SECTION 411 - PORTLAND CEMENT CONCRETE PAVEMENT

411.01 Description. This section describes constructing portland cement concrete (PCC) pavement, with or without reinforcement, on a prepared surface.

411.02 Materials.

- Structural Concrete (minimum 14-day flexural strength, f'_c = 650 psi) 601
- Joint Filler 705.01
- Joint Sealer 705.04
- Reinforcing Steel 709.01
- Curing Materials 711.01

411.03 Construction.

(A) Paving Plan. Submit paving plan for review and acceptance by the Engineer. The Engineer will review the paving plan in accordance with Subsection 105.04 – Review and Acceptance Process. The plans include the following:

1. Mix design.
2. Construction method.
3. Description of mixing, placing, finishing, curing, and lighting equipment for night work.
5. If applicable, early usage of concrete pavement.
6. Location, sequence, and construction leave-outs indicated in the contract documents or required by the Contractor’s operation.

Submit revised paving plan prior to conducting work that deviates from plan accepted by the Engineer. Paving shall not start until the paving plan is acceptable to the Engineer.

(B) Equipment.

1. Batching Plant and Mixers. Batching plant and mixers shall conform to Section 601 - Structural Concrete.
(2) **Hauling Equipment.** Hauling equipment shall conform to Section 601 - Structural Concrete.

(3) **Finishing Equipment.**

(a) **Finishing Machine.** Finishing machine shall be self-propelled and equipped with at least two oscillating-type, transverse screeds that shall finish the surface to meet requirements specified in Subsection 411.03(N) - Surface Test and Subsection 411.03(T) - Pavement Thickness. Finishing equipment shall not displace reinforcement, side forms, or joints.

(b) **Vibrators.** Vibrators for full-width concrete consolidation may be either internal-type, with immersed tube or multiple spuds, or surface pan type. Vibrators shall be attached to spreader or finishing machine, or shall be mounted on separate carriage. Vibrators shall not come in contact with reinforcement, load transfer devices, subgrade, and side forms.

Furnish vibrators that operate at frequencies not less than the following: 3,500 impulses per minute for surface vibrators; and 5,000 impulses per minute for internal and hand vibrators. Furnish tachometer for measuring and indicating vibration frequencies.

(c) **Mechanical Floats.** Mechanical floats shall be self-propelled and designed to finish pavement surface uniformly smooth and true to grade. Run mechanical floats either on side forms or on adjacent lanes of concrete.

Floats shall be constructed of hardwood, steel, or steel-clad wood and shall be equipped with devices to permit adjusting underside to a true flat surface.

(d) **Slip-Form Pavers.** Slip-form pavers shall be self-propelled and equipped with traveling side forms of sufficient dimensions, shape, and strength to spread, consolidate, and screed freshly placed concrete in one complete pass, with minimum hand finishing. Pavers shall produce dense and homogeneous pavement, true to cross section and profile indicated in the contract documents.

Slip-form pavers shall be equipped with high-frequency internal vibrators that vibrate concrete for full paving width and depth.
Vibrators may be mounted with their axes either parallel or normal to pavement alignment. Where vibrators are mounted with their axes parallel to pavement alignment, space vibrators at intervals not to exceed 2.5 feet, measured center to center. Where vibrators are mounted with their axes normal to pavement alignment, space vibrators such that lateral clearance between individual vibrating units does not exceed 0.5 feet.

While pavement is being spread, compacted, and shaped, operate vibrating units such that longitudinal axis, at the center of each unit, is not more than 0.5 feet above existing paving surface.

Paving operations may be conducted using either one machine or mechanical spreader followed by separate finishing unit.

(4) **Concrete Saw.** If sawed joints are specified or elected by the Contractor, furnish power-driven concrete saws sufficient in number, power, and type of blade to cut joints. Provide at least one back-up saw and replacement blades during concrete sawing operations. Equip saws with blade guards and guides or devices to control alignment and depth. Remove all cuttings, slurry, and other by-products of the sawing operations from the work site.

(5) **Forms.** Use 10-foot-long straight side forms made of metal having thickness not less than 7/32 inch, depth equal to prescribed pavement edge thickness, and base width not less than 80 percent of prescribed pavement thickness. Horizontal form joints will not be allowed unless built-up forms, as specified in this subsection, are accepted by the Engineer. Forms shall be sufficiently rigid to prevent edge alignment distortion under subgrading and equipment loads or concrete pressure, or combination thereof. Furnish form sections that are straight, free from bends, warps, indentations, and other defects. Sections that deviate from true plane along top of form more than 1/8 inch in 10 feet or along face of form more than 1/4 inch in 10 feet will be rejected.

Join form lengths in a manner that ensures tight, neat joints at form connections and prevents springing from occurring under subgrading and paving equipment loads or concrete pressure, or combination thereof. Built-up forms may be used by rigidly attaching section of suitable width and thickness to either top or bottom of form. If built-up is attached to top of form, use metal built-up.
For curves of 100-foot radius or less, use flexible forms or curved forms having proper radius. Special forms of wood or metal may be used for curved form lines having radius of 200 feet or less. Five-foot-long, straight metal form sections may be used for curved form lines having radius greater than 100 feet. Straight metal forms in sections 10 feet or less in length may be used for form lines having radius greater than 200 feet.

Special forms of wood or metal may be used for curved form lines having radius of 200 feet or less. Where use of standard pavement forms is not feasible, submit working drawings at least 10 working days before production. Five-foot-long, straight metal form sections may be used for curved form lines having radius greater than 100 feet.

Use of wood forms as a track for operating paving and finishing equipment will not be allowed.

(C) Preparing the Proper Grade. Trim beyond edges of proposed concrete pavement to accommodate forms and slip-form paving equipment. Fill and compact areas that are below established grade with subgrade or base course material, in lifts up to 1/2 inch, for widths of 18 inches on both sides of form base. Tamp and trim areas above established grade, as necessary.

(D) Setting Forms. Before placing forms, compact foundation to ensure continuous contact with forms. Set forms and check for correct line and grade before placing concrete. Tamp inside and outside edges of form base. Use three pins for each 10-foot section to stake forms in place. Place pins on each side of every joint. Lock form sections to prevent play or movement in any direction. Forms shall withstand impact and vibration due to consolidation operations and shall remain true to within 1/4 inch. Before placing concrete, clean and coat forms with form release agent or oil, accepted by the Engineer. At least one working day prior to placing concrete, notify the Engineer that forms are ready for inspection.

(E) Conditioning of Subgrade or Base Course. Unless waterproof cover material is indicated in the contract documents, keep subgrade and base course uniformly moist before placing concrete.

(F) Handling, Measuring, and Batching Materials. Handle, measure, and batch materials in accordance with Section 601 - Structural Concrete.

(G) Mixing Concrete. Mix concrete in accordance with Section 601 - Structural Concrete.
(H) **Mixing Limitations and Water Supply.** Provide for adequate natural or artificial lighting when mixing, placing, and finishing concrete.

Place mixed concrete only when concrete temperature is between 50 and 90 degrees F. Use Plastic Shrinkage Evaporation Chart ACI 305 as a guide to determine if additional precautions should be taken to prevent shrinkage cracks.

Before placing concrete pavement, provide adequate supply of water for entire work period. Inadequate water supply will be sufficient cause for delaying or stopping mixing operations. If there is a water supply deficiency, give first water-use priority to curing concrete already placed before using water for mixing concrete.

(I) **Placing, Consolidating, and Shaping Concrete.**

(1) **General.** Make advance arrangements for preventing delay in concrete delivery and placement. An interval of more than 45 minutes between placement of two consecutive batches or loads shall constitute cause for stopping paving operations and requiring construction joint to be placed, at no increase in contract price or contract time, at location and of the type ordered by the Engineer.

Prior to placing concrete, demonstrate proper adjustment of screeds and floats on slip-form pavers by measurements from grade stakes driven to known elevations. Placement of concrete shall not start until this is done. Demonstrate satisfactory operation and adjustments of propulsion and control equipment, including pre-erected grade and alignment lines, by running slip-form pavers and finishing machines over 500-foot length of prepared subgrade or base course with propulsion and control equipment fully operational.

Unless otherwise indicated in the contract documents, construct pavement in full-lane widths separated by longitudinal weakened plane joints, or monolithically in multiples of full-lane widths, with longitudinal weakened plane joints at each traffic lane line.

Deposit concrete with minimum of handling. Spread concrete uniformly over entire area between forms, without segregation, using mechanical spreader. Where hand methods are necessary due to pavement design, equipment breakdown, or other factors, use shovels, not rakes, for hand spreading. Place concrete continuously between transverse joints without using intermediate bulkheads. Prohibit workers from walking in concrete with boots or shoes coated with earth or foreign substances.
Improperly proportioned concrete will be rejected. Remove and dispose of concrete rejected by the Engineer in accordance with Subsection 201.03(E) - Removal and Disposal of Material, at no increase in contract price or contract time.

Spread, consolidate, and shape concrete so that completed pavement will conform to thickness and cross-sectional requirements indicated in the contract documents. Sides of pavement may be constructed with batter not exceeding one horizontal to six vertical, provided that pavement top width is maintained as indicated in the contract documents.

Where widening PCC pavement contiguous with existing parallel concrete pavement not constructed as part of the contract, spread, consolidate, and shape concrete so that completed pavement will conform to thickness and cross-sectional requirements indicated in the contract documents and to the following:

(a) Elevation of completed pavement surface shall be such that water will not pond on either sides of longitudinal joint with existing pavement.

(b) New pavement surface at longitudinal joint shall conform to elevation of existing concrete pavement. If necessary, provide smooth transition between new and existing pavement by hand finishing new pavement within one foot of existing pavement, adding or removing concrete, as necessary.

(c) Transverse straightedge, longitudinal straightedge, and Profile Index requirements specified in Subsection 411.03(M) - Final Strike-Off, Consolidation, and Finishing and Subsection 411.03(N) - Surface Test will not apply to pavement surface within 1-foot of existing concrete pavement unless in the opinion of the Engineer the surface finish of the installed concrete pavement exhibits poor workmanship, e.g., finished surface is rougher than existing surface, roughness of surface cannot be attributed to the existing concrete pavement.

(d) Profiles of completed pavement surface specified in Subsection 411.03(N) - Surface Test will not be required within four feet of longitudinal contact joint with existing concrete pavement unless in the opinion of the Engineer the surface finish of the installed concrete pavement exhibits poor workmanship, e.g., finished surface is rougher than existing surface, roughness of surface cannot be attributed to the existing concrete pavement.
(e) Thickness measurements specified in Subsection 411.03(T) - Pavement Thickness will not be made in pavement within one foot of existing concrete pavement.

(f) Transverse weakened plane joints shall be constructed in pavement widening to match spacing and skew of weakened plane joints in existing pavement.

Where concrete is to be placed adjacent to previously constructed pavement, keep mechanical equipment off previously constructed pavement until that concrete pavement has attained flexural strength of not less than 550 pounds per square inch when tested in accordance with AASHTO T 97.

Where concrete is being placed adjacent to existing pavement, provide that part of equipment supported on existing pavement, with protective pads on crawler tracks or rubber tired wheels; and offset bearing surface to run a sufficient distance from pavement edge to avoid breaking or cracking that edge.

(2) Stationary Side Form Construction. Provide sufficient quantity of forms so that there shall be no delay due to lack of forms. Spread, consolidate, and shape concrete by one or more machines. Use machines that uniformly distribute and consolidate concrete without segregation, so that completed pavement conforms to cross section indicated in the contract document, with minimum handwork.

Furnish paving machines in sufficient number and capacity to finish work at rate equal to that of concrete delivery.

Consolidate concrete for full paving width using surface or internal vibrators, or by other method of consolidation that produces equivalent results without segregation.

Operate vibrators at manufacturer’s recommended frequencies based on compatibility with pertinent factors, including the following: mix design, concrete slump, paver speed, and vibrator spacing. Vibration amplitude shall be sufficient to be perceptible on concrete surface more than one foot from vibrating element.

Do not rest vibrators on new pavement or side forms. Connect power to vibrators so that vibration ceases when forward or backward motion of machine is stopped.

(3) Slip Form Construction. Slip form paving equipment shall spread, consolidate, and screed freshly placed concrete to produce dense, homogeneous pavement, true to cross section and profile, with minimum handwork.
Use reference lines outside the finished concrete limits to regulate paver alignment and elevation during concrete placing and finishing operations. Abrupt changes in longitudinal alignment will not be allowed. Limit horizontal deviation to no more than 0.1 foot from alignment established by the contract documents.

Coordinate operations of mixing, delivering, and spreading concrete to allow slip form paving equipment to operate in continuous forward movement, with minimal stopping and starting. When paver forward movement is stopped, immediately cease vibrating and tamping operations. Do not apply tractive force to paving machine except that which is controlled from the machine.

Consolidate concrete for full paving width using high-frequency vibrators. Operate vibrators at manufacturer’s recommended frequencies based on compatibility with pertinent factors, including the following: mix design, concrete slump, paver speed, and vibrator spacing. Vibration amplitude shall be sufficient to be perceptible on concrete surface along entire length of vibrating units and for a distance of at least one foot therefrom.

(J) Test Specimens. Furnish concrete necessary for casting test beams and cylinders and for testing air and slump. Unless otherwise indicated in the contract documents, furnish, maintain, and clean beams or cylinder molds, or both. Beams or cylinder molds, or both shall conform to AASHTO T 23. Cure beams, as specified for pavement, in accordance with AASHTO T 23. For early opening to traffic, cure flexural test specimens at same time and in same manner as pavement.

Additional flexural strength test specimens will be required due to concrete placement conditions or to determine concrete strength where early opening of pavement to traffic is dependent on concrete strength test results.

(K) Striking-Off Concrete and Placing Reinforcing Steel. After placement, strike off concrete to cross section indicated in the contract documents.

Where pavement is placed in two layers, strike off and consolidate bottom layer to depth necessary to place fabric or reinforcing steel mat directly on concrete. Support reinforcing steel as needed to maintain its correct position.

Place top layer within 30 minutes of first layer, or remove and replace lower layer with freshly mixed concrete.

Where pavement is placed in one layer, position reinforcing steel before placing concrete.
For reinforcing steel, Subsection 602.03(B) - Storage, Surface Condition, and Protection of Reinforcement shall apply.

(L) Joints. Construct joint faces normal to pavement surface, as indicated in the contract documents. Use chalk line, string line, sawing template, or other methods to provide true joint alignment. Prior to contract acceptance, maintain joints free of soil, gravel, concrete or asphalt mix, and other foreign material except filler material.

Where sawing method is used to cut pavement grooves, use saw conforming to Subsection 411.03(B)(4) - Concrete Saw. Saw joints before uncontrolled shrinkage cracking occurs, but only after concrete has hardened sufficiently to prevent excessive tearing or raveling, or both during sawing operations. Determining concrete readiness for sawing transverse contraction and longitudinal joints in accordance with requirements specified herein shall be the Contractor’s responsibility. Cut grooves to minimum width possible for type of saw used, but limit groove width to 0.02 foot.

Once sawing has commenced for any day’s concrete placement, continue sawing for 12 hours after placement. Should sawing fail to be completed within 12 hours of concrete placement, limit subsequent concrete placements to quantities that can be sawed in 12 hours. Restore curing membrane disturbed during sawing operations by spraying disturbed areas with additional curing compound.

(1) Longitudinal Joints. Place deformed tie bars, two-piece connectors accepted by the Engineer, and smooth dowels, as indicated in the contract documents, perpendicular to longitudinal joint. Deformed tie bars and two-piece connectors shall be 30 inches long. Grade 60 No. 5 bars, placed 30 inches apart at mid-depth of slab. Where deformed tie bars are to be bent and later straightened, use Grade 40 bars. Place bars using mechanical equipment, or secure bars with chairs or other supports in accordance with Section 602 - Reinforcing Steel. Use other required sizes, grades, lengths, and spacings, based on slab width, thickness, and type of underlying base.

Unless otherwise indicated in the contract documents, tie bars may be inserted into plastic concrete. If this method results in tie bar misalignment, poor consolidation around tie bars, or concrete surface or edge slumping, or combination thereof, discontinue using this method and complete work using other methods accepted by the Engineer.

Construct longitudinal joints by sawing method at traffic lane lines in multilane, monolithic concrete pavement. Cut longitudinal joint to minimum depth d = t/3, where:
d = minimum depth of cut, rounded up to nearest 0.01 foot;
\( t \) = greatest pavement thickness (feet) in each lane.

Where adjacent lanes are constructed separately, use deformed tie bars or smooth dowels, as indicated in the contract documents. Two-piece connectors accepted by the Engineer may be used.

Clean all joint faces of any curing compound, primer or any material that may be deleterious to the bonding of the new concrete to the existing or previously poured concrete.

(2) Transverse Expansion Joints. Extend transverse expansion joint to full cross section of PCC pavement and install continuous piece of preformed joint material. Where installing joint filler, depress filler 1/2 inch below pavement surface.

Hold expansion joint filler in vertical position and limit deviation to not more than 1/4 inch from straight line along centerline of joint. Hold filler on line with metal channel. Remove channel after initial concrete set.

(3) Transverse Contraction Joints. Construct transverse contraction joints by forming or sawing grooves in pavement surface. Where indicated in the contract documents, include dowel bars and assemblies.

Transverse contraction joints may be formed by depressing tool or device into plastic concrete before initial concrete set.

If uncontrolled shrinkage cracking occurs during or before joint sawing, modify sawing sequence accordingly or use other methods accepted by the Engineer. If necessary to eliminate uncontrolled shrinkage cracking, add more sawing units or use early entry concrete cutting machines with special blades that cut through relatively fresh concrete without needing water. Where transverse crack occurs prior to sawing and any point on crack is within 5 feet of planned transverse contraction joint, omit sawing planned joint.

Unless otherwise indicated in the contract documents, construct groove between depths of 1/3 to 1/4 of pavement thickness.

(4) Construction Joints. When concrete placement is interrupted for more than 30 minutes, construct longitudinal and transverse construction joints in accordance with the contract documents. Placement of construction joint within 10 feet of another transverse joint will not be allowed. At time of interruption, if sufficient concrete
has not been mixed to form slab greater than 10 feet long, remove and dispose of concrete back to preceding joint, at no increase in contract price or contract time. When concrete placement is stopped, provide bulkhead having sufficient cross-sectional area to prevent deflection, notched to receive dowels, and shaped to pavement cross section. Bulkhead shall be placed perpendicular to the baseline and shall also be one straight across the entire width of the pavement.

(5) Dowels for Longitudinal, Transverse, Expansion, and Contraction Joints. As indicated in the contract documents, provide smooth, straight dowels, conforming to Subsection 709.01(E) - Dowels; and deformed dowels conforming to Subsection 709.01(F) - Tie Bars.

At transverse joints, space dowels in pavement at one-foot centers, parallel to pavement surface and traffic direction.

Use joint assemblies or wire baskets that remain in pavement to hold dowels in place during concrete placement and finishing. For referencing, properly mark center of dowel assembly on both sides of pavement slab.

For expansion joints, unless otherwise indicated in the contract documents, use dowels with one end of each coated dowel encased in cap conforming to Subsection 709.01(E)(2) - Joint Dowels.

Place dowels in pavement with alignment tolerance of ±1/4 inch per dowel and depth \( d = \frac{t}{2} \), where:

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\begin{align*}
d &= \text{minimum depth, rounded up to nearest 0.01 foot;} \\
t &= \text{pavement thickness (feet) in each lane.}
\end{align*}
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Maintain dowel position and arrangement when placing and consolidating concrete around dowels.

Unless otherwise indicated in the contract documents, coat entire length of each dowel with de-bonding material accepted by the Engineer. At the Contractor’s option, dowels may be lightly coated with grease accepted by the Engineer. Use of cutback asphalts, emulsions, or oils will not be allowed for coatings.

(M) Final Strike-Off, Consolidation, and Finishing.

(1) Sequence. Sequence operations as follows: strike-off, consolidate, float, remove laitance, straightedge, and perform final surface finish. Provide work bridges and other equipment necessary to reach pavement surface to inspect, straightedge, finish, and perform corrective work as necessary.
Finish concrete surface without adding water to surface.

(2) **Finishing at Joints.** Strike-off, consolidate, and finish, in a manner that does not damage or misalign, or both, joint assemblies, load transfer devices, and other embedded items. Vibrate concrete mechanically next to joints without creating voids or segregation, or both.

If finishing operation causes segregation, damage, or joint misalignment, or combination thereof, stop finishing equipment when screed is approximately 8 inches from joint. Remove segregated concrete surrounding joint. Lift front screed and set it directly over joint before continuing forward motion. Lift and carry second screed over joint when it is close enough to force excess mortar over joint. If segregation is prevented, subsequent finishing over joint without lifting screeds will be allowed.

(3) **Machine Finishing.**

(a) **Nonvibratory Method.** Use finishing equipment to strike off, screed, and texture concrete immediately after it is distributed or spread. Avoid excessive finishing. Keep top of forms free of concrete and debris.

Maintain uniform ridge of concrete along entire paving width and ahead of screed during first pass of finishing machine.

(b) **Vibratory Method.** Vibrators for full-width vibration of concrete paving slabs shall conform to Subsection 411.03(B)(3)(b) - Vibrators. When uniform and satisfactory concrete density is not obtained by vibratory method, furnish other equipment and methods that produce pavement conforming to the contract. Where not in conflict with provisions in Subsection 411.03(M)(3)(a) – Nonvibratory Method, provisions for vibratory method, shall govern.

(4) **Hand Finishing.** Use hand-finishing methods only under the following conditions and locations:

(a) When mechanical equipment breaks down, stop concrete placement and hand-finish concrete already in place.

(b) In areas of narrow widths or irregular shapes, hand-finish those areas that cannot be finished by mechanical equipment.
(c) Hand floating in other portions of the contract documents shall be performed.

Use portable screed to strike-off and screed concrete. Provide second portable screed to strike-off bottom concrete layer when placing reinforcing steel during two-layer concrete placement.

Use metal screed or metal-reinforced screed, that is at least 2 feet longer than widest part of slab to be placed.

Consolidate concrete with hand-operated vibrator.

Move screed along forms in forward motion that combines longitudinal and transverse shearing motion without raising either end from side forms. Repeat this strike-off process until pavement is true to grade and cross section, and surface texture is uniform and free of porous areas.

(5) Floating. After striking off and consolidating concrete, use float to finish surface to specified grade and smoothness. Use one of the following methods:

(a) **Hand Method.** Use hand-operated, longitudinal float at least 12 feet long and 6 inches wide and sufficiently rigid to retain its shape. Operate longitudinal float from footbridges. Work float in sawing motion while holding it in position parallel to road centerline and passing it gradually from one side of pavement to the other.

Move ahead along pavement centerline, advancing not more than one-half of float length. Waste excess water and laitance over side forms on each pass.

(b) **Mechanical Method.** Adjust tracks and float to required crown. Coordinate float with adjustments of transverse finishing machine so that small quantity of mortar is maintained ahead of float. Operate float over pavement as few times and at such intervals as is necessary to produce surface of uniform texture. Excessive operation over a given area will not be allowed. Waste excess water and laitance over side forms on each pass.

(c) **Alternate Mechanical Method.** Use equipment with cutting and smoothing float or floats, suspended from and guided by rigid frame mounted on four or more visible wheels. Maintain constant contact of all four wheels with forms.
After mechanical floating, use hand method to fill open-textured areas in pavement or if the method does not provide an acceptable finish.

(d) Slip-Form Finishing. Construct pavement with preliminary float finish using devices incorporated in slip-form paver. Suitable machine floats may be used to supplement finish achieved by slip-form paver.

Before concrete has hardened, correct pavement edge slump, exclusive of edge rounding, in excess of 0.02 foot.

(6) Straightedge Testing and Surface Correction. After completing floating and removing excess water and laitance, correct surface irregularities while concrete is plastic. Fill, strike-off, consolidate, and refinish depressions. Cut down and refinish high areas. Smooth surface across joints to tolerances indicated in the contract documents.

Test concrete surface for trueness using 10-foot straightedge swung from handle that is 3 feet longer than one-half of slab width. Hold straightedge in contact with surface in successive positions parallel to road centerline. Test entire pavement width, moving from one side of slab to the other, as necessary. Advance testing operation along road, in successive stages of not more than one-half straightedge length.

(7) Final Finish. After surface sheen has disappeared, texture pavement surface without tearing it. Texture final surface using artificial turf drag followed immediately by metal comb transverse grooving device.

Use artificial turf made of molded polyethylene with synthetic turn blades measuring approximately 0.85 inches long and containing approximately 7,200 individual blades per square foot. Submit sample of artificial turf at least five working days before production.

Attach artificial turf to self-propelled equipment having external alignment control. Device shall be separate piece of equipment to be used exclusively for texturing operation and shall not be attached to other paving-train equipment. Artificial turf shall be full pavement width and of sufficient size that during finishing operation, approximately 2 feet of turf, parallel to pavement centerline, is in contact with pavement surface. Maintain downward pressure on pavement surface with turf, so as to achieve uniform texturing without measurable variations in pavement profile.
Metal comb shall include single line of randomly spaced, tempered spring steel tines of size and stiffness sufficient to produce grooves of specified dimensions in plastic concrete without edge slumping and severe surface tearing. Attach metal comb to mechanical device capable of traversing entire pavement width in single pass at uniform speed. Operate grooving device to produce random pattern of grooves perpendicular to pavement centerline. Randomly spaced grooves shall have in the harden pavement surface a minimum spacing of 0.4 inch and maximum spacing of 1.5 inches between centers, with no more than 50 percent of spaces exceeding 1 inch, 1/8 inch to 3/16 inch deep, and 1/10 inch to 1/8 inch wide. Provide hand combs with steel tines to use in event of mechanical comb breakdown.

Ramps, tapers, and miscellaneous areas may be textured manually.

(8) Edging at Forms and Joints. After final finish, tool pavement edges to radius of 1/4 inch, along both sides of each slab; and on both sides of transverse expansion joints, formed joints, and construction joints. Produce smooth, dense mortar finish.

Eliminate tool marks on slab, next to joints. Avoid disturbing rounding of slab corners. Remove concrete from joint filler top.

Before concrete sets, test joints with straightedge and correct unevenness between joints and adjacent slabs.

(N) Surface Test. Request testing to take place not more than 14 days following concrete placement. If the Engineer does not test the surface until after the 14-day period, the results shall be accepted as if it took place within the 14-day time period. Finished pavement shall conform to the following requirements when tested by the Engineer:

(1) Conduct surface test using 12-foot straightedge at locations determined by the Engineer. When straightedge is laid on finished pavement in direction parallel or normal to centerline, surface shall not vary more than 1/4 inch from lower edge.

(2) The Engineer will determine profile of pavement surface using profilograph in accordance with HDOT TM 6 and these specifications. The Engineer will take profiles 3 feet from and parallel to each pavement edge and at approximate location of each longitudinal joint.

Make profile test request to the Engineer at least seven calendar days before desired testing date. When request for testing is made, submit total area to be tested. Clean and clear obstructions from area to be tested. The Contractor shall provide traffic control for
profilograph testing. The Engineer will perform initial and one follow-up profilograph test, at no cost to the Contractor. Based on initial profilogram, the Contractor shall perform remedial work before requesting follow-up profilograph testing. The Contractor shall perform additional remedial work and the Engineer will perform follow-up testing until acceptable surface is obtained. Additional testing, beyond initial test and one follow-up, will be performed at cost to the Contractor of $1,000 per test per day.

During initial paving operations or after a long shutdown, when concrete has cured sufficiently to allow testing, furnish, operate, and test pavement surface using California-type profilograph, to calculate profile index.

Repair curing membrane damaged during surface remediation and testing operations.

The Contractor and the Engineer will use initial profile testing results to aid in evaluating paving methods and equipment. When average profile index exceeds 15 inches per mile, suspend paving operations. Resumption of paving operations will not be allowed until corrective action is taken and accepted by the Engineer. Subsequent paving operations will be tested in accordance with initial testing procedures.

Use paving equipment and methods that produce riding surface having profile index of 10 or less, except as provided herein.

Profile testing will not be required for the following pavement areas:

(a) Within superelevation transition on horizontal curves having centerline curve radius less than 1,000 feet.

(b) Within 15 feet of transverse joint that separates pavement from existing pavement not constructed under the contract or from structural deck or approach slab.

Reduce individual high points over 0.3 inch, as determined by profilogram measurements in accordance with HDOT TM 6, by grinding until such high points shown by profilograph reruns do not exceed 0.3 inch.

After completing grinding of high points, perform additional grinding as necessary to reduce Profile Index in accordance with requirements specified in Subsection 411.05 – Payment.
Perform additional grinding as necessary so that lateral limits of grinding are at constant offset from and parallel to nearest lane line or pavement edge. Perform additional grinding, as necessary, to extend area ground within any one surface area, in each longitudinal direction so that grinding begins and ends at lines normal to pavement centerline. Ground areas shall be neat, rectangular areas having uniform surface appearance.

Do not grind pavement to smooth or polished finish. Unless otherwise indicated in the contract documents, grinding shall provide a line-type texture that contains parallel, longitudinal corrugations with ridge peaks approximately 1/16 inch higher than groove bottoms; and with 55 to 60 evenly spaced grooves per foot. Pick up grinding-operation residue using vacuum attached to grinding machine. Prevent residue from flowing across pavement and from being left on pavement surface. Dispose of grinding residue.

Use of bush hammers and other impact devices will not be allowed for pavement surface remediation.

Complete corrective work before determining pavement thickness in accordance with Subsection 411.03(T) - Pavement Thickness.

(O) Curing. After finishing operations have been completed and as soon as marring of concrete will not occur, cure entire newly placed concrete surface and edges in accordance with one of the methods described in this subsection. When curing requires use of water, assign highest priority for project water supply allocation to curing operations. Suspend concrete operations if there is insufficient cover material or water supply for curing and other project requirements. Do not leave concrete exposed for more than 30 minutes between stages of curing or during curing period. Use atomized fog spray to place water into the air to increase the humidity as an interim cure or other methods accepted by the Engineer until final curing medium is in place. Cure concrete for at least 72 hours immediately after finishing operation.

(1) Cotton or Burlap Mats. Cover surfaces to be cured with cotton or burlap mats having dimensions that when placed, extend at least 2 feet beyond edges of concrete strip placed. Overlap mats at least 6 inches. Place and maintain mats in complete contact with surface being cured, throughout curing period. Keep mats fully moist and in position for entire portion of required cotton or burlap curing period.
(2) **Waterproof Paper.** Thoroughly wet pavement surface and edges before placing paper. Cover surfaces to be cured with waterproof paper, sized to extend when sheets are placed, at least 2 feet beyond edges of concrete strip; or sized to match pavement width and supplemented with 2-foot paper edge strips. Overlap sheets at least 18 inches. Place and maintain paper in complete contact with surface being cured, throughout curing period. When sheets are laid longitudinally, seal paper so that it does not open up or separate during curing period.

(3) **White-Pigmented Curing Compound.** Immediately after finishing surface and before concrete set has taken place, spray uniformly surfaces to be cured with white-pigmented curing compound. When cotton or burlap mats are used to initially cure pavement, apply white-pigmented curing compound upon removal of mats. Do not apply curing compound during and immediately after rainfall.

Use fully atomized mechanical sprayer equipped with tank agitator and wind guard to apply curing compound, under pressure, at rate of at least one gallon per 100 square feet. Before spraying, compound shall be in thoroughly mixed condition with pigment uniformly dispersed throughout vehicle. Mechanically agitate compound continuously during application. Hand-pump sprayers will be allowed only for spraying irregular widths and shapes and concrete surfaces exposed by form removal. Do not apply curing compound to inside faces of joints to be sealed. Provide means to verify application rate.

If curing film is damaged during required curing period, immediately repair damaged portions with additional curing compound. Upon removal of side forms, immediately protect exposed slab edges with curing treatment equivalent to that provided for pavement surface.

(4) **White Polyethylene Sheeting.** Cover surfaces to be cured with polyethylene sheeting, sized to extend when sheets are placed, at least 2 feet beyond edges of concrete strip. Overlap sheets at least 18 inches. Place and maintain sheeting in complete contact with surface covered, throughout curing period.

(P) **Removing Forms.** Keep forms in place for at least 12 hours. Protect pavement from damage during form removal. After removing forms, immediately cure exposed surfaces in accordance with Subsection 411.03(O) - Curing. Pavement areas containing major honeycombed areas will be rejected. Remove and replace rejected pavement areas that are full-lane-wide sections and at least 10 feet long; and in those areas where
removal and replacement are necessary, remove remaining portions of slab that are less than 10 feet long and adjacent to joints.

(Q) Sealing Joints. Clean and seal joints after completion of curing period and before pavement is opened to traffic. Clean each joint thoroughly of foreign matter, including debris, dirt, dust, concrete, saw cuttings, and curing material. Collect and dispose of all removed material.

Dry joint surfaces before sealing joint. Apply sealing material as indicated in the contract documents. If hot sealer is used, stir material during heating to prevent localized overheating. Pour sealing material without spilling on exposed concrete pavement surfaces. Immediately remove and clean excess material from pavement surface. Use of sand or similar material as a cover for sealing material will not be allowed.

(R) Protection of Pavement. Protect pavement and its appurtenances from public and construction traffic. Protection shall include using flaggers to direct traffic; and erecting and maintaining warning signs, lights, pavement bridges, and crossovers.

Where indicated in the contract documents, construct pavement crossings for convenience of public traffic in accordance with Subsection 104.09 - Maintenance of Traffic.

Furnish and install materials for edge and surface protection of unhardened concrete. Edge protection materials include standard metal forms and wood planks having nominal thickness of not less than 2 inches and nominal width of not less than pavement-edge thickness. Surface protection materials include burlap or cotton mats, curing paper, and plastic sheeting. Stop paving operations when rain appears imminent.

Repair or replace damaged pavement before final acceptance.

(S) Opening to Traffic. Allow traffic on pavement when test specimens conforming to Subsection 411.03(J) - Test Specimens have attained flexural strength of 550 pounds per square inch when tested in accordance with AASHTO T 97. Traffic will not be allowed on pavement sooner than seven days after concrete placement, regardless of strength attainment.

Clean, sign, mark pavement properly, and clear pavement of obstructions before opening roadway to public traffic.

Construction traffic, equipment, and materials will not be allowed on pavement during curing period.

(T) Pavement Thickness. The Engineer will determine coring locations and observe coring operation. The Engineer will check thickness of pavement by cores obtained by the Contractor in accordance with
AASHTO T 24. The Engineer will measure cores in accordance with AASHTO T 148, except that measurement will be taken to nearest one thousandth of an inch; and average of such measurements will be taken to nearest one hundredth of an inch. Take thickness core samples after completion of corrective work.

The Engineer will remove non-PCC pavement materials from bottom of core before determining pavement thickness.

Thickness core samples will be evaluated on basis of primary and secondary units. Primary pavement unit is defined as that area of mainline pavement placed in each day's paving operations, but not to exceed 1,300 square yards. Each ramp, including tapers, each intersection, and each crossover will be considered separate primary units. Drill one core for each primary unit.

Secondary pavement unit is defined as 1,000 linear feet, or fraction thereof, of each mainline traffic lane and each shoulder in each primary unit. Additionally, each 1,300 square yards of pavement in ramps, tapers, intersections, and crossroads will be considered secondary units, regardless of when concrete was placed. Drill one core for each secondary unit.

When the primary or secondary unit core is deficient by more than 0.2 inch but less than 0.6 inch, drill two additional cores within same secondary unit. Length of initial and two additional cores will be averaged.

When the primary of secondary unit core is deficient by more than 0.6 inch, that core will not be used to determine average thickness of the primary or secondary unit. Drill additional cores at intervals not exceeding 10 feet in each direction from deficient core, measured parallel to centerline, until one core is obtained in each direction, which is not deficient by more than 0.6 inch. Pavement thickness between these two additional cores will be evaluated separately from balance of pavement in that lot.

Pavement limits for separate evaluation will be longitudinal weakened plane or construction joint on each side of core and next transverse weakened plane, construction, or expansion joint, beyond each of last two cores. Unless the Engineer allows pavement within evaluation limits to remain, remove and replace with pavement of specified thickness, at no increase in contract price or contract time. Drill one additional core in remaining portion of the primary or secondary unit. That portion will be evaluated separately for payment in accordance with provisions specified in Subsection 411.05 - Payment.

After replacing deficient pavement, drill one core at random in the primary or secondary unit beyond limits of replaced pavement and drill one core in replaced pavement. The Engineer will evaluate for payment, pavement represented by core taken beyond limits of replaced pavement in
accordance with provisions specified in Subsection 411.05 - Payment.

Before filling, apply epoxy grout conforming to Subsection 712.04(B) - Epoxy Grout to core holes. Fill core holes completely with concrete accepted by the Engineer.

411.04 Measurement.

(A) Concrete pavement will be paid on a lump sum basis. Measurement for payment will not apply.

(B) The Engineer will measure transverse contraction joints per linear foot in accordance with the contract documents.

411.05 Payment. The Engineer will pay for the accepted pay items listed below at the contract price per pay unit, as shown in the proposal schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Engineer will pay for each of the following pay items when included in the proposal schedule:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Pavement</td>
<td>Lump Sum</td>
</tr>
<tr>
<td>Transverse Contraction Joint</td>
<td>Linear Foot</td>
</tr>
</tbody>
</table>

The Engineer will pay for:

(A) 80 percent of the contract bid price upon completion of furnishing and placing formed joints or cutting grooves in pavement.

(B) 20 percent of the contract bid price upon completion of cleaning up, including removal of saw-cutting residue.

When the primary or secondary unit core thickness is deficient by not more than 0.2 inch from planned thickness, the Engineer will pay for that primary or secondary unit at 100 percent.

When the primary or average secondary unit core thickness indicates pavement thickness is deficient by more than 0.2 inch but not more than 0.6 inch, the Engineer will determine pay for that the primary or secondary unit an adjusted price that will be the final adjusted price after adjustments have been made for other deficiencies, if any are applicable.

The Engineer will not pay for pavement allowed to remain with thickness deficiency greater than 0.6 inch.
When the Engineer determines that thickness-deficient areas warrant removal, remove and replace those areas with concrete having thickness indicated in the contract documents. Replacement pavement will be in accordance with requirements of Subsection 411.03(T) - Pavement Thickness and this subsection.

When profile index does not exceed 10, the Engineer will pay for the accepted pavement. When profile index exceeds 10, but less than or equal to 15, the Contractor may elect to accept a reduced price adjustment as determined by the Engineer in lieu of reducing profile index. Profile index over 15 shall require corrective work.

The Engineer at its sole digression determines an adjusted price using planned thickness of PCC pavement. Adjusted price will apply to total area of the 0.1-mile section for lane width represented by profilogram.

END OF SECTION 411