DIVISION 7
CONCRETE PAVEMENTS AND SHOULDERS

SECTION 700
GENERAL REQUIREMENTS FOR PORTLAND CEMENT CONCRETE PAVING

700-1 DESCRIPTION

Perform the work covered by this section, which includes but is not limited to the construction of a single course non-reinforced portland cement concrete pavement on a prepared base, in accordance with these Specifications and with the lines, grades, thickness, and typical sections shown on the plans or as directed.

The Department accepts concrete paving with respect to strength, thickness, and ride quality on a lot by lot basis subject to adjusted unit prices as provided in Sections 710 and 720.

Use any combination of equipment that will effectively perform the necessary construction operations. Have the equipment at the job site sufficiently ahead of the start of construction operations for the Engineer to examine thoroughly and approve.

Maintain all equipment in a satisfactory operating condition while in use on the work.

Prior to placing concrete pavement, submit for approval a Process Control Plan addressing all operations necessary in the production, and placement of concrete pavement.

700-2 CONCRETE PRODUCTION EQUIPMENT

Use batch plants, central mix plants, and truck mixers that meet the requirements of Section 1000.

700-3 CONCRETE HAULING EQUIPMENT

Transport concrete to the point of placement either in a truck agitator, a truck mixer operating at agitating speed, or in non-agitating equipment meeting the provisions below. Bottom or belly dump equipment is prohibited. Provide and secure material covers on the equipment bodies for protection against detrimental environmental conditions.

Prevent the accumulation of hardened concrete in the delivery vehicles. Discharge all flushing water before charging with the next concrete load.

When using non-agitating hauling equipment, provide bodies which are smooth, watertight, metal containers with rounded internal corners equipped with vibrators and gates to discharge the concrete without segregation or damage.

For concrete hauled in a truck agitator or truck mixer, use Table 1000-2 to determine the maximum elapsed time for placement of concrete. For concrete hauled in non-agitating equipment, minimize the elapsed time to be 30 minutes or less, unless otherwise approved. The elapsed time is defined as the period from first contact between mixing water and cement until the entire operation of placing and finishing, including corrective measures if necessary, has been completed.

Deliver the concrete to the work site in a thoroughly mixed and uniform mass.

If at discharge, the concrete is not thoroughly mixed and homogeneous, the hauling distance, charging sequence, size of load, mixing time or any combination thereof should be altered to meet these requirements; otherwise, utilize other equipment capable of delivering a thoroughly mixed and uniform concrete mass.

700-4 PREPARATION OF SUBGRADE AND BASE

Prepare the subgrade and base beneath portland cement concrete pavement in accordance with the applicable sections of these Specifications. Use approved automatically controlled grading and paving equipment to produce final subgrade and base surfaces meeting the lines, grades, and cross sections required by the plans or as

directed. When in the judgment of the Engineer the use of such equipment is impractical, this requirement will be waived.

Dampen the surface of the base at the time the concrete is placed. Sprinkle the base when necessary to provide a damp surface. Ensure that no free water or ponding is present at the time of concrete placement. Correct all damaged areas in the subgrade or base prior to placing concrete.

Do not allow traffic on the underlying asphalt courses other than necessary local traffic and that developing from the operation of essential construction equipment as may be authorized by the Engineer. Repair any defects that develop in the underlying asphalt courses or any damage caused by local or construction traffic at no cost to the Department.

Unless otherwise approved, utilize and maintain a braided metal cable stringline reference to be used to control the profile and alignment of the concrete pavement. Monitor the stringline for accuracy and tautness. Set pins at a maximum distance of 15.2 m apart. When located on a vertical curve, set pins at a maximum distance of 7.6 m.

700-5 PLACING CONCRETE

(A) General

Use a slip form paver to place concrete except where impractical due to irregular areas or areas of existing pavement adjacent to the proposed pavement.

Place concrete only in the presence of the Engineer or his authorized representative.

Handle concrete in such a manner as to prevent segregation and keep free from mud, soil, or any other foreign matter.

Where finishing operations must be completed after dark, provide acceptable artificial light in accordance with Section 1413.

Do not begin paving operations or discontinue paving operations when any of the following conditions exist.

(1) When a descending air temperature in the shade and away from artificial heat reaches 1.7°C, stop paving. Do not resume paving until an ascending air temperature in the shade and away from artificial heat reaches 1.7°C.

(2) When the subgrade or base course is frozen.

(3) When aggregates to be used in the mix contain frozen particles.

(4) When air temperature in shade is 32.2°C and rising or the concrete temperature is greater than 35°C.

Where additional pavement must be placed adjacent to new pavement by machine methods, do not place it until the concrete has attained a flexural strength of at least 4.1 MPa.

Construction equipment or hauling equipment will not be allowed over the pavement until the concrete has attained a flexural strength of 4.1 MPa.

Spread the concrete uniformly over the entire area without segregation. Perform the spreading with a mechanical spreader independent of the paver except where hand methods are necessary due to pavement design, equipment breakdown, or other emergencies.

(B) Slip Form Paver Method

Use a slip form paver that is an approved self-propelled machine(s) designed to spread, consolidate, screed, and float finish the concrete in one complete pass of the machine in such a manner that requires a minimum of hand finishing to provide a smooth, dense, and homogeneous pavement. Use a slip form paver equipped with forms of sufficient length and rigidity to support the edges of the

slab so as to minimize hand finishing. Use slip form pavers equipped with both horizontal and vertical automatic controls.

Operate the paver with continuous forward movement and coordinate all operations of mixing, delivering, and spreading the concrete to provide uniform progress and minimize stopping and starting of the paver.

Provide concrete that has sufficient cohesion to prevent appreciable slumping of the pavement edges. Longitudinal straight edge tolerance of 6.4 mm in 3 m will apply to the area within 152.4 mm of the edge of pavement. Edge slump is limited to no more than 6.4 millimeters.

(C) Fixed Form Method

Apply the requirements of this section to all paving operations where a slip form paver is not being used.

Use forms made of metal and of such section and design that they will adequately support the concrete and the construction equipment.

Use forms that have a depth not less than the edge thickness of the pavement to be constructed and not more than 25.4 mm greater than the edge thickness of the pavement to be constructed. Use a form which has the base width at least equal to the height of the form.

Use a form in which the top face does not vary from a true plane more than 3.2 mm in 3 m and the upstanding leg does not vary more than 6.4 millimeters.

Use straight forms that have at least 3 pin pockets per 3 m in length and at least 2 pin pockets per 1.5 m in length.

Use form pins that are metal and capable of holding the forms rigidly in place during construction operations. The Engineer may require pinholes in the base to be sealed prior to placing subsequent pavement.

Connect the form sections by a locking joint that will keep the forms free from vertical and horizontal movement.

Use straight forms 3 m in length on tangents and on curves having a radius of 61 m or more. For curves having a radius of between 61 m and 15.2 m use either straight forms 1.5 m in length or flexible forms. Use flexible forms for curves having a radius of less than 15.2 m.

Clean all forms before they are set and oil all forms before placing concrete. Check the bearing of the forms and correct all areas of inadequate bearing.

Remove all rejected forms immediately from the project.

Set forms a sufficient distance in advance of the point where the concrete is being placed to provide for a continuous operation in placing the concrete and for proper inspection of line and grade.

All forms used for construction joints shall meet the requirements of this section except that provisions shall be made for inserting dowel bars where required.

700-6 VIBRATING CONCRETE

Uniformly vibrate the concrete after it has been spread. Consolidate the full width and depth of the portland cement concrete in a single pass.

Vibrators for full width vibration of concrete paving slabs may be either the surface pan type or the internal type with either immersed tube or multiple spuds. Attach the vibrators to the spreader or the finishing machine, or mount the vibrators on a separate carriage.

Furnish an electronic vibrator monitoring device, displaying the operating frequency of each individual vibrator on the paving equipment. Operate the electronic vibrator monitoring device in areas where the mainline, ramp, or loop pavement exceeds 183 m in length. Record the time, station location, paver track speed, and operating frequency of

each individual vibrators after every 7.6 m of paving or after each 5 minute time interval has elapsed. Provide a report of the vibrator data to the Engineer daily for the first 3 days of paving and weekly thereafter. The Engineer may determine that more frequent submissions are necessary, particularly if equipment is malfunctioning.

Set the internal vibrators to approximately mid slab depth and provide a locking device to avoid contact with any joint, load transfer device, tie bar, subgrade, or side form. Provide an operating position locking device so that no part of the vibrating unit can be lowered to the extent that it will come in contact with dowel bars, dowel bar assemblies or tie bars while paving.

Set the horizontal spacing of vibrators to the manufacturer's recommendations, but in no case exceed 406.4 mm from center to center.

Operate internal and spud vibrators within a frequency range of 3500 to 8000 vpm and surface vibrators within a frequency range of 3500 to 6500 vpm. Operate vibrators in a manner not to cause a separation of the mix ingredients. A reduction in vibrator frequency may be required when the forward motion of the paver is reduced to avoid separation of the mix. Either discontinue the use or remove from contact with the concrete, the machine mounted vibrators, whenever the forward motion of the machinery is stopped.

Should the electronic monitoring device fail to operate properly, immediately check the vibrators manually in the presence of the Engineer or his representative. If the vibrators are functioning properly, paving may continue. Repair the monitoring device within 3 production days or suspend paving.

700-7 FINISHING

Finish concrete pavement or concrete shoulders in accordance with Article 710-6 or Article 720-7, respectively.

700-8 PROTECTION OF PORTLAND CEMENT CONCRETE PAVEMENT

(A) General

Protect the portland cement concrete pavement from environmental conditions.

Remove and replace concrete pavement damaged as a result of environmental conditions at no cost to the Department.

Have protective covering that will protect the surface of the freshly placed pavement from rain or cold weather readily available each day at the location of each proposed day's operation prior to beginning work. Store an adequate quantity of these materials at the paving train.

(B) Cold Weather

When the temperature is anticipated to drop below 1.7°C for more than 6 hours within any 24 consecutive hours of the curing period, defined in Article 700-9, insulate the portland cement concrete pavement to prohibit the concrete from cooling at a rate greater than 1.7°C per hour, and to prevent the surface temperature from dropping below 4.4°C during the curing period.

(C) Hot Weather

When the anticipated daily high temperature is above 27°C, place the concrete at the coolest temperature practical. Control concrete temperatures to assure proper placing, consolidation, finishing, curing, and to prevent plastic shrinkage cracking.

(D) Rain

When rain appears imminent, stop all paving operations, and have all available personnel protect the surface of the unhardened concrete. Failure to properly protect the concrete pavement may constitute cause for removal and replacement of the damaged pavement, at no cost to the Department.

700-9 CURING

(A) General

Immediately after finishing operations have been completed and surface water has disappeared, cover all exposed surfaces of the pavement by one of the methods covered by this article.

Apply the selected curing method to the edges of the pavement immediately after the forms are removed.

Use a curing period of 3 curing days for straight cement mix designs and 7 curing days for pozzolan mix designs. A curing day will be considered any consecutive 24 hour period, beginning when the manipulation of each separate mass has been completed, during which the air temperature adjacent to the mass does not fall below 40°F.

(B) Membrane Curing Compound

After final finish and immediately after the free surface moisture has disappeared, use a minimum application rate of 0.27 l/m^2 when the application equipment is mechanically operated. Provide an inline flow-metering device to ensure the proper application rate is provided. Apply the curing compound such that puddling or ponding does not occur on the fresh concrete surface.

Use mechanically operated application equipment designed to apply a uniformly agitated continuous flow of the curing compound at the prescribed rate to all concrete surfaces.

Hand spraying shall only be permitted for irregular widths or shapes and surfaces exposed by removal of forms. The rate of application for these areas shall be 0.41 l/m^2.

Do not expose newly placed concrete for more than 30 minutes before being covered with curing compound. Failure to cover the surfaces of the concrete shall be cause for immediate suspension of the paving operation.

Protect the membrane curing compound film at all times during the curing period, and repair any damage immediately. Have available a sufficient amount of polyethylene film, burlap, or other approved material to provide for protection of the concrete during rain or when the application equipment fails to apply the curing compound uniformly to all surfaces.

Re-spray concrete surfaces that are subject to heavy rainfall within 3 hours after curing compound has been applied in the same manner as described above.

(C) Polyethylene Film

Spread the sections of the film in a manner that will not damage the finished pavement surface. Securely tape or provide lap joints for the sections that are at least 304.8 mm wide, and take suitable precautions to prevent the circulation of air beneath the film. Cover all exposed surfaces and beyond the edge of the pavement surface.

Use black or dark plastic sheets when the daily high ambient temperature is between 4.4°C – 15.6°C. Use white opaque reflective plastic sheet when the daily ambient temperature is above 15.6°C. Plastic sheets shall meet the requirements of ASTM C 171.

Check the film for damage when it is spread and during the curing period. Repair or replace any damaged sections immediately.

(D) Burlap

Spread the sections of burlap in a manner that will not damage the finished pavement surface. Provide lap joints that are at least 152.4 mm wide.

Use an amount of burlap that is not less than 372 g per running meter based on a 1,016 mm width and may be either 1 layer of Class 4 burlap or 2 layers of Class 1, 2, or 3 burlap.

Saturate the burlap thoroughly prior to placing on the concrete and keep thoroughly wet throughout the curing period.

700-10 REMOVING FORMS

Do not remove forms from freshly placed concrete until at least 12 hours after placement and the concrete has hardened sufficiently to resist spalling, cracking, or any other damage. Repair any honeycombed areas along the sides or edges of the slab by filling with mortar immediately after the forms have been removed. Use mortar consisting of 1 part cement to 2 parts fine aggregate.

700-11 JOINT CONSTRUCTION

(A) General

Construct all joints in accordance with the requirements of these Specifications and the details shown on the plans. Saw all transverse joints and seal them with joint sealer in accordance with the dimensions and details shown in the contract. Seal joints in accordance with the requirements of Article 700-12.

Utilize an early entry dry-cutting sawing system. Have an adequate amount of sawing equipment available to match the production and concrete paving operations. A minimum of one standby sawing unit is recommended. Construct the joint groove using a 3.2 mm saw blade to a minimum depth of 76.2 mm. Perform sawing as soon as the concrete has hardened sufficiently without undercutting, spalling and raveling to control random cracking. Complete all saw cutting before seven hours has elapsed from the time of concrete placement.

Saw the concrete pavement as soon as it can support the weight of the equipment and operator without disturbing the final finish. Saw joints in a neat, vertical straight line without chipping, spalling, tearing or disturbing the final finish.

Immediately reapply curing membrane following the sawing operation.

Deviations from the method of joint construction specified in the plans or Specifications requires prior approval in writing. Such approval is conditional and is subject to obtaining satisfactory results.

The Engineer may order any concrete pavement or shoulder where uncontrolled cracking has occurred prior to final acceptance to be removed and replaced at no cost to the Department. Where permitted, the Contractor may be allowed to repair the cracking in a manner acceptable to the Engineer.

Prior to placing either concrete pavement or concrete shoulders adjacent to a previously placed pavement, cover the transverse joint opening on the edge of the existing slab to prevent intrusion of grout into the opening.

(B) Transverse Contraction Joints

Construct transverse contraction joints in accordance with the details, dimensions and intervals as shown on the plans.

(C) Longitudinal Contraction Joints

Construct longitudinal contraction joints in all pavements wider than 4.9 m in accordance with the details and dimensions shown on the plans.

(D) Transverse Construction Joints

(1) General

Construct transverse construction joints by use of an approved form at the end of each day's operations (planned joint) or whenever the placing of concrete is suspended for more than 30 minutes (emergency joint).

(2) Planned Transverse Construction Joints

Locate this type of joint at the same spacing required for contraction joints. Use dowel bars of the size and spacing shown on the plans.

(3) Emergency Transverse Construction Joints

Use this type of joint when the placing of concrete is suspended for more than 30 minutes. Use tie bars of the size and spacing shown on the plans.

Do not change the spacing of contraction joints due to emergency construction joints. Locate the emergency construction joints at least 1.8 m from any contraction joint or planned construction joint.

(E) Longitudinal Construction Joints

Construct longitudinal construction joints using tie bars in accordance with the details shown on the plans.

(F) Transverse Expansion Joints

Construct transverse expansion joints in accordance with the details shown on the plans utilizing an approved joint assembly.

700-12 SEALING JOINTS

(A) General

Seal all joints with low modulus silicone sealant in the presence of the Engineer.

Install backer rod and sealant in accordance with the details shown in the plans and the manufacturer's recommendations.

Any failure of the joint material will be cause for rejection. Repair the failed joint material as approved by the Engineer at no cost to the Department.

When requested, have a representative of the silicone sealant manufacturer present on the project during the sealing operation.

(B) Age of Pavement

Do not seal the joints until the concrete is at least 14 calendar days old.

Do not perform final sawing and sealing of concrete pavement joints until after surface testing, correction of surface deficiencies, and all adjacent earth and paved shoulder construction has been completed.

(C) Temperature

Do not place joint sealant when the air temperature near the joint is less than 7.2°C or is 7.2°C and falling.

(D) Sealing the Joint

Immediately after sawing the joint to the dimensions as shown on the plans, completely remove the resulting slurry from the joint by flushing with a jet of water under pressure. Use sand blasting to clean joint faces before applying sealant. Make as many passes with a sand blaster as are necessary to provide a clean joint wall.

Blow all joints clear of deleterious materials with air using a nozzle pressure of at least 620 kPa before installing the backer rod. Use rotary screw compressors for this purpose that are equipped with traps capable of removing water and oil from the air. Maintain the traps in accordance with manufacturer's instructions.

Apply sealer only on thoroughly clean and dry joints. Place the sealer to closely conform to dimensions shown on the plans. Any unreasonable deviation will be cause for rejection.

(E) Cleaning Pavement

After a joint has been sealed, remove surplus joint sealer on the pavement as soon as possible.

700-13 USE OF NEW PAVEMENT OR SHOULDER

Traffic or other heavy equipment will not be allowed on the concrete pavement or shoulder until the estimated flexural strength of the concrete using the maturity method has exceeded 4.1 MPa unless otherwise permitted.

Estimate the flexural strength of concrete pavement in accordance with the most current version of ASTM C 1074 *Standard Practice for Estimating Concrete Strength by the Maturity Method* unless otherwise specified herein.

Furnish thermocouples or thermistors and digital data logging maturity meters that automatically compute and display the maturity index in terms of a temperature-time factor. The maturity meters must be capable of storing a minimum of 28 days worth of data and exporting data into an excel spreadsheet. Submit the proposed equipment to the Engineer for approval.

When establishing a strength-maturity relationship, perform flexural tests at ages 1, 3, 5, 7, 14 and 28 days in accordance with Test Method C 78. Substitute flexural strength in lieu of compressive strength when developing the strength–maturity relationship in accordance with ASTM C 1074.

Use the temperature-time factor maturity function to compute the maturity index from the measured temperature history of the concrete. Set the datum temperature at –10°C to calculate the temperature-time factor in Equation 1 of ASTM C 1074.

Establish and submit a strength-maturity relationship in conjunction with each concrete pavement mix design. Determine the temperature-time factor corresponding to the strength-maturity relationship at 4.1 MPa, TTF. Any changes to plant operations, material sources, or mix proportions will affect the strength-maturity relationship. If any changes occur during production, develop a new strength-maturity relationship unless otherwise directed.

Verify the strength-maturity relationship during the first day's production. Utilize the temperature-time factor developed at mix design TTF to verify the production strength-maturity relationship. Verify the strength-maturity relationship at a minimum of every 10 calendar days or when production is suspended for more than 10 days. If the verification sample's strength when tested at TTF is less than 3.8 MPa, immediately suspend early opening of traffic on pavement that has not obtained TTF until a new strength-maturity relationship is developed.

No permanent traffic will be allowed on the pavement until construction of the joints, including all sawing, sealing, and curing that is required, has been completed.

Take particular care to protect the exposed pavement edges and ends.

700-14 CONTRACTOR'S RESPONSIBILITY FOR PROCESS CONTROL

Perform process control sampling and testing of concrete materials and operations in accordance with the requirements of Article 1000-3. The Contractor's roadway foreman and all personnel involved in the batching, sampling, testing, and acceptance of portland cement concrete pavement shall be NCDOT certified Portland Cement Concrete Pavement Technicians.

700-15 ACCEPTANCE TESTS FOR CONCRETE

(A) Responsibility

The Engineer will conduct acceptance sampling and testing of concrete. Provide access to all materials to be sampled and tested. The following tests will be performed on both concrete pavement and concrete shoulders to determine acceptance.

(B) Lot Definition

A lot for acceptance purposes is defined and described in Article 710-4.

(C) Air Content

The air content of the concrete will be determined on the roadway at a frequency established by the Engineer, and in accordance with Subarticle 1000-3(B). The sample taken for determination of air content will be obtained immediately after the concrete has been discharged on the road.

Concrete failing to meet specification requirements for air content will be subject to rejection.

(D) Slump

The slump of the concrete will be determined in accordance with AASHTO T 119 at a frequency established by the Engineer. The sample taken for determination of slump will be obtained immediately after the concrete has been discharged on the road.

When the slump of the concrete is questionable by visual observation, do not place the concrete on the road until tested for slump by the Engineer.

Concrete failing to meet specification requirements for slump will be subject to rejection.

(E) Flexural Strength

Determine the flexural strength of concrete by testing a minimum of one set of two 152.4 x 152.4 x 508.0 mm beams at 28 calendar days. Test beams will be made by the Engineer from the concrete as it comes from the mixer. The beams will be made and cured in accordance with AASHTO T 23 except that immersion in saturated lime water will not be required. Beams will be tested by the Engineer in accordance with AASHTO T 97. Furnish curing facilities for the test beams in accordance with Section 725.

(F) Thickness

The thickness of the pavement will be determined by measurement of cores in accordance with AASHTO T 148 as modified by the Department. Copies of the modified test procedures are available upon request from the Construction Unit.

Take 101.6 mm diameter cores in the presence of the Engineer. Take the cores when the concrete has attained a flexural strength of at least 3.1 Mpa and at least 72 hours have elapsed since placement of the pavement. If the concrete has not attained a flexural strength of at least 4.1 MPa, the gross vehicle weight rating of vehicles supporting the coring operation may not exceed 3,175 kg. Take cores no later than 30 days after the pavement has been placed. The core locations for each lot will be selected at random by the Engineer.

Patch all core holes within 72 hours of taking the core, using a Department approved nonshrink grout compatible with the pavement or shoulder concrete.

(G) Surface Smoothness

Perform acceptance testing for surface smoothness on concrete pavements in accordance with Article 710-7.

SECTION 710
CONCRETE PAVEMENT

710-1 DESCRIPTION

Perform the work covered by this section, including but not limited to designing the concrete mix; furnishing and placing concrete; furnishing of all admixtures and additives; constructing all joints and furnishing joint materials; marking the pavement; curing the pavement and furnishing all curing materials; furnishing concrete necessary for making

test beams; performing maturity testing; coring and patching the pavement; calibrating and checking the operation of batching equipment; taking actions necessary to prevent or to repair cracking; sawing and sealing joints; removing and replacing of defective pavement; and constructing portland cement concrete pavement in accordance with these Specifications and with the lines, grades and dimensions shown on the plans.

710-2 MATERIALS

Refer to Division 10.

Item	Section
Portland Cement Concrete	1000
Curing Agents	1026
Joint Filler	1028-1
Low Modulus Silicone Sealant	1028-4
Water	1024-4
Dowels and Tie Bars	1070-6

710-3 COMPOSITION OF CONCRETE

Design the concrete mix in accordance with Section 1000.

710-4 ACCEPTANCE OF CONCRETE

Test the concrete pavement for acceptance with respect to flexural strength and thickness on a lot by lot basis in accordance with the requirements of Article 700-15 and the following requirements:

For all concrete pavement, including mainline, shoulders, ramps, tapers, intersections, entrances, crossovers, and irregular areas not otherwise defined, produce a lot consisting of 1,115 m^2 or fraction thereof placed within 28 calendar days. From each lot, make a minimum of one set of two 152.4 x 152.4 x 508 mm beams from a randomly selected batch of concrete. The average flexural strength of the two beams is considered one test. If Division of Highways personnel make and test additional sets of beams for a lot, these sets will be averaged with the original set to determine the flexural strength. In the case of low strength, the Engineer reserves the right to use beams made by certified Contractor personnel from the same sample of concrete and tested by Division of Highways personnel to evaluate the lot. If the Engineer elects to use these beams, the flexural strength of all additional beams tested will be averaged with the original two beam strengths to determine the flexural strength.

710-5 CONSTRUCTION METHODS

Construct concrete pavement in accordance with Section 700.

Place concrete in 2 lane minimum widths in a single operation except as follows:

(A) Where the total number of lanes is an odd number, in which case one of the lanes may be placed in a separate operation.

(B) Areas such as ramps or auxiliary lanes where the total width is less than 2 lanes.

710-6 FINISHING

Screed and float finish the concrete to the required cross section that minimizes or eliminates hand finishing. Additional water for finishing will not be allowed. Hand finishing will not be permitted except under the following conditions:

(A) Narrow widths, or irregular areas, where operation of mechanical equipment is impractical.

(B) In the event of breakdown of mechanical equipment, hand methods may be used to finish only that concrete deposited on the base when the breakdown occurred.

(C) Abnormal circumstances of short duration subject to approval.

Produce a final finish on the pavement surface true to grade and uniform in appearance and free of irregular, rough, or porous areas.

Following the finishing of the pavement by screeding, floating, and checking with straightedges, further finish the surface of the pavement by burlap dragging, or other acceptable method to produce a uniform surface texture. Pull the burlap drag in a longitudinal direction.

Produce the final surface finish on all mainline pavement, auxiliary lanes, and ramps by mechanical equipment for grooving plastic concrete which utilizes spring steel tines. Hand finishing may be permitted when the use of mechanical equipment is impractical. Use mechanical equipment that produces transverse grooves that are spaced at random intervals of 12.7 mm, 15.9 mm, or 19.1 mm center to center. Do not overlap adjacent grooving. Produce grooves in the hardened surface, which are 2.0 mm to 3.0 mm wide and 3.8 mm to 6.4 mm deep.

After final finishing, hand finishing may be required on the edges of pavement and/or joints whenever irregularities in surface texture or alignment occur. Care should be taken in hand finishing pavement edges in order to avoid ridges or high places that will prevent water from draining out of the transverse grooves.

The use of excessive water during the finishing operations will not be permitted.

710-7 FINAL SURFACE TESTING

Perform acceptance testing of the longitudinal profile of the finished pavement surface in the presence of the Engineer. Furnish and operate a Rainhart Profilograph (Model No. 860) to determine and record the longitudinal profile on a continuous graph (profilogram) for acceptance testing of the pavement. Take profiles the day after the pavement has been placed except where impractical, but in no event later than 72 hours following placement of the pavement.

Operate the profilograph over the pavement at a speed not exceeding 3.2 km per hour. If a propulsion vehicle is used, it shall be approved, and the gross vehicle weight shall not exceed 453.6 kg. Take profiles with the recording wheel parallel to and approximately 1.1 m inside the two outer edges of the travel lanes and at the location of each longitudinal joint. Take profiles over the entire length of through lane and ramp pavement exclusive of structures and approach slabs. Take additional profiles only to define the limits of an out-of-tolerance surface variation. Upon completion of each day's testing, submit the profilograms to the Engineer for analysis. The Engineer will retain the profilograms.

At the beginning and end of each day's testing, and at other times as determined necessary, operate the profilograph over a calibration strip so that the Engineer can verify correct operation. The Engineer will select the section of pavement used as the calibration strip. Furnish obstructions of known dimensions and temporarily install them in the path of the profilograph. Operate the profilograph in the same manner as it is operated over pavement outside of the calibration strip.

Plot the profilogram at a horizontal scale of 0.3 m/mm with the vertical scale plotted at a true scale. Record station numbers and reference lines on the profilograms, and make sure that the distances between reference locations do not exceed 61 meters.

The Engineer will determine the profile index in accordance with the procedure titled "Determination of Profile Index". Copies of this procedure can be obtained from the Construction Unit.

Construct the concrete so that the completed concrete pavement surface has a profile index (PI) along any line tested not exceeding 395 mm/km, as determined with a 0.00 mm blanking band, over any 183 m section of pavement. Individual deviations shall not exceed 7.6 mm over any 7.6 m length of the line tested. Correct areas found to exceed this tolerance by grinding and texturing or by using other approved corrective measures that produce smooth and skid resistant surfaces. Verify corrective measures have obtained the smoothness requirements.

Promptly repair membrane curing compound damaged during acceptance testing.

In the event the Contractor does not produce a pavement surface that meets the requirements of this section, the Engineer may suspend the Contractor's operations until such time as the Contractor satisfies the Engineer, by making necessary adjustments to equipment, methods, or personnel, that he can produce a pavement surface that will meet these surface requirements.

The use of excessive grinding to meet these requirements will not be permitted.

710-8 PAVEMENT MARKING

Mark the pavement at locations as shown on the plans with station numbers. Mark the pavement by pressing beveled-face metal dies between 101.6 mm and 152.4 mm high into the plastic concrete.

At locations where shoulder drain outlets are placed, mark the edge of pavement nearest the outlet to indicate the presence of the outlet. Provide a mark consisting of the letters "OL". Use the same marking procedure as for station numbers.

710-9 THICKNESS TOLERANCES

A lot for thickness acceptance testing is defined in Article 710-4.

To establish an adjusted unit price, if appropriate, for mainline pavement, take one 101.6 mm diameter core from each lot at a random location as directed. Core each location in the presence of the Engineer and deliver the core to the Engineer for measurement.

Other areas such as intersections, entrances, crossovers, ramps, etc. will each be considered as one lot and the thickness of each of these lots will be determined separately. Small irregular areas may be included as part of another lot. Take one core for each 1,115 m^2 of pavement or fraction thereof in the lot

When the measurement of the core from a lot is not deficient more than 5.1 mm from the plan thickness, full payment will be made. When such measurement is deficient by more than 5.1 mm and not more than 25.4 mm from the plan thickness, take 2 additional cores at intervals not less than 91.4 m apart within the lot and determine the average of the 3 cores. In determining the average thickness of the pavement, the Engineer will use all 3 core measurements with the exception that measurements which are in excess of the plan thickness by more than 5.1 mm will be considered as the plan thickness plus 5.1 mm. If the average measurement of these 3 cores is not deficient more than 5.1 mm from the plan thickness, full payment will be made. If the average measurement of the 3 cores is deficient more than 5.1 mm but not more than 25.4 mm from the plan thickness, an adjusted unit price provided in Subarticle 710-10(B) will be paid for the lot represented.

When the measurement of any core is less than the plan 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 center line in each direction from the affected location until in each direction a core is found which is not deficient by more than 25.4 mm. Areas found deficient in thickness by more than 25.4 mm will 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. Patch all core holes within 72 hours of taking the core, using a Department approved nonshrink grout compatible with the pavement concrete.

710-10 MEASUREMENT AND PAYMENT

(A) General

The quantity of portland cement concrete pavement to be paid for will be the actual number of square meters of concrete pavement that has been completed and accepted. In measuring this quantity, the width of the pavement will be as called for on the plans or as directed. The length will be the actual length constructed, measured along the centerline of the pavement.

Separate measurement will be made of pavement that is deficient in thickness by more than 5.1 mm and of pavement that is deficient in flexural strength.

The quantities of portland cement concrete pavement will be paid for at the contract unit price per square meter for "____ mm Portland Cement Concrete Pavement, Through Lanes, (with dowels)", "____ " Portland Cement Concrete Pavement, Ramps, (with dowels)", or "____ mm Portland Cement Concrete Pavement, Miscellaneous, (without dowels)", or if applicable, at such contract unit prices adjusted in accordance with the requirements shown below. No unit price adjustments on lots will be made until a final determination of the lot strength and depth is made. Pavement will be classified as through lane, ramp, or miscellaneous pavement in accordance with the classification shown on the plans.

Payment for all work of surface testing will be made at the contract lump sum price for *Surface Testing Concrete Pavement*. Partial payments for surface testing will be proportional to the percentage of pavement which has been surface tested at the time the partial estimate is prepared.

(B) Pavement Deficient In Thickness

The quantities of portland cement concrete pavement which are deficient in thickness by more than 5.1 mm but not deficient by more than 25.4 mm, measured as provided in Article 710-10, will be paid for at an adjusted contract unit price per square meter for "____ mm Portland Cement Concrete Pavement, Through Lanes, (with dowels)", or "____ mm Portland Cement Concrete Pavement, Ramps, (with dowels)", or "____ mm Portland Cement Concrete Pavement, Miscellaneous, (without dowels)" completed in place and accepted. The adjusted contract unit price will be as follows:

Deficiency, mm	Pay Factor (%)
0.0 to 5.1	100
5.2 to 7.6	80
7.7 to 10.2	72
10.3 to 12.7	68
12.8 to 19.1	57
19.2 to 25.4	50

Pavement areas deficient in thickness by more than 25.4 mm will be removed and replaced.

Where pavement deficient by more than 25.4 mm is removed and replaced, the replacement pavement will be paid for at the contract unit price per square meter for "____ mm Portland Cement Concrete Pavement, Through Lanes, (with dowels)", or "____ mm Portland Cement Concrete Pavement, Ramps, (with dowels)", or "_____ mm Portland Cement Concrete Pavement, Miscellaneous, (without dowels)" which price and payment will be full compensation for all work of placement, removal, restoration of subgrade and base, and replacement.

(C) Concrete Pavement Varying In Flexural Strength

The pay factor for pavement achieving a flexural strength in 28 days of 4.5 MPa or greater is 100%. The pay factor for pavement achieving a flexural strength in 28 days between 4.1 Mpa and 4.5 MPa is determined by the following formula:

$$\left[\begin{array}{l} \text{Pay Factor (\%)} = 100.0 - \quad 4.5 \ - \ \text{MPa} \\ \\ \text{(Pay factor rounded to nearest tenth of one percent)} \end{array}\right]$$

The quantities of portland cement concrete pavement that meet these criteria, will be paid for at an adjusted unit price per square meter for "____ mm Portland Cement Concrete Pavement, Through Lanes, (with dowels)", or "____ mm

Portland Cement Concrete Pavement, Ramps, (with dowels)", or "____ mm Portland Cement Concrete Pavement, Miscellaneous, (without dowels)" completed in place and accepted. The adjusted contract unit price will be determined by multiplying the contract unit price by the pay factor level determined for the average strength of concrete in each lot and will be applicable to the total square meters of concrete in each lot.

Any pavement that fails to attain 4.1 MPa is subject to removal. If allowed to remain in place, the pavement will be accepted at a reduced unit price based on a pay factor level of 50% as provided in Article 105-3.

Where pavement deficient in strength is removed and replaced, the replacement pavement, if acceptable, will be paid for at the contract unit price for "____ mm Portland Cement Concrete Pavement, Through Lanes, (with dowels)", or "____ mm Portland Cement Concrete Pavement, Ramps, (with dowels)", or "____ mm Portland Cement Concrete Pavement, Miscellaneous, (without dowels)" which price and payment will be full compensation for all work including placement, removal, restoration of subgrade and base, and replacement.

(D) Multiple Adjustments in Price

Pavement found deficient in both thickness and strength will be evaluated by the Engineer to determine if it may be permitted to remain in place. Pavement permitted to remain in place will be paid for at a reduced price determined by successively multiplying the contract price by the appropriate factor indicated for each deficiency.

(E) Compensation

Payment at the contract unit prices for "____ mm Portland Cement Concrete Pavement, Through Lanes, (with dowels)" and "____ mm Portland Cement Concrete Pavement Ramps, (with dowels)" and "____ mm Portland Cement Concrete Pavement, Miscellaneous, (without dowels)" will be full compensation for all work covered by this section.

Payment at the contract lump sum price for "Surface Testing Concrete Pavement" will be full compensation for all work of surface testing including but not limited to furnishing, maintaining, and operating the profilograph and towing equipment; for furnishing graph paper and any other materials and supplies for performing the surface testing; and for repairing membrane curing compound damaged during surface testing.

(F) Payment will be made under:

Pay Item	Pay Unit
__ mm Portland Cement Concrete Pavement, Through Lanes (with dowels)	Square Meter
__ mm Portland Cement Concrete Pavement, Ramps (with dowels)	Square Meter
__ mm Portland Cement Concrete Pavement, Miscellaneous (without dowels)	Square Meter
Surface Testing Concrete Pavement	Lump Sum

SECTION 720
CONCRETE SHOULDERS

720-1 DESCRIPTION

Perform the work covered by this section including but not limited to the construction of portland cement concrete shoulders in accordance with these Specifications and with the lines, grades, and dimensions shown on the plans; designing the mix; furnishing and placing the concrete shoulders; furnishing maturity testing equipment; furnishing all admixtures and additives; constructing joints; furnishing joint materials; curing the shoulder and furnishing curing materials; coring and patching core

holes; taking actions to prevent or repair cracking; and removing and replacing unsatisfactory shoulder.

720-2 MATERIALS

Refer to Division 10.

Item	Section
Portland Cement Concrete	1000
Curing Agents	1026
Joint Filler	1028-1
Low Modulus Silicone Sealant	1028-4
Water	1024-4
Dowels and Tie Bars	1070-6

720-3 COMPOSITION OF CONCRETE

Design the concrete mix in accordance with Section 1000.

720-4 ACCEPTANCE OF CONCRETE

Concrete shoulders will be tested for acceptance with respect to flexural strength and thickness on a lot by lot basis. A lot is defined in Article 710-4.

720-5 EQUIPMENT

Use equipment in the production and placement of the concrete shoulders in accordance with Section 700 and Section 1000.

720-6 CONSTRUCTION METHODS

Place the concrete shoulders only in the presence of an authorized representative of the Engineer. Construct concrete shoulders in accordance with Section 700.

Place the full width of the shoulder in a single operation.

720-7 FINISHING

Finish the shoulder surface with approved equipment. Hand finishing will be permitted when the use of mechanical finishing equipment is impractical.

Perform the final finishing of the shoulder surface by burlap dragging or brooming, or other acceptable methods that will produce a similar surface texture acceptable to the Engineer.

720-8 JOINTS

Construct and seal all joints in accordance with Article 700-11 and 700-12 except as provided in this article. Saw all joints in the concrete shoulder and seal with joint sealer as shown in the plans.

Dowels will not be required at the transverse joints in the concrete shoulder. Use tie bars between the concrete pavement and the concrete shoulder.

Match the transverse joints in the concrete shoulder with the transverse joints in the adjacent concrete pavement.

720-9 THICKNESS TOLERANCES

The thickness of the shoulder will be determined by measurement of cores tested in accordance with AASHTO T 148 as modified by the Department. Copies of the modified test procedures are available upon request from the Construction Unit.

A lot for thickness acceptance testing is defined in Article 710-4.

Take one core from each lot at a random location as directed. Core each location in the presence of the Engineer. Take cores with a diameter of 101.6 mm and deliver them to the Engineer for measurement. When the required thickness for the shoulder varies, each core will be measured and compared to the required thickness for the shoulder at the location of the core. The deviation of the measured core thickness from the required

thickness will be recorded as a plus or minus value for each core. Thickness tolerances in Article 710-9 apply for concrete shoulders.

720-10 MEASUREMENT AND PAYMENT

(A) General

Concrete Shoulders Adjacent to __mm Pavement will be measured and paid for as the actual number of square meters of shoulders that have been completed and accepted. In measuring this quantity, the width of the shoulders will be as called for on the plans or as directed by the Engineer. The length will be the actual length constructed, measured along the surface of the shoulders at the centerline of each shoulder.

(B) Shoulder Deficient in Thickness

Pay factors are determined in accordance with Subarticle 710-11(B). When the shoulder is deficient in thickness by more than 25.4 mm, the Engineer will determine if the shoulder can be left in place or be removed and replaced. Where the Engineer determines the shoulder can be left in place, the shoulder will be accepted at a reduced unit price not to exceed 50% as provided in Article 105-3.

(C) Concrete Shoulder Varying In Flexural Strength

Concrete shoulders shall meet the strength requirements of Subarticle 710-11(C).

The quantities of concrete shoulder that fail to meet 4.5 MPa, measured as provided in Article 710-10, will be paid for at an adjusted unit price per square meter, completed in place and accepted. The adjusted contract unit price will be determined by multiplying the contract unit price by the pay factor level determined for the average strength of concrete in each lot and will be applicable to the total square meters of concrete in each lot.

Where concrete shoulder deficient in strength is removed and replaced, the replacement pavement, if acceptable, will be paid for at the contract unit price for Concrete Shoulders Adjacent to ____ mm Pavement, which price and payment will be full compensation for all work of placement, removal, and replacement.

(D) Multiple Adjustments in Price

Concrete shoulder found deficient in both thickness and strength will be evaluated by the Engineer to determine if it may be permitted to remain in place. Concrete shoulder permitted to remain in place will be paid for at a reduced price determined by successively multiplying the contract price by the appropriate factor indicated for each deficiency.

(E) Pay Items

Payment will be made under:

Pay Item	Pay Unit
Concrete Shoulders Adjacent to __ mm Pavement	Square Meter

SECTION 725
FIELD LABORATORY FOR
PORTLAND CEMENT CONCRETE PAVEMENT

725-1 DESCRIPTION

Perform the work covered by this section including but not limited to providing and maintaining the building or trailer and the curing shelter for the exclusive use of the Engineer at concrete plants producing portland cement concrete for use in pavement to be constructed on the project; furnishing water, heat, electricity, and other utility services; and any other equipment that may be necessary.

725-2 GENERAL REQUIREMENTS

Furnish and maintain for the exclusive use of the Engineer a field laboratory in which to house and use all testing equipment needed. Provide a laboratory that is dust and water tight, floored, and has an adequate foundation so as to prevent excessive floor movement. Provide a laboratory which contains 6 or more 110 volt electrical double outlets properly grounded and spaced; a telephone; at least 2 windows, satisfactory locks on all doors and windows; adequate lighting, heating, and air conditioning; sink; running water to sink; and satisfactory exhaust fan. Provide a laboratory that meets the following approximate minimum requirements: 18.6 m^2 of floor space; 3 m interior width; 2 m interior height; 1.9 m^2 of counter space, 0.8 to 0.9 m high and 0.6 m deep with cabinets or drawers below the counter top; and 0.6 m^2 of desk space not enclosed with cabinets. Locate the laboratory in a position that will permit full view of the plant from the interior of the laboratory. At or near the laboratory, furnish toilet facilities, with waste disposal, available for use of the Department personnel. Maintain these toilets in a neat and clean condition.

Provide a curing shelter adjacent to the laboratory that is at least 18.6 m^2 in area, approximately 3 m wide, 6.1 m long, and 2.1 m in height. Provide a workbench that is approximately 3 m long, 0.6 m wide, and 0.6 m high across the end of the shelter. Provide, in the shelter, a sand bed at least 0.3 m deep, and approximately 3 m wide and 4.3 m long, which is enclosed on all 4 sides by timbers. Equip the shelter with curtains made of burlap, canvas, or other suitable materials, that may be raised or lowered to protect the sand bed and workbench from the sun. Furnish a wooden mixing board at least 19.1 mm thick and approximately 1.2 m wide and 1.2 m long, which is covered on one side with sheet metal of at least 22 gage, at the shelter. Provide a water supply to maintain the sand bed in a moist condition. Provide facilities to maintain the test beams at temperature between 15.6°C and 26.7°C during curing.

In lieu of equipping the curing shelter with a sand bed as required above, the Contractor may provide a similar facility meeting all of the above requirements except equipped with water storage tanks. Construct the water storage tanks of non-corroding materials and have requirements for automatic control of the water temperature. Maintain the water in the tank at a temperature of 22.8°C ±1.7°C. Equip each tank with a recording thermometer with its bulb located in the water. Provide sufficient tank volume to maintain all beams, stored with the long axis vertical, in a fully submerged condition for the duration of the required curing period.

725-3 MEASUREMENT AND PAYMENT

Field Laboratory Rental, Portland Cement Concrete Pavement will be paid for at the contract lump sum price which will be made for furnishing and maintaining all field laboratories which have been made available for use by the Engineer at any concrete plant producing portland cement concrete for use in pavement to be constructed on the project. Partial payments for field laboratory rental will be made with the first and last partial pay estimates which include concrete pavement and/or concrete shoulders. Payments will be made at the rate of 50 percent of the lump sum price for "Field Laboratory Rental, Portland Cement Concrete Pavement" on each of these partial pay estimates.

Payment will be made under:

Pay Item	Pay Unit
Field Laboratory Rental, Portland Cement Concrete Pavement	Lump Sum