

## **DIVISION 7 CONCRETE AND BRIDGE WORKS**

### **TABLE OF CONTENTS**

SPECIFICATION SECTION 07100 - CONCRETE AND CONCRETE STRUCTURES

SPECIFICATION SECTION 07250 - BORINGS FOR PILE BEARING CAPACITY

SPECIFICATION SECTION 07300 - BORED PILE

SPECIFICATION SECTION 07400 - PRESTRESSED CONCRETE

SPECIFICATION SECTION 07500 - REINFORCING STEEL

SPECIFICATION SECTION 07600 - BRIDGE BEARINGS

SPECIFICATION SECTION 07700 - WATERPROOFING

SPECIFICATION SECTION 07800 - EXPANSION JOINT

SPECIFICATION SECTION 07950 - CAST INSITU BOX CULVERT



## **SPECIFICATION SECTION 07100 – CONCRETE AND CONCRETE STRUCTURES**

### **TABLE OF CONTENTS**

1. DESCRIPTION.....	5
2. REFERENCE STANDARDS .....	5
3. CONSTRUCTION REQUIREMENTS .....	7
3.1 Method Statement.....	7
3.2 Materials for Concrete .....	7
3.2.1 General.....	7
3.2.2 Cement .....	8
3.2.3 Water for Concrete Mixing and Curing .....	9
3.2.4 Aggregates .....	9
3.2.5 Admixtures.....	12
3.3 Concrete Classes .....	12
3.3.1 Approved Mix Design .....	14
3.3.2 Water - Cement Ratio .....	14
3.3.3 Adjustments during Progress of Work.....	14
3.3.4 Submittals .....	15
3.4 Formwork and Falsework .....	16
3.4.1 Design .....	16
3.4.2 Construction of Formwork.....	17
3.4.3 Removal of falsework and formwork .....	19
3.5 Concreting.....	20
3.5.1 General.....	20
3.5.2 Batching .....	21
3.5.3 Mixing and Delivery.....	22
3.5.4 Concrete Consistency .....	24
3.5.5 Pumping .....	24
3.5.6 Placing and Compacting .....	24
3.5.7 Placing of Concrete in or Under Water.....	26
3.5.8 Weather Precautions .....	26
3.5.9 Continuity of Concrete Work .....	27
3.6 Joints .....	27
3.6.1 General .....	27

3.6.2	Construction Joints .....	27
3.6.3	Bonded Construction Joints .....	28
3.6.4	Joint between the Deck Slab and the Coping.....	29
3.7	Concrete Finishing .....	29
3.7.1	Finishing Concrete Surfaces .....	29
3.7.2	Remedial Treatment of Finished Surfaces .....	30
3.7.3	Fixing of Ironwork .....	30
3.7.4	Reconstruction of Faulty Work .....	30
3.8	Curing .....	30
3.8.1	Methods Using Water .....	31
3.8.2	Preventing Moisture Loss .....	31
3.8.3	Waterproof Paper.....	31
3.8.4	Plastic Sheets.....	31
3.8.5	Curing Compounds.....	31
3.9	Precast Concrete.....	32
3.9.1	Materials .....	32
3.9.2	Fabrication .....	32
3.10	Quality Control of Concrete.....	33
3.10.1	General .....	33
3.10.2	Technicians at Mixing Plant .....	33
3.10.3	Sampling of Mixed Concrete.....	34
3.10.4	Compressive Strength Testing .....	35
3.11	Testing frequencies.....	37
	TCVN 4453-95: Monolithic Concrete and Reinforced Concrete Structures – Codes for Construction, Check and Acceptance.....	37
3.12	Acceptances Test and Tolerances .....	37
3.12.1	Strengths .....	37
3.12.2	Dimensions .....	38
4.	MEASUREMENT AND PAYMENT .....	38
4.1	Method of Measurement.....	38
4.2	Basis of Payment .....	38

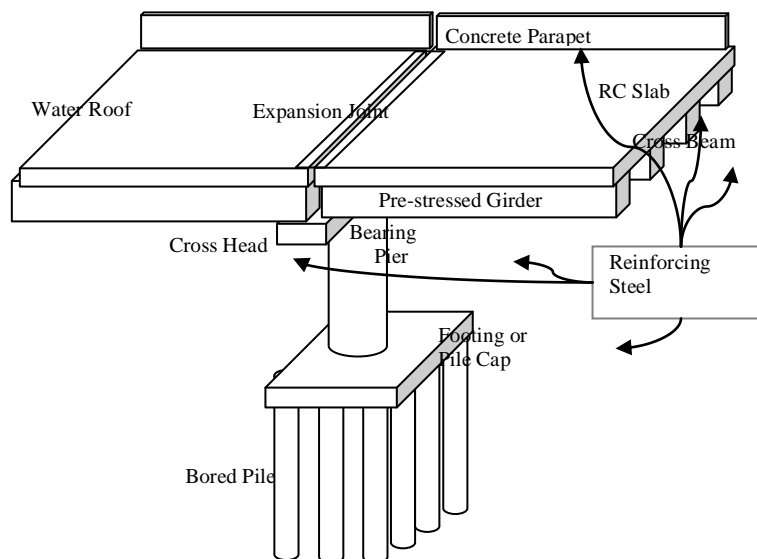
## SPECIFICATION SECTION 07100 - CONCRETE AND CONCRETE STRUCTURES

### 1. DESCRIPTION

This Specification Section prescribes the supply, transport and placing of concrete mixes of different classes and concrete construction work in accordance with the lines, grades, sections and other detail shown on the Drawings or subject to approval by the Engineer.

Figure 1 shows the applicable referencing of structural sections:

Figure 1 for Payment Item



### 2. REFERENCE STANDARDS

The most recent edition of the following Standards shall be applied to the Works covered by this Specification.

Vietnamese Standard:

TCVN 5438-04	Cements - Standard Specification for Terminology and Definitions
TCVN 5439-04	Cements - Standard Specification for Classification
TCVN 2682 - 2009	Standard Specification for Portland Cement
TCVN 6260 - 2009	Portland blended Cement – Specifications
TCVN 4029-85	Cements - Technical Requirement Procedure for Physical Contents

	Testing
TCVN 4030-03	Cement. Test Method for Determination of Fineness
TCVN 4031-85	Cements - Method for Determination of Standard Workability Setting Time and Volume Stability
TCVN 4032-85	Cements - Methods for Determination of Bending and Compressive Strength
TCVN 6016-95	Cements - Test methods - Determination of Strength
TCVN 6017-95	Cements - Test methods - Determination of Setting Time and Soundness
TCVN 7570:06	Aggregates for Concrete and Mortar – Specifications;
TCVN 7572:06	Aggregates for Concrete and Mortar – Test Methods;
TCVN 8826:2011	Chemical Admixtures for Concrete;
TCVN 4453:1995	Monolithic Concrete and Reinforced Concrete Structures – Codes for Construction, Check and Acceptance
TCVN 4506:2012	Water for mixing Concrete and Mortar – Technical specification
TCVN3105:1993	Heavyweight concrete compounds and heavyweight Concrete-Sampling, making and curing of test specimens
TCVN3106:1993	Heavyweight Concrete Compounds-Slump Test
TCVN 3118:1993	Heavyweight Concrete- Method for Determination of Compressive Strength
TCVN 9345:2012	Concrete and Reinforced Concrete structures-Guide on Technical Measures for Prevention of Cracks Occurred under the Action of Local Hot humid Climate
International Standard:	
AASHTO T22 ASTM C39	Compressive Strength of Cylindrical Concrete Specimens;
AASHTO T23 ASTM C31	Making and Curing Concrete Test Specimens in the Field;
AASHTO T96	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine;
AASHTO T119 ASTM C143	Slump of Portland Cement Concrete;

AASHTO T141	Sampling Freshly Mixed Concrete;
AASHTO T224	Correction for Coarse Particles in the Soil Compaction Test;
ASTM C94	Standard Specification for Ready-Mixed Concrete;
ASTM C109	Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens);
ASTM C827	Change in Height at Early Ages of Cylindrical Specimens of Cementations Mixtures;
ASTM C1017	Chemical Admixtures for Use in Producing Flowing Concrete;
ASTM C1077	Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation.

### 3. CONSTRUCTION REQUIREMENTS

#### 3.1 Method Statement

The Contractor shall submit, for the approval of the Engineer, a method statement detailing the requirements of this Specification Section and his proposal for the organization of concreting activities at the Site. The method statement shall include the following items:

- a) Proposed plant;
- b) Location and layout of concrete production facility including precast concrete facilities;
- c) Size and details of materials storage facilities;
- d) Source of water supply and origin of aggregates;
- e) Proposed method of organization of concrete production facility;
- f) Maximum hourly and daily production capacities and an estimate of maximum volume to be poured monthly;
- g) Transport and placing of concrete;
- h) Maximum pour size anticipated and specific proposals for large pours including methods for control of temperature differentials;
- i) Handling, placing, finishing and curing procedures;
- j) Quality control procedures for concrete and concrete materials;
- k) Staffing for control of production.

#### 3.2 Materials for Concrete

##### 3.2.1 General

- a) The Contractor shall submit samples of all materials to be used in concrete mixes together with test results confirming their compliance with this Specification Section for the approval of the Engineer.
- b) The Contractor shall use approved materials to prepare mix designs and for trial mixes to be approved by the Engineer.
- (c) No materials shall be delivered to the Site until materials, mix designs and trial mixes have been approved by the Engineer.

### 3.2.2 Cement

- a) Cement shall be Portland cement (type 1) or Portland blended cement (type 2) as classified in Vietnamese Standard TCVN5439:2004, complying in all respects with Vietnamese Standard TCVN 2682-2009 or TCVN 6260-2009. However the Contractor may submit to the Engineer for his approval fully supported proposals for the use of other types of cement whose tests comply with Vietnamese Standards: TCVN4029:1985, TCVN 4030:2003, TCVN4031:1985, TCVN4032:1985, TCVN6016:1995 and TCVN6017:1995. All cement shall be manufacturer's standard cement unless otherwise specified on the Drawings. Only one brand of cement shall be used for all concrete works throughout the Works unless otherwise authorized by the Engineer.
- b) Cement shall be delivered to the Site in sealed bags or in bulk. The Contractor proposed source of supply of cement shall be submitted to the Engineer for his approval. All deliveries of cement to Site shall include appropriate test certificates, certified by an independent agency in the country of origin, confirming that the material delivered complies with the specification.
- c) Bagged cement shall bear the manufacturer's name, cement type and the date of manufacture and shall be stored in waterproof sheds or other such temporary buildings used exclusively for the storage of cement. Cement shall be stored in dry conditions on areas raised above ground level. Storage capacity shall be sufficient to hold enough cement for the largest units to be cast. Bags shall not be stored more than 8 high and a free passage of at least one meter shall be left between the cement and the side walls of the sheds.
- d) Cement delivered by bulk carriers shall be stored in silos made for cement storage. All handling shall be by methods that prevent contamination of the cement. The silos shall be provided with interior moisture control devices that keep the cement dry and prevent premature hydration. The silos shall be provided with access ladders and access points to enable samples to be taken from various levels of each silo for testing purposes.
- e) Access ways shall be provided between storage containers such that every

container can be visually inspected. Each delivery shall be stored separately from previous deliveries. Deliveries shall be used in the order in which they were delivered. Any delivery which has become caked or otherwise adversely affected shall be removed from the Site at the Contractor's expense.

- f) The Contractor shall provide weighing machines which shall be kept permanently in each shed for checking the weight of the bags.

#### 3.2.3 Water for Concrete Mixing and Curing

- a) The Contractor's proposed water source shall be submitted to the Engineer for his approval together with test results confirming that water from the source complies with this Specification Section.
- b) Water for concrete mixes, curing concrete and other products containing cement shall be clean water free from oil, salt, acid, sugar, vegetable or any other substance injurious to the concrete in according with Vietnamese Standard TCVN 4506:2012.

#### 3.2.4 Aggregates

- a) Aggregates shall be free of substances that react deleteriously with alkali in the cement sufficiently to cause unacceptable expansion of the concrete. The Engineer's approval of aggregate sources will be based on satisfactory evidence furnished by the Contractor that the aggregate is free from such materials. This evidence shall include certified records of tests by a testing laboratory that the aggregates meet the requirements of Vietnamese Standard TCVN 7570:2006 and may include service records of concrete of comparable properties placed under similar conditions of exposure. Tests shall be made in accordance with Vietnamese Standard TCVN 7572:2006
- b) All aggregates shall consist of tough, hard, durable uncoated particles. The Contractor shall be responsible for processing aggregates to meet the requirements of this Specification Section. The Contractor's proposed sources of aggregates shall be submitted to the Engineer for his approval. Samples shall be taken in the presence of a representative of the Engineer and the Contractor for testing and approval before materials are brought to the Site.
- c) Aggregates shall be stored in stockpiles that ensure the materials remain free draining and are adequately separated to prevent cross contamination. Stockpiles shall be placed on a properly prepared surface to ensure no contamination occurs when materials are re-handled. Materials shall be handled in a manner which avoids segregation. All stockpiles are to be labeled with markers indicating the material type in the stockpile.

Materials previously approved but rendered unacceptable due to inadequate storage or handling will be rejected. Aggregates shall be stored in sufficient quantity to ensure that there is no interruption of concreting work at any time. Aggregates shall be stored near the mixing plant and shall be checked and approved by the Engineer prior to use by the Contractor.

- d) Fine and coarse aggregates shall be tested in accordance with Vietnamese Standard TCVN 7572:06. Source approval shall be withdrawn if aggregates do not meet the requirements of this Specification Section during routine testing.

(1) Fine Aggregate

- i) Fine aggregate shall consist of natural sand with hard, strong, durable particles or other inert materials with similar characteristics. Fine aggregate shall be clean and free from extraneous materials, clay balls, organic matter or other detrimental material in accordance with Vietnamese Standard TCVN 7570:06.
- ii) Fine aggregate shall be reasonably graded and shall meet the grading requirements mentioned in Table 1.
- iii) Fine aggregate shall be of such uniformity that the fineness modulus as defined in Vietnamese Standard TCVN 7570:06 shall not vary more than 0.20 in either way from the fineness modulus of the representative samples used in the mix designs.

Table 1: Grading Requirements of Fine Aggregate

Sieve Size	Percentage Passing by Weight (%)
2.5mm	80 – 100
1.25mm	55 – 85
630µm	30 - 65
315µm	10 – 35
140µm	0 – 10

Source: TCVN 7570:2006

(2) Coarse Aggregate

- i) Coarse aggregate can be provided under the form of blend of many particle sizes or separate particle sizes. The gradation of coarse aggregate, shown by quantity of accumulated residuary on the meshes, is mentioned in Table 1a.

Table 1a – Grading Requirements of Coarse Aggregate

Sieve Size mm	Quantity of accumulated residuary on the Sieve, % quantity, corresponding with the smallest particle size and biggest particle size, mm						
	5-10	5-20	5-40	5-70	10-40	10-70	20-70
100				0		0	0
70			0	0-10	0	0-10	0-10
40		0	0-10	40-70	0-10	40-70	40-70
20	0	0-10	40-70	...	40-70	...	90-100
10	0-10	40-70	...	...	90-100	90-100	
5	90-100	90-100	90-100	90-100			

Source: Vietnamese standard TCVN 7570:2006

- ii) Content of silt, dust, clay in the coarse aggregate depends on the concrete grade which shall not exceeded the values in Table 1b.

Table 1b – Content of silt, dust and clay in the coarse aggregate

Concrete compressive strength	Content of silt, dust and clay, % quantity, not greater than
> 30MPa	1,0
From 15MPa to 30MPa	2,0
< 15MPa	3,0

Source: Vietnamese standard TCVN 7570:2006

- iii) The compressive strength of rock used for coarse aggregate in concrete shall be ascertained from the original rock sample or shall be determined through press test inside the cylinder. In the latter case (1) igneous and metamorphic rock shall have a compressive strength 2 times higher than compressive strength of the concrete and (2) sedimentary rock shall have a compressive strength 1.5 times higher than the compressive strength of the concrete.
- iv) The wearability of coarse aggregate when impacting is tested by the Los Angeles machine, it is not greater than 50 % of quantity.
- v) Content of flat particle in the coarse aggregate shall not exceed 15% for concrete compressive strength > 30MPa and shall not exceed 35%

for concrete compressive strength  $\leq 30\text{MPa}$ .

- vi) Organic contaminant in gravel is determined by the method of colour comparison, it is not darker than the standard colour.
- vii) Content of iron  $\text{Cl}^-$  (acid-soluble) in the coarse aggregate, is not exceeded 0.01%.
- viii) Reactivity of alkali – silica for the coarse aggregate is stipulated same as for fine aggregate.

#### 3.2.5 Admixtures

The use of any admixtures will require the approval of the Engineer. Each type and each location or purpose shall be approved individually. Approval will be dependent upon the submission of mix designs and satisfactory trial mixes in according with Vietnamese Standard TCVN 8826:2011 or ASTM C1017 to demonstrate the function of the admixture.

### 3.3 Concrete Classes

- a) Concrete shall be of one of the classes shown in Table 2. All concrete classes shall be tested using cylinders in accordance with Vietnamese Standard TCVN 3118:1993 or AASHTO T22 and T23 (ASTM-C39 and C31 respectively).
- b) The strength requirements for each class of concrete as determined by testing cylinders at 28 days in accordance with the requirements of this Specification Section are given in Table 2 below. The table also includes other information which is provided as guidance for the Contractor in determining the contents and properties of his proposed concrete mixes.
- c) The class of concrete to be used in each part of the Works shall be as detailed on the Drawings subject to confirmation by the Engineer. However, a guide is given in Table 3 below.

Table 2. Concrete Classes

	C45	C35	C30	C30 (Tremie Mix)	C25	C20	C15	C10	P
Minimum Compressive Strength at 28days (150x300mm Cylinder) (Mpa)	45	35	30	30	25	20	15	10	5(Min. Flexural Strength)
Maximum size of Course Aggregate (mm)	20	20	20	20	20	25	25	40	25
Minimum Cement Content (kg/m3)	450	380	350	350	330	330	280	175	350
Maximum W/C Ratio (%)	35	39.5	45	49.4	50	55	55	76	40
Slump (mm)*	50÷100			180±20	50÷100				0÷50
Coarse Aggregate	Percentage Passing by Weight (%)								
Sieve Size									
37.5mm	---				100				
25.0mm	100				90÷100				95÷100
19.0mm	90÷100				---				---
12.5mm	30÷70				25÷60				25÷60
4.75mm (No.4)	0÷10				0÷10				0÷10

\* When water-reducing admixtures are used, Table 2 slump limits may be exceeded as permitted by the Engineer.

Table 3 Concrete Class - Location

Concrete Class	Location
Class C45	Precast Girder (I)
Class C40	Void slab
Class C35	CIP Deck Slab (incl. Link Slab), Crossbeam of (I) Girder
Class C30	Abutment, Pier, Precast Concrete Plank for (I) Girder,
Class C30 (Tremie Mix)	Bored Pile
Class C25	Parapet, Approach Slab, Box Culvert, Pipe Culvert & Median Barrier
Class C20	Unreinforced Concrete, Headwall, Wingwall of Inlet and Outlet, Concrete Curb
Class C15	Seal Concrete (for construction pier cap under water), Pipe Culvert Cradle, Unreinforced Concrete Retaining Wall
Class C10	Blinding Concrete
Class P	Portland Cement Concrete Pavement (PCCP)

- d) Acceptable ranges for concrete slump shall be determined by appropriate mix design and subsequent trial mix testing. Slumps shall be measured in accordance with Vietnamese standard TCVN 3106 or AASHTO T119 or ASTM C143.

#### 3.3.1 Approved Mix Design

- a) The Contractor shall submit his proposed mix designs to the Engineer for his approval. Upon approval of the mix designs the Contractor prepare trial mixes for the approval of the Engineer before carrying out mixing concrete on a large scale. The mix design shall include the target mean strength for the mix and shall be submitted with the results of satisfactory tests from trial mixes. The mix design and the trial mixes shall use only those materials that have previously been given source approval by the Engineer.
- b) No concrete work will be allowed to commence until the Engineer approves the Contractor's proposed mix design(s).
- c) A new mix design shall be submitted to the Engineer for his approval if there are any changes in characteristics or source of supply of any of the component parts of the mix. Any delay due to such changes shall be entirely the responsibility of the Contractor.
- d) During the execution of the Works the Engineer may require additional tests to be made on the work mix to check compliance with the approved mix design.

#### 3.3.2 Water - Cement Ratio

- a) The Contractor's proposed water content and water cement ratio shall be included in the mix designs, supported by trial mixes, submitted to the Engineer for his approval. The water content shall be the least amount that produces a workable homogeneous plastic mixture. Excess water shall not be permitted and any batch containing such excess shall be rejected.
- b) The total water content for any batch of concrete shall include an allowance for water contained in the aggregates. The Contractor shall determine the water content of the aggregates before concrete batching begins and admixture (if any). The water added to the mix shall be adjusted for the water contained in the aggregates.
- c) Frequent slump tests shall be carried out to ensure that the workability of the concrete remains consistent.

#### 3.3.3 Adjustments during Progress of Work

After a mix design has been approved, the mix shall not be changed during

the progress of the work except as follows:

If it is found impossible to obtain concrete of the desired workability with the mix proportions originally determined, changes in aggregate weights may be made subject to the approval of the Engineer.

If it is found impossible to produce concrete of the minimum compressive strength specified, the cement content may be increased subject to the approval of the Engineer.

#### 3.3.4 Submittals

- a) The Contractor's submissions shall be made well before the start of any concrete work on Site. The Contractor shall bear in mind the time required for submitting and gaining the approval of all constituents of the mix and the time required preparing mix designs and proving them by trial mixes and subsequent cylinder tests. The Contractor shall also allow sufficient time for the Engineer to review the submissions and to conduct any additional trial mixes and tests that might be necessary.
- b) Each mix design submittal shall include, but not be limited to, the following:
  - (i) Contract identification;
  - (ii) Name and address of the Contractor and concrete producer;
  - (iii) Mix design designation;
  - (iv) Class of concrete and intended use;
  - (v) Material proportions;
  - (vi) Name and location of material sources for aggregate, cement, admixtures, and water;
  - (vii) Type of cement and type of cement replacement if used.  
Fly ash, ground iron blast-furnace slag, or silica fume may partially replace cement if complying with pertinent specifications subject to approval by the Engineer.
  - (viii) Cement content in kilogram per cubic meter of concrete;
  - (ix) The saturated surface dry batch mass of the coarse and fine aggregates in kilogram per cubic meter of concrete;
  - (x) Water content (including free moisture in the aggregate plus water in the drum, exclusive of absorbed moisture in the aggregate) in kilogram per cubic meter of concrete;
  - (xi) Target water/cement ratio;
  - (xii) The water/cement ratio for modified concrete is the ratio of the mass of water to the combined mass of Portland cement and cement substitute;
  - (xiii) Dosage of admixtures;
  - (xiv) Sieve analysis of fine and coarse aggregates;
  - (xv) Absorption of fine and coarse aggregates;

- (xvi) Bulk specific gravity (dry and saturated surface dry) of fine and coarse aggregates;
- (xvii) Dry rodded unit mass of coarse aggregate in kilogram per cubic meter;
- (xviii) Fineness modulus (FM) of fine aggregate;
- (xix) Material certifications for cement, admixtures, and aggregate (if applicable);
- (xx) Target values for concrete slump with and without high-range water reducers;
- (xxi) Target values for concrete air content (if required);
- (xxii) Concrete unit mass;
- (xxiii) Compressive strengths of 7 and 28-day concrete.

### **3.4 Formwork and Falsework**

#### **3.4.1 Design**

- a) The Contractor shall submit a method statement for formwork and falsework, including design calculations, shop drawings, working drawings and details of all materials and manufactured goods included in the formwork and falsework to the Engineer for his approval at least two months before the start of construction work on Site. Work shall not start until approval has been given.
- b) The Contractor shall be solely responsible for the design of the formwork and its supporting falsework. The design shall include all necessary strutting, bracing and temporary foundations to ensure the support of all Temporary Works, equipment, the weight of the plastic concrete or any other loading resulting from methods adopted for the placing and compaction of the concrete or any incidental loading. There shall be no harmful deformation of the forms during the concreting operations. No accessory for supporting the formwork or staging shall be built into the permanent structure except with the Engineer's approval.
- c) The design shall be appropriate for such Temporary Works and shall take into full consideration all loads arising from the procedures and work sequences, the prevailing conditions at the Site, in particular likely wind loading and the nature of the existing ground. The Contractor shall carry out all additional soils investigation necessary to confirm his assumptions concerning the nature of the existing ground.
- d) Formwork and falsework shall be designed for vertical load and lateral pressures in accordance with Vietnamese Standard TCVN 4453-1995 and where appropriate, any increased or readjusted loading that may result from prestressing forces. If retarding admixtures are used their effect shall be duly considered during the calculation of the lateral pressures of the fresh concrete. The formwork and falsework shall be designed and

constructed to ensure completed concrete surfaces comply with the tolerances specified in Vietnamese Standard TCVN 4453-1995 or elsewhere in this Specification Section.

- e) The shop drawings and working drawings shall show the proposed details of construction of members, spacing of bents, posts, studs, wailings, stringers, collars, bolts, wedges, bracing, rate of pour, and the manufacturer's recommended safe working capacity of all form ties and column clasps. All assumptions, dimensions, material properties and other data used in the structural analysis shall be noted on the shop drawings. The Contractor shall furnish copies of the design calculations to the Engineer for his consideration when approving the Contractor's proposals.
- f) The design calculations and shop drawings or working drawings shall be certified and stamped by a qualified structural engineer experienced in the preparation of such designs.
- g) When manufactured formwork, shoring or scaffolding units are used the manufacturer's recommendations for allowable loads shall be followed. In such cases the Contractor shall provide certificates and test reports or records of successful experience. Reduced allowable load values may be required for materials which have or will experiences substantial number of reuses.
- h) Where falsework openings are required for maintaining traffic flows or for pedestrian access the Contractor shall provide all necessary additional features to protect the public and to ensure that the falsework will remain stable, particularly if subject to impact by a vehicle. Where openings are provide the design shall include but not be limited to:
  - i) The anchoring of stringers to caps or frames in adjacent spans.
  - ii) Adequate bracing during construction or removal and
  - iii) At least a 300mm gap between the falsework and protective railing.

#### 3.4.2 Construction of Formwork

- a) The formwork shall be constructed accurately to represent the shape of the structure as detailed on the Drawings. It shall be of suitable design and appropriate construction and shall have been approved by the Engineer. The Contractor shall make any necessary adjustments to allow for shrinkage, settlement or deflection which may occur during construction so that the finished concrete sections conform accurately to the specified dimensions true to line, level, location and camber.
- b) Wooden boards shall be cut accurately to shape and fixed such that there are no openings after the wetting of the formwork prior to placing concrete.

- c) Unless otherwise required by the Engineer concrete class C10 shall be placed to a minimum depth of 10 cm in the footings of foundations to structures to provide a working platform and to ensure stability of the foundation soils. The concrete area shall be sufficient to provide support for the Contractor's proposed formwork.
- d) All formwork surfaces shall be fabricated to comply with the requirements of subsection 3.7 of this Specification Section unless otherwise required by the Drawings or other Specification Sections. Surfaces which are completely enclosed or hidden below the permanent surfaces of the ground or surfaces with no specified finish may be formed of sawn boards or similar material. Any lumber or material which is damaged or warped prior to placing of the concrete shall be rejected. All exposed surfaces shall be formed using plywood or metal formwork. The surfaces of plywood or metal formwork shall be kept clean and in good condition at all times to ensure that all concrete surfaces have a consistent appearance that complies with this Specification Section. The Engineer will reject formwork that does not comply with this Specification Section and rejected formwork shall be removed from Site.
- e) All exposed sharp edges and corners shall be chamfered using triangular fillets not less than 2 cm by 2 cm in size, unless otherwise directed by the Engineer. The triangular fillets or chamfer strips shall be milled from clear, straight grain lumber and shall have a finished surfaced on all sides. Curved surfaces shall be formed of plywood, metal or other suitable material.
- f) All formwork and falsework shall be constructed using stiff walings (separators) fixed at right angles to studs. Walings shall be paired and tied together by ties or clamps which pass through the formwork. Bolts, ties and form clamps to hold formwork together shall be positive in action and shall have sufficient strength and be sufficient in number to prevent spreading of the forms. Lifting anchors may be installed in precast members. Bolts, ties, form clamps and lifting anchors shall be entirely removed or cut back, leaving no metal within 3 cm from the concrete surface.
- g) Drainage holes and weep holes shall be constructed as detailed on the Drawings. Forms for weep holes shall be approved by the Engineer.
- h) The Contractor shall ensure that all required inserts, anchors, expansion joint and bearing elements, sleeves, and other items in this Specification Section are installed in the formwork. The Contractor shall coordinate the installation with other trades to ensure proper location of such items. Ends of piping and sleeves embedded in concrete shall be closed with caps or plugs.

- i) No concrete shall be placed in the formwork until construction of the formwork and falsework, the provision and fixing of reinforcement, the provision of ducts, anchorages and prestressing steel and the provision and fixing of all inserts, anchors and expansion joint and bearing elements has been completed for the unit and the unit has been cleaned and sealed to prevent grout leaks all to the satisfaction of the Engineer.
- j) With the exception of permanent formwork all formwork surfaces which shall have concrete against them shall be treated with a release agent which shall be subject to the approval of the Engineer. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with the reinforcement or prestressing tendons and anchorages. Different release agents shall not be used in formwork for concrete that will be visible in the finished Works. Forms shall be saturated with water before concrete is placed. The surfaces of formwork shall be free from any material that shall adhere to or discolor the concrete and all materials applied to the surfaces shall be nonstaining.
- k) The general tolerances in Table 4 below shall apply to dimensions shown on the Drawings.

Table 4 General Tolerances

Item	Tolerances
Spacing of reinforcement	Within $\pm 10\text{mm}$
Concrete cover for superstructure	Within $\pm 5\text{ mm}$
Concrete cover for other structure	Within $\pm 10\text{mm}$

Source: Reference TCVN 4453:1995

- l) If during the placing of concrete movement of the formwork or falsework occurs that exceeds allowances in the Contractor's design or will result in completed work unacceptably out of tolerance, then placing of concrete shall stop. Placing of concrete shall not restart until such time as corrective measures satisfactory to the Engineer have been taken by the Contractor. If such measures are not taken before the initial set of the concrete placing of concrete shall not be permitted to restart. In such case a joint shall be formed and all unacceptable concrete removed all to the satisfaction of the Engineer.

### 3.4.3 Removal of falsework and formwork

- a) Concrete shall have reached the strengths indicated in Table 5 below before the removal of formwork and false-work. No formwork or falsework shall be removed without the approval of the Engineer.

Table 5 Removable Time of Form/False work

Formwork/Falsework	Time / % of Design Strength of Concrete
Precast Girder (I)	- / 90%
Void slabs	- / 100%
Support members/Pier head (30 MPa)	- / 100%
Centering under girders, beams, frames or arches.	14 days / 80%
Floor slabs	14 days / 70%
Columns	2 days / 70%
Walls, sides of beams and all other vertical surfaces	1 day / 70%
To enable finishing, forms used for parapets, barriers, and exposed vertical surfaces may be removed between 24 hours and 48 hours after casting, depending on weather conditions.	

Source: Reference TCVN 4453:1995

- b) In continuous structures falsework for a particular span shall not be released until adjoining spans which will be subject to loading as a result of such release have reached their specified strengths. Falsework or formwork for all spans which affect the loading of a particular span shall be released before concrete is placed in railings, parapets or other elements for the particular span. Release of falsework and formwork for continuous spans or cantilevers shall be carried to ensure a gradual application of working stresses.
- c) Where appropriate formwork to columns shall be removed before the removal of formwork and falsework to beams and girders to ensure the columns are satisfactory.
- d) At the discretion of the Contractor and subject to the approval of the Engineer, formwork and falsework may be left in place for footings within coffer dams or crib work should the removal endanger the safety of the coffer dams or cribs, provided that such forms are not visible in the finished structure. All other formwork or falsework both above and below water level shall be removed.

### 3.5 Concreting

#### 3.5.1 General

- a) No concrete shall be placed until the formwork and falsework has been completed in accordance with subsection 3.4.2 hereinabove and approved by the Engineer. No concrete shall be placed without the approval of the Engineer.
- b) Concrete may be mixed at the Site of construction, at a central point, by a combination of central point and truck mixing or by a combination of central point mixing and truck agitating.

- c) All concrete shall be batched by weight unless otherwise directed by the Engineer. The weight batching machines shall be of a type approved by the Engineer and shall be kept calibrated, accurate and in good condition. Checks shall be made as required by the Engineer to determine that the weighing devices are registering correctly. Each mixer shall be fitted with a water measuring device having accuracy within one percent of the quantity of water required for the batch. The measuring device shall be such that its accuracy is not affected by variations in the water supply pressure.
- d) Where aggregate batching by volume is permitted each size of aggregate shall be measured in a metallic container, the depth of which shall be at least equal to its greatest width. The containers shall be of such shape that their volume can be easily checked by measurement. Cement shall be batched by weight and water by weight or volume.
- e) The batching of concrete shall not begin until such time as all the equipment and labor required for batching, transporting, placing, compacting, finishing and curing the concrete is in place in accordance with the Contractor's approved method statement.

### 3.5.2 Batching

- a) Measurement and batching of materials shall be done at a batching plant and all concrete shall be machine mixed.
- b) The Contractor shall submit his method statement for the batching and mixing of concrete to the Engineer for his approval. The statement shall include the location of the batching and mixing plant, the type or types of mixers and machines to be used, arrangements for the storage of aggregates and the batching and mixing of concrete and transporting concrete from the batching plant to the Site. Each material in the storage yard shall be separated by full height partitions. The storage yard and the conveyor belts shall be protected from the rain by rain proof covers.
- c) The type of mixer shall be a drum mixer. Mixers of less than 0.5 cubic meter capacity shall not be used to batch structural concrete. The use of continuous mixers will not be permitted.
- d) The batching plant shall include separate bins for the bulk cement, fine aggregate and for each size of coarse aggregate, a weighing hopper, and scales capable of determining accurately the weight of each component of the batch. Scales shall be accurate to one percent throughout the range of use and it shall be calibrated every three months and when so requested by the Engineer.
- e) If there is no prior experience with the approved mix design or if special handling procedures, such as pumping, change one or more of the

characteristics between discharge of the load and placing in the forms, the Contractor shall correlate the discharge tests with the placement tests to define these changes.

- f) The Contractor shall also provide documentation, repeat the correlations as often as necessary or as directed by The Engineer.

(1) Portland Cement or Portland blended Cement

- i) Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete.
- ii) All bulk cement shall be weighed on an approved weighing device. The bulk cement weighing hopper shall be properly sealed and vented to prevent the escape of cement dust. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement will not lodge in it nor leak from it.
- iii) Accuracy of batching shall be within 1 percent of the required weight.

(2) Water

- i) Water may be measured either by volume or by weight. The accuracy of water measurement shall be within one percent of the required weight or volume.
- ii) About 10 percent of the water required for the batch shall be poured into the drum before the cement and aggregates, and the remainder of the water shall be added uniformly while the drum is in action and all the water shall be in the drum by the end of the first quarter of the mixing time.

(3) Aggregates

- i) All aggregates produced or handled by hydraulic methods or that have been washed shall be stockpiled or binned for draining at least 12 hours before being batched. Where the moisture content of aggregates is high or variable, they shall be stored or stockpiled for a period in excess of 12 hours subject to approval by the Engineer.
- ii) The accuracy of measurement of aggregates shall be within two percent of the required weights.

### 3.5.3 Mixing and Delivery

- a) Bulk cement shall be transported to the mixer either in waterproof compartments or between the fine and coarse aggregates. Where cement is placed in contact with moist aggregates batches will be rejected unless mixed within 1.5 hours of such contact. Bagged cement may be transported on top of the aggregates.

- b) The concrete shall be mixed until a uniform color and consistency is obtained.
- c) Mixing and delivery of concrete shall be in accordance with the requirements of Vietnamese standard TCVN 4453-1995 or ASTM C94 except where modified in this Specification Section for truck mixing or a combination of central point and truck mixing or truck agitating. Delivery of concrete shall be so regulated that placing is at a continuous rate unless delayed by the placing operations. The intervals between deliveries of batches shall not be so great as to allow the concrete in place to harden partially and in no case shall such an interval exceed 45 minutes.
- d) Any arrangements for the cooling of the mixing water and the handling of admixtures shall be subject to approval by the Engineer.
- e) Additional mixing water and/or admixture may not be added to the concrete after leaving the batching plant unless specifically authorized by the Engineer and if the water/cement ratio in the approved job mix is not exceeded and the truck mixer is loaded to no more than 70 percent of its rated capacity.
- f) The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity as shown on the manufacturer's standard rating plate on the mixer. Water shall be added as required by subsection 3.5.2 (2) f, ii) hereinabove.
- g) Mixing time is determined through the technical characteristics of the equipment used for mixing. In case of no precise specifications of above equipment, the minimum time for a batch by mixer may be taken from Table 6.

Table 6 The Minimum Time for Mixing

Mixers having a capacity of 0.5 m <sup>3</sup> or less	minimum 60 seconds
Mixers having a capacity from 0.5 to 1.0 m <sup>3</sup>	minimum 90 seconds
Mixers having a capacity greater than 1.0 m <sup>3</sup>	minimum 120 seconds

Source: Vietnamese Standard TCVN 4453-1995

- h) Mixing time shall be measured from the time all materials, except water, are in the drum.
- i) The timing device on stationary mixers shall be equipped with a bell or other suitable warning device to give a clearly audible signal each time the lock is released. If the timing device fails the Contractor may continue operations for up to 24 hours while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. After 24 hours the mixer shall not be used until repairs are made.
- j) On cessation of work, including all stoppages exceeding 20 minutes, the

mixers and all handling plant shall be washed with clean water. Any deposits of old concrete in the drum shall be cleaned out by rotating clean aggregate and water in the drum before any fresh concrete is mixed.

- k) Concrete that is not in place within one hour of the time when ingredients were charged into the mixing drum or concrete that has developed an initial set, shall be rejected.

#### 3.5.4 Concrete Consistency

The concrete slump shall be determined by the Contractor's trial mixes and shall be measured in accordance with Vietnamese Standard with TCVN3106:1993 or equivalent AASHTO standard.

#### 3.5.5 Pumping

- a) Placing of concrete by pump is subject to the approval of the Engineer.
- b) Where concrete is conveyed and placed by pump the equipment shall be fit for purpose and of sufficient capacity for the work.
- c) The operation of the pump shall produce a continuous stream of concrete without air pockets.
- d) When pumping is completed, if the concrete remaining in the pipeline after completion of placing is to be used, it shall be ejected in such a manner that there shall be no contamination of the concrete or separation of the ingredients.

#### 3.5.6 Placing and Compacting

- a) The Contractor shall include the method and sequence of placing concrete in his method statement. Concrete shall not be placed until formwork and reinforcement have been approved by the Engineer.
- b) Concrete shall be placed gently in position and shall not have a free fall of more than 1.5m to avoid segregation of the materials and displacement of the reinforcement.
- c) The use of pipes or chutes for transporting concrete shall not be permitted without the approval of the Engineer.
- d) Where the use of pipes or chutes is permitted they shall be rubber or metal. Where steep slopes are required chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement. The use of; aluminum chutes, tremie pipes, troughs and pipes will not be permitted.
- e) Pipes or chutes may be allowed for small sections and bottom dump buckets or other suitable vessels may be allowed for large sections to convey the concrete as near as possible to its final position.

- f) Concrete shall be placed so as to prevent water from collecting at the ends, corners or along the faces of the forms, and water shall not be placed in large quantities at a given point and allowed to run or be worked over a long distance in the form.
- g) All concrete shall be placed and compacted in even layers with each batch and each layer merged with the previous one.
- h) The thickness of concrete layers shall be between 15cm and 30cm for reinforced concrete and up to 45 cm for none reinforced concrete.
- i) Concrete shall be compacted by mechanical or electromechanical poker vibrators. Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete, but shall not last more than 30 seconds. Vibrators shall be withdrawn gradually and vertically to ensure that no air pockets are formed. Over vibration of concrete will not be permitted. Vibrators shall not be in contact with reinforcement in any circumstances. Vibrators shall not be used to distribute concrete in the formwork.
- j) When required vibrating shall be supplemented by hand held equipment to assure proper and adequate compaction
- k) The Contractor shall provide standby vibrators during all concrete pours. At least two vibrators shall be available at the site when more than 25 m<sup>3</sup> of concrete are to be placed.
- l) All vibration, compaction and finishing operations shall be completed immediately after the placing of concrete in its final position.
- m) Concreting in any one part or section of the work shall be carried out in one continuous operation and no interruption of work will be allowed.
- n) Where beams and slabs together form an integral part of the structure, they shall be poured in one operation, unless otherwise specified or an approved provision is made to form a construction joint.
- o) After a beam, wall or column has been cast an interval of one hour shall be allowed before casting the continuous slab. The same applies for all abrupt changes in sections.
- p) During placing exposed concrete surfaces shall be worked by means of tools of an approved type to force all coarse aggregate from the surface, to bring mortar against the forms to produce a smooth finish, substantially free from water and air pockets, or honeycombing. Excessive working which produces layers of laitance on the surface will not be permitted.
- q) Freshly placed concrete shall be adequately protected from rain, dust storms, chemical attack and the harmful effects of sun, heat, wind, flowing water, vibrations and shocks. It shall also be fenced off or

otherwise protected to prevent persons from walking thereon or articles being placed or thrown thereon. This protection shall continue until the concrete is sufficiently set such that it can no longer be damaged by these factors. The protection shall not be less than 24 hours after the time of placing subject to the approval of the Engineer.

#### 3.5.7 Placing of Concrete in or Under Water

- a) The Contractor shall submit his proposed methods for placing concrete in or under water to the Engineer for his approval before proceeding with the work.
- b) The method of placing concrete in or under water shall be such as to keep as much as possible the concrete being placed out of direct contact with the water to avoid any rapid movement or agitation of the exposed concrete surface.
- c) Tremie pipes shall be; smooth bored, watertight, fitted with quick release joints and have an adequate cross section for the size of aggregate to be used. Aluminum pipes shall not be used.
- d) Bottom opening skips shall be straight sided, smooth and fitted with externally operated bottom opening double doors and overlapping canvas flaps.
- e) Where concrete is to be placed in or under water the actual mix proportions and selection of aggregates shall be such as to ensure a resulting concrete with good flow and cohesion characteristics.
- f) The cement content shall be 25 percent greater than for a comparable concrete mix for use above the water level. The minimum strength of test cylinder for all concrete shall be approved by the Engineer on the basis of comparison with the concrete mixes for use in dry conditions.

#### 3.5.8 Weather Precautions

- a) During hot weather steps shall be taken to reduce the concrete temperature. When the air temperature in the shade is 35°C and rising, precautions shall be taken during all concrete operations so that the temperature of the concrete when placed does not exceed 32°C.
- b) The concrete mixing plant shall be screened and covered to protect it from the sun (and wind and rain). Similar precautions shall be taken throughout the transit, placing and curing of the concrete whenever conditions require them.
- c) Aggregates shall be shaded and mixing water shall be cooled and other steps taken to the satisfaction of the Engineer including the provision of ice production facilities if required.

- d) Fresh concrete placed at air temperatures of 35 °C or higher shall be shaded from the direct rays of the sun to the satisfaction of the Engineer.

#### 3.5.9 Continuity of Concrete Work

- a) The Contractor shall carry out the work in such a manner that the placing of concrete in any particular section of the structure shall be executed without any interruption whatsoever from the beginning to the end of the operation. If interruptions occur no fresh concrete shall be deposited on or against the concrete placed before the interruption such time as the concrete is sufficiently set to permit the formation of a construction joint.
- b) Particular care shall be taken to ensure that partially set concrete shall not be damaged by shock or any other cause whatsoever.
- c) To ensure continuity casting of concrete shall not commence until sufficient approved material is at hand to ensure completion of the operation and there is sufficient equipment in reserve for use in the case of breakdown.

### 3.6 Joints

#### 3.6.1 General

- a) Joints shall be limited to the positions indicated on the Drawings and shall be of the type specified.
- b) Expansion joints shall incorporate in their construction adequate protection against the entry of debris or other material that may interfere with the closing of the joints.
- (c) Construction joints are detailed on the Drawings which shall as a rule be formed at right angles to the axis of the members.

#### 3.6.2 Construction Joints

- a) Construction joints shall be made only at locations indicated on the Drawings or as specified herein, except in cases of breakdowns or other unforeseen and unavoidable delays, in which case the a joint shall be formed to the satisfaction of the Engineer.
- b) Construction joints in abutment walls, wing walls and barrels of box culverts shall be placed at intervals not exceeding 10 meters except as otherwise indicated on the Drawings or as may be approved by the Engineer.
- c) All joints which are exposed to view shall be carefully finished true to line and elevation. After the header board has been removed, laitance shall be removed from the surface by washing with water under pressure or by sandblasting to expose clean, well bonded aggregate. After the

surface has been prepared the concrete shall be left saturated with water until the new concrete is placed or it shall be saturated for a period of 4 hours before placing the new concrete. Shear keys or steel dowels shall be used where required. Shear keys formed into the concrete shall be formed by the insertion and subsequent removal of beveled wood strips which shall be thoroughly saturated with water prior to insertion. The size and spacing of the keys and dowels shall be subject to approval by the Engineer.

- d) Care shall be exercised not to damage the concrete or break the concrete to steel bond at any time. On bridge slabs workmen shall not be permitted to stand or walk on the reinforcement until the concrete has hardened. Suitable boards or platforms supported on the slab formwork shall be provided for access during casting.

### 3.6.3 Bonded Construction Joints

Except where otherwise specified, bonded construction joints shall be made using any of the following procedures, as appropriate.

- a) After the header board has been removed laitance shall be removed from the surface by washing with water under pressure or by sandblasting to expose clean, well bonded aggregate. When the concrete has been cured for the normal period the second pour shall be bonded to the first pour by the application of a two component liquid polysulphide polymer epoxy resin concrete adhesive to the concrete joint surface. The epoxy concrete adhesive shall be subject to approval by the Engineer.
- b) The surface on which the adhesive is to be applied shall be free of oil, dirt, and loose concrete. All unsound concrete shall be removed until a base of strong, undamaged concrete on which to apply the adhesive is exposed. Heavy deposits of dirt or oil products shall be removed by wire brushing or sandblasting. The surface shall be free of moisture and dry before application of the adhesive.
- c) Immediately before application the two adhesive components shall be combined in the proportions and to the methods specified by the manufacturer. All components shall be fully blended. The amount of adhesive mixed at one time shall be limited to that quantity which can be conveniently applied within the pot life indicated by the manufacturer.
- d) The resulting adhesive shall be applied to the concrete in accordance with the manufacturer's recommendations. Concrete shall not be placed against the joint until the adhesive has become tacky or otherwise recommended by the manufacturer. Areas that have been allowed to dry shall be recoated before concrete is placed.
- e) Adhesives may be toxic or otherwise injurious to health or otherwise be

classified as hazardous materials. The Contractor shall obtain from the manufacturers of the materials complete instructions as to the health and safety precautions that must be exercised with respect to the materials to be used and as to the procedure that shall be followed in the event that workmen come in contact with such materials. Before they are permitted to proceed with the work workmen shall be instructed on the hazards to which they will be exposed the necessary safety precautions and the procedure to be followed in the event of accidental contact with the materials.

#### 3.6.4 Joint between the Deck Slab and the Coping.

The bonding between the deck slab and the coping shall be broken by using an approved elastic material which shall allow movement between the slab and the coping. The Contractor shall submit his proposal for the breaking the bond between the layers to the Engineer for his approval.

### 3.7 Concrete Finishing

#### 3.7.1 Finishing Concrete Surfaces

All concrete surfaces shall be finished as indicated on the Drawings or as otherwise approved by the Engineer.

- a) Permanently exposed concrete surfaces to Class F4, F3 and F2 finish shall be protected from rust marks and stains of all kinds.
- b) Unless otherwise described in this Specification Section, all formwork joints for exposed surfaces of concrete to Class F2, F3 and F4 finish shall form a regular pattern with horizontal and vertical lines continuous throughout each structure and all construction joints shall coincide with these horizontal or vertical lines.
- c) The types of surface finishes and the formwork class are set out on Table 6:

Table 6: Type of Concrete Finishes

	Finishing	Description	Formworks
Formed Finish	Class F1	No particular requirements for finishing	Sawn Formwork for unexposed concrete surfaces
	Class F2	With specified regularities on the finish	Wrought Formwork of steel or plywood or timber.
	Class F3	With accurate finishing to provide a smooth finish of uniform texture and appearance	Lined Formwork using material approved by the Engineer to be of the same type and obtained from one source throughout for any one structure.
	Class F4	With accurate finishing on the use of internal ties and embedded metal parts	

Unformed Finish	Class U1	Leveled by wooden float etc.	-
	Class U2	Steel float finishing	
	Class U3	Finishing by steel trowel	

Note: Types of surface finishes specified in the Drawings

### 3.7.2 Remedial Treatment of Finished Surfaces

- a) Any remedial treatment to finished surfaces shall be agreed with the Engineer following inspection immediately after removing the formwork and shall be carried out without delay.
- b) Any concrete the surface of which has been treated before being inspected by the Engineer will be liable to rejection.

### 3.7.3 Fixing of Ironwork

All brackets, lag bolts and other ironwork for which holes have been boxed out or left in the concrete of a structure shall be carefully grouted into their correct positions.

### 3.7.4 Reconstruction of Faulty Work

In the event any members or portion of the work proves, after removal of the formwork, to be of inferior workmanship or to be in any way whatsoever defective or should crushing tests on samples taken from the work show that the concrete used therein is of inferior of quality such work shall, at the discretion of the Engineer, be cut out and replaced.

## 3.8 Curing

- a) All newly placed concrete shall be cured. Curing shall begin as soon as the concrete stiffens enough to prevent marring or erosion of the surface and shall continue for at least 7 days. Curing is required to prevent drying out of the concrete and shall be considered an integral part of the concreting operations.
- b) Improperly cured concrete will be considered defective. Concrete work will not be permitted to continue until proper procedures are put into effect by the Contractor.
- c) Curing of concrete shall be included in the Contractor's method statement and shall be subject to the approval of the Engineer. The methods detailed below may be used.
- d) Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period.
- e) When forms are removed before the end of the 7 day curing period,

specified curing procedures shall be applied by the Contractor and continued until the end of the 7 day period as specified.

#### 3.8.1 Methods Using Water

Surfaces may be kept moist by ponding, sprinkling, or fogging. Coverings such as burlap shall be used to retain water so supplied. The use of sawdust will not be allowed and coverings that cause unsightly discoloration of concrete shall not be used. Any method that results in the concrete being alternately wet and dry will be considered an improper curing procedure. Coverings shall be placed as soon as possible after finishing operations have been completed and there is no danger of surface damage. The coverings shall be kept continuously moist.

#### 3.8.2 Preventing Moisture Loss

Moisture loss may be prevented by the use of approved waterproof paper, plastic sheets or liquid membrane curing compound except where other requirements prohibit the use of these compounds. If a formed surface is to be rubbed the concrete shall be kept moist before and during the rubbing and the curing shall be initiated immediately following the first rub while the concrete surface is still moist.

#### 3.8.3 Waterproof Paper

The paper shall have the widest practicable width and adjacent sheets shall overlap a minimum of 15 cm and shall be tightly sealed with a pressure sensitive tape, mastic, glue or other approved methods to form a complete waterproof cover of the entire concrete surface. The paper shall be secured so as not to be displaced by wind. If any portion of the sheets is broken or damaged before expiration of the curing period the broken or damaged portion shall be immediately repaired. Sections that have lost their waterproof qualities shall not be used.

#### 3.8.4 Plastic Sheets

The sheets shall be used in the same manner as required above for waterproof paper.

#### 3.8.5 Curing Compounds

- a) Curing compounds shall not be used on areas receiving a rubbed finish. Only type 2 liquid membrane curing compound complying with Vietnamese Standard TCVN 9345:2012 or equivalent AASHTO standard may be used subject to approval by the Engineer. Curing compounds shall be applied to unformed areas as soon as the water sheen has practically disappeared from the concrete, or as soon as the forms have been removed from surfaces. If there is any expected delay in applying curing

compound the surface shall receive moist curing until the compound can be applied.

- b) All curing compounds shall be thoroughly agitated just prior to use and shall be applied with equipment that will produce a fine spray. The compound shall be applied in two coats sprayed at right angles to each other. The rate of each application shall be not less than 1 liter for each 3.6 square meters of surface or as detailed in the manufacturer's information.
- c) Care shall be taken to prevent application to surfaces where a concrete bond is required and to joints where joint sealer is to be placed. If the membrane film is broken or damaged at any time during the curing period, the broken or damaged area(s) shall be replaced so it meets the original requirements.

### **3.9 Precast Concrete**

- a) Precast concrete elements shall be provided as detailed in the Drawings.
- b) The Contractor shall install all precast elements complete in accordance with the locations indicated on the Drawings or as may be required by the Engineer.
- c) The precast constituents and component work shall include but not be limited to, the supply and installation of the precast elements, necessary grout and grouting and all appurtenances required for their proper installation.

#### **3.9.1 Materials**

- a) Concrete materials incorporated in precast elements shall comply with the requirements of this Specification Section and shall be of the class of concrete as noted on the Drawings or as may be required by the Engineer.
- b) Grout shall be an approved, free flowing, non shrink, and non metallic grout containing sulphate resistant cement. The grout shall have a minimum 28 day compressive strength of 20 MPa when tested in accordance with appropriate sections of ASTM C109. The grout shall show no expansion after the final set takes place when tested in accordance with ASTM C827 or an equivalent test method that may be approved by the Engineer. The grout shall have an initial setting time of not less than 45 minutes.

#### **3.9.2 Fabrication**

- a) Girders shall be cast horizontally.
- b) The dimensional length of beams shown on the Drawings is the required

length including allowances for elastic shortening creep or shrinkage.

- c) To ensure proper bond to the deck slab the top surface of girders in contact with deck slabs shall be given a rough exposed aggregate finish. At approximately the time of initial set all laitance shall be removed by a wire brush to expose the concrete aggregate.
- d) Precast elements that are manufactured off Site shall not be transported from the fabrication area until the concrete has achieved its 28 day strength.
- e) All precast members shall be lifted and supported only at the points indicated on the Drawings or as may be otherwise approved by the Engineer.
- f) Precast items shall be lifted and handled to in such a way that no damage occurs. Any damage to precast items that occurs during transportation or placement shall be inspected by the Engineer. The Engineer may reject damaged precast items if, in his opinion, such damage will adversely affect the strength or the appearance of precast items.

### **3.10 Quality Control of Concrete**

#### **3.10.1 General**

- a) The quality control of concrete shall be included in the Contractor's quality assurance scheme for the Works. The Contractor shall make particular reference to the target mean strength of the concrete in his quality scheme and shall describe clearly all factors relevant to its determination.
- b) All quality control tests must be carried out in a manner acceptable to the Engineer and shall be conducted by an independent laboratory or the Contractor's Laboratory on Site.

#### **3.10.2 Technicians at Mixing Plant**

- a) The Contractor shall designate a competent and experienced concrete technician to be in charge of the mixing plant and to be responsible for quality control including but not limited to, the following:
  - (i) The proper storage and handling of all components of the mix.
  - (ii) The proper maintenance and cleanliness of plant, trucks, and other equipment.
  - (iii) The gradation testing of fine and coarse aggregates.
  - (iv) The determination of the fineness modulus of fine aggregate.
  - (v) The measurement of moisture content of the aggregates and adjustment of the mix proportions as required before each day's production or more often if necessary to maintain the required water/cement ratio.

- (vi) The computation of the batch masses for each day's production and the checking of the plant's calibration as necessary.
- b) He shall be assisted by at least one competent and experienced concrete technician at the Site responsible for concrete sampling and testing during placing of concrete.
- c) He shall ensure furnishing on behalf of the Contractor of all equipment and consumables necessary for the performance of; temperature, unit mass, slump, and other tests to verify compliance with this Specification Section before, during and after each placement operation.
- d) He shall verify that adjustments to the mix before discharge comply with the specifications.
- e) He shall ensure completion of the batch ticket, which shall include the detail below and the recording of the apparent water/cement ratio and the time discharge is completed including; furnishing the Engineer with a copy of each batch ticket at the time of placement.

Concrete supplier

Ticket serial number

Date and truck number

Contractor

Structure or location of placement

Mix design and concrete class

Component quantities and concrete total volume

Moisture corrections for aggregate moisture

Total water in mix at plant

Time of batching

Time at which discharge must be completed

- g) Ensure testing to determine the unit mass, slump and temperature according to this Specification Section.
- h) The provision of copies of work sheets and test results as they are completed.

### 3.10.3 Sampling of Mixed Concrete

- a) The frequency of sampling and testing shall be included in the quality control plan for concrete and subject to the approval of the Engineer.
- b) Samples shall be taken from each work item or batch as in the Contractor's approved quality control plan and in accordance with Vietnamese Standard TCVN3105:1993 or AASHTO-T141. The temperature and slump of the concrete shall be tested for each load at discharge or at such frequency as may be approved by the Engineer. Test

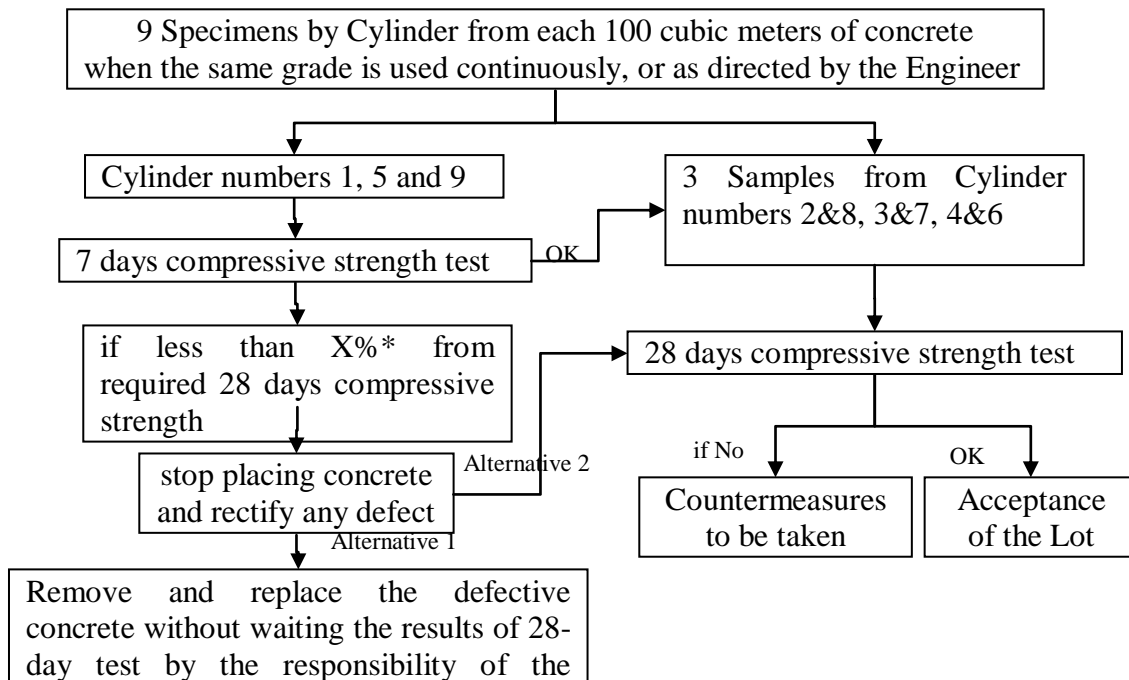
will not be deemed to have been carried out unless witnessed by the Engineer or his representative. The method of making the slump test shall conform to Vietnamese Standard TCVN3106:1993 or AASHTO T119/ASTM C143.

- c) Sampling at discharge shall be after at least 0.2 cubic meters are discharged and before placing any of the batches in the forms.
- d) The initial testing frequency shall be resumed if a test shows a failing temperature or slump or when required by the Engineer.
- e) The Contractor shall bear all expenses for obtaining, cutting out or sampling all specimens and/or component parts for testing.

#### 3.10.4 Compressive Strength Testing

- a) Testing to determine the compressive strength of concrete shall be used for the following purposes:
  - (i) To allow early stripping of forms.
  - (ii) Permit the application of post tensioning force.
  - (iii) Permit the launching of the traveller.
  - (iv) Acceptance of the completed work
- b) The procedure for strength testing shall be in accordance with Vietnamese Standard TCVN3118:1993 or ASTM C1077 or an equivalent procedure approved by the Engineer.
- c) The Contractor's quality control plan shall include details of his proposed procedure for the determination of early concrete strengths. This procedure shall use conventional test cylinder results to substantiate strength predictions for each class and location of concrete pours. Figure 2 is an example of an acceptable the procedures.

Figure 2. Example of Concrete Strength Quality Control Flow Chart



\*Note: This percentage or strength shall be decided in accordance with the test results of trial mixing as mentioned in subsection 3.1 of this Specification Section - Concrete Mix Design and with the proposal by the Contractor.

### 3.11 Testing frequencies

Testing frequencies shall be accordance with Vietnamese Standards: TCVN 4453-95 as shown on Table 8:

Table 8: Frequency of Tests

Item	Test Description	Test Frequency	Remarks
1	TCVN 4453-95: Monolithic Concrete and Reinforced Concrete Structures – Codes for Construction, Check and Acceptance.		
a	Material testing & preparation work before construction: (for material & quarries approval)		
	+ General requirement	Article 5.1	
	+ Cement	Article 5.2	
	+ Sand	Article 5.3	
	+ Quality of aggregate for concrete	Article 5.4	
	+ Water for concrete :	Article 5.5	
	+ Others requirement index for concrete ; additive cement ...	Article 5.6, 5.7	
	+ Formworks and falsework	Article 3	
	+ Reinforcement for concrete	Article 4	
b	During construction period:	Article 6	
c	After construction period: (For acceptance of construction works)	Article 7 : Table 19	

Source: TCVN 4453:1995

### 3.12 Acceptances Test and Tolerances

#### 3.12.1 Strengths

- a) Final acceptance of concrete work will be based on 28 day tests for compressive strength testing and the dimensions of the completed Works.
- b) The work is considered in compliance if the average of the samples equals to or exceeds the minimum specified strength for the class of concrete being placed.
- c) If the results of the 28 day tests do not satisfy the minimum technical requirements the Contractor shall conduct such additional test as may be required by the Engineer.
- d) If the concrete does not comply with the Specification Section the Engineer may order the Contractor to remove the defective concrete and replace it with concrete of the specified quality.
- e) At the discretion of the Employer and subject to there being no risk to the completed structure the Employer may accept a reduced payment for work which is not in compliance with the provisions in this Specification Section. Any such reduced payment will be determined by the Engineer in co-operation with the Employer.

### 3.12.2 Dimensions

- a) The finished dimensions of concrete structures shall be as shown on Table 7.

Table 7 Dimension Tolerances

	Footing Pile Cap	Pier Column	Bearing Pedestal	Wing wall	Apron	Approach Slab	Concrete Railing
Top Level	±10 mm	±5 mm	±2.5 mm	±5 mm	±5 mm	±5 mm	-
Center Position	±5 mm	±5 mm	±5 mm	-	-	±5 mm	±5 mm
Dimension	- 10 to +50 mm*						-
Verticality	-	±1/300	-	±1/ 300	-	-	±1/500
Top Grade Irregularities	-	-	1 in 200	-	±2.5 mm in 3 m	±5 mm in 3 m	±3 mm in 3 m (1/1000)
Wall Flatness	-	-	-	±5 mm	-	-	-

Source: Vietnamese Standard TCVN 4453:1995

## 4. MEASUREMENT AND PAYMENT

### 4.1 Method of Measurement

- Each class of concrete shall be measured separately in cubic meters and measurement shall be made to the lines of the structures as indicated on the Drawings and as described in the Bill of Quantities. No deduction shall be made for the volume of chamfers, the volume of reinforcement, the volume of box outs or the volume of items cast in concrete.
- The Concrete and Concrete Structures provisions and construction requirements identified in this Specification Section shall be measured for payment in pay items 07100-03, 07100-04, 07100-05, 07100-06, 07100-07, 07100-08 and 07100-09.
- Any Concrete and Concrete Structures Works not specifically identified in this Specification Section but which are necessary for the performance of the Works shall be deemed to be included in pay items 07100-03, 07100-04, 07100-05, 07100-06, 07100-07, 07100-08 and 07100-09.
- Measurement and payment for concrete for bored piles and precast prestressed “I” girders is including in other Sections of this Specification.
- Seal concrete (used in the construction of caps to the piers, under water,) shall not be measured for payment in this Specification Section. The costs of seal concrete shall be included in the unit rates for the pay item 03200-01 in Specification Section 03200 Structural Excavation.

### 4.2 Basis of Payment

- a) The work under this Specification Section shall be paid for in accordance

with the applicable unit prices as indicated in the Bill of Quantities and given below. Payment shall constitute full compensation for performing the requirements of the Contract for the item of work as specified including furnishing all necessary labor, materials, tools, equipment, tests and incidentals including but not limited to placing and removal of temporary jetty/guide frames, falseworks and falsework testing, under water Works, placing concrete under water, pumping and dewatering by submersible pumps, all necessary barges/marine equipment, all necessary tug boats, and auxiliary river crafts, the Contractor's observance of all rules and regulations from Competent Authorities regarding interference or maintenance of the flow in relevant canals, watercourses, channels or pipes.

- b) At the discretion of the Engineer a payment of 80% of the bill item may be included in a certificate for concrete which has been completed in an otherwise satisfactory manner but for which the final curing is not complete or the test for the 28 days compressive strength could not be completed.
- c) No separate measurement or payment shall be made for the formwork and falsework or supports of any nature and shall be deemed included in the applicable items of the Bill of Quantities.
- d) Composite Unit No. 07100-05: Abutments and piers includes for but is not limited to concrete and formwork/support system for pier, abutment, temporary bridge(s), service bridge(s), temporary bank, elastic layer and water stops.
- e) Composite Unit No. 07100-06: Parapet includes for but is not limited to concrete, formwork, anchor bolts/nuts/washers for M12 U bolts/nuts/washers for anti-glare plate, bitumen and elastic layer.

<u>Pay Item</u>	<u>Description</u>	<u>Unit</u>
<b>07100</b>	<b>Concrete and Concrete Structures</b>	
07100-03	Concrete Class C40	m <sup>3</sup>
07100-04	Concrete Class C35	m <sup>3</sup>
07100-05	Concrete Class C30	m <sup>3</sup>
07100-06	Concrete Class C25	m <sup>3</sup>
07100-07	Concrete Class C20	m <sup>3</sup>
07100-08	Concrete Class C15	m <sup>3</sup>
07100-09	Concrete Class C10	m <sup>3</sup>

