

## SECTION 4.01 CONCRETE PAVEMENT

**4.01.01--Description:** This pavement shall consist of Portland Cement Concrete, with or without reinforcement, in conformity with the lines, grades, thickness, and typical cross section as shown on the plans.

**4.01.02--Materials:** The materials for this work shall conform to the requirements for concrete pavement under M.03. Reinforcing steel shall conform to M.06.01.

### **4.01.03--Construction Methods:**

**A. Composition:** The composition of the concrete shall be in accordance with the requirements set forth in Article M.03.01--General Composition of Concrete Mixes, as well as the applicable sections of ACI 211 and ACI 318. The Contractor shall submit all concrete mix designs to the Division of Materials Testing for review and approval prior to production of the design. At the option of the Contractor, other approved cementitious material may be used to replace a portion of the required portland cement in accordance with the requirements of Section M.03.

Since the yield is theoretical, the Department will not be responsible for any variation in yield as actually obtained on the job. Consistency of the concrete shall be uniformly maintained within the allowable range of slump. The slump shall be measured in accordance with AASHTO Method T119.

The concrete shall be air-entrained and shall contain an air content of 6 percent  $\pm$  1 1/2 percent at the time the concrete is deposited on the grade. Air entrainment shall be obtained by use of an approved air-entraining admixture added to the concrete at the time of mixing.

The air content of the plastic concrete shall be determined in accordance with AASHTO Method T152, Pressure Method. No alternative method will be accepted.

No change in the source or character of the materials shall be made without due notice to the Engineer, and no new material shall be used until the Engineer has accepted such materials and has designated new proportions based upon tests of new trial mixes as provided hereinbefore.

**B. Material Storage:** Each cementitious material shall be stored in a separate, weatherproof compartment clearly identified.

Sites for aggregate stockpiles shall be reasonably smooth, hard, well-drained areas. Aggregates from different sources and of different gradation shall not be stockpiled together.

Aggregates shall be handled from stockpiles or other sources to the batching plant in such manner as to minimize segregation of the material. Aggregates that have become segregated, or mixed with earth or foreign material, shall not be used.

**C. Batching Plant and Equipment:** Equipment necessary for handling materials and performing all parts of the work shall be approved by the Engineer as to design, capacity, and mechanical condition. The equipment shall be at the job site sufficiently ahead of the start of construction operations to be examined thoroughly and approved. After approval, the Contractor shall maintain all equipment and tools in a satisfactory working condition until the completion of the work.

**1--General:** The batching plant shall include storage bins, mass determining hoppers, scales, and metering equipment as required. A separate scale for cementitious materials shall be used.

**2--Scales:** Scales for measuring concrete ingredients may be horizontal beam-type, springless scales or electronic devices and shall conform to the applicable requirements of the NIST Handbook 44 except as otherwise specified herein.

Mass-indicating devices shall be in full view and near enough to be read accurately by the operator while charging the hoppers. The operator shall have convenient access to all controls.

When beam-type scales are used, a "Tell-tale" dial shall be provided for indicating to the operator that the required load in the measuring hopper is being approached. A device on measuring beams shall indicate critical positions clearly. The dial faces of springless dial scales shall be of a material not affected by moisture. The graduated dial scale shall be provided with the required number of suitable markers in front of the dial face which may be set at the required positions of the indicator for predetermined masses.

Methods for measuring (electric, hydraulic, loadcells, etc.) other than the methods noted above, which meet the required measuring tolerances may be approved by the Engineer.

**3--**Ten certified standard 22.7 kg masses shall be available at the batching plant for checking the accuracy of the scales. Masses shall be certified by the Department of Consumer Protection.

**4--**The Contractor shall notify the Engineer two days in advance that the scales are in proper adjustment and ready to be sealed. The bins shall be filled sufficiently to perform the tests required, and the Contractor shall have available a man skilled in making any adjustments necessary to seal the scales. The Engineer may request that the scales, after checking with a 227 kg mass, be resealed at any time, if in his opinion the scales are out of adjustment. Scales shall be "sealed" at the expense of the Contractor by the "Sealer of Weights and Measures." Scales shall be inspected and sealed at least once every twelve months.

**5--Automation:** All plants shall be equipped with an approved automatic cycling and monitoring system installed as part of the batching equipment, unless otherwise indicated in the plans or specifications or in the opinion of the Engineer, job conditions warrant otherwise. The system shall include equipment for accurately proportioning the various components of the mixture by mass.

Admixtures and water may be measured volumetrically. The automatic proportioning system shall be capable of consistently delivering each constituent within the tolerances specified.

There shall be auxiliary interlock cutoff circuits to interrupt and stop the automatic batching operations whenever an error exceeding the acceptable tolerance occurs in proportioning for all material components except water. Zero return tolerance shall be equal to that of the delivery tolerances for the minimum batch size.

When the masses of the aggregate sizes are taken cumulatively, the tolerance for each bin draw mass shall be based on the total aggregate batch mass. If aggregate sizes are measured separately, the percentage shall apply to each scale mass. When the other approved cementitious material is measured cumulatively with the cement, the other approved cementitious material shall be last in the measuring sequence, and the batching delivery tolerance for each material draw mass shall be based upon the total mass of cement plus other approved cementitious material.

The electrical circuits used to check delivery tolerances may be set at any span within the full allowable tolerance for any approved batch size. For plants not equipped to automatically adjust tolerances, the tolerance span shall be set for the minimum approved batch size whenever varying batch sizes are being produced.

**(a) Batching Delivery Tolerances:**

Cementitious materials	±	1% (by mass)
Aggregate	±	2% (by mass)
Water	±	1% (by mass or volume--applies at central mix plants only)
Admixtures	±	3% (by mass or volume--or ± 30 mL, whichever is greater)

The automatic proportioning system shall be capable of rapidly selecting and proportioning at least three classes of concrete. In addition, the system shall have the capability of batching materials in at least two batch sizes. These provisions will not be required for project-site plants batching only one class of concrete for a project. The system shall be interlocked during the batching of cement and aggregates so that:

No inlet gate can be opened while the measuring hopper discharge gate is open.

No measuring hopper discharge gates can be opened--

(a) While the hopper is being filled.

(b) Until the full batch mass is within the delivery tolerance.

No new batch can be measured until the hopper is entirely empty of the previous batch and the scale has returned to "zero."

When the manual batching is permitted, the constituents shall be batched within the indicated delivery tolerances for the automatic proportioning system.

**6--Slump Control:** Controls shall be provided so that the batch plant operator can produce concrete of the slump required by the paving operation. Included shall be a moisture compensation system, a slump -meter, and a slump -adjust control. The moisture compensation control can be automatically or manually set for the amount of moisture in the fine aggregate. A moisture compensation system shall compute the adjustment to the water and the fine aggregate components of the concrete to be measured by the automatic batching plant. The actual amounts of each material batched shall be recorded in the manner required elsewhere in these specifications.

**7--Batch Recording Instruments:** All concrete batching plants shall be equipped with digital or graphical recording instruments approved by the Engineer. The recording instruments shall be designed to record the quantities of each aggregate component, cement, other approved cementitious materials (when used), water (at central mix batch plants), and the presence of admixture for each batch of concrete produced. All records of batches shall show the batch number, the day, the month, the year, and the time of day to the nearest minute for each batch. This information shall be imprinted on the record so that each batch may be permanently identified. The Department shall be provided with a clear and legible copy of all batch records for concrete supplied to the Department.

Cement, other approved cementitious material, and aggregate component masses shall be recorded separately. Water at central mix plants may be recorded by mass or volume.

When a digital tape or ticket recorder is used, masses shall be recorded as indicated on the batching scale or meter within an accuracy of  $\pm 1$  scale or meter graduation. The minimum resolution of digital recorders shall be equivalent to the minimum graduation on the scale meter, unless otherwise approved by the Engineer.

If graphical recorders or multiple recorders, either digital or graphical, are used, they shall be subject to the approval of the Engineer.

The control system shall include a mixer timer which is interlocked with the mixer discharge control, such that the concrete will be mixed for the approved time.

If any of the above equipment fails to operate satisfactorily, the Engineer shall be notified immediately, and the Engineer will assign an inspector to the plant to monitor plant operation. Only if job conditions warrant, the Engineer may allow concrete to be delivered to the project without an inspector at the plant to monitor plant operation. When the plant is permitted to operate by manual control during periods of automatic equipment failure, a manually written ticket providing all the specified batch information required from the automatic "batch recording instrument" will be required for each batch supplied to the Department.

The plant shall be returned to compliance with these specifications within two (2) working days of the equipment failure. After that period, concrete will not be accepted by the Department. No costs will be incurred by the Department for any production loss, or delays due to the enforcement of this requirement.

#### **D. Mixing Equipment:**

**1--General:** Concrete may be mixed at the site of construction or at a central point. Truck-mixed or transit-mixed concrete may be used with the permission of the Engineer for limited amounts of pavement and for other exceptional cases. Each mixer shall have attached in a prominent place a manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

**2--Mixers at site of construction or at a central point:** Mixing shall be in an approved mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period, and of discharging the mixture without segregation.

**3--Mixing time:** The mixing time requirements shall be in accordance with the recommendations of the manufacturer of the mixer. If a mixing time of less than 60 seconds is recommended, the Contractor shall furnish test data acceptable to the Engineer, verifying that the reduced mixing time will produce uniform concrete conforming to the provisions of AASHTO M157.

The mixer shall be operated at a drum speed as shown on the manufacturer's name plate on the approved mixer. Any concrete mixed less than the specified time shall be discarded and disposed of by the Contractor at his expense. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic meter, as shown on the manufacturer's standard rating plate on the mixer, except that an overload up to 10 percent above the mixer's nominal capacity may be permitted provided concrete test data for strength and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

#### **E. Hauling Units:**

**1--Truck mixers and truck agitators:** Truck mixers used for mixing and hauling concrete, and truck agitators used for hauling central-mixed concrete, shall conform to the requirements of Subarticle 6.01.03-1(b), "Truck-Mixed and Transit-Mixed Concrete."

**2--Nonagitator trucks:** Bodies of non-agitating hauling equipment for concrete shall be smooth, mortar-tight, non-aluminum metal containers and shall be capable of discharging the concrete at a satisfactory controlled rate without segregation. Covers shall be provided when needed for protection.

**3--Hauling central mix concrete:** Mixed concrete from the central-mixing plant shall be transported in truck mixers, truck agitators, or non-agitating trucks. The time elapsing from the time water is added to the mix until the concrete is deposited in place at the site of the work shall not exceed 30 minutes when the concrete is hauled in non-agitating trucks, nor 60 minutes when hauled in truck mixers or truck agitators, except that in hot weather or under other conditions contributing to quick stiffening of concrete, the maximum allowable time may be reduced by the Engineer.

**4--Addition of water in truck mixers:** When mixed concrete is transported in approved truck mixers, water may be added to the concrete at the delivery site, with the permission of the Engineer, to achieve the required slump, provided the specified water-cement ratio for the concrete is not exceeded and the concrete is mixed for at least thirty additional revolutions at mixing speed to ensure thorough mixing of the water into the concrete. Further addition of water to the concrete after the initial slump adjustment will not be permitted.

#### **F. Placing Concrete:**

All forms, slip form pavers, and other equipment used in the placing, curing, and finishing of concrete shall be of a design acceptable to the Engineer.

**1--Forms:** Forms shall be set by the contractor to true line and grade.

The specified grade shall be set and compacted prior to the setting of forms.

**Conditioning of Subgrade or Base Course:** The subgrade or base course shall be brought to proper cross section. High areas shall be trimmed to proper elevation. Low areas shall be filled and compacted to a condition similar to that of surrounding grade. The finished grades shall be maintained in a smooth and compacted condition until the pavement is placed.

**2--Slip Form Paving:** When slip form paving, the subgrade, or the surface of the subbase over which the tracks of the slip form paver will travel shall not vary more than  $\pm 5$  mm from the grade established by the Engineer.

Except when the Contractor elects to place reinforcement in a two layer procedure, the slip form paving equipment shall spread, consolidate, screed and float finish the freshly placed concrete in one pass in a manner such that a minimum of hand floating will be required. The operations of depositing, spreading, consolidating and finishing shall be such that, insofar as possible, continuous operation of the paver will be maintained. Frequent starting and stopping of the paver should be kept to a minimum.

**3--Placement:** Where concrete is to be placed adjoining a previously constructed lane of pavement, and hauling units and mechanical equipment will be operated upon that previously constructed lane of pavement, that lane shall have attained the strength specified for opening the pavement to vehicular traffic. If only finishing equipment is carried on the existing lane, paving in adjoining lanes may be permitted after the concrete is tested in accordance with 4.01.03(I) and has attained a modulus of rupture of 2800 kPa.

Concrete shall be thoroughly consolidated against and along the faces of all forms 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 five seconds in any one location.

Concrete shall be deposited as close to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket or hopper on to a joint assembly unless the hopper is well centered on the joint assembly.

Should any concrete materials fall on or be worked into the surface of a completed slab, they shall be removed immediately by approved methods.

In order that the concrete may be properly protected against the effects of rain before the concrete is sufficiently hardened, the Contractor will be required to have available at all times materials for the protection of the edges and surface of the unhardened concrete.

**4--Placing Reinforcement:** If mechanical means are used to place pavement reinforcement and/or pavement fabric, the mechanical placement equipment shall be capable of positioning the reinforcement or fabric within the tolerances specified.

When reinforced concrete pavement is placed in two layers, the entire width of the bottom layer shall be struck off and consolidated to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off and screeded.

Any portion of the bottom layer of concrete which has been placed more than 45 minutes without being covered with a top layer 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 laced in plastic concrete after spreading, by mechanical or vibratory means.

Reinforcing steel shall be free from dirt, oil, paint, grease, mill scale, and loose or thick rust which could impair bond of the steel with the concrete.

#### **5--Finishing:**

**(a) Sequence:** The sequence of operations shall be the strike-off and consolidation floating and removal of laitance, and final surface finish. Work bridges or other devices necessary to provide access to the pavement surface for the purpose of finishing, straightedging, and making corrections as hereinafter specified, shall be provided by the Contractor.

In general, the addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted. If the application of water to the surfaces is permitted, it shall be applied as a fog spray by means of approved spray equipment.

**(b) Finishing at Joints:** The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material, 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.

**(c) Hand Finishing :** Unless otherwise specified, hand finishing methods will not be permitted except under the following conditions:

- i. In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade when the breakdown occurs.
- ii. Narrow widths or areas of irregular dimensions where operations of the mechanical equipment is impractical may be finished by hand methods.

Concrete, as soon as placed, shall be struck off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete if reinforcement is used.

**(d) Floating:** After the concrete has been struck off and consolidated it shall be further smoothed, trued, and consolidated by means of a float.

**(e) Final Finish:** When all irregularities have been removed, and the edges of the slabs and joints given their initial edging, the pavement shall be subjected to the following two-stage texturing treatment:

- i. **Dragging with Burlap:** The burlap shall be at least 1.0 m wide and a length of 0.6 m greater than the width of the lane or lanes being placed. The burlap shall not have frayed edges and shall be kept wet and clean of accumulations of dried concrete particles or other foreign materials, which might leave distinctive undesirable marks. The burlap shall be drawn longitudinally along the surface in a slow manner so as to have an even texture. When not in use, the burlap shall not be allowed to rest on the pavement.
- ii. **Texturing with Tines:** As soon as possible, after the pavement surface has been dragged with the burlap, mechanical equipment shall be used to texture the surface with deep transverse grooves.

The equipment shall consist of a self-propelled device capable of applying a textured finish transverse to the centerline of the pavement. The texturing shall be done with tines 0.75 mm thick, 2.0 mm wide, and 100.0 mm to 150.0 mm in length with an average spacing of 12.0 mm on centers.

The transverse grooving shall be performed when the condition of the concrete is optimum. This condition will prevail when the grooves can be formed to a depth of 3.2 mm to 6.4 mm with relative ease and without the walls of the grooves closing back in on each other. Other adjustments to the tining procedure may be permitted by the engineer to obtain grooves of the proper width and depth.

The tined grooving shall extend from edge to edge of the pavement, and shall be perpendicular to the centerline of the pavement. The tining mechanism shall be aligned so as to prevent overlapping of grooves in any two successive passes. The depth of the grooves formed in the surface by the tines shall be checked randomly with a tire-tread depth-measuring gage furnished by the Contractor to ensure compliance with the required limits of 3.2 mm to 6.4 mm. The original surface of the concrete shall serve as the datum for the depth measurements.

**(f) Edging at Forms and Joints:** After the final finish, but before the concrete has taken its initial set, the edges of the pavement along each side of each slab, and on each side of transverse expansion joints, formed joints, transverse construction joints, and emergency construction joints shall be worked with an approved tool and rounded to the radius required by the plans.

A well-defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting the tool during use.

At all joints, any tool marks appearing on the slab adjacent to the joints shall be eliminated by brooming the surface. In doing this, the rounding of the corner of the slab shall not be disturbed. All concrete on top of the joint filler shall be completely removed. All joints shall be tested with a straight edge before the concrete has set, and correction made if one side of the joint is higher than the other or if they are higher or lower than the adjacent slabs.

**6--Joints:** Joints shall be constructed of the type and dimensions, and at the locations required by the plans or specifications. All joints shall be protected from the intrusion of injurious foreign material until sealed.

**(a) Longitudinal Joint:** Deformed steel tie bars of specified length, size, spacing and material shall be placed perpendicular to the longitudinal joints; they shall be placed by approved mechanical equipment or rigidly secured by chairs or other approved supports to prevent displacement. Tie bars shall be coated with epoxy conforming to AASHTO M284. When shown on the plans and when adjacent lanes of pavement are constructed, steel side forms shall be used which will form a keyway along the construction joint. Tie bars may be bent at right angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is placed, or in lieu of bent tie bars, approved two-piece connectors may be used.

Longitudinal formed joints shall consist of a groove or cleft, extending downward from, and normal to, the surface of the pavement. These joints shall be effected or formed by an approved mechanically or manually operated device to the dimensions and line indicated on the plans and while the concrete is in a plastic state. The groove, or cleft, shall be filled with either a pre-moulded strip or poured material.

The longitudinal joint, however formed, shall be continuous. There shall be no gaps in either transverse or longitudinal joints at the intersection of the joints.

Longitudinal sawed joints shall be cut by means of approved concrete saws to the depth, width and line shown on the plans. Suitable guidelines or devices shall be used to assure cutting the longitudinal joint on the true line as shown on the plans. The longitudinal joint shall be sawed within 36 hours of placement and before any other equipment or vehicles are allowed on the pavement. The sawed area shall be thoroughly cleaned and the joint shall immediately be filled with sealer.

**(b) Transverse Expansion Joints:** The expansion joint fillers shall be continuous from edge to edge, shaped to the subbase and to the keyway along the edge. Preformed joint filler shall be furnished in lengths equal to the pavement width or equal to the width of one lane. Damaged or repaired joint filler shall not be used unless approved by the Engineer.

The expansion joint filler shall be held in a vertical position. An approved installing bar, or other device shall be used if required to secure preformed expansion joint filler at the proper grade and alignment during placing and finishing of the concrete. Finished joints shall not deviate more than 6.4 mm in the horizontal alignment

from a straight line. If joint fillers are assembled in sections, there shall be no offsets between adjacent units. No plugs of concrete shall be permitted anywhere within the expansion space.

**(c) Transverse Contraction Joints:** Transverse contraction joints shall consist of planes and of weakness created by forming or cutting grooves in the surface of the pavement and, when shown on the plans, shall include transfer assemblies.

- i. Formed grooves shall be made by depressing an approved tool or device into the plastic concrete. The tool or device shall remain in place until the concrete has attained its initial set and shall then be removed without disturbing the adjacent concrete, unless the device is designed to remain in the joint.
- ii. Sawed contraction joints shall be created by sawing grooves in the surface of the pavements of the dimensions and at the spacing and lines shown on the plans with an approved concrete saw. After each joint is sawed, the saw cut and adjacent concrete surface shall be thoroughly cleaned.

Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling, usually 4 to 24 hours. All joints shall be sawed before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on both during the day and night, regardless of weather conditions. The sawing of any joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. In general, all joints should be sawed in sequence. If extreme conditions exist, which make it impractical to prevent erratic cracking by early sawing, the contraction joint groove shall be formed prior to initial set of concrete as provided above. The engineer will review and approve procedures and methods to correct random cracking.

- iii. Transverse formed contraction joints shall comply with the requirements for the longitudinal formed joint.

**(d) Transverse Construction Joints:** Transverse construction joints shall be constructed when there is an interruption of more than 30 minutes in the concreting operations. No transverse joint shall be constructed within 3.0 m of an expansion joint, contraction joint, or plane of weakness. If sufficient concrete has not been mixed at the time of interruption to form a slab at least 3.0 m long, the excess concrete back to the last preceding joint shall be removed and disposed of as directed.

**(e) Load Transfer Devices:** Load transfer devices shall conform to the requirement of Subarticle M.03.01-5.

**(f) Sealing Joints:** Joints shall be sealed as soon after completion of the curing period as feasible and before the pavement is opened to traffic, including the Contractor's equipment. Just prior to sealing, each joint shall be thoroughly cleaned of all foreign material, including membrane curing compound and the joint-faces shall be clean and surface dry when the seal is applied.

The sealing material shall be applied to each joint opening to conform to the details shown on the plans or as directed by the Engineer. Material for seal applied hot shall be stirred during heating so that localized overheating does not occur. The pouring shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete. The use of sand or similar material as a cover for the seal will not be permitted. Poured joint-sealing material shall not be placed when the air temperature in the shade is less than 10° C, unless approved by the Engineer.

Preformed elastomeric gaskets for sealing joints shall be of the cross sectional dimensions shown on the plans. Seals shall be installed by suitable tools, without elongation, and secured in place with an approved lubricant adhesive which shall cover both sides of the concrete joints. The seals shall be installed in a compressed condition and shall at time of placement be below the level of the pavement surface by approximately 6 mm. The seals shall be in one piece for the full width of each transverse joint.

**7--Curing:** Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface of the newly placed concrete shall be covered and cured in

accordance with one of the methods below. Liquid Membrane -- Forming Cure is the preferred method of curing. Moist curing and cover sheet curing must be approved by the Engineer prior to paving operations. In all cases in which curing requires the use of water, the curing shall have prior right to all water supply or supplies. Failure to use, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 30 minutes between stages of curing or during the curing period.

When concrete is being placed and the air temperature may be expected to drop below 2° C a sufficient supply of straw, hay, grass, or other suitable blanketing material shall be provided along the work and any time the temperature may be expected to reach the freezing point during the day or night, the material so provided shall be spread over the pavement to a sufficient depth to prevent freezing of the concrete. During the period of time such protection, the Contractor shall be responsible for the quality and strength of the concrete placed during cold weather, and any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

**(a) Liquid Membrane-Forming Cure:** The liquid curing compound shall conform to Subarticle M.03.01-10. When resin-based curing compound is used, it shall be applied following the final finishing immediately after the disappearance of the water sheen and before any surface checking or marked dehydration of the concrete occurs.

When water-soluble, linseed oil-based compound is used, it shall be applied immediately following the final finishing.

The compound shall be applied by an approved self-propelled mechanical pressured sprayer delivering a fine, even spray with uniform coverage. This equipment shall be provided with a suitable device for adequate agitation of the compound to prevent settlement. For the sides of concrete pavement exposed after removal of the forms and for areas where the use of self-propelled equipment is not practical, approved hand-held spray bars delivering a fine, even spray may be used; and the compound shall be drawn from a tank equipped with an approved device to prevent settlement or by a method which will prevent settlement.

If the compound is applied in two applications, the second application shall follow the first application within 30 minutes. The compound shall be applied in a continuous, uniform film at not less than one liter for 3.7 m<sup>2</sup>.

If rain falls on the newly coated pavement before the film has dried sufficiently to resist damage, or if the film is damaged in any other way, the Contractor will be required to apply a new coat of material to the affected areas equal in curing value to that specified for the original coat. The treated surface shall be protected by the Contractor from injury for a period of at least 7 days. All traffic, either foot or otherwise, will be considered as injurious to the film of the applied compound.

The Contractor shall have on the project sufficient approved cover sheet or cotton mats for the protection of the pavement in case of rain or breakdown of the spray equipment. The cotton mats shall be maintained in a wet condition during the period of use, as elsewhere herein specified.

Transverse joints shall be protected from the compound by means or methods approved by the Engineer.

**(b) Moist Curing:** After the surface of the concrete has been given its final finish, it shall be protected by covering it with moist mats of the size and quality specified in Article M.03.01-10. These mats shall be laid longitudinally over the surface of the finished pavement by unrolling from the supported roll so as not to bring an excessive mass upon or to mark the new surface of the pavement. After placing, these mats shall be saturated and kept saturated for a period of 7 days, at the end of which time they may be removed, and no further wetting or artificial curing will be required.

**(c) Cover Sheet Curing:** As soon as practicable after the finishing operations, paper or polyethylene cover sheets conforming to Article M.03.01-10. shall be placed in such a manner that the surface of the concrete shall not be marred. The adjoining covers shall overlap at least 500 mm, and the lap shall be securely fastened down

to form a closed joint. On removal of the forms, the edges shall be covered down to the bottom of the pavement. The cover sheets shall remain in place for a period of 7 days.

In the event that hair-checking develops before the cover can be placed, the procedure set forth shall be modified at the direction of the Engineer. Moist curing mats shall then be used for the initial 24 hours of the curing period, and the cover sheets placed for the remainder of the curing period.

Before reusing paper or polyethylene covers, they shall be checked for holes or tears, and any such perforations shall be repaired. Covers which have become unserviceable will be rejected by the Engineer.

**G. Protection of Pavement:** The Contractor shall protect the pavement and its appurtenances against public traffic and traffic caused by his own employees and agents until the pavement is opened to traffic.

Any damage to the pavement occurring prior to the opening of the pavement to traffic by the State shall be repaired or the pavement replaced.

#### **H. Riding Surface Tests:**

**1--Surface Test (Profilograph) and Correction:** The finished surface of all mainline pavement shall be tested and corrected to a smoothness as described herein. Mainline pavement is defined as all pavement for traffic lanes and climbing lanes, but excluding concrete base, acceleration and deceleration lanes, and all taper sections, pavement widening, shoulders, and side street returns. Pavement on horizontal curves having a baseline radius of curvature of 6 degrees or greater and super elevation transitions of such curves will also be excluded.

The surface smoothness of pavement not classified as mainline pavement shall be determined by the Surface Test (straightedge) as described hereinafter. The smoothness of the pavement surface will be determined by using a California Type Profilograph over each designated lane to develop a Profile Index. The equipment shall be furnished and maintained by the Contractor, and will be operated by the Engineer in accordance with Department test methods.

The Contractor shall furnish paving equipment and employ methods that produce a riding surface having a Profile Index of 190 mm per kilometer, or less. The profile will terminate 15 m from each pressure relief joint or existing pavement which is joined by the new pavement.

Pavement profiles will be taken 1 m from and parallel to each edge of pavement for pavement placed at a 3.7 m width or less. When pavement is placed at a greater width than 3.7 m, the profile will be taken 1 m from and parallel to each edge and at the approximate locations of each planned longitudinal joint. Additional profiles may be taken only to define the limits of an out of tolerance surface variation.

During the initial paving operations, either when starting up or after a long shut down period, the pavement surface will be tested with the profilograph as soon as the concrete has cured sufficiently to allow testing. Membrane curing damaged during the testing operation shall be repaired by the Contractor as directed by the Engineer. The purpose of this initial testing is to aid the Contractor and the Engineer in evaluating the paving methods and equipment. Once the initial pavement smoothness, paving methods, and paving equipment are acceptable to the Engineer, the Contractor may proceed with the paving operation. Subsequent to the aforementioned initial testing, daily profiles of each day's paving will be run as soon as possible, preferably during the next working day following placement of the pavement.

A daily average Profile Index will be determined for each day's paving. A day's paving is defined as a minimum of 300 m of full-width pavement placed in a single day. If less than 300 m is paved, the day's production shall be grouped with the subsequent day's production. If an average Profile Index of 315 mm per kilometer is exceeded in any daily paving operation, the paving operation will be suspended and will not be allowed to resume until corrective action is taken by the Contractor. In the event that paving operations are suspended as a result of the average Profile Index exceeding 315 mm per kilometer, subsequent paving operations will be tested in accordance with the initial paving testing procedures.

For the purpose of determining pavement sections where corrective work or pay adjustments will be necessary, the pavement will be evaluated in 150 m sections. Within each 150 m section, all areas represented by high points having deviations in excess of 13 mm in 7.6 m or less shall be removed by the contractor with an approved grinding device or a device consisting of multiple saws. The final texture of the concrete pavement shall be such that texture, appearance, and skid resistance are comparable to adjacent sections that do not require corrective work. The use of a bush hammer or other impact device will not be permitted. Deviations in excess of 13 mm will be determined from the profilogram in accordance with Department Test Methods.

After removing all individual deviations in excess of 13 mm in 7.6 m, additional cutting shall be performed if necessary to reduce the Profile Index.

On those 150 m sections where corrections are necessary, second profilograph runs will be performed to verify that corrections have produced an average Profile Index 315 mm per kilometer or less. If the initial average Profile Index is less than 190 mm per kilometer, only the areas in excess of 13 mm deviations will be reprofiled for correction verification.

After removing all individual deviations in excess of 13 mm, as stated above, additional correction shall be performed if necessary to reduce the average Profile Index to 315 mm per kilometer or less. All correction work shall be completed prior to determinations of pavement thickness.

**2--Surface Test (Straightedge) and Corrections:** As soon as the concrete has hardened sufficiently, the pavement surface, except as specified herein above for mainline pavement, shall be tested by the Contractor with an approved 3 m straightedge placed both transversely and longitudinally to the centerline at sufficient intervals to check the surface profile. Areas showing high spots of more than 3.2 mm, exclusive of tining corrugations, shall be marked by the Engineer and removed by the Contractor to an elevation where the area or spot will not show surface deviations in excess of 3.2 mm when tested with a 3 m straightedge. Correction of surface irregularities and resulting surface finish shall conform to the requirements specified herein for mainline pavement.

**I. Flexural Testing of Concrete:** The flexural strength of the concrete pavement shall be monitored by the evaluation of compressive strength cylinders. The compressive strength specimens shall be cast and cured in the field in accordance with ASTM C 31 (AASHTO T 23). After proper curing, these cylinders shall be transported to the Division of Materials Testing for strength evaluation.

**J. Opening to Traffic:** Vehicular traffic shall be excluded from the pavement until sufficient curing has taken place. The pavement shall be opened to traffic with the attainment of a compressive strength of 25 MPa.

Any damage to the pavement from traffic or any other causes, occurring prior to acceptance of this contract, shall be repaired by the Contractor at his own expense.

In order to expedite the opening of a pavement, or part thereof, to traffic, the Engineer may direct the Contractor to supply a concrete with a higher cement factor, or the substitute TYPE III Portland Cement for the type being used. The mix design for this concrete must be approved by the Engineer. The State shall only pay the extra cost per ton for the cement used.

If the Contractor wants to increase the early strength of the pavement in order to facilitate his plan for the paving sequence, he may substitute TYPE III Portland Cement, or use a concrete with a higher cement factor. The mix design for this concrete must be approved by the Engineer. The extra costs for the cement used shall be borne by the Contractor.

**4.01.04--Method of Measurement:** It is the intent of these specifications that the pavement shall be constructed strictly in accordance with the thickness and widths shown on the plans. The State will not be liable for payment for any thickness and widths in excess of that required.

**A.--Pay Adjustment for Surface Smoothness:** Payment to the Contractor will be based on the average Profile Index per 150 m section according to the following table:

<b>AVERAGE PROFILE INDEX</b>	<b>CONTRACT UNIT PRICE ADJUSTMENT</b>
millimeters per kilometer per 150 m section	Percent of pavement until bid price
0-95	106
95-125	104
125-160	102
160-190	100
190-220	98
220-250	96
250-285	94
285-315	92
over 315	

When the average Profile Index exceeds 190 mm per kilometer per 150 m section but does not exceed 315 mm per kilometer per 150 mm section, the Contractor may elect to accept a contract unit price adjustment in lieu of reducing the average Profile Index.

The unit bid price adjustment will be computed using the designed thickness of Portland Cement pavement or as adjusted under Section 4.01.04. This unit bid price adjustment will apply to the total area of the 150 m long section for the lane width represented by the profile (usually 3.7 m wide). No payment will be made for any pavement which has an average profile index in excess of 315 mm per kilometer until corrective work has been completed by the contractor and the pavement re-profiled to verify that the average Profile Index has been reduced to 315 mm per kilometer or less.

**B.--Pay Adjustment for Pavement Thickness:**

**1--Determination of Pavement Thickness:** The pavement thickness shall be measured after surface correction is completed.

The thickness of fixed form pavement shall be determined by using measurements and/or elevations obtained by the Contractor and submitted to the Engineer prior to the placement of concrete. Thickness measurements using cores tested in accordance with AASHTO T 148 shall remain the option of the Engineer.

The thickness of slip form pavement will be determined by average caliper measurements of cores tested in accordance with AASHTO T 148.

For the purpose of establishing an adjusted unit price for pavement, units to be considered separately are defined at 300 m of pavement in each traffic lane starting at the end of the pavement bearing the smaller station number. The last unit in each lane shall be 300 m plus the fractional part of 300 m remaining. One core will be taken at random by the Department in each unit. When the measurement of the core from a unit is not deficient more than 5.1 mm from the plan thickness, full payment will be made. When such measurement is deficient more than 5.1 mm and not more than 25.4 mm from the plan thickness, two additional cores at intervals not less than 100 m will be taken and used in the average thickness for that unit. If the average measurement of these three cores is not deficient more than 5.1 mm from the plan thickness, full payment will be made. If the average

thickness of the three cores is deficient more than 5.1 mm but not more than 25.4 mm from the plan thickness, an adjusted unit price as provided in (B.2) will be paid for the area represented by these cores.

Other areas such as intersections, entrances, crossover ramps, etc., will be considered as one unit, and the thickness of each unit will be determined separately. Small irregular unit areas may be included as part of another unit. At such points as the Engineer may select in each unit, one core will be taken for each 1000 m<sup>2</sup> of pavement, or fraction thereof, in the unit. If the core so taken is not deficient more than 5.1 mm from the plan thickness, full payment will be made. If the core is deficient in thickness by more than 5.1 mm but not more than 25.4 mm from the plan thickness, two additional cores will be taken from the area represented and the average of the three cores determined. If the average thickness of the three cores is deficient more than 5.1 mm but not more than 25.4 mm from the plan thickness, an adjusted unit price as provided in (B.2) will be paid for the area represented by these cores.

In calculating the average thickness of the pavement, measurements that are in excess of the specified thickness by more than 5.1 mm will be considered as the specified thickness plus 5.1 mm, and measurements that are less than the specified thickness by more than 25.4 mm will not be included in the average.

When the measurement of any core is less than the specified thickness by more than 25.4 mm, the actual thickness of the pavement in this area will be determined by taking additional cores at (not less than) 3 m intervals parallel to the centerline in each direction from the effected location until in each direction a core is found that is not deficient by more than 25.4 mm. Areas found deficient in thickness by more than 25.4 mm shall be evaluated by the Engineer, and if, in his judgement, the deficient areas warrant removal they shall be removed and replaced with concrete of the thickness shown on the plans. Exploratory cores for deficient thickness will not be used in averages for adjusted unit price. The cost of all thickness measurements made to determine average thickness variation or to isolate areas that are deficient by more than 25.4 mm, including filling holes with concrete, will be deducted from any monies due or that may come due to the Contractor under the Contract at the rate of \$50.00 per core.

**2--Determination of Adjusted Payments:** After the thickness of pavement has been determined on the basis of core measurements as hereinbefore described, the following rules for payment shall be applied.

Where the average thickness of pavement is deficient in thickness by more than 5.1 mm, but not more than 25.4 mm, payment will be made at an adjusted price as specified in the following table.

#### **Concrete Pavement Deficiency**

Deficiency in Thickness Determined by Cores millimeters	Proportional Part of Contract Price Allowed
0.0 to 5.1	100 percent
5.2 to 7.6	80 percent
7.7 to 10.2	72 percent
10.3 to 12.7	68 percent
12.8 to 19.1	57 percent
19.2 to 25.4	50 percent

When the thickness of pavement is deficient by more than 25.4 mm, the Engineer will determine whether the area of such deficiency will be left in place or replaced in accordance with the provisions of subsection 1.05.03. All additional work required and any delay to the Contractor's operation as a result of these specifications will not be cause for additional compensation for an extension of time.

On all sections of pavement which have to be removed, the Contractor shall bear the entire cost of the initial construction and the removal of the pavement including all concrete, reinforcement steel and joint material.

Measured for payment hereunder will be only the items of construction entering into the replacement of the concrete pavement to the specified thickness.

**C.--Measurement for Payment:** This work will be measured for payment as follows:

**1--Concrete Pavement:** The quantity of concrete included under this item shall be the number of cubic meters of accepted concrete pavement contained in the theoretical computed volume of the pavement having the required thickness and widths, but subject to adjusted proportional payment or non-payment as stated hereinbefore.

**2--Fabric or Bar Mat Reinforcement:** This material will be measured by the number of square meters of completed and accepted reinforced concrete pavement.

**3--Transverse Expansion Joint:** This material will be measured by the number of meters of completed and accepted transverse expansion joint.

**4--Contraction Joint:** This material will be measured by the number of meters of completed and accepted contraction joint.

**5--Longitudinal Joint Support Assembly:** This material will be measured by the number of joint support assemblies actually incorporated in the completed and accepted concrete pavement. If multilane construction methods are used, two longitudinal joint tie bars will be measured as one longitudinal joint support assembly.

**6--Expansion Joint Filler:** This material, when not part of a transverse joint assembly, will be measured by the number of meters of expansion joint filler of the type and thickness specified and of the width required, actually installed and accepted.

**4.01.05--Basis of Payment:** Payment for the concrete pavement will be made as follows:

**1--Concrete:** This material will be paid for at the contract unit price per cubic meter for "Concrete for Pavement" complete in place, which price shall include all equipment, tools, labor, work incidental thereto and all materials, except reinforcement and joints.

No direct payment will be made for the concrete testing equipment, the instruction in its use, in-situ testing, the concrete in or curing of the required test beams and cylinders as specified hereinbefore, but the cost of this work shall be considered included in the general cost of the work.

The transporting and testing of beams and cylinders will be done by the Department without expense to the Contractor.

**2--Reinforcement:** The reinforcement for the concrete pavement will be paid for at the contract unit price per square meter of pavement for "Mat Reinforcement for Concrete Pavement," complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

**3--Joints:** The expansion joints and the contraction joints will be paid for respectively at the contract unit price per meter for "Transverse Expansion Joint" and for "Transverse Contraction Joint," complete in place, which price shall include all joint filler where required, all joint seal, load transfer devices, and all other material, equipment, tools, labor and work incidental thereto. Longitudinal joints and dummy joints including seal, will not be paid for directly: but the cost thereof shall be considered as included in the general cost of the work.

**4--Longitudinal Joint Support Assembly:** The devices required in connection with longitudinal construction joints will be paid for at the contract unit price each for "Longitudinal Joint Support," complete in place, which price shall include all materials, supports, equipment, tools, labor and work incidental thereto.

**5--Expansion Joint Filler:** The expansion joint filler, other than that which is a part of the transverse joint assembly, will be paid for at the contract unit price per meter for "Expansion Joint Filler" of the type and thickness specified, complete in place, which price shall include all joint filler, joint seal and all other materials, equipment, tools, labor and work incidental thereto.

**6--Type III Portland Cement:** When such material is substituted for other Portland Cement at the direction of the Engineer in order to expedite the opening of pavement to traffic, it will be paid for at the actual unit cost per barrel to the Contractor for the quantity actually incorporated in the pavement less the actual unit cost per barrel to the Contractor for an equal quantity of the Portland Cement so replaced, which cost shall include all equipment, labor, storage, transportation and work incidental to its inclusion in the concrete and incorporation in the finished pavement.

Pay Item	Pay Unit
Concrete for Pavement	m <sup>3</sup>
Mat Reinforcement for Concrete Pavement	m <sup>2</sup>
Transverse Expansion Joints	m
Transverse Contraction Joints	m
Longitudinal Joint Support	EA.
Type and Thickness Expansion Joint Filler	m