

SPECIFICATION SECTION 06500 – PORTLAND CEMENT CONCRETE PAVEMENT

TABLE OF CONTENTS

1.	DESCRIPTION	5
2.	MATERIAL REQUIREMENTS	5
2.1	Reference Standards	5
2.2	Water	6
2.3	Aggregates.....	6
2.4	Cement	6
2.5	Pre-molded Joint Filler	6
2.6	Joint Sealer	6
2.7	Steel Reinforcement.....	6
2.8	Welded Steel Wire Fabric.....	6
2.9	Dowels	7
2.10	Curing	7
2.11	Admixtures	7
2.12	Epoxy-Resin	7
2.13	Material Acceptance	7
2.14	Concrete Mixes.....	7
3.	CONSTRUCTION REQUIREMENTS	8
3.1	Equipment	8
3.1.2	Finishing Equipment	9
3.1.3	Vibrators	9
3.1.4	Concrete Saws.....	10
3.1.5	Side Forms	10
3.1.6	Pavers	10
3.2	Preparation of Base surface.....	10
3.2	Form Setting	11
3.3	Handling, Measuring, and Batching Material	11
3.4	Mixing Concrete	12
3.5	Limitations on Mixing and Placing	12
3.5.1	Visibility	12
3.5.2	Hot Weather	12

3.6	Placing Concrete.....	13
3.6.1	Side-form Method	13
3.6.2	Slip-form Method.....	14
3.7	Strike-Off of Concrete and Placement of Reinforcement	15
3.8	Joints	15
3.8.1	Joint Construction	15
3.8.2	Contraction Joints.....	16
3.8.3	Expansion Joints	16
3.8.4	Key for Joint	16
3.8.5	Tie Bars.....	17
3.8.6	Dowel Bars	17
3.8.7	Installation of Joints	17
3.8.8	Sawing of Joints	18
3.9	Final Strike-Off, Consolidation, and Finishing	19
3.9.1	Sequence	19
3.9.2	Finishing at Joints	19
3.9.3	Machine Finishing.....	19
3.9.4	Hand Finishing	20
3.9.5	Floating	20
3.9.6	Straight-edge Testing and Surface Correction	20
3.10	Surface Texture.....	21
3.11	Curing	21
3.11.1	Impervious Membrane Method.....	21
3.11.2	Water Method.....	22
3.11.3	Waterproof Cover Method.....	22
3.12	Sealing Joints.....	22
3.12.1	Time of Application.....	22
3.12.2	Preparation of Joints	22
3.12.3	Installation of Sealant	23
3.13	Protection of Pavement	23
3.14	Opening to Traffic.....	23
3.15	Rejection of Concrete Batches	24
3.16	Acceptance of the Pavement	24
3.16.1	Acceptance Sampling and Testing	24
3.16.2	Flexural Strength.....	24

3.16.3	Pavement Thickness	25
3.16.4	Pavement Roughness.....	25
3.16.5	Acceptance Criteria for Concrete Pavement.....	25
4.	MEASUREMENT AND PAYMENT	25
4.1	Method of Measurement	25
4.2	Basis of Payment	26

SPECIFICATION SECTION 06500 - PORTLAND CEMENT CONCRETE PAVEMENT

1. DESCRIPTION

This Specification Section prescribes the requirements and procedures for the placement of pavement composed of Portland cement concrete, laid on a prepared base surface in conformance with the lines, grades, thickness, and typical cross sections shown on the Drawings.

2. MATERIAL REQUIREMENTS

2.1 Reference Standards

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

AASHTO M254 Corrosion Resistant Coated Dowel Bars

AASHTO PP37 Standard Practice for Determination of International roughness Index (IRI) to Quantify Roughness of Pavements

TCVN8865-2011 Determination of International Roughness Index (IRI) to Quantify Roughness of Pavements

22TCN223-95 Specification for Rigid Pavement Design

Decision No. 1951/QĐ-BGTVT dated 17th August 2012 “Temporary Regulations on Technical Construction and Acceptance of Cement Concrete Pavement”

ASTM E950 Standard Test Method for Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference

ASTM C31 (/C31M-03a) Standard Practice for Making and Curing Concrete Test Specimens in the Field

ASTM C78 Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

ASTM C94 (/C94M-05) Standard Specification for Ready-Mixed Concrete

ASTM-C143 (/C143M-05a) Standard Test Method for Slump of Hydraulic Cement Concrete

ASTM-C172-04 Standard Practice for Sampling Freshly Mixed Concrete;

ASTM-C174 (/C174M-06) Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores

ASTM C494 (/C494M-05a) Standard Specification for Chemical Admixtures for Concrete

ASTMC881 (/C881M-02) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

ASTM C1077-06 Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

ASTM D994-98 (2003) Preformed Expansion Joint Filler for Concrete (Bituminous Type)

ASTM D3665-06 Standard Practice for Random Sampling of Construction Materials

ASTM D6690-06 Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements

AC1305R Specification for Hot Weathering Concreting

2.2 Water

Water shall conform with requirements of Specification Section 07100 Concrete and Concrete Structures.

2.3 Aggregates

Aggregates shall conform with requirements for type P Class concrete under Specification Section 07100 Concrete and Concrete Structures.

2.4 Cement

Cement shall conform with requirements of Specification Section 07100 Concrete and Concrete Structures.

2.5 Oil Paper

Oil paper shall be used as a separator between the aggregate subbase course and the concrete layer. The oil paper shall meet the requirements of Standard TC01-2010.

2.6 Preformed Joint Filler

- (a) Preformed joint filler for expansion joints shall conform to the requirements of ASTM D994, with a nominal thickness of 13 mm. Joint filler must be compatible with joint sealant and shall be punched to admit dowels.
- (b) The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint. When the use of more than one piece is required for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means.

2.7 Joint Sealer

- (a) Joint sealer shall be in accordance with ASTM D6690-06 - Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt 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.

2.8 Steel Reinforcement

Steel reinforcement shall be placed as shown on the Drawings, in accordance with Specification Section 07500 Reinforcing Steel.

2.9 Welded Steel Wire Fabric

- (a) Welded steel wire fabric shall be placed as shown on the Drawings and in

accordance with Specification Section 07500 Reinforcing Steel Welded. Wire fabric for concrete pavement works shall be furnished in flat sheets only.

2.10 Dowels

- (a) Dowels shall be as shown on the Drawings and conform with Specification Section 07500 Reinforcing Steel. Dowel bars shall be plain and shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the Site each dowel bar shall be painted on all surfaces with one coat of rust preventive paint approved by the Engineer. If plastic or epoxy coated steel dowels are used no paint coating is required, except when specified for a particular situation on the Drawings. Coated dowels shall conform to the requirements of AASHTO-M254.
- (b) Where called for on the Drawings, painted or coated dowels shall be lubricated with MC-70. The sleeves (expansion cap) for dowel bars used in expansion joints shall be metal or other type of an approved design to cover 50 mm to 75 mm of the dowel, with a closed end and with a suitable stop to hold the end of the bar at least 25 mm from the closed end of the sleeve. Sleeves shall be of such design that they will not collapse during construction.

2.11 Curing

Materials used for curing shall conform with the requirements for materials of Specification Section 07100 Concrete and Concrete Structures and Subsection 3.11 Curing of Concrete Pavement hereof.

2.12 Admixtures

Admixtures shall conform to requirements of Specification Section 07100 Concrete and Concrete Structures

2.13 Epoxy Resin

Epoxy resin used to anchor dowels and tie bars in pavements shall conform to the requirements of ASTM C881, Type I, Grade 3, Class C.

2.14 Material Acceptance

- (a) Prior to the use of materials the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction. The certification shall show the appropriate ASTM test(s) for each material, the test results, and a statement that the material passed or failed. The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformity with specifications.

2.15 Concrete Mixes

- (a) Concrete shall be of Class P in accordance with the requirements of Specification Section 07100 Concrete and Concrete Structures. The mix

shall be designed using the procedures contained in Chapter 7, Design and Control of Concrete Mixtures of the Portland Cement Association's manual.

- (b) Prior to the start of paving operations and after approval of all materials to be used in the concrete, the Contractor shall submit a mix design to the Engineer, for review and approval, showing the proportions and flexural strength of concrete tested at 7 and 28 days.
- (c) 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.
- (d) Production shall not begin until the Engineer approves the mix design in writing.
- (e) Should a change in sources be made or admixtures be added or deleted from the mix, a new mix design must be submitted to the Engineer for consent.
- (f) Flexural strength test specimens shall be prepared in accordance with ASTM-C31 and tested in accordance with ASTM-C78. The mix determined shall be workable concrete having a slump for side form concrete between 25 mm and 50 mm as determined by ASTM C143. For vibrated slip form concrete the slump shall be between 13 mm and 38 mm.
- (g) Admixtures: Water reducing, set controlling and other approved admixtures can be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted on trial mixes, with the materials to be used in the work, in accordance with ASTM C494.
- (h) Testing Laboratory: The Laboratory used to develop the mix design shall meet the requirements of ASTM C1077.

3. CONSTRUCTION REQUIREMENTS

3.1 Equipment

Batch Plant and Equipment: The batch plant and equipment shall conform to the requirements of ASTM C94. If slip form paving methods are used a central plant mixer shall be used.

The Contractor shall furnish all equipment and tools necessary for handling materials and performing all parts of the work.

Mixers and Transportation Equipment

- (a) General

Concrete may be mixed at a central plant, or wholly or in part in truck mixers. Each mixer shall have attached in a prominent place a manufacturer's nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

(b) Central Plant Mixer

Central plant mixers shall 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 19 mm 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.

(c) Truck Mixers and Truck Agitators

Truck mixers used for mixing and hauling concrete and truck agitators used for hauling centrally mixed concrete shall conform to the requirements of ASTM C94.

(d) Non Agitating Trucks

Non agitating hauling equipment shall conform to the requirements of ASTM C94.

3.1.2 Finishing Equipment

- (a) The finishing equipment shall be of sufficient weight and power for proper finishing of the concrete. The finishing machine shall be designed and operated to strike off, screed and consolidate the concrete such that laitance on the surface is less than 3 mm thick.

3.1.3 Vibrators

- (a) Vibrator shall be of either internal type with immersed tube or multiple spuds or surface type vibrating pan or screed. For pavements 20 cm or more thick 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 - 0.13 cm.
- (b) For pavements less than 20 cm thick, vibrating surface pans or screeds will be allowed. Operating frequencies for surface vibrators shall be between 3,000 and 6,000 vibrations per minute. The number, spacing, and frequency shall be as necessary to provide a dense and homogeneous pavement. Adequate power to operate all vibrators shall be available on the paver. The vibrators shall be automatically controlled so that they shall be stopped as forward motion ceases. Hand held vibrators may be used in irregular areas.

3.1.4 Concrete Saws

- (a) The Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions.
- (b) The Contractor shall provide at least one standby saw in good working order and a supply of saw blades at the Site of the work at all times during sawing operations.

3.1.5 Side Forms

- (a) Straight side forms shall be made of steel and shall be furnished in sections not less than 3 m 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.
- (b) 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 3 mm in 3 meters 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.
- (c) Wood forms shall not be used.

3.1.6 Pavers

- (a) Pavers shall be fully energized, self-propelled 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 and without displacement. Pavers shall be equipped with electronic or hydraulic horizontal and vertical control devices.

3.2 Preparation of Base surface

- (a) After the base surface has been placed and compacted to the required density the areas shall be trimmed or graded to the plan grade elevation and profile by means of a properly designed machine. The grade of the base surface shall be controlled by a positive grade control system using lasers, string lines, or guide wires.
- (b) If the density of the base surface is disturbed by the trimming operations it shall be corrected by additional compaction and retested at the option of the Engineer before the concrete is placed. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately

before the placement of concrete.

- (c) The prepared grade shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete.
- (d) Damage caused by hauling or usage of other equipment shall be corrected and retested. If damage occurs to the base and or subbase the Contractor shall correct it to the full depth.
- (e) 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. All excess material shall be removed and wasted. Low areas shall be filled and compacted to a condition similar to that of the surrounding grade.
- (f) The template shall be maintained in accurate adjustment, at all times by the Contractor and shall be checked daily.

3.2 Form Setting

- (a) Forms shall be set sufficiently in advance of the concrete placement to ensure continuous paving operation. Before setting forms the base surface shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside of the forms. After the forms have been set to correct grade the 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.
- (b) 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.

3.3 Handling, Measuring, and Batching Material

- (a) 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.
- (b) 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. Rail shipments requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage.
- (c) 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.

3.4 Mixing Concrete

- (a) Concrete may be mixed at the work Site in a central mix plant or in truck mixers. 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.
- (b) Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators, or nonagitating trucks. 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 60 minutes.

3.5 Limitations on Mixing and Placing

Re-tempering concrete by adding water or by other means will not be permitted, except when concrete is delivered in transit mixers. With transit mixers, additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements provided that the addition of water is performed within 45 minutes after the initial mixing operations and provided that the water/cement ratio specified in the mix design is not exceeded.

3.5.1 Visibility

Concrete shall be mixed, placed or finished under the natural light. When the light is insufficient an adequate artificial lighting system approved by the Engineer shall be provided.

3.5.2 Hot Weather

- (a) During periods of hot weather when the maximum daily air temperature exceeds 30⁰C, the following precautions shall be taken.
- (b) The forms and/or the base 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 35⁰C.
- (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.

- (d) 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. If necessary, wind screens shall be provided to protect the concrete from an evaporation rate in excess of 0.2 psf (equivalent to 1kg/m²) per hour as determined in accordance with Figure 2.1.5 in ACI 305R, Hot Weather Concreting, which takes into consideration relative humidity, wind velocity, and air temperature.
- (e) 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 wind screens, 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.

3.6 Placing Concrete

- (a) The prepared base surface shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete.
- (a) 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 base surface shall not exceed 1 meter.
- (b) Hauling equipment or other mechanical equipment can be permitted on adjoining previously constructed pavement when the concrete strength reaches a flexural strength of 3,800 kPa. Also, subgrade and subbase planers, concrete pavers, and concrete finishing equipment may be permitted to ride upon the edges of previously constructed pavement when the concrete has attained a minimum flexural strength of 2,750 kPa.

3.6.1 Side Form Method

- (a) For the side Form method the concrete shall be deposited on the moistened grade to require as little rehandling 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 between transverse joints without the use of intermediate bulkheads. 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.

- (b) Concrete shall be deposited as near to expansion and contraction 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.
- (c) 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.

3.6.2 Slip Form Method

- (a) 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 Specification Section. 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 of subsection 2.14 (f) hereof. Final finishing shall be accomplished while the concrete is still in the plastic state.
- (b) 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 600 linear meters of single lane paving the Contractor shall complete the balance of the work with the use of standard metal forms and the formed method of placing and curing.

3.7 Strike Off of Concrete and Placement of Reinforcement

- (a) After being placed, the concrete shall be struck off to conform to the cross section shown on the Drawings and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement shall be at the elevation shown on the Drawings.
- (b) When reinforced concrete pavement is placed in two layers the bottom layer shall be struck off to such length and depth that the sheet of reinforcing steel fabric or bar mat can be laid in full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off and screeded.
- (c) If any portion of the bottom layer of concrete has been placed more than 30 minutes without being covered with the top layer or if initial set has taken place it shall be removed and replaced with freshly mixed concrete at the Contractor's expense. When reinforced concrete is placed in one layer, the reinforcement may be positioned in advance of concrete placement or it may be placed in plastic concrete by mechanical or vibratory means after spreading.
- (d) 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.

3.8 Joints

- (a) 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 13 mm from their designated position and shall be true to line with not more than 6 mm variation in 3 meters.
- (b) The surface across the joints shall be tested with a 3 meter straightedge 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.

3.8.1 Joint Construction

- (a) Longitudinal construction joints shall be slip formed or formed against side forms with or without keys, as shown on the Drawings.
- (b) Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for more than 30 minutes or it appears

that the concrete will obtain its initial set before fresh concrete arrives. The installation of the joint shall be located at a planned contraction or expansion joint. If placing of concrete is stopped the Contractor shall remove the excess concrete back to the previous planned joint.

3.8.2 Contraction Joints

- (a) Contraction joints shall be installed at the locations and spacing as shown on the Drawings. Contraction joints shall be installed to the dimensions required by forming a groove or cleft in the top of the slab while the concrete is still plastic or by sawing a groove into the concrete surface after the concrete has hardened.
- (b) When the groove is formed in plastic concrete the sides of the grooves shall be finished even and smooth with an edging tool. If an insert material is used, the installation and edge finish shall be in accordance with the manufacturer's instructions. The groove shall be finished or cut clean so that spalling will be avoided at intersections with other joints. Grooving or sawing shall produce a slot at least 3 mm wide and to the depth shown on the Drawings. Saw joints shall be carried out after about 4-6 hours, depending on the temperature.

3.8.3 Expansion Joints

- (a) Expansion joints shall be installed as shown on the Drawings. The preformed filler of the thickness, as shown on the Drawings, shall extend for the full depth and width of the slab at the joint, except for the space for sealant at the top of the slab. The filler shall be securely staked or fastened into position perpendicular to the proposed finished surface.
- (b) A cap shall be provided to protect the top edge of the filler and to permit the concrete to be placed and finished. After the concrete has been placed and struck off the cap shall be carefully withdrawn leaving the space over the premolded filler. The edges of the joint shall be finished and tooled while the concrete is still plastic. Any concrete bridging the joint space shall be removed for the full width and depth of the joint.

3.8.4 Key for Joint

- (a) Key shall be formed in the plastic concrete by means of side forms or the use of key liners, which are inserted during the slip form operations. The key shall be formed to a tolerance of 6 mm in any dimension and shall be of sufficient stiffness to support the upper key flange without distortion or slumping of the top of the flange.
- (b) The dimensions of the key forms shall not vary more than plus or minus 6 mm from the mid depth of the pavement. Liners that remain in place permanently and become part of the keyed joint shall be made of galvanized steel, copper clad, or of similar rust resistant material compatible with plastic and hardened concrete and shall not interfere

with joint reservoir sawing and sealing.

3.8.5 Tie Bars

- (a) Tie bars shall consist of deformed bars installed in joints as shown on the Drawings. Tie bars shall be placed at right angles to the centerline of the concrete slab and shall be spaced 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.
- (b) When tie bars extend into an unpaved lane they may be bent against the form at longitudinal construction joints, unless threaded bolt or other assembled tie bars are specified. These bars shall not be painted, greased or enclosed in sleeves.
- (c) When slip form operations call for tie bars, two piece hook bolts can be installed in the female side of the keyed joint provided that the installation is made without distorting the keyed dimensions or causing edge slump. If a bent tie bar installation is used the tie bars shall be inserted through the key liner only on the female side of the joint. In no case shall a bent tie bar installation for male keys be permitted.

3.8.6 Dowel Bars

- (a) Dowel bars or other load-transfer units of a specified type shall be placed across joints in the manner as shown on the Drawings. They shall be of the dimensions and spacing as shown and 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.
- (b) 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. A metal dowel expansion cap or sleeve shall be furnished for each dowel bar used with expansion joints.
- (c) These caps shall be substantial enough to prevent collapse and shall be placed on the ends of the dowels as shown on the Drawings. The caps or sleeves shall fit the dowel bar tightly and the closed end shall be watertight.
- (d) Dowel bars shall be painted with rust preventative paint. The expansion caps at half of the bar shall be thoroughly coated with asphalt MC-70 to prevent the concrete from bonding to that portion of the dowel.

3.8.7 Installation of Joints

All devices used for the installation of expansion joints shall be as specified.

- (a) 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. The preformed joint material shall be placed and held in a vertical position; if constructed in sections there shall be no offsets between adjacent units.

- (b) 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.
- (c) 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 ensure 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.
- (d) The Contractor shall furnish a template for checking the position and alignment of the dowels. Dowel bars shall not be less than 25 cm from a transverse joint and shall not interfere with dowels in the transverse direction.

3.8.8 Sawing of Joints

- (a) Joints shall be cut as shown on the Drawings. Equipment shall be as described in subsection 3.1 of this Specification 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.
- (b) 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.
- (c) The joints shall be sawed at the required spacing, consecutively in sequence of the concrete placement.

3.9 Final Strike Off, Consolidation, and Finishing

3.9.1 Sequence

The sequence of operations shall be the strike off, floating and removal of laitance, straight edging, and final surface finish. The addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted.

3.9.2 Finishing at Joints

- (a) 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.
- (b) 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.

3.9.3 Machine Finishing

- (a) The concrete shall be spread as soon as it is placed and it shall be struck off and screeded 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.
- (b) 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.
- (c) 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.

3.9.4 Hand Finishing

Hand finishing methods will not be permitted, except under the following conditions:

- (a) In the event of breakdown of the mechanical equipment hand methods may be used to finish the concrete already deposited on the grade;
- (b) In areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical.
- (c) Concrete, as soon as placed, shall be struck off and tamped.. When reinforcement is used the first layer shall be struck off and tamped prior to starting the next layer. The screed for the surface shall be a 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.

3.9.5 Floating

After the concrete has been struck off and consolidated it shall be finished off with a longitudinal float using one of the following methods:

- (a) **Hand Method**
Longhandled floats shall not be less than 3.6 meters in length and 15 cm in width and stiffened as necessary. The float shall be operated from either an overhead platform spanning but not touching the concrete or from the edge of the pavement. The floati 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 laitance in excess of 3 mm thick shall be removed.
- (b) **Mechanical Method**
The Contractor may use a powerfloatsuspended from a rigid frame and anchored to the side forms or the ground beyond the pavement. If necessary, long handled floats with blades not less than 1.5 meters long and 0.15 meters wide may be used to smooth parts of the pavement. When the contours 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 laitance, in excess of 3 mm thick, shall be removed. Successive drags shall be lapped one half the length of the blade.

3.9.6 Straight Edge Testing and Surface Correction

- (a) After the pavement has been struck off and while the concrete is still plastic it shall be tested for trueness with a 3meter straightedge.
- (b) The straight edge 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.

- (c) Any depressions shall be immediately filled with freshly mixed concrete; struck off, consolidated and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the smoothness requirements of subsection 3.16.5 of this Specification Section.
- (d) Straight edge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and until the slab conforms to the required grade and cross section.
- (e) 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.

3.9.7 Removal of Formwork

The formwork may be struck when concrete strength has achieved between 30%-35% of the nominal compressive strength, specified in this Specification Section at 28 days.

3.10 Surface Texture

- (a) The surface of the pavement shall be finished with a broom type finish applied when the water sheen has practically disappeared.
- (b) The corrugation equipment shall be used within 20-30 minutes after placed concrete and operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 2 - 4mm in depth, and distance of trench from 15-25mm interval.
- (c) 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.

3.11 Curing

- (a) The construction requirements for curing shall conform with the requirements of Specification Section 07100 Concrete and Concrete Structures and this Subsection.
- (b) Immediately after finishing operations are completed in compliance with this Specification Section the entire area of the newly placed concrete shall be cured in accordance with the methods described below. Failure to provide sufficient cover 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.
- (c) The Contractor shall utilize one of the following types of curing methods:

3.11.1 Impervious Membrane Method

- (a) 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.

- (b) The curing compound shall not be applied while it is raining. Curing compound shall be applied by mechanical sprayers, under pressure, at the rate of 4 liters to not more than 14 square meters. 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.
- (c) 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.
- (d) 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.
- (e) 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.

3.11.2 Water Method

Keep the concrete surface continuously wet by ponding, spraying or with a covering material. The covering material may consist of; cotton mats, multiple layers of burlap or others that do not discolor or otherwise damage the concrete. Cover the entire surface of the pavement and the edges of the slab with water saturated mats. Extend the mats at least twice the thickness of the pavement beyond the edge of the slab. Place the mats in full contact with the surface. Use weights or other approved methods to maintain contact.

3.11.3 Waterproof Cover Method

Thoroughly wet the surface using a fog mist applicator. Place the cover in full contact with the entire surface.. Laps shall be at least 460 mm. Extend the cover beyond the edges of the slab at least twice the thickness of the pavement.

3.12 Sealing Joints

3.12.1 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.

3.12.2 Preparation of Joints

Immediately before sealing the joints shall be thoroughly cleaned of all laitance, curing compound and other foreign material. Sandblasting and/or wire brushing shall be used. Upon completion of cleaning the joints shall be blown out with compressed air. The joint faces shall be surface dry when the seal is applied. Prior to resealing joints any existing joint material shall be removed.

3.12.3 Installation of Sealant

The width, depth, alignment, and preparation of the joints shall be subject to the approval of the Engineer before sealing is allowed. Sealant shall be installed in accordance with the following requirements:

- a) Hot poured sealant shall be uniformly applied and shall be filled without formation of entrapped air or voids.
- b) 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.
- c) The sealant shall not be heated below the safe heating temperature.
- d) The allowable heating temperature shall be obtained from the manufacturer's catalogues.
- e) A direct connecting pressure type extruding device with nozzles shaped for insertion into the joint shall be provided.
- f) Any sealant spilled on the surface of the pavement shall be removed immediately.

3.13 Protection of Pavement

- (a) The Contractor shall protect the pavement and its appurtenances against both public traffic and all other traffic. This shall include watchmen to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, crossovers and protection of unsealed joints from intrusion of foreign material, etc.
- (b) Any damage to the pavement occurring prior to the issue of the Taking-Over Certificate shall be repaired or the pavement replaced at the Contractor's expense.
- (c) 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 green concrete.
- (d) Such protective materials shall consist of rolled polyethylene sheeting, at least 0.1 mm thick, of sufficient length and width to cover the concrete slab and any edges.
- (e) The sheeting may be mounted on either the paver or a separate mobile platform, from which it can be unrolled without dragging over the plastic concrete surface.
- (f) 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.

3.14 Opening to Traffic

The pavement shall not be opened to traffic until test specimens, cured in accordance with ASTM C31 have attained a flexural strength of 3,790 kPa when

tested in accordance with ASTM C78. 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.

3.15 Rejection of Concrete Batches

The Engineer may at any time reject and require the Contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to contamination, segregation or improper slump. Such rejection may be based on only visual inspection. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Engineer and if it can be demonstrated in the Laboratory, in the presence of the Engineer, that such material was erroneously rejected payment will be made for the material at the unit price in the Contract.

3.16 Acceptance of the Pavement

3.16.1 Acceptance Sampling and Testing

- (a) The Contractor's testing laboratory shall perform all acceptance sampling and testing necessary to determine conformity with the requirements of 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 the results.
- (b) Acceptance sampling and testing shall be conducted for each lots. A lot size shall be proposed by the Contractor and approved by the Engineer before the commencement of the Work. Normally the size is desirable to be 1500 m² of pavement or one day's placement (whichever is less).
- (d) Testing organizations performing these tests shall meet the requirements of ASTM-C1077.

3.16.2 Flexural Strength

- (a) Minimum two times a day sampling shall be taken at the batching plant. The concrete shall be sampled in accordance with ASTM C172.
- (b) Cubes shall be made in accordance with ASTM-C31 and the flexural strength shall be determined in accordance with ASTM-C78. The Contractor shall provide adequate facilities for the curing of cubes.
- (c) The Contractor may request the Engineer's approval of the flexural strength test by the compression test by submitting the calibration test results of the relationship between the flexural strength and the compressive strength before the work. The Engineer has a authority to order to the Contractor to carry out the recalibration tests according to the Site and material conditions.
- (d) During the 24 hours after pouring the concrete, the temperature immediately adjacent to the cubes must be maintained in the range of 16⁰C to 27⁰C and loss of moisture from the cubes must be prevented.

3.16.3 Pavement Thickness

- (a) Each lot shall be divided into four equal sub lots and the Contractor shall take one core from each sub lot. Sampling locations shall be in accordance with random sampling procedures contained in ASTM D3665. The Contractor shall fill core holes with a non shrink grout approved by the Engineer within one day after sampling. The Contractor shall furnish all tools, labor and materials for cutting cores and filling the hole.
- (b) The thickness of the cores shall be determined by the average caliper measurement in accordance with ASTM C174.

3.16.4 Pavement Roughness

- (a) At least 21 days before use the roughness of the pavement surface shall be measured. For this purpose the Contractor shall provide a Multi Purpose Profiling System (including all the necessary devices, hardware and software) for calculation of the International Roughness Index (IRI) (AASHTO PP37 or ASTM E950).

3.16.5 Acceptance Criteria for Concrete Pavement

Acceptance will be based on the following characteristics of the completed pavement:

Table 1: Tolerances of Items to be Applied

Parameters	Tolerance
Surface levels	± 5 mm
Width	± 10 mm
Thickness by Site Core Sample	± 8mm
Flexural Strength (Class P,in Specification Section 07100)	Min. 98%
Surface Irregularity by 3m straight edge	± 5 mm
IRI values	≤ 2.00 (m /km)

4. MEASUREMENT AND PAYMENT

4.1 Method of Measurement

- (a) Portland Cement Concrete Pavement shall be measured for payment in square meters (m²) from the Drawings or the Contractor's approved shop drawings upon acceptance of the work by the Engineer.
- (b) Subbase, base and levelling courses shall be paid separately through the following pay items:

05100-01 Aggregate Subbase Course	m ³
05100-02 Aggregate Base Course	m ³
- (c) The Portland Cement Concrete Pavement provisions, material requirements and construction requirements identified in this Specification Section shall be measured for payment in pay items 06500-01 and 06500-03.

- (d) Any Portland Cement Concrete Pavement 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 06500-01 and 06500-03.

4.2 Basis of Payment

The work under this Specification Section shall be paid for in accordance with the applicable 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, inter alia, furnishing all necessary labor, materials, tools, equipment, tests and incidentals, including all joints, joint sealant and filler materials, appurtenances to complete the concrete pavement, finishing, reinforcement, dowels (including tie bars, dowels lubrication and painting), epoxy grouting of dowels, dowel supports, expansion cups, formwork, joint sawing, pavement curing, oil paper, surveying, testing and sampling.

Pay Item	Description	Unit
06500	Portland Cement Concrete Pavement	
06500-01	PCC Pavement for Frontage Road and Crossing Road, thickness 18cm	m2
06500-03	PCC Pavement for Toll Gate, thickness 28cm	m2