor shall be familiar with the environment of the working place and make the necessary arrangements to complete the work in time.

The Contractor shall make his own camping arrangement and find necessary access to the site and drilling site. After completion of work, the area shall be cleared by the contractor of all unnecessary materials used during construction period.

The Contractor shall necessarily mobilize suitable drilling rig and accessory machineries and equipment to ensure timely completion of the said work.

The tubewell shall be drilled to the depth specified by the Engineer and shall be electrically logged, cased, screened, gravel packed, sealed, developed, tested and completed as production well.

##### **(b) Drilling**

Drilling can be done by any of the following methods:

- Direct rotary drilling method

- Reverse rotary drilling method, and
- Percussion drilling method

It is up to the Contractor to choose the suitable drilling method to drilled in the formation of the area according to their machineries and equipment bearing in mind that the works mentioned in this contract shall be completed within the stipulated time.

At first pilot hole drilling shall be carried out up to the required depth using an appropriate size drill bit.

The record of the strata encountered during the course of pilot hole drilling shall necessarily be maintained by the Contractor. The lithologic samples each of 0.5kg at an interval of 1.5m or at the change of strata shall be collected in plastic bags. These samples should be submitted to the Engineer at the earliest possible along with lithologic log records.

After completion of drilling the pilot bore hole, the contractor, in presence of the Engineer shall carry out down the hole electrical logging (resistivity & self-potential) for the verification of visual lithologic samples. Based on the lithologic samples and electrical logging data and interpretation results, the contractor shall submit the proposed well assembly (well design). Approval of this proposed design from the Engineer, must be received in written by the contractor before installation of the tubewell.

The pilot bore hole shall be enlarged (reamed) by using the appropriate diameter drill bits up to the designed depth approved by the Engineer.

The final bore hole shall be reconditioned so that all the drill cuttings shall be removed completely from the bore hole.

Verticality of the bore hole must be checked after the drilling of pilot hole and then while lowering the approved well assembly using centralizers at a maximum of 12 m spacing. The number of centralizers in each set should be three. In no case the axis of the well assembly should deviate more than 30 mm from an imaginary plumb line.

A successful tubewell should be able to yield in the range of discharge of 20-30 liters/sec to be accepted by the Engineer.

#### **(c) Tubewell Assembly**

Immediately after drilling and reaming the bore hole to the specified diameter and depth, the contractor shall make necessary arrangement for lowering the well assembly in accordance with the design approved by the Engineer.

The Contractor shall provide all necessary materials required for the complete well assembly including housing pipe, casing pipe, well screen, collar, plug, centralizes etc. All the materials of well assembly shall be as specified and as per the prevalent practice, if not specified. Well assembly shall be approved by the Engineer before installation.

The well assembly shall be installed in the bore hole in the presence of the Engineer. After installation a verticality test shall be carried out and the permissible limit shall be 1 cm. in 40m.

**(d) Gravel Packing**

The gravel pack material to be used in gravel packing, shall be composed of hard, non-calcareous, durable, well rounded particles containing no clays, silt, organic or any foreign materials. The size of gravel shall be in between 3 to 8 mm in diameter.

Immediately after lowering the well assembly into final position, the contractor shall fill the annular space between the well assembly and the wall of the bore hole with pea gravel approved by the Engineer using the continuous backwashing method to prevent bridging and reduce the possibility of damage to the tubewell assembly by sudden collapse of bridged gravel.

The gravel packing process should be continuous until the entire annular space is filled with the gravel, and then clean water should be pumped in through the casing to remove drilling mud.

Tubewell sounding must be carried out to ensure well clearance upto bottom and also the verticality of well assembly.

**(e) Well Development**

After the well assembly installation and gravel packing, the well shall be developed by the contractor using the combination of the following four methods. Well development shall be carried out for a minimum of 72hrs or as directed by the Engineer using suitable equipment of sufficient capacity.

- Backwashing (inner and outer washing)
- Hydraulic Jetting (water jetting)
- Air lift pumping (air compressor development)
- Over pumping by submersible pump

The completion of the well development shall be certified by the Engineer only when the water becomes clear and contains less than 5 (five) PPM of silt or sand particles.

**(f) Pumping Test**

Following the satisfactory completion of well development, the contractor shall carry out the drawdown and recovery tests by using a suitable pump of not less than 6" diameter bowl assembly. The pumping test should be carried out for a minimum of 72 hrs. or as directed by the Engineer.

The Contractor shall perform (a) Step drawdown test, (b) Constant drawdown test and (c) Recovery test.

- ✓ The Contractor shall perform the Step drawdown test by pumping water at four different constant discharge rates of approximately 30%, 60%, 90% and



120% of the anticipated yield of well after development at the instruction of the Engineer. For each step, the contractor shall carefully and accurately record simultaneous readings of water level, time since commencement of pumping and discharge (flow) at the intervals of 10 minutes for the period of 4 hours for each step.

- ✓ The Contractor shall perform the Constant drawdown test by pumping water at a constant discharge rate of the tubewell as guided by step drawdown test. The constant pump discharges shall be measured and recorded by the contractor using a standard v notch weir or discharge meter at the interval of 1/2, 1, 1 1/2, 2, 3, 4, 5, 7, 9, 10, 15, 20, 25, 30, 35, 45, 60, 90, and 120 minutes till the water level stabilizes itself.
- ✓ On completion of test, the Contractor shall cease pumping and accurately record the simultaneous readings of water levels in the well and the time since cessation of pumping, at the same time intervals of the pumping test, until the static water level has attained its pre-pumping level.

All test results with interpretation and graph plotted shall be handed over to the Engineer and the whole pumping test should necessarily be conducted in presence and close coordination with Engineer.

#### **(g) Well Disinfection**

After completion of all tests the well shall be thoroughly disinfected by means of placing a hypochlorite solution in the well. The Contractor must submit full details of his proposals for disinfection for approval by the Engineer before carrying out well disinfection. Disinfection shall be carried out by circulation of heavily chlorinated water within the well.

#### **(h) Standards**

- IS 4270.....Specification for steel tubes used for water wells
- IS 2800.....Code of practice for tube well construction
- IS 4097.....Specification for gravel for use as pack in tube wells

### **8009 GROUND WATER/SURFACE WATER TREATMENT PLANT**

#### **(1) Aeration Tower**

Aeration tower vessel shall be fabricated out of mild steel (MS) plate as per Indian Standard (IS)-226. The side shell and head shall be fabricated out of 10 mm thick plate. The tower shall have standard dished ends at both ends. Each tower shall be tested under hydraulic pressure 50% in excess of the designed working pressure. The tower shall be equipped with all necessary flanges and connections required for internal and external piping. The manhole shall have an exterior bolt on cover with easily removable gaskets.

Aeration tower shall be packed with packing material specified in the design with



particular specification. The air blower/compressor shall be able to supply air with air/water ratio given in the design. It shall be able to supply sufficient quantity as specified at a pressure sufficient to flow air in the upward direction. The air blower/compressor shall confirm ISI or equivalent.

## (2) Pressure Filter

Pressure filter vessel shall be fabricated out of mild steel (MS) plate as per Indian Standard (IS)-226. Filter shall be tested under hydraulic pressure 50% in excess of the designed working pressure. The filter shall be equipped with all necessary flanges and connections required for internal and external piping. The manhole shall be big enough to allow human access for manual inspection and shall have an exterior bolt on cover with easily removable gaskets.

All the pipes including inlet and outlet shall be of specified diameter. All connections to the filter vessels shall be of heavy steel and shall be drilled and bolted in position. Filter exterior pipes shall be joined with flanges. Filter exterior shall be provided with all necessary pipes, valves and fittings to make complete unit. The filter shall be provided with air release valve and pressure gauge. Gauge shall be mounted for easy reading. All the interconnecting pipe fittings and valves shall be best quality and confirm ISI or equivalent. Filter shall have required provisions for back washing at specified rate and adequate space for specified bed expansion during backwash.

### (a) Filter Media

#### ♦ Filter Sand:

Sand should be hard and resistant quartz or quartzite and free from clay, fine particles, soft grains and dirt. Ignition loss should not exceed 0.7% by weight. The specific gravity should be in the range of 2.55 to 2.65. Its silica content should be 90% or higher. Acid loss in hydrochloric acid should not exceed 5% by weight in 24 hours. Wearing loss should not exceed 3%. Effective size (d<sub>10</sub>) shall be between 0.45-0.70 mm. The uniformity coefficient (d<sub>60</sub>/d<sub>10</sub>) should be between 1.3 and 1.7.

#### ♦ Filter Gravel:

Filter gravel shall consist of hard, preferably rounded stones with an average specific gravity of not less than 2.5 and shall be free from clay, sand, loam and organic impurities of any kind. The gravel shall contain no more than 2 percent by mass of thin, flat or elongated pieces (in which the largest dimension exceeds three times the smallest dimension) determined by hand picking. Gravel should be free from excessive amount of limestone or shells and acid solubility test should not exceed the following limits:

- For gravel sizes 10 mm or larger ..... 10% solubility
- For sizes smaller than 10 mm ..... 5% solubility

## (3) Slow Sand Filter Media

### (a) Filter Sand

It should be hard, rounded grains and free from clay, fine particles, soft grains and dirt. Any sample of filter sand shall not contain more than 5 percent by volume of impurities, such as clay, loam, silt, etc., in one hour settlement after shaking a 1000ml calibrated measuring cylinder half filled with filter sand to be tested and add filled with water until up to three-fourths of the cylinder. Ignition loss should not exceed 0.7% by weight. The specific gravity should be in the range of 2.55 to 2.65. Its silica content should be 90% or higher. Acid loss in hydrochloric acid should not exceed 5% by weight in 24 hours. Wearing loss should not exceed 3%. Effective size ( $d_{10}$ ) shall be between 0.15-0.35 mm. The uniformity coefficient ( $d_{60}/d_{10}$ ) should be preferably between 2 to 3.5 and shall not exceed 5.

**(b) Filter Gravel**

Filter gravel shall consist of hard, preferably rounded stones with an average specific gravity of not less than 2.5 and shall be free from clay, sand, loam and organic impurities of any kind. The gravel shall contain no more than 2 percent by mass of thin, flat or elongated pieces (in which the largest dimension exceeds three times the smallest dimension) determined by hand picking. Gravel should be free from excessive amount of limestone or shells and acid solubility test should not exceed the following limits:

- ♦ For gravel sizes 10 mm or larger .....10% solubility
- ♦ For sizes smaller than 10 mm .....5% solubility

**8010 MISCELLANEOUS WORKS**

**(1) Gabion Works**

These works shall be made, measured and paid in accordance with the specifications of Section VI(B) and Section VI(C), Sun-Clause 2401: “Gabions”.

**(2) Supply of Tools and Equipment**

**(a) Scope**

This clause requires supply of tools and equipment as mentioned in the BOQ and as further required by the Project. The Tools and Equipment shall be provisioned under contingency item and shall be supplied as per the instruction of the Engineer.

**(b) Details of Supply Conditions**

The lists of tools and equipment to be supplied have been enlisted in the BOQ. However, actual requirement can be changed as decided by the Project and instructed through the Engineer. Basic rate of the Contractor shall be equally applicable for the increased or decreased quantity.

Quality of the tools and equipment shall be as mentioned in the BOQ. Where not mentioned, the quality shall be those having IS or NS mark or as instructed by the Engineer. Before procurement and delivery of tools and equipment, the Contractor shall reconfirm the stipulated quantity and shall get approval of the brand/quality with

the Engineer. The Engineer shall have the right to disapprove the inferior quality tools and order for their replacement if required.

**(3) Road Works**

These works shall be made, measured and paid in accordance with the relevant specifications of Section VI(B) and Section VI(C).

**8011. MEASUREMENT AND PAYMENT**

**(1) Measurement**

The works for the Water Supply described in these specifications shall be measured in lump sum but summarized in the Sub-Sections described in the BOQ as shown below, prorating the actually provided and installed items against the total of each Sub-Section:

**I. Civil Works**

A. Well development

B. Platform, RVT, Valve Chamber, Guard and Pump House

**II. Pipe and Fittings Supply Including Installation of Fittings and Valve**

A. Pipes (Supply)

B. Fittings and Valves Supply and Installation

**III. Electromechanical Works**

**IV. Miscellaneous Works**

The following items shown in the BOQ shall not be measured nor paid separately but shall be deemed included in the main items for the BOQ of Water Supply works:

- List 1: (Lab apparatus and consumables)
- Glassware
- Chemicals and Reagents

The items to be counted shall be only those duly installed, tested in accordance with the requirements of this Specifications, and approved by the Engineer.

For final measurement, each Sub-Item shall be measured counting only the items that have been satisfactorily tested according to the Quality Control and Commissioning herein described, and in accordance with Section VI(C), Sub-Clause 509(3): “Testing and Commissioning” and conforming the requirements of Clause 9: “Test on Completion” of the General Conditions of Contract, and after confirmation of proper function of the established system, satisfying all requirements of these Specifications, in accordance with the Drawings, and approved by Engineer.

**(2) Payment**

The works for the Water Supply, measured as described above, shall be paid under this Section in lump sum which shall be the full and the final compensation to the Contractor as per Section VI(B) and Section VI(C) Clause 112 including the cost provision of all materials, equipment, all operations required for construction as shown in the Drawings and described in this Item including drawings, tests, testing for commissioning, civil works and all other ancillary works and any incidental work needed to complete the work as per these Specifications and/or directed by the Engineer.

**BILL OF QUANTITIES  
FOR WATER SUPPLY WORKS**



## **Bill of Quantities for Water Supply Works**

### **A. Preamble**

The Preamble of the Bill of Quantities of Part 1: Bidding Procedures, Section IV: Bidding Forms shall apply, prevail and govern also the Bill of Quantities for Water Supply here below described.

The cost of Items against which the Contractor has failed to enter a rate or price shall be deemed to be covered by other rates and prices entered in the Bill of Quantities for Water Supply Works or the main BOQ of Section IV of the Bidding Documents.

The whole cost of complying with the provisions of the Contract shall be included in the Items provided in the priced Bill of Quantities for Water Supply Works, and where no Items are provided, the cost shall be deemed to be distributed among the rates and prices entered for the related Items of Work.

In case a discrepancy between the total amount stated in the BOQ for Water Supply Works herein detailed, and the total amount stated in the main BOQ of Section IV Item 8000, the lower amount shall be applied and corrections shall not be allowed.

### Bill of Quantities for Water Supply Works

SN	Particular of Items	Quantity	Units	Rate NRs	Amount NRs
<b>I. CIVIL WORKS</b>					
<b>A. Well development</b>					
1	Mobilization and Demobilization	1	job		
2	Camp and Rig Setting and Preparation of site for work	1	job		
3	Vertical Electrical Sounding work	1	job		
4	Guide Pipe Works (550mm dia)	10	m		
5	Drilling of pilot hole by std bit ranging from 7 <sup>5</sup> / <sub>8</sub> " to 9 <sup>7</sup> / <sub>8</sub> " dia.	180	m		
6	Electrical Resistivity Logging Test Work	1	job		
7	Complete drilling for total Reaming work (at least two) by std bit above 9 <sup>7</sup> / <sub>8</sub> " and below 17 <sup>1</sup> / <sub>2</sub> " with drilling rig machine	180	m		
8	Reconditioning of bore hole before lowering of pipe assembly 8-10" dia	180	m		
9	Lowering of pipe assembly of 8-10" dia to a depth of 180m	180	m		
10	Collection of lithological samples (at interval of 1.5m and at the change of strata)	1	well		
11	Supply and place approved size pea gravel (4-8mm) packing in a continuous operation	34	m <sup>3</sup>		
12	Cementation for sanitary protection and well support work	4	m <sup>3</sup>		
13	Supply and install gravel top up 80mm dia GI pipe (M) and seal bore hole with cement	5	m		
14	Supply and Installation of Pipes and accessories:				
	250mm ND mild steel ERW housing pipe of thickness 7mm having male and female ends	70	m		
	200mm ND mild steel ERW housing pipe of thickness 7mm having male and female ends	80	m		
	200mm ND Stainless steel slotted pipe of thickness heavy duty with slots 1.6mmx75mm and percentage opening minimum 50% having male and female ends	30	m		
	Supply of 250mmx200mm dia MS reducer	1	Nos		
	Supply and Installation of well caps, cross bars, centralizers, bottom plug and other necessary accessories required for complete execution of borehole	1	job		
15	Well development by drilling rig machine for well size of 10" dia (Back washing and inner washing)	180	m		
16	Well development by drilling rig machine for well size of 10" dia (water jetting)	180	m		
17	Well development by compressor machine for well size of 10" dia	1	well		
18	Well development by pump 10" dia	1	well		
19	Time draw down pump test for seep tubewell	1	well		
20	Step draw down pump test for deep tubewell (well test)	1	well		
21	Recovery test for Deep tubewell	1	well		
22	Conducting water quality test and disinfection work	1	well		
23	Preparation of report and submission (3 copies)	1	job		



SN	Particular of Items	Quantity	Units	Rate NRs	Amount NRs
B. Platform, RVT, Valve Chamber, Guard and Pump House					
1	PIPE GI-150 (M)	1	m		
2	PIPE GI-100 (M)	10	m		
3	Layout & setting out including site clearance of grass, shrubs, excavation of loose/soft soil to maximum depth of 150mm including dressing, levelling and disposal the excavated materials within the premises as per drawing, specification and instruction of engineer.	2,183	sqm		
4	Earthwork in excavation of all type of soil in foundation trenches of semi basement pits raft etc depth up to 3.5m including dressing of sides, ramming of bottom, trenches, shoring and disposing the excavated material up to 10m lead as per drawing and specification all complete.	1,263	cum		
5	Supplying & placing of Fe 415/500 reinforcement bar for column beams, slab, etc. placed in position and binding with 14 gauge binding wire including cutting, binding, carrying, lifting, etc. all complete as per drawing, specification and instruction of engineer.	29	mt		
6	Fabrication and installation of shutter with 24 gauge G.I. mosquito net in 38 x 75 mm Salwood frame (based on shutter size 1.092 x 2.058 = 2.25sqm)	4	sqm		
7	Fabrication and installation of Salwood frame for door and windows	0.15	cum		
8	Fabrication and installation of panel shutter in 38 x 75 mm salwood frame (based on shutter size 1.07 x 1.982 = 2.12 sqm)	1	sqm		
9	Providing & Laying dry stone soling in foundation trenches with bond stone blinding in perfect line & level all complete as per drawing & specification.	59	cum		
10	12.5 mm thick cement sand plastering works in 1:3 ration in walls and floor	2,118	sqm		
11	Random rubble (hammer dressed) stone masonry work with 1:4 cement sand mortar including the cost of scaffolding, curing, cleaning and racking the joints all complete as per drawing, specification & instruction.	15	cum		
12	Supplying mixing, placing, compacting plane/reinforced cement concrete of M10(1:3:6) excluding the cost of reinforcement bars & formwork as per drawing, specification and instruction of engineer all complete.	51	cum		
13	Supplying, mixing, placing, compacting reinforced cement concrete of 1:1.5:3 (M20 grade, 1 Cement :1.5 Sand: 3 Aggregate 20 mm and down well graded) excluding the cost of reinforcement bars & formwork as per drawing, specification and instruction all complete.	85	cum		

SN	Particular of Items	Quantity	Units	Rate NRs	Amount NRs
14	Supplying, mixing, placing, compacting reinforced cement concrete with waterproof chemical of 1:1:2 (M25 grade, 1 Cement :1 Sand : 2 Aggregate 20 mm and down well graded) excluding the cost of reinforcement bars & formwork as per drawing, specification and instruction all complete.	150	cum		
15	Providing, placing, fixing centering and shuttering for plywood or steel formwork for slabs, walls, columns and beams (with necessary provision of extension of reinforcement for ties) and other RCC works including nails, propping supports and bracings of steel pipes including lead & lift upto 0 to 4 m height & removal and disposal of the same all complete as per drawing specification & approval of engineer.	1,530	sqm		
16	CI Manhole	45	No.		
17	Fabrication of Angle post (MS 50x50x4 2.3m high)	137	No.		
18	Fabrication of MS Grill gate 1.2mx 1.5m	3	set		
19	Barbed Wire Fencing	429	kg		
20	Sand filling with compaction and sprinkling of water	8	cum		
21	Supply and fitting Casement door of aluminum section in naturally anodized color. Section size (100x38x1.30) mm and 5 mm glass.	9	sqm		
22	Supplying and fitting Casement double panel aluminum windows with Ventilation section of (88x78x1.1) mm with sash 38x34x1.1mm and 5mm glass.	9	sqm		
23	Provide and laying of Porcelain glazed tiles overlay in 1:4 cement sand mortar	12	sqm		
24	Providing, mixing and laying neat cement punning on floors in true line & level including curing all completed as per drawing, specification & instruction of engineer.	77	sqm		
25	Dry brick soling in foundation and floors with first class chimney made bricks in true line & level including watering and ramming all complete as per drawing, specification & instruction of engineer.	49	sqm		
26	Provide and lay 25 mm Kota stone flooring on 20mm thick 1:4 cement sand mortar	22	sqm		
27	Providing, mixing and laying 12.5mm thick plaster on wall with 1:4 cement sand mortar in perfect line and level including scaffolding, curing etc. all complete as per drawing, specification & instruction of engineer.	12	sqm		
28	Providing, mixing and laying 20mm thick plaster on wall with 1:4 cement sand mortar in perfect line and level including scaffolding, curing etc. all complete as per drawing, specification & instruction of engineer.	64	sqm		
29	Providing and application of two or more coats of distemper paint over base paint of approved brand and colour on exterior fair face wall surface to give even and uniform shade all complete as per drawing, specification and approval of engineer.	151	sqm		

SN	Particular of Items	Quantity	Units	Rate NRs	Amount NRs
30	Providing and application of two or more coats of cement paint over base paint of approved brand and colour on exterior fair face wall surface to give even and uniform shade all complete as per drawing, specification and approval of engineer.	124	sqm		
31	12.5mm dia. GI pipe supply and laying works (with pipe)	15	m		
32	20mm dia. GI pipe supply and laying works (with Pipe)	6	m		
33	Filling with ordinary soil stacked at site with 200 mm thick layers with well compaction, water sprinkling, etc. all complete in pipe trench as per drawing, specification and instruction of engineer.	34	cum		
34	Providing & laying First class chimney made brick masonry work in foundation and Ground Floor with 1:6 cement sand mortar (1 cement: 6 sand) including lead upto 30 m curing, cleaning & racking out mortar joint and making ducts, recesses where required as per drawing, specification and instruction of engineer.	98	cum		
35	Providing, placing, fixing centering and shuttering for plywood or steel formwork for slabs, walls, columns and beams (with necessary provision of extension of reinforcement for ties) and other RCC works including nails, propping supports and bracings of steel pipes including lead & lift upto 0 to 4 m height & removal and disposal of the same all complete as per drawing specification & approval of engineer.	150	sqm		
36	PVC Pipe 100mm Supply and installation all complete	3	Rm		
37	PVC Pipe 75mm Supply and installation all complete	18	Rm		
38	PVC Pipe 50mm Supply and installation all complete	5	Rm		
39	Stainless Steel Sink Supply and installation all complete	2	Nos.		
40	Fabrication of MS Grill for Windows Supply and installation all complete	322	Kg.		
41	20mm Gate Valve with fitting Supply and installation all complete	1	Nos.		
42	Chrome Plate (CP) 15mm taps Supply and installation all complete	2	Nos,		
43	Glazed Indian Type WC Set Supply and installation all complete	2	Nos.		
44	Inspection Chamber 450x450x450 with RCC Cover Supply and installation all complete	4	Nos.		

SN	Particular of Items	Quantity	Units	Rate NRs	Amount NRs
45	Supply, installation and commissioning of Main Distribution Board(MDB) wall mounting concealed type, dust and vermin proof made of 16 SWG mild steel sheet cubical with double cover covering the MCB with the locking arrangement as per drawing and specification. Main Distribution Board 1 no of 20 amp SP MCB Havells/ Siemens of equivalent 1set of 30 A amp bus bars 1 no of earth bus bar 2 nos. of 16 amp SP MCB (4.5 kA) Havells\Siemens or equivalent 4 nos. of 10 amp SP MCB (4.5 kA) Havells\Siemens or equivalent	1	No		
46	Supply and installation of light point wiring from DB to various points with 2 nos of 3/22 PVC insulated copper wire through 20 mm internal dia HDPE conduit concealed via junction box as per drawing and specification including the cost of switch and metal box	17	No		
47	Supply and installation of 3 pin (15 A) socket point wiring with 2 nos of 7/22 + 1 no of 1/18 pvc insulated copper wire through 20 mm internal dia HDPE conduit concealed from SDB to various points as per drawing and specification including the cost of Switch socket and metal boxes	7	No		
48	Supply and installation of 2 pin ( 5 A) socket point wiring with 2 nos of 3/20 pvc insulated copper wires through 20 mm internal dia HDPE conduit concealed from SDB to various points as per drawing and specification including the cost of Switch socket and metal boxes.	2	No		
49	Supply and installation of 9" sweep exhaust fan as per drawing and specification including GI sheet boxing.	2	No		
50	Supply and installation of 42" sweep ceiling fan as per drawing and specification including GI sheet boxing.	2	No		
51	Supply and installation of earth electrode made of 30cm x 30cm x 3mm copper plate including 8 SWG bare copper wire connection to DB's.	1	No		
52	Chieseling, laying conduits cables the main line distribution from MDB to Floor DB,s with 2 x 7/16 size cable in 20 mm HDPE conduit.	7	No		
53	Made of 25x38mm MS angle and 3x18mm MS Strip with metal polish all complete	1	no		
54	Made of 25x38mm MS angle and 3x18mm MS Strip with metal polish all complete	3	no		
55	Made of sisam wood of 25x38mm section, dunlop at seat and back rest with rexin cover, having hand rest, 3 coats chapra polish all complete	2	no		
56	MS cupboard made of 20 gauge MS Sheet for Clothes Store : Godrej or Equivalent	1	no		
57	Single Bed made of 50x75 salwood section	4	no		
58	Laboratory Equipment as per Attached List (List 1)	1	Lot		

SN	Particular of Items	Quantity	Units	Rate NRs	Amount NRs
59	Supply and installation of light point wiring from DB to various points with 2 nos of 3/22 PVC insulated copper wire through 20 mm internal dia HDPE conduit concealed via junction box as per drawing and specification including the cost of switch and metal box	2	pts.		
60	Supply and installation of 3 pin (15 A) socket point wiring with 2 nos of 7/22 + 1 no of 1/18 pvc insulated copper wires through 20 mm internal dia HDPE conduit concealed from SDB to various points as per drawing and specification including the cost of Switch socket and metal boxes	2	pts		
61	E/W excavation in hard clay	10	cum		
62	Brick soling on flat with sand	25	sqm		
63	Lab equipment and consumable as per List (List 1)	1	job		
64	Pipe Line Excavation and Refilling (0.6m*0.9m Trench)	7,711			
65	HDPE Pipe laying and Jointing	12,680			
66	GI Pipe laying and Jointing	1,600			
67	Blacktopped dismantle and reinstatement work	1,000	sqm		
<b>II. PIPE AND FITTINGS SUPPLY INCLUDING INSTALLATION OF FITTINGS AND VALVE</b>					
<b>A. Pipes (Supply)</b>					
	PIPE GI-75 (M)	1,600	m		
	PIPE HDPE-50/10	5,399	m		
	PIPE HDPE-63/10	2,420	m		
	PIPE HDPE-75/10	972	m		
	PIPE HDPE-90/6	199	m		
	PIPE HDPE-110/6	237	m		
	PIPE HDPE-110/10	1,170	m		
	PIPE HDPE-125/10	1,276	m		
	PIPE HDPE-140/6	448	m		
	PIPE HDPE-140/10	246	m		
	PIPE HDPE-160/6	313	m		
<b>B. Fittings and Valves Supply and Installation</b>					
1	Pipe/Fittings and Valve for tubewell for 100mm riser pipe as per drawing all complete (except the Pipe)	1	Set		
2	Bulk meter (100mm dia)	3	No		
3	Bulk meter (200mm dia)	1	No		
4	Bulk meter (75mm dia)	2	No		
5	DI Double Flange Tail Piece (100mm Dia)	2	No		
6	DI Double Flange Tail Piece (150mm Dia)	1	No		
7	DI Double Flange Tail Piece (75mm Dia)	7	No		
8	DI Double Flanged Bend (100mm dia)	7	No		
9	DI Double Flanged Bend (150mm dia)	2	No		
10	DI Double Flanged Bend (200mm dia)	1	No		
11	DI Flange Tail Piece (100mm Dia)	8	No		
12	DI Flange Tail Piece (150mm Dia)	2	No		
13	DI Flange Tail Piece (200mm Dia)	5	No		
14	DI Flange Tail Piece (300mm Dia)	2	No		
15	DI Flange Tail Piece (75mm Dia)	12	No		

SN	Particular of Items	Quantity	Units	Rate NRs	Amount NRs
16	DI Flanged Tee (150mm dia)	1	No		
17	DI Flanged Tee (75mm dia)	2	No		
18	DI Mechanical Coupling (100mm Dia)	6	No		
19	DI Mechanical Coupling (150mm Dia)	4	No		
20	DI Mechanical Coupling (200mm Dia)	4	No		
21	DI Mechanical Coupling (75mm Dia)	13	No		
22	DI reducer (200/75mm)	1	No		
23	DI Sluice Valve (100mm Dia)	4	No		
24	DI Sluice Valve (150mm Dia)	1	No		
25	DI Sluice Valve (200mm Dia)	1	No		
26	DI Unequale Tee (200/100mm)	1	No		
27	DI Unequale Tee (200/75mm)	1	No		
28	Gate Valve (75mm)	6	No		
29	DI/HDPE Mechanical Coupling (100mm)	1	No		
30	DI/HDPE Mechanical Coupling (75mm)	5	No		
31	DI Double Flange Bend 90degree (75mm)	6	No		
32	DI Reducer (100/75mm)	2	No		
33	GI Equal Tee (40mm dia)	5.00	No		
34	GI Equal Tee (50mm dia)	2.00	No		
35	GI Equal Tee (75mm dia)	2.00	No		
36	HDPE/GI Flange (110/100mm dia)	6.00	No		
37	HDPE/GI Flange (125/110mm dia)	6.00	No		
38	HDPE/GI Flange (140/125mm dia)	5.00	No		
39	HDPE/GI Flange (50/40mm dia)	47.00	No		
40	HDPE/GI Flange (63/50mm dia)	3.00	No		
41	HDPE/GI Flange (75/63mm dia)	8.00	No		
42	HDPE/GI Flange (90/75mm dia)	3.00	No		
43	100mm Long GI Nipple (100mm dia)	18.00	No		
44	100mm Long GI Nipple (125mm dia)	8.00	No		
45	100mm Long GI Nipple (40mm dia)	81.00	No		
46	100mm Long GI Nipple (50mm dia)	6.00	No		
47	100mm Long GI Nipple (65mm dia)	12.00	No		
48	100mm Long GI Nipple (80mm dia)	5.00	No		
49	HDPE reducer (110mm to down size)	1.00	No		
50	HDPE reducer (110mm to down size)	1.00	No		
51	HDPE reducer (125mm to down size)	2.00	No		
52	HDPE reducer (125mm to down size)	1.00	No		
53	HDPE reducer (140mm to down size)	3.00	No		
54	HDPE reducer (160mm to down size)	2.00	No		
55	HDPE reducer (63mm to down size)	1.00	No		
56	HDPE reducer (75mm to down size)	3.00	No		
57	GI Unequal Tee (100x100x40mm)	5.00	No		
58	GI Unequal Tee (100x100x50mm)	1.00	No		
59	Equal Tee (125mm)	1.00	No		
60	GI Unequal Tee (125x125x75mm)	1.00	No		
61	GI Equal Tee (40mm)	8.00	No		
62	GI Unequal Tee (65x65x40mm)	2.00	No		
63	GI Unequal Tee (65x65x50mm)	2.00	No		



SN	Particular of Items	Quantity	Units	Rate NRs	Amount NRs
64	GI Unequal Tee (75x75x40mm)	1.00	No		
65	Bronze Valve (100mm)	6.00	No		
66	Bronze Valve (125mm)	3.00	No		
67	Bronze Valve (40mm)	34.00	No		
68	Bronze Valve (50mm)	3.00	No		
69	Bronze Valve (63mm)	4.00	No		
70	Bronze Valve (75mm)	2.00	No		
<b>III. ELECTROMECHANICAL WORKS</b>					
1	Submersible pump (including 1 spare pump) complete with riser pipe, control panel, electrical work required for the operation of the system; (Conforming ISO 9001) for 11 lps discharge and 175m total pumping head including 30m for the operation of Pressure Filter	1	Job		
2	Centrifugal pump (including 1 spare pump) complete with control panel, electrical work and accessories required for the operation of the system; (Conforming ISO 9001) for 5 lps discharge 55m total pumping head	1	Job		
3	Centrifugal pump (including 1 spare pump) complete with control panel, electrical work and accessories required for the operation of the system; (Conforming ISO 9001) for 3 lps discharge 125m total pumping head	1	Job		
4	Supply, Installation and commissioning of Pole mounted 100 KVA Transformer, protection system and all accessories (Poles, Bracket etc.) including Line to Control Panels and Distribution Boards with following materials in coordination with the Nepal Electricity Authority with complete required accessories	1	Job		
5	Spare parts, for above pump sets to be detailed by the manufacturer	3	sets		
6	Supply, Installation and Commissioning of 100 KVA, 50Hz. Stand by diesel generator including reserve diesel tank of 1000 liter, MS steel platform for diesel tank erection, fire extinguisher (ABC powder type), all wiring necessary for running the pump	1	sets		
7	Water Treatment System	1	PS		
IV. Miscellaneous Works		1	PS		

	<b>LIST 1: (LAB APPARATUS AND CONSUMABLES)</b>	No
L-1	Thermometer	3
L-2	Reversing thermometer	1
L-3	Centrifuge	1
L-4	Tintometer	1
L-5	Underwater Photometer	1
L-6	Nephelometer (Turbidimeter)	1
L-7	Colorimeter	1
L-8	Reflux flask	1
L-9	Condenser (For measure of COD)	1
L-10	Conductivitimeter	1
L-11	pH meter with probes (Griffin pH meter)	1

	<b>LIST 1: (LAB APPARATUS AND CONSUMABLES)</b>	No
L-12	DO meter with probes and Electrical Stirrers	1
L-13	Karl-Fischer Titrator	1
L-14	Jar Test Apparatus with Jar beakers (Min 6 nos.)	1
L-15	Colony Counter	1
L-16	Dry Hot Air Oven or Vacuum Oven	1
L-17	Desiccator	1
L-18	Chemical Weighing Balance	1
L-19	Hot water bath	1
L-20	Standard color charts	3
L-21	Colored glass discs	2
L-22	Bunsen Burner	2
L-23	Tripod (Burner) Stand	2
	<b>GLASSWARE</b>	
G-1	Nessler's tubes (Diff capacities)	LS
G-2	Sample Glass Tubes (Diff. Capacities)	LS
G-3	Beakers (Diff. Capacities)	LS
G-4	Bottles (Diff. Capacities)	LS
G-5	Glass rods (Diff. Capacities)	LS
G-6	Conical Flasks (Diff. Capacities)	LS
G-7	Volumetric Flasks (Diff. Capacities)	LS
G-8	Funnels	3
G-9	Pipettes (Diff. Capacities)	LS
G-10	Stands	3
G-11	Filter Papers (Watman)	LS
G-12	Membrane filter circle (paper)	LS
G-13	Filter paper holders	3
G-14	Evaporating Dish	3
G-15	Titrimeter (narrow neck calibrated tube well fitted with glass stopper) for Winkler Titration	2
	<b>CHEMICALS AND REAGENTS</b>	
C-1	Distilled Water	
C-2	Deionized water	
C-3	Litmus papers	
C-4	EDTA Solutions	
C-5	EBT indicators	
C-6	Starch Indicators	
C-7	Buffer solutions	
C-8	Various Chemical reagents	