Section 2301. Portland Cement Concrete Pavement

2301.01 DESCRIPTION.

A single course of PCC pavement of the type and class specified in the contract. If the class of concrete is not specified, Class C concrete shall be used.

A. Standard Concrete Pavement.
Standard concrete pavement may be reinforced or non-reinforced. Use the class of concrete specified in the contract documents. Reinforce as shown in the contract documents. Place within fixed forms, consolidate, and finish by equipment operating on forms.

B. Slip Form Pavement.
Slip form pavement may be reinforced or non-reinforced concrete of the class specified in the contract documents. Reinforce as shown in the contract documents. Place, consolidate, and finish without the use of fixed forms.

2301.02 MATERIALS.

A. General.

1. Meet the requirements for the respective items in Division 41. Unless specified otherwise, use coarse aggregate of the durability class required by Section 4115.
2. Ensure compatibility of all material combinations. If the concrete materials are not producing a workable concrete mixture, a change in the material may be required. Changes will be at no additional cost to the Contracting Authority.

B. Portland Cement Concrete Pavement.

1. General.

a. Proportion materials for pavement concrete in one of the mixtures identified in Materials I.M. 529 for the class of concrete specified in the contract documents. Any of the mixtures may be used, at the Contractor's option, provided the gradation of the separate aggregates complies with the gradation required for that mixture. Do not use C-5 and C-6 concrete mix proportions for pavements on Interstate or Primary highways.
b. After October 31, use Class A concrete to construct all items of concrete pavement specified to be constructed with Class B concrete. The Engineer will either require completion by continuing placement operations past October 31, or allow the Contractor the option of a winter shutdown. When completion is required, the Contracting Authority will pay the net increase in cost of materials resulting from the change in proportions for any pavement placed within the contract period or authorized extension of the contract period. Other increases shall be at no additional cost to the Contracting Authority.

2. Combined Fine and Coarse Aggregate.

a. If using an approved fine and coarse aggregate combination, fix the proportions on the basis of the relative amount of fine and coarse aggregate contained so as to be equivalent to one of the appropriate mixes specified for screened aggregates. These proportions are based on a specific gravity of 2.62 for Class V aggregate and 2.65 for other aggregates.
b. If the material furnished shows an average specific gravity other than the above values, adjust the proportions by the ratio of the actual average specific gravity to the above values.

3. Water, Consistency, and Batch Yield.

a. Use an amount of mixing water that will produce workable concrete of uniform consistency. Unless specifically modified by the Engineer, ensure slump, measured according to Materials I.M. 317, is no less than 1/2 inch (15 mm) or no more than 4 inches (100 mm). Slump requirements will not apply to slip form paving.
b. If it is not possible to produce concrete having the required consistency without exceeding the maximum allowable water cement ratio specified, the cement content may be increased or water reducing admixture may be added. Obtain the Engineer’s approval. Do not exceed the maximum water cement ratio. Additional cement or water reducer will be considered incidental, with no additional cost to the Contracting Authority.

c. The basic absolute volume of water per unit volume of concrete is based on average conditions. If material characteristics require that the total quantity of water used to secure the required consistency reduces the batch yield (computed on the basis of absolute volumes of the batch quantities used) by more than 2.0%, the Engineer may adjust the proportions to correct the yield. This adjustment will not be a basis for adjustment of the contract unit price.

4. Entrained Air Content.
Use an approved air entraining agent. The target air content as determined by Materials I.M. 318 is 8.0%, with a tolerance of ± 2% when measured on the grade just prior to consolidation. Air content for non slip form paving is 7.0% ± 1.5%. The target air content may be adjusted by the Engineer based on random tests of the consolidated concrete behind the paving machine. These additional random tests will be used to consider the need for a target change, and will not be used in the acceptance decision.

5. Admixtures.
Approved admixtures complying with Section 4103 may be used with the Engineer's authorization.

6. Use of Supplementary Cementitious Materials.
The maximum allowable fly ash substitution rate is 20%. The GGBFS substitution rate shall not be more than 35% by weight (mass). The total mineral admixture substitution rate shall not exceed 40%. When Type IP or IS cement is used in the concrete mixture, only fly ash substitution will be permitted. Substitution of Type I/II cement with both GGBFS and fly ash will be permitted in ready mix concrete mixtures only. Between October 16 and March 15, fly ash substitution will be allowed only when maturity method is used to determine time of opening.

C. Proportioning and Mixing of Concrete Materials.
Proportion and mix materials according to the following requirements:

1. Storage and Handling of Aggregates.

a. Store and handle aggregates to avoid contamination and frequent variations in specific gravity, gradation, or moisture content of the materials used.
b. Keep fine and coarse aggregate stored in piles or bins entirely separate of one another.
c. When aggregates are trucked to the proportioning plant, the trucks must dump off a ramp or into a walled pit. In either case, they must dump into a floored area. This floor shall consist of a substantial platform or a layer of similar aggregate at least 18 inches (0.5 m) thick placed entirely below the elevation of the surrounding ground.
d. Reduce, to a minimum the Engineer considers practical, the number of changes from one material to another having different frictional characteristics, class of durability, or average specific gravity.
e. At the time of proportioning or placing in proportioning bins, the moisture content of the aggregates shall be such that water will not drain or drip from a moisture sample. Handle aggregates in a manner that will prevent variations of more than 0.5% in moisture content of successive batches. Thoroughly wet coarse aggregates having an absorption greater than 0.5% and allow to drain for at least 1 hour before being used.
f. Drain fine aggregate at least 24 hours after washing and before batching.
g. Do not allow aggregates from two sources to commingle in stockpiles or in the finished pavement, except with the Engineer's approval.

2. Storage and Handling of Cement and Fly Ash.

a. Store cement in suitable weatherproof enclosures and handle to prevent loss.
b. Apply Section 4101 to cement which has developed lumps or which has been stored for extended periods.
c. Transport and store fly ash in suitable weatherproof enclosures in a manner to keep it dry.
d. Use proportioning equipment meeting the requirements of Article 2001.20, B.

3. Measurement of Materials.
Measurement of materials shall meet the requirements for the type of equipment used and the following additional requirements:

a. Operate cement scales within a delivery tolerance of 1.0% of the mass of cement per batch. When operated manually, balance scales to tare before each batch is weighed and after each batch is discharged.

b. Use cement and fly ash scales with automatic controls which meet the requirements of Article 2001.20, B, for all bid items involving more than 6000 square yards (5000 m^2) of pavement base. Items made up of irregular areas, such as crossovers, turn lanes, and so forth, are excluded from this requirement.

c. Do not use manual controls for a period longer than 1 working day after a failure of the automatic controls, except with the Engineer's permission.

d. On work requiring automatic scales, the performance of the scale will be determined near the end of the first full day of production. Afterwards, performance of the scale will be determined at a frequency not to exceed 10,000 cubic yards (10,000 m^3) of concrete produced. Performance will be determined by comparing the accumulated mass of cement proportioned with the corresponding accumulated mass of cement shipped to the project. The Contractor shall cooperate. Cement scale performance determinations are not required when a permanent, commercial ready mix plant is used to furnish less than 10,000 cubic yards (10,000 m^3) of concrete for a contract.

e. Determine the performance of fly ash scale, if present, as in Paragraph d above.

f. Operate aggregate scales within a delivery tolerance of 1.0% for each aggregate.

g. Measure water within a delivery tolerance of 1.0% of intended quantity.

h. Measure admixtures with approved equipment and procedures that assure the quantity measured is within a delivery tolerance of 3.0% of batch quantity. Clean and flush out mechanical dispensing equipment daily, and more frequently if necessary to ensure proper operation.

4. Mixing of Materials.

a. General.

1) Mix concrete materials either at the site of placement or in a construction or stationary mixer to be used for work on the project only. Concrete may also be ready mixed or transit mixed. During any one individual placement, use the same cement, aggregates, and admixtures throughout the placement unless the Engineer approves otherwise. With the Engineer's approval, concrete mixtures may be furnished from multiple plants provided the same materials are used in each mixture and mix consistency can be maintained.

2) Mix concrete material as provided in Article 2001.21 for the type of equipment used.

3) Do not use concrete transported without continuous agitation if the elapsed period between the time the concrete is mixed and the time it is placed is greater than 30 minutes. With the Engineer's approval, an approved retarding admixture may be used at the rate prescribed in Materials I.M. 403. Also with the Engineer's approval, the mixed-to-placed time period may be extended an additional 30 minutes.

4) Do not use concrete transported with agitation when the time between start of mixing and placement is more than 90 minutes.

5) Deliver and handle concrete in a manner that will:

- Prevent objectionable segregation or damage to the concrete, and
- Facilitate placing with a minimum of handling.

6) Thoroughly clean and flush the compartment in which the concrete is transported to the work at intervals necessary to ensure hardened concrete will not accumulate in the compartment. Discharge flushing water from the compartment before it is charged with the next batch.

7) Obtain Engineer's approval for plant equipment, operation, and procedures.

b. Concrete Mixed in a Construction or Stationary Mixer.

1) Use a method of handling batches and charging the mixer that ensures complete introduction of each batch separately without loss of materials.

2) Concrete discharged from the mixer is required to be uniform in composition and consistency. If this condition is not produced because of the size of the batch, the batch size may be reduced or the mixing time increased, or both, until this result is obtained.

c. Ready Mixed Concrete.

1) Ready mixed concrete is defined as concrete for which the required materials are as follows:

a) Proportioned in a central plant and mixed in a stationary mixer for transportation in trucks with or without agitation.

b) Proportioned and then mixed in a transit mixer prior to or during transit.

2) When additional mixing water is required at the site of placement, mix the batch for at least an additional 30 revolutions of the drum at mixing speed.

3) For main portions of the work designed to support public vehicular traffic:

a) Demonstrate to the Engineer before the work starts that each vehicle in which concrete will be delivered to the work is capable of discharging concrete having a slump not over 2 inches (50 mm) at an overall rate for its entire load of no less than 1.25 cubic yards (1 m^3) per minute.

b) Ensure concrete is delivered at a rate sufficient to maintain a sustained rate of progress no less than 100 feet (30 m) per hour for the width and depth of slab to be placed.

c) Ensure adequate and properly staffed dispatching system is utilized.

4) Ready mixed or transit mixed concrete may be used for other portions of the work under other restrictions specified for bid items involving 6000 square yards (5000 m^2) of pavement or less. Ready mixed or transit mixed concrete may also be used for irregular pavement areas such as crossovers and turn lanes.

2301.03 CONSTRUCTION.

When the contract allows for either standard or slip form pavement, the method used is the Contractor's option. When the contract allows only one type, use the type specified. When slip form is specified, small or irregular areas may be constructed with fixed forms. Irregularly shaped areas of either type of pavement may be formed and finished by hand methods.

A. Equipment.

1. General.

Provide sufficient equipment to perform all operations necessary to complete the work. Use equipment meeting the appropriate requirements of Section 2001 and the following provisions.

2. Proportioning and Mixing Equipment.

Use equipment that complies with the following:

a. Weighing and Proportioning Equipment.

Apply Article 2001.20.

b. Mixing Equipment.

Apply Article 2001.21.

c. Bins.

Apply Article 2001.06.

3. Construction Equipment for Portland Cement Concrete Pavement.

Use equipment that complies with the following requirements:

a. Equipment for Standard Concrete Pavement.

1) Side Forms.

a) General.

(1) Use side forms with a height (without horizontal joint) at least equal to the design thickness of the pavement at its edge. The additional height represented by integral curb may be secured by bolting extra forms on the top of the main form.

(2) Ensure the top face of a form does not vary from a true plane by more than 1/8 inch in 10 feet (3 mm in 3 m). Ensure the vertical face does not vary from a true plane by more than 1/4 inch in 10 feet (6 mm in 3 m).

(3) For curves having radii of 100 feet (30 m) or less, use flexible or curved forms.

b) Forms Required to Support Heavy Equipment.

(1) Use steel no thinner than U.S. standard 5 gauge (approximately 7/32 inch (5 mm)). Equip with a device that permits adjustment for horizontal and vertical curves for holding abutting sections firmly in alignment.

(2) If using forms having a height of 8 inches (200 mm) or more, ensure the base is no less than 8 inches (200 mm) wide. If using forms having a height less than 8 inches (200 mm), ensure their base width is no less than their height. Equip with no less than three staking points per each 10 feet (3 m) of length, with means for securely locking the form to each stake. Extend

flange braces and staking pockets outward on the base no less than 65% of the height of the form.

c) Forms Not Required to Support Heavy Equipment.

(1) Forms not required to support heavy equipment may be made of wood or steel. Ensure forms have sufficient stiffness and are staked to remain vertical and true to line and grade during placing and finishing of concrete.

(2) Use nominal 2 inch (50 mm) stock straight wood forms.

(3) Use wood forms that are finished on the side supporting the concrete and on their upper edge.

2) Integral Curb Forms.

a) Use metal forms to form the back of all integral curbs, except where returns have a small radius or other special sections making the use of metal forms impractical.

b) Rigidly attach back forms for curb to the side forms for the pavement slab. Use all fastenings provided by the form manufacturer. Supply a sufficient length of curb forms and number of fastenings to make it possible to leave the forms in place for at least 6 hours after the curb is place.

c) At the time the curb form is placed, ensure the top of the pavement is free of all substances which prevent the rigid fastening or accurate alignment of the curb form. Ensure the curb form extends the plane of pavement form without a variation of more than 1/8 inch (3 mm). Set the top of the curb form at the elevation of top of curb being built, except at curb runouts.

d) Sloping faced curb not more than 4 inches (100 mm) in height may be shaped to the desired cross section with a curb mule without the use of face forms.

e) For straight sections of integral curb more than 4 inches (15 mm) high, the Contractor may use face forms or a slip form curb mule. If face forms are used, provide no less than 100 feet (30 m) for each curb being constructed. Properly secure face forms to maintain their shape and position during use. Ensure the face forms produce a curb cross section matching that of the details within the contract documents. Approved hand tools and methods may be used to supplement the forms in shaping the top roll and on returns and other special sections.

f) If a slip form curb mule is used, use a slip form curb mule that is no less than 6 feet (1.8 m) long, unless mounted on a machine. Obtain the Engineer's approval before using the slip form curb mule. Both back and face forms will be required when constructing barrier curbs or any curb having a top width of 8 inches (200 mm) or more.

3) Supplementary Rails.

a) Provide suitable metal rails capable of being securely attached to the top of the side forms to provide a track which will allow spreading, finishing, and curing equipment to back over the end of the previous day's run.

b) Ensure metal rail length is sufficient to accommodate all equipment which must be backed out of the way. Also ensure the rails are of such a height that all wheels and flanges of wheels will clear the previously placed concrete by at least 1/2 inch (15 mm).

4) Form Line Excavating Machine.

Excavate form lines for all forms supporting mechanical finishing equipment to line and grade by:

- A machine designed for this purpose and approved by the Engineer, or
- An approved machine which concurrently trims the subgrade or subbase to grade.

5) Subgrade Preparation.

Trim the subgrade or subbase to grade with a machine having electronic elevation controls. The Engineer's approval is required for other trimming methods.

6) Consolidating and Finishing Equipment.

For placing and finishing standard type pavement, the following equipment will be required:

a) Vibrators.

(1) Consolidate, with a single pass of an approved internal or surface vibrator, the full width and depth of concrete requiring a finishing machine. Operate internal vibrators within a frequency range of 4000 to 8000 vibrations per minute. The Engineer may authorize the minimum vibration frequency to be

lowered to 3500 vibrations per minute for particular sections of paving, such as superelevations. Operate surface vibrators within a frequency range of 3500 to 6000 vibrations per minute.

(2) Avoid operating vibrators in a manner to cause a separation of mix ingredients, either a downward displacement of large aggregate particles or an accumulation of laitance on the surface of the concrete. When forward motion of the paver is reduced, vibrator frequency may need to be reduced to avoid separation of the mix.

(3) If a vibrator fails to operate within the specifications, repair or change the vibrator before paving begins:

- The following day, or
- The same day if the continuous paving that day is stopped at a header or the end of a session.

(4) If two adjacent vibrators fail to operate within specifications, stop paving operations and repair or replace the vibrators.

(5) Stop vibrators whenever forward motion of the paver is stopped.

(6) Use an electronic vibrator monitoring device displaying the operating frequency of each individual internal vibrator for all Interstate and Primary contracts with PCC paving quantities of mainline paving over 50,000 square yards (40,000 m^2) and other projects when specified in the contract documents. When required on a contract, the vibrator monitoring device will only be required in areas where mainline pavement length exceeds 600 feet (175 m). When project staging necessitates small mainline sections be paved separately from the majority of mainline paving, the Engineer may waive this requirement for those small sections.

(7) Use a vibrator monitoring device that meets all of the following:

(a) Has a readout display near the operator's controls visible to the paver operator and the Engineer.

(b) Operates continuously while paving.

(c) Displays all vibrator frequencies with manual or automatic sequencing among all individual vibrators.

(d) Records, at a minimum, the clock time, station location, paver track speed, and operating frequency of individual vibrators. Make recordings after each 25 feet (8 m) of paving or after each 5 minutes of time.

(8) Provide the Engineer with an electronic record daily for the first 3 days of paving and weekly thereafter. The Engineer may determine that more frequent submission is necessary, particularly if equipment malfunctions occur.

(9) If the electronic monitoring device fails to operate properly, manually check vibrators immediately. If vibrators are functioning properly, paving may continue, but correct the problem as soon as possible. If recording device fails to operate, paving may continue, but correct the malfunction within 3 paving days. The Engineer may allow additional time if circumstances are beyond the Contractor's control.

(10) Set the internal vibrator penetration depth into the concrete pavement slab to mid slab or as deep as possible while passing above reinforcing steel. 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 reinforcing steel or tie bars while paving.

(11) Do not exceed the manufacturer's recommendations for vibrator horizontal spacing. Do not exceed 16 inches (410 mm) from center to center.

(12) Mount longitudinal axis of vibrator body approximately parallel to direction of paving. Tilt trailing end of each vibrator downward to an approximate slope of 15 degrees below horizontal.

(13) Use vibrators that meet or exceed the following specifications at the manufacturer's design frequency of 10,000 vpm:

(a) Amplitude (peak to peak) 0.070 inches (1.75 mm).

(b) Centrifugal force 1200 pounds (5500 N).

b) Finishing Machine.

(1) Where side clearance is provided, a finishing machine designed for concrete paving will be required on all uniform width slabs 8 1/2 feet (2.6 m) or wider upon which a continuous line of forms more than 600 feet (180 m) in length

may be set. Obtain Engineer's approval before using this machine. Utility accesses, intakes, and other small fixtures will not be considered as an obstruction to the continuity of the form line. Railroad tracks, bridges, and existing paved intersections will be considered as obstructions in the continuity of the form line.

(2) Use a finishing machine that leaves the top of the concrete slab smooth with the desired crown and at the proper elevation. When the contract documents require the pavement to be laid partly with crown and partly without crown, equip the screed so that it can be adjusted to the change in shape at the required rate of change.

(3) If during the operation of subgrade or finishing equipment it is necessary to operate one or both sets of wheels or tracks on previously placed concrete, adjust or alter the wheels or tracks so that the bearing on the concrete will not be closer than 3 inches (75 mm) from the pavement edge. When operating with one side of the machine on pavement and the other side on forms, the wheels operating on the forms may be double flanged. Use flangeless, rubber faced wheels on the pavement. When operating over the edge of concrete less than 2 months old, support the ends of the finishing machine screeds with an approved device to provide from 1/16 to 1/8 inch (2 mm to 3 mm) clearance between the screed and previously placed pavement.

(4) Suspension resulting in a pendulum effect will not be approved.

(5) Sections of pavement not required to be finished with a finishing machine may be finished by hand equipment as provided in Article 2301.03, A, 3, d.

b. Equipment for Slip Form Concrete Pavement.

1) Form Line Excavating Machine.

When it is necessary to excavate to line and grade the path over which the pavement laying machine travels, use either:

- A machine designed for this purpose and approved by the Engineer, or
- A machine which operates concurrently with the trimming of the subgrade or subbase.

2) Subgrade Preparation.

Use an electronically controlled machine to trim the subgrade or subbase to grade to the Engineer's satisfaction.

3) Placing, Consolidating, and Finishing Equipment.

a) Use a slip form paving machine that meets all of the following:

(1) Is designed for the specific purpose of placing, consolidating, and finishing concrete pavement slabs without the use of fixed side forms.

(2) Leaves the edges of the slab vertical.

(3) Is self propelled and equipped with a means for spreading the concrete to a uniform depth before it enters the throat.

(4) Vibrates the concrete to the full width and depth being placed in a single passage. Accomplish vibration with vibrating tubes or arms working in the concrete or a vibrating pan operating on the surface of the concrete. Apply Article 2301.03, A, 3, a, for the amplitude, rate of vibration, monitoring, and locking device for depth.

(5) Produces a surface reasonably free of voids and tears.

b) When slip form paver is operated with one or both tracks on previously placed concrete, use tracks that are rubber faced, or travel on cushions of wood or belting, to prevent damage to the pavement surface.

c) Use a paver equipped with automatic horizontal and vertical grade controls.

4) False Forms.

With Engineer's approval, false forms may be used on slip form pavement work in areas that:

- Are to be subsequently abutted with other lanes of pavement in the 20 feet to 30 feet (5 m to 10 m) preceding a day's work joint, or
- Require vertical edge support.

c. Curing Equipment.

1) To apply liquid curing compounds (if used) on surfaces of pavements of uniform width for a continuous length of over 5000 feet (1500 m), use approved mechanical spraying equipment operating on the forms or outside the pavement edges. Use

equipment with a shield provided to prevent undue loss of curing compound by wind action.

2) Hand spraying equipment may be used on vertical edges, hand finished sections, and all other pavement surfaces.

d. Finishing Equipment, Hand Method.

Apply the following for placing and finishing concrete by hand methods:

1) Vibrators.

Use:

- Vibration rate between 3500 to 6000 vibrations per minute, and
- Amplitude sufficient to be perceptible on the surface of the concrete more than 12 inches (0.3 m) from the vibrating unit.

2) Screed.

Use a screed that is:

- True to crown (may be of wood or metal), and
- Adjustable for crown (or furnish a separate screed for each variation in crown).

e. Finishing Tools.

Provide all finishing tools necessary for proper finishing of the concrete, including straight edges for checking and correcting finished concrete surfaces.

f. Washing Water.

Maintain an adequate supply of water suitable for washing testing equipment. Place at a convenient location near the site of concreting operations, as directed by the Engineer and at no additional cost to the Contracting Authority.

B. Subgrade Construction.

1. Unless a subbase is specified, prepare the subgrade for standard pavement according to Section 2109.

2. Comply with the following for subgrade construction for slip form pavement:

a. When the contract documents include a bid item for Class 10 excavation, perform all the work necessary for proper preparation of the subgrade.

b. When the contract documents do not include a bid item for Class 10 excavation, it may be assumed that the subgrade has been or will be shaped and compacted by others. Acceptable tolerance for that work is described in Article 2102.03, L, except that at approaches to existing improvements or structures, corrections will be based on a practical minimum cut and fill for the project.

3. Shape and compact subgrade according to the applicable following method:

a. Subbase Not Specified.

If no subbase is specified, prepare the subgrade according to the requirements of Section 2109.

b. Subbase Specified.

If a subbase under pavement is specified, prepare the subgrade according to the requirements for that type of subbase.

c. Proof Rolling Requirements.

1) Proof roll subgrades (with or without subbase) no more than 1 week prior to trimming of the final grade. Perform proof rolling with a minimum of one pass using equipment meeting the requirements of Article 2001.05.

2) Treat all areas not meeting the requirements of 2107.03, E, as specified in Section 2109.

C. Setting of Forms.

1. When side forms are used, set them accurately to the required grade and alignment. Found and secure them to maintain the required grade and alignment while concrete is being placed and finished and until it is time for the forms to be removed. Set forms on properly compacted materials.

2. Set forms with:

- The base at the design elevation of the subgrade of the pavement at its edge, and
- The top at the design elevation of the surface of the pavement at its edge.

3. With the Engineer's approval, forms having a height greater than design thickness of the edge of the pavement may be used when set as follows:
   a. **Side Forms.**
      Side forms may be set with their tops at the design elevation of the finished surface of the pavement and their bases at an elevation lower than the design base, subbase, or subgrade elevation. However, base, subbase, or subgrade material shall be excavated to meet the lower edge of the form with a straight, lateral slope no steeper than one vertical to four horizontal. Additional excavation and concrete required by this method will be at no additional cost to the Contracting Authority.
   b. **Integral Curb Forms.**
      Forms for integral curb shall be rigidly attached to supporting side forms using all fastenings provided by the manufacturer. Take special care to remove all water and laitance from the edge of the pavement before the curb is placed.

4. After setting and locking forms, tamp on both sides throughout their entire length using a suitable tool. Ensure tamping forces suitable material into contact with the base of the form for its entire length and width. Tamp the forms that are to support mechanical finishing machines. Tamping of forms set on bases or subbases may be waived if the excavation and bedding of the forms meet the Engineer's approval. If rain or standing water softens the earth or subbase so that the form is not adequately supported, reset the form on suitable material before concrete is placed.

5. Clean forms before resetting. Coat with form oil before concrete is placed against them. Use an oil that will produce a film to prevent concrete from adhering to form.

D. Fixtures in Pavement Surface.

1. Adjust utility accesses, intakes, valve holes, or other fixtures encountered within the area to be paved to conform to the finished surface of the pavement to be built. Prior to placing the concrete, clean foreign material from the outside of the fixtures for the depth of the concrete.

2. Construct fixtures as shown in the contract documents. Fixtures that fall in a form line may be boxed out if a finishing machine is being used. Do not cut or divide boxed out concrete on the original form line.

E. Placing Reinforcement and Placing Dowel Bars.

1. **Placing Reinforcement.**
   a. Place reinforcement prior to vibration so it will be in its intended position in the completed concrete according to Article 2404.03, D. For slip form paving, tie bars may be installed after vibration, provided the concrete is consolidated around the bars. Reinforcing bars may be supported by approved chairs or be placed in position by a machine or method approved by the Engineer.
   b. Use approved continuous bolsters with runners to support reinforcement for bridge approach sections. Place supports transversely across the approach and space them longitudinally no greater than 4 feet (1.2 m). For double reinforced approach sections the top layer of reinforcing may be chaired off the bottom layer of reinforcing using approved continuous high chairs with runners, provided they are positioned directly above the continuous bolsters with runners supporting the bottom layer of reinforcing. Hold epoxy coated reinforcing steel in place with epoxy or plastic coated bar supports and epoxy or plastic coated tie wires. Use continuous bolsters with runners and continuous high chairs with runners, either plastic or steel, meeting the requirements of Materials I.M. 451.01.
   c. When welded wire fabric reinforcement is used (alternate methods of placing welded wire fabric reinforcement will be considered for approval):
      1) Strike the concrete off at the elevation specified for fabric reinforcement.
      2) Place the sheets as indicated in the contract documents. Handle and place the fabric carefully to ensure its installation in the proper position. Ensure the fabric is flat.
      3) Deposit the balance of the concrete and vibrate in a manner that will not displace or distort the fabric. Sheets that have become bent or kinked may be rejected.

2. **Placing Load Transfer Devices.**
   a. Load transfer devices may be required in the contract documents. Accurately place these assemblies as shown. To prevent their movement during subsequent concrete paving operations, securely stake or fasten to the base to line and grade. Assemblies may be placed in fresh PCC concrete of a class A subbase, as provided in Article 2114.03, A, 2, to assure a firm connection for the subsequent paving operation. Do not use mechanical dowel bar inserters.
   b. Do not use damaged assemblies. Ensure horizontal and vertical alignment of the load transfer bars does not exceed 1/4 inch (5 mm) from parallel to line and grade. Place each assembly so bars are in a horizontal plane at T/2 ± 1/2 inch (15 mm).
   c. Check placement of each assembly and the position of the bars within the assembly using a suitable template or other device approved by the Engineer. If assembly is found to be placed outside the above tolerances, correct the placement.
   d. Cutting the tie wires of the load transfer assemblies is optional.

3. When dowels or tie bars or other articles are to be anchored in existing concrete, use a grout system listed in Materials I.M. 491.11 or 491.22 according to the manufacturer's instructions. Obtain Engineer's approval.

4. For horizontal installation of dowels or tie bars, use either a pressure injection system with mechanical proportioning and mixing, or encapsulated chemical anchors. Install as follows:
   a. Ensure drilled or preformed holes to receive the grout match the dimensions and spacing shown in the contract documents. When not shown in the contract documents, the maximum nominal diameter of the hole must be 1/8 inch (3 mm) larger than the outside diameter of the dowel or bar, or as recommended by the manufacturer. Blow the hole clean with compressed air immediately prior to placing the grout.
   b. Pressure inject the grout into the rear of the hole. Use sufficient grout so that when the bar, insert, or other article to be grouted is placed in position, excess grout will be forced out the front of the hole. Rotate the article to be grouted during the insertion process to ensure complete coating with the grouting material. Hand proportioning and mixing will not be allowed.

5. If using grout with approved encapsulated anchors, install according to the manufacturer's recommendations.

6. Use installation procedures for vertical or angled installations that are similar to those for horizontal installation. Pourable grouts may be used. Pourable grouts shall be mechanically mixed.

F. **Placing Concrete.**

1. The contract documents will show the width the pavement will be constructed. Unless otherwise shown, construct the pavement in a single pass.

2. Unless the Engineer permits otherwise, place pavement to be constructed using ready mix concrete in single lane widths only. Permission will be based on evaluation of type, quality, and quantity of equipment to be used and its anticipated rate of production.

3. At the Contractor's option, pavements may be placed in single traffic lane widths under the following conditions:
   a. Submit a proposed plan of operation for approval of the Engineer.
   b. Furnish (at no additional cost to the Contracting Authority) additional dowels, tie bars, or extra concrete required to conform to the approved, modified method of operation.
   c. Deposit concrete upon the supporting surface in a manner which will minimize segregation and disturbance of reinforcement.
   d. Except when welded wire fabric reinforcement is used, deposit concrete to the full depth of the pavement in a single operation. When welded wire fabric is used, apply Article 2301.03, E.

4. Operate vibrating units as recommended by the manufacturer and in a manner which complies with Article 2301.03, A, 3, a.

5. Cure vertical edges of pavements and backs of curbs according to Article 2301.03, K.

6. Repair honeycombed areas on pavement edges immediately after removal of forms.

7. Place backfill material behind curbs, as directed by the Engineer, to prevent a flow of water in this area and subsequent undermining of pavement.

G. Multiple Lane Construction.

1. Construct all lanes and sections of pavement to the widths shown in the contract documents unless written approval has been secured for alternate methods described in Article 2301.03, F.

2. Construct expansion and contraction joints to be continuous across all lanes. Do not stagger expansion and contraction joints.

3. Edge the edge of the pavement adjacent to the steel form, or at any supplemental form or bulkhead that will be abutted by a subsequent slab, using a tool with a radius of 1/8 inch (3 mm) or less. Extend the cutting edge of the tool moving along the form downward beyond the rolled edge of the form to its vertical face. Tool the edge on abutting lanes in the same manner.

4. When keyed joints are required, fasten the keyway to the form by a method that will ensure construction of the keyed joint. Use fasteners that can remain in place until the concrete has been placed adjacent to and above the keyway.

H. Finishing and Texture.

Finish the concrete promptly after it has been placed and consolidated. Following the finishing operations, apply texture to the surface.

1. **Finishing.**
   a. After the concrete has been consolidated, use the screed to strike off the surface to the true section. Finish the surface true to line and grade.
   b. Ensure additional water is not added directly to the surface by spray wand, brush, or other methods. Burlap may be attached behind the screed and a small amount of water may be used to wet the burlap to facilitate finishing operations. Avoid wetting the surface to the extent a slurry is created.
   c. Ensure the edge is true and uniform. Hand corrections may be needed if this is not accomplished by the paver.
   d. When finishing by hand methods, consolidate concrete using vibrating units operating in the concrete. If the vibrating apparatus cannot consolidate the full width of the concrete in a single pass, use a definite system or pattern when operating the vibrator that ensures the full width of concrete in each linear foot (meter) of lane receives adequate and uniform consolidation. Obtain the Engineer's approval for the vibrating system and methods. Do not use vibrating equipment as a tool for moving concrete laterally on the grade.
   e. The Contractor may use a float on the pavement surface.

2. **Microtexture.**
   a. Microtexture is constructed to produce a roughened surface on the driving areas of the pavement.
   b. Drag artificial turf, coarse carpet, or burlap longitudinally over the finished surface to produce a tight, uniform, textured surface. Burlap may be dampened to prevent adhesion of PCC mixture.
   c. When, for any reason, the desired texture normally obtained by the drag is not secured, the Engineer may require that the final finish be a broom finish in lieu of, or in addition to, the drag finish. To obtain a broom finish, drag a suitable broom transversely across the surface of the plastic concrete.

3. **Macrotexture.**
   a. **General.**
      1) Macrotexture is constructed by placing grooves in the surface of a pavement, normally while the concrete is plastic. The Contractor may either transversely or longitudinally provide macrotexture tining.

2) When longitudinal grooving is used on mainline pavement, transverse grooving may be used on other pavement on the same project.

b. Application.

1) Where the speed limit is greater than 35 mph (60 km/h), place macrotexture on all mainline pavement, turn lanes, and the traveled portion of ramps. Macrotexturing is not required on radii, crossovers, paved medians, shoulders, and other irregular areas.
2) Transversely or longitudinally groove gapped sections of mainline pavement that utilize longitudinal texture. Hand methods may be used on these mainline sections.
3) When surface corrections are made in the hardened concrete, no macrotexture replacement is required.
4) Unless specified otherwise, groove or otherwise finish bridge approach sections in the same manner as either the adjacent bridge or pavement surface.
5) When finishing by hand methods, except for mainline pavement and ramps as described above, only microtexture will be required.

c. Operation.

1) **General.**
For grooving, use a mechanical device that:
- Has a single row of tines that are 1/8 inch ± 1/64 inch (3 mm ± 0.5 mm) wide, and
- Forms grooves in the plastic concrete that are1/8 inch (3 mm) deep as a target, with a ± 1/16 inch (± 1.5 mm) tolerance.

2) **Transverse Grooving.**
a) For transverse grooves, randomly space the tines from 3/8 inch to 1 5/8 inch (10 to 40 mm) with no more than 50% of the spacing exceeding 1 inch (25 mm).
b) At transverse joints, leave a 4 inch to 6 inch (100 to 150 mm) wide strip of pavement surface (centered along the joint) that is not grooved for the length of the joint.

3) **Longitudinal Grooving.**
a) For longitudinal grooves, uniformly space the tines at 3/4 inch (20 mm) intervals.
b) Accomplish longitudinal grooving using equipment with horizontal and vertical string line controls to ensure straight, uniform grooves.
c) At longitudinal joints, leave a 2 inch to 3 inch (50 to 75 mm) wide strip of pavement surface (centered along the joint) that is not grooved for the length of the joint.

d. Limitations.

1) Form grooves in a time and manner producing the desired surface texture while minimizing displacement of larger aggregate particles. Complete grooving before pavement surface permanently sets.
2) Where abutting pavement is to be placed, extend grooving as close as possible to the edge without damaging the edge. Where abutting pavement is not to be placed, do not groove the 6 inch (150 mm) area nearest the edge or 1 foot (300 mm) from the face of the curb.
3) Do not groove the outside 2 feet (0.6 meters) if placing structural rumble strips (rumble strips placed in the outside 2 feet (0.6 meters) of PCC pavements, as shown in the contract documents, to deter traffic).
4) Uniform width slabs of 20 feet (300 mm) or narrower and less than 600 feet (200 m) long may be grooved by hand methods. Mainline and ramp pavement may also be grooved by hand methods during equipment breakdowns.

4. Smoothness.

a. Construct the pavement to have a smooth riding surface within the following tolerances:
1) Periodically check the pavement longitudinally with a 10 foot (3 m) straightedge. The surface is not to deviate from a straight line by more than 1/8 inch in 10 feet (3 mm in 3 m).
2) If slip form methods are used, the 6 inches (150 mm) nearest the edge may exceed the 1/8 inch (3 mm) tolerance, but is not to exceed 1/2 inch deviation in 10 feet (13 mm deviation in 3 m).
3) Where abutting pavement is to be placed adjacent to the pavement being checked, the surface is not to deviate by more than 1/4 inch (6 mm) when checked 1 inch (25 mm) from the edge with:
- A 3 foot (1 m) straightedge used transversely, and
- A 10 foot (3 m) straightedge used longitudinally.

b. Apply Section 2317 to all PCC Pavement bid items of a Primary project if any individual PCC Pavement bid item for that project is 5000 square yards (4200 m^2) or greater. Apply Section 2316 to all other Primary projects or when specifically required for other projects.

I. Integral Curb.

1. Before placing curb concrete, remove all free water, laitance, dust, leaves, or other foreign matter which may have collected on the edge of the slab.

2. Construct integral curbs before the initial set, but following the main paving slab finishing, except as provided for in Article 2301.03, J.

3. Do not use concrete which has dried, partially hardened, or requires retempering.

4. Construct integral curb as rapidly as paving slab finishing operations will permit. Complete integral curb construction the same day the slab is placed, except for the length of section required at the end of the day's run to accommodate the mechanical placing and finishing equipment. In the section left for subsequent curb placement, depress the paving slab surface along the line of the inside curb slope so that the new concrete placed for curb is no less than 1 1/2 inches (40 mm) thick. Tie this section of curb to the slab by using No. 3 (Size 10) hooked steel bars spaced at 1 foot (300 mm) intervals. Roughen the surface of the slab back of the key notch. Create a depression around each dowel so it will project at least 2 inches (50 mm) into the curb concrete.

5. Consolidate curb concrete to secure adequate bond with the paving slab and eliminate honeycomb in the curb. Avoid disturbing the alignment of forms or gutter flow line.

6. After removing face forms or shaping with the curb slip form, complete the final finish on curbs using hand methods, including the use of a 6 foot (1.8 m) straightedge. Check the resulting surfaces of both curb and gutter using the 10 foot (3 m) straightedge. Correct if necessary. When removing forms, avoid creating slumps and disturbing partially set concrete.

7. When curb is built on slabs traversed by headers or contraction or expansion joints, extend the joints through the curb directly over the joint in the slab at the same thickness as in the main slab.

8. Edge, protect, and cure all curbs the same as other parts of the paving slab.

J. End of Run.

1. General.

a. Install an approved header whenever 30 minutes or more have elapsed since the last concrete has been deposited on the subgrade, or if such a delay is anticipated.

b. Do not construct a header joint:

- Within 5 feet (1.5 m) of an intended or previously placed contraction joint.
- Opposite a contraction joint in multiple lane construction.

c. When a header joint is installed, wait a minimum of 6 hours to resume paving which abuts the header. When concrete delivery is resumed, place it adjacent to the exposed face of the header. Thoroughly consolidate the concrete and finish with an edging tool at the joint. Sawing and sealing of this joint is not required.

d. When the end of the day's run occurs in curb section, omit sufficient curb to accommodate equipment which must be backed out of the way. Construct the portion of the curb omitted as shown in the contract documents and according to Article 2301.03, I.

2. Headers Constructed in Plastic Concrete.

a. Construct the header true to line and grade with the face perpendicular to the surface and at right angles to the centerline of the pavement. Ensure tie bar reinforcement is level, true to line and grade, and normal to the header joint.

b. Concrete collected by a finishing machine during its first pass must not be used adjacent to the header board. Promptly remove concrete screeded over the header during finishing.

c. Consolidate concrete against the header and finish with an edging tool.

d. Remove the header board and all supports before paving is resumed.

3. **Headers Constructed in Hardened Concrete.**
The Contractor may pave past the location of the header. After the concrete has hardened, saw the pavement perpendicular to the centerline of the pavement, creating a vertical face. Drill holes for the tie bar reinforcement and grout the reinforcement into the holes according to Article 2301.03, E. Paving operations may begin adjacent to the header after a minimum of 1 hour following the placement of the reinforcement bars.

K. Curing and Protection of Pavement.

1. **General.**
   - **a.** After finishing operations are complete, cure concrete pavement according to Article 2301.03, K, 2. Cure bridge approaches, medians, curbs, and ramps according to Article 2301.03, K, 2.
   - **b.** Cure vertical edges of pavement and backs of curbs by the same method used for curing the surface.

2. **Curing with White Pigmented Liquid Curing Compound.**
   - **a.** Apply curing compound in a fine spray to form a continuous, uniform film on the surface and vertical edges of the pavement slab.
   - **b.** Apply curing compound as soon as the free water has appreciably disappeared, but no later than 30 minutes after finishing. With the Engineer's approval, cure application timing may be adjusted due to varying weather conditions and concrete mix properties to achieve acceptable macrotexturing.
   - **c.** Use an application rate of no less than 0.067 gallon per square yard covering 15 square yards per gallon (0.3 L/m^2 covering 3 m^2/L).
   - **d.** Ensure liquid curing materials are well agitated in the supply drum or tank immediately before transfer to the distributor. Keep curing materials well agitated during application.
   - **e.** Apply using power spraying equipment capable of producing a fine spray which will not damage the surface of the concrete. Hand operated sprayers may be used for spraying the sides and irregular areas.
   - **f.** If forms are used, coat vertical edges of the pavement within 30 minutes of form removal using curing material applied at the same rate as on the surface.
   - **g.** If, due to other operations, the coating is damaged within 72 hours after being applied, immediately re-coat the affected areas. Coating of the sawed surface with curing compound will not be permitted on joints that are to be sealed. When pavement is opened to traffic prior to 72 hours after application of the curing coating, a re-coating will not be required.
   - **h.** Apply a white pigmented curing compound meeting the requirements of Section 4105.

3. **Cold Weather Protection.**
   - **a.** Apply cure to all concrete pavement, including exposed edges of the slab, according to Article 2301.03, K, 2, prior to applying protection.
   - **b.** Protect concrete pavement less than 36 hours old as shown in Table 2301.03-1. Payment will be made as provided in Article 2301.05.

Table 2301.03-1: Concrete Pavement Protection Requirements

Night Temperature Forecast	***Type of Protection[(a)]***
35°F to 32°F (2°C to 0°C)	*One layer of burlap for concrete.*
31°F to 25°F (-1°C to -4°C)	*Two layers of burlap or one layer of plastic on one layer of burlap.*
Below 25°F (-4°C)	*Four layers of burlap between layers of 4 mil (100 µm) plastic, insulation blankets meeting the requirements below, or equivalent commercial insulating material approved by the Engineer.*

(a) The protection is to remain until one of the following conditions is met: *1. The pavement is 5 calendar days old.* *2. Opening strength is attained.* *3. Forecasted low temperatures exceed 35°F (2°C) for the next 48 hours.* *4. Forecasted high temperatures exceed 55°F (13°C) for the next 24 hours and subgrade temperatures are above 40°F (4°C).*

c. When insulation blankets are used, use blankets consisting of a layer of closed cell polystyrene foam protected by at least one layer of plastic film, rated by the manufacturer with a minimum R-value of 1.0 (0.1761 for metric units).

d. Shut down paving operations in time to comply with protection requirements outlined above. The cover may be temporarily removed to perform sawing or sealing. The Engineer may modify temperature restrictions and protection requirements.

4. Rain Protection.

a. Protect the pavement from rain damage.

b. To protect against the effects of rain on paving, have materials available near the worksite for proper protection of the edges and surface of concrete. Protective material may consist of sheets of burlap, paper, or plastic film. Keep planks (or other material with suitable stakes) on hand that can be used as temporary forms.

c. Failure to properly protect concrete may constitute cause for removal and replacement of defective pavement.

d. When pavement is placed directly on natural subgrade (Section 2109) construct earth check dams immediately after removing forms or after the slip form passes. This will prevent water from flowing along the edge of the pavement and undermining the slab. Space earth check dams and construct them wide enough such that they do not provide an approach over which a vehicle may be driven onto the pavement.

L. Safety Fence for Pavement.

1. In addition to the requirements of Article 1107.09, install a safety fence for the full width of the slab near the end of each day's run.

2. Support the safety fence by setting posts near to the edge of the slab. Extend posts at least 2 feet (0.6 m) into the ground. Between the posts, stretch and secure a 48 inch (1.2 m) nominal height orange mesh safety fence meeting the requirements of Article 4188.03. Cut the twisted ends of the wire off flush with the twist so that a tool would be required to cut or otherwise release the fastening.

3. Support the fence span between the posts with no less than four equally spaced plastic drums weighted to make them stable and difficult to move. Use drums approved according to Materials I.M. 488.02.

4. On urban work where it is not feasible to set posts, steel drums or sand box supports may be substituted for the end posts.

5. Place a similar safety fence parallel to and within 50 feet (15 m) from the edge of the slab at public road and side street intersections. Construct these fences similar to the end of day's run safety fences.

6. To prevent traffic from entering on and damaging the pavement slab, install safety fences within 1 hour of the completion of finishing and curing operations at the fence location. Leave safety fences in place and maintain until the concrete has attained the strength and age requirements of Article 2301.03, U.

7. Intermediate safety fences may be required for the purpose of opening the slab for access to a side road, side street, or entrance.

M. Removal of Forms.

1. Leave side forms and curb forms in place for no less than 6 hours after the concrete is placed, unless earlier removal is required by Article 2301.03, N.

2. Exercise care when removing forms to prevent cracking, spalling, or over stressing the concrete.

3. Remove all stakes in any form before the form is raised.

4. If the method of form removal causes damage to the concrete, the Engineer may require forms to remain in place for more than 6 hours.

N. Sawing Joints.

1. Saw joints in a single cutting operation for a specific joint. Make saw cuts true to line and to the dimensions shown in the contract documents.

2. Begin joint sawing as soon as the concrete has hardened sufficiently to permit sawing without raveling or moving of aggregate. Saw joints before uncontrolled cracking takes place.

3. Control joints may be sawed by any saw designed for concrete sawing.

4. If necessary, use continuous sawing operations regardless of weather or daylight conditions.

5. Discontinue sawing a joint if a crack develops ahead of the saw.

6. A heavy span saw which is supported on the new pavement will not be allowed for sawing pavements and concrete overlays less than 7 inches (180 mm) deep.

7. If the pavement has been covered or protected due to cold weather, rain, or snow, saw joints by conventional saw equipment only.

8. Saw joints requiring compression sealant materials to be installed according to Article 2301.03, P, so that the compression sealant material can be installed and function correctly.

9. Repair uncontrolled cracking or random transverse cracking (at no additional cost to the Contracting Authority). Use repair methods approved by the Engineer.

10. When the normal pavement section is reduced by box-outs, such as for intakes, construct a contraction joint by sawing. Begin at one end of the box-out and extend to the pavement edge. Alternate types of transverse joints will be considered for approval. If box-out length exceeds 15 feet (4.5 m), construct a contraction joint at both ends.

O. Expansion Joints.

1. Install preformed joint material perpendicular to the pavement surface. Exercise care throughout pavement construction to ensure that the joint material remains in proper position.

2. Set reference stakes or markers showing exact joint location prior to placing concrete adjacent to the joint. After the mechanical finishing equipment has passed over the joint, check the joint for movement. If movement in excess of 1/2 inch (10 mm) has occurred, immediately correct the installation to its intended position.

3. After the surface finishing has been completed, edge the joint as shown in the contract documents with minimum disturbance to the adjacent concrete. Supplemental vibration equipment is required for proper consolidation of the concrete.

P. Sealing Joints.

1. Unless provided otherwise, seal joints as designated in the contract documents before any portion of the pavement is opened to the Contractor's forces or to general traffic. Saw or prepare joint openings to the designated dimensions. Clean and seal joint openings with one of the appropriate materials described in Section 4136.

2. Use joint sealer described in Article 4136.02, A, to seal sawed joints in PCC pavement, shoulders, medians, crossovers, and side road pavements, unless specified otherwise in the contract documents.

3. Within 3 hours after a joint has been wet sawed to the finished dimension, flush the wet sawing residue away from the sawed faces using a high pressure water blast operating with a minimum pressure of 1000 pounds per square inch (7000 kPa). Within 3 hours after the joint has been dry sawed to the finished dimension, blow the dry sawing residue from the joint. Use air compressors that provide moisture and oil free compressed air.

4. Immediately prior to installation of sealant, clean joints with an air blast. Do not perform sealing until visual examination verifies the joint surfaces appear dry, in addition to being clear of dust and contamination. Prepare joint sealer and install in the joint and to the proper level as shown in the contract documents and as recommended by the manufacturer. Heat hot poured sealers in a thermostatically controlled heating kettle. Heat the material to the temperature required for use, but not above that recommended by the manufacturer. After sealing, remove excess sealer from the pavement surface.

5. Place joint sealer only when the pavement and ambient air temperatures are 40°F (4°C) or above. When near this minimum, additional air blasting or drying time, or both, may be necessary to assure a satisfactory bond to the joint faces. When this sealer cannot be properly placed due to late fall work, submit a joint construction plan and sealing details to the Engineer for approval before commencing paving. Delay the cleaning, sealing, and, if required, resawing of joints until the following spring. This delay requires the Engineer's approval.

6. When surface correction is required, repair seals damaged from the corrective work. Joint preparation, cleaning, and sealing may be delayed until after corrective work, provided the pavement is not opened to traffic before corrective work is performed.

7. The Engineer may limit the wheel loads and axle loads of equipment operating on the pavement during preparation, cleaning, and sealing operations, if prior to the age and strength specified in Article 2301.31. Additional tests to determine the modulus of rupture may be required.

8. If early pavement opening is specified, the cleaning, sealing, and, if required, resawing of joints shall be accomplished after the pavement is opened to traffic if hot pour sealing material is used.

Q. Concrete Median Strip.

Where the contract documents call for construction of concrete median strip between adjacent slabs, construct the median strip to conform to the dimensions shown and to the following provisions:

1. Construct the subgrade for the median strip to the elevation shown according to Article 2109.03, A.

2. Use the class of concrete specified for the pavement. Use placement and finishing methods that meet the requirements of Section 2301. Hand methods may be used and surface texturing will not be required.

3. Saw and seal joints as required for jointed pavement. When spacing is not designated, space joints as required for jointed pavement. Match median joints with joints in the abutting pavement.

4. Gore areas will be considered median strips. When constructed or reconstructed while the highway is open to public traffic, use Class M concrete.

R. Bridge Approach Sections, Reinforced Paved Shoulders, and Full-width Reinforcement for Pavements.

1. Construct bridge approach sections, reinforced paved shoulders, and full-width reinforcement for pavements as shown in the contract documents.

2. Use epoxy coated reinforcing according to Article 4151.03, except that cut or sheared ends need not be recoated.

3. Unless otherwise noted in the contract documents, use a clear distance of 2 inches (50 mm) between the face of concrete to near reinforcing steel.

4. Use Class C Concrete with coarse aggregate durability according to Section 4115.

S. Restriction of Operations Because of Weather.

1. Do not place concrete when stormy or inclement weather will prevent good quality work.

2. Do not use aggregates containing frozen lumps.

3. Do not place concrete on a frozen subgrade.

4. Concrete mixing and placement may be started, if weather conditions are favorable, when the air temperature is at least 34ºF (1ºC) and rising. At the time of placement, concrete shall have a temperature of at least 40ºF (4ºC).

5. Stop mixing and placing when the air temperature is 38ºF (3ºC) or less and falling.

6. During cold weather conditions, protect concrete less than 36 hours old in the manner specified in Article 2301.03, K, 3.

T. Night Operation.

Do not place concrete when darkness would prevent good quality work in placing and finishing operations. Unless shown in the contract documents or approved by the Engineer, placing and finishing operations under artificial light will not be permitted. Organize work accordingly.

U. Time for Opening Pavement for Use.

1. The time for opening pavement for use will be based on the restrictions listed in Table 2301.03-2, with flexural strength determined from beam specimens made during the progress of the work.

Table 2301.03-2: Minimum Flexural Strength

Strength Class of Concrete	Minimum Age	psi (MPa)
A	14 calendar days[(a)]	500 (3.45)
B	14 calendar days	400 (2.80)
C	7 calendar days[(b)]	500 (3.45)
M	48 hours	500 (3.45)

(a) 10 calendar days for concrete 8 inches (200 mm) thick or more.
(b) 5 calendar days for concrete 9 inches (230 mm) thick or more.

2. At the Contractor's option (unless specified otherwise in the contract documents), the time for opening pavement may be determined through the use of the maturity method as described in Materials I.M. 383.

3. Apply the following when the maturity method is used:
   a. The time for opening pavement will be based on strength requirements only, as specified in Table 2301.03-2. Furnish all labor, equipment, and materials necessary for the development of the maturity-strength relationship as described in Materials I.M. 383.
   b. The Engineer will determine if sufficient strength has been achieved for opening a section of pavement. The Contractor's maturity testing may be used as the basis for this determination. Provide sufficient documentation of maturity testing before opening a section to traffic.

c. Should circumstances arise which are beyond the Contractor's or Engineer's control and strength cannot be determined by the maturity method, apply minimum age, minimum flexural strength, and fly ash restrictions.

d. Develop a new maturity curve for any change of a material source or proportion in the concrete mixture.

4. Personnel performing maturity testing are required to be Level I PCC certified technicians with training for maturity testing.

5. In cases where early opening of pavement is desirable, the Engineer may require the use of Class M concrete mixtures. Such sections of pavement may be opened to traffic in accordance with Table 2301.03-2.

6. At the Contractor's option, when Type I/II cements are used, Class C fly ash may be substituted for up to 10%, by weight (mass), of the cement in Class M concrete mixtures. Type IP and Type IS cements may be used in Class M concrete mixtures without fly ash substitution.

V. Shoulders.
Construct shoulders according to Section 2121, 2122, or 2123, as indicated in the contract documents.

W. Surfacing Approaches to Intersecting Roads, Driveways, and Turnouts.
Surface approaches to intersecting roads, driveways, and turnouts as provided in Section 2315.

2301.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Portland Cement Concrete Pavement.

1. Square yards (square meters) of the type specified in the contract documents.

2. The coring requirements for thickness do not apply to detour pavements, paved drives, and temporary pavements. The thickness of pavement constructed will be determined from core depths as follows:

a. The division of sections, lots, and core locations will be according to Materials I.M. 346.

b. At locations determined by the Engineer, cut samples from the pavement, as directed above, by drilling with a core drill that will provide samples with a 4 inch (101.6 mm) outside diameter. Restore the surface by tamping low-slump concrete into the hole, finishing, and texturing. The Engineer will witness the core drilling, and identify and measure the cores immediately. The Engineer will measure the cores and determine the thickness index according to Materials I.M. 346. After measurement on the grade, deliver the cores to the Engineer’s office or field laboratory. When cores are not measured on the grade, the Engineer will take immediate possession of the cores.

c. Coring of pavement and other work for thickness determination may be waived by mutual agreement for sections of the same design thickness less than 5,000 square yards (4200 m^2).

d. Only sections which are cored will be included in the thickness index determination. Areas not cored will be paid for at the contract unit price.

B. Integral Curb.
Incidental to the other items of work. Not measured for payment.

C. Concrete Median.
Square yards (square meters) shown in the contract documents. This will be calculated to the nearest 0.1 foot (0.1 m) of the length along the surface and the overall width of median when no integral curb is involved, or the width from back to back of curb when integral curb is involved.

D. Bridge Approach Sections.
Square yards (square meters) shown in the contract documents.

E. Excavation.

1. When the contract provides a unit price per station (meter) for earth shoulder finishing and a price per cubic yard (cubic meter) for excavation, the excavation required for preparation of natural subgrade will be measured as provided in Article 2102.04. The volume measured for payment will include only the materials actually removed above the elevation of the pavement subgrade and between vertical planes 1 foot (0.3 m) outside the edge of the finished pavement.

2. Other work connected with preparation of natural subgrade will not be measured for payment.

3. When the contract provides a unit price for earth shoulder construction (whether or not a unit price per cubic yard (cubic meter) of excavation is provided in the contract), excavation required for preparation of natural subgrade will not be measured for payment. Unless otherwise provided in the contract documents, work connected with preparation of natural subgrade will not be measured for payment.

F. Driveway Surfacing Material.
Tons (megagrams) or cubic yards (cubic meters), as provided in the contract and in Section 2315, placed at intersecting roads, drives, and turnouts. Excavation required for placement of this material will not be measured for payment.

G. Portland Cement Concrete Pavement Samples.
Not individually counted for payment when furnished according to Article 2301.04, A, or when required in the contract documents.

H. Saw Cut and Joint Sealing.

1. Saw cut for constructing joints in new pavement will not be measured for payment.

2. Saw cut for cutting old existing pavement, which is to be abutted with new pavement, will not be measured for payment.

3. Joint sealing will not be measured for payment.

I. Safety Fence for Pavement.
Not measured for payment.

2301.05 BASIS OF PAYMENT.

Payment will be as follows:

A. Portland Cement Concrete Pavement.

1. Contract unit price for Standard or Slip-Form Portland Cement Concrete Pavement of the type specified per square yard (square meter).

2. Payment for the quantities of pavement in square yards (square meters) will be at a percentage of the contract unit price according to Table 2301.05-1.

Table 2301.05-1: Payment Schedule for Quantities of Pavement

Thickness Index Range	Percent Payment	Thickness Index Range	Percent Payment
English (Metric)		English (Metric)	
0.00 or more (0.00 or more)	103	-0.56 to -0.60 (-13.98 to -15.24)	91
-0.01 to -0.05 (-0.01 to -1.27)	102	-0.61 to -0.65 (-15.25 to -16.51)	90
-0.06 to -0.10 (-1.28 to -2.54)	101	-0.66 to -0.70 (-16.52 to -17.78)	89

-0.11 to -0.15 (-2.55 to -3.81)	100	-0.71 to -0.75 (-17.79 to -19.05)	88
-0.16 to -0.20 (-3.82 to -5.08)	99	-0.76 to -0.80 (-19.06 to -20.32)	87
-0.21 to -0.25 (-5.09 to -6.35)	98	-0.81 to -0.85 (-20.33 to -21.59)	86
-0.26 to -0.30 (-6.36 to - 7.62)	97	-0.86 to -0.90 (-21.69 to -22.86)	85
-0.31 to -0.35 (-7.63 to -8.89)	96	-0.91 to -0.95 (-22.87 to -24.13)	84
-0.36 to -0.40 (-8.90 to -10.16)	95	-0.96 to -1.00 (-24.14 to -25.40)	83
-0.41 to -0.45 (-10.17 to -11.43)	94	-1.01 to -1.05 (-25.41 to -26.67)	82
-0.46 to -0.50 (-11.44 to -12.70)	93	-1.06 to -1.10 (-26.68 to - 27.94)	81
-0.51 to -0.55 (-12.71 to -13.97)	92	-1.11 or less (-27.95 or less)	80

3. Use the following formula to determine the thickness index for the section of pavement thickness:

$$TI = (\overline{X} - S) - T$$

Where:

TI = thickness index for the section.
$\overline{X}$ = mean core length for the section.
T = design thickness.
S = core length standard deviation (of the sample) for the section.

4. Replace pavement represented by cores deficient from design thickness by 1 inch (25 mm) or greater. The deficient areas and the replacement of the deficient cores will be determined according to Materials I.M. 346.

5. At the Contractor's option, cores that are three standard deviations or greater than design thickness may be removed from analysis for thickness index determination. Do not remove more than 10% of the total cores in a section. Do not replace cores removed from the analysis.

6. Gaps in the pavement less than 500 feet (150 m), required by staging, will be considered irregular areas for analysis of pavement thickness determinations.

7. The percent payment for projects which have all core lengths greater than design thickness will be at least 100%.

B. Integral Curb.
Not paid for separately.

C. Concrete Median.
Contract unit price per square yard (square meter).

D. Bridge Approach Sections.

1. Contract unit price for bridge approach pavement per square yard (square meter).

2. Payment is full compensation for:
- Excavation for modified subbase and subdrain.
- Furnishing and installing subdrain.

- Furnishing and installing subdrain outlet.
- Furnishing and installing polymer grid.
- Furnishing and placing porous backfill material.
- Furnishing and placing modified subbase backfill material.
- Saw cutting.
- Furnishing and installing reinforcing steel, tie bars, and dowel assemblies.
- Placing, finishing, texturing, grooving, and curing.
- All joint construction.
- All other materials and labor to construct the Bridge Approach Section as shown in the contract documents.

E. Excavation.

1. When the contract provides a unit price per station (meter) for earth shoulder finishing and the contract also provides a price per cubic yard (cubic meter) for excavation, payment will be the contract unit price per cubic yard (cubic meter) for excavation in connection with subgrade preparation and building shoulders.

2. When the contract provides a unit price for earth shoulder construction, the excavation required for preparation of subgrade and construction of shoulders will not be paid for as a separate item. It is incidental to pavement construction and earth shoulder construction and is to be included in those contract prices.

3. When no price per cubic yard (cubic meter) for excavation is provided in the contract and no unit price is provided for earth shoulder finishing or earth shoulder construction, excavation necessary for subgrade preparation is incidental to pavement construction and is to be included in that contract unit price.

F. Driveway Surfacing Material.
Contract unit price as provided in Section 2315 for the quantity of driveway surfacing placed.

G. Portland Cement Concrete Pavement Samples.

1. Lump sum contract price for furnishing samples of finished pavement or other course according to Article 2301.04, A, or when required in the contract documents.

2. Payment is full compensation for furnishing all such samples for all courses or items of work.

H. Saw Cut and Joint Sealing
Incidental to the price for pavement.

I. Safety Fence for Pavement.
Incidental to the price for pavement.

J. General.

1. Deduction will not be made from the area of pavement for fixtures with an area less than 9 square feet (1 m^2). When the adjustment of a fixture to the finished grade line involves a change in elevation of 1 foot (0.3 m) or less, this adjustment shall be made without extra compensation. When this adjustment involves a change in elevation more than 1 foot (0.3 m), this work will be paid for as extra work, as provided in Article 1109.03, B.

2. When any of the types of additional protection described in Article 2301.03, K, 3, is necessary, additional payment will be made as extra work at the rate of $1.00 per square yard ($1.20 per square meter) of surface protected. Payment will be limited to protection necessary within the contract period. Protection necessary after November 15 will be paid for only when the Engineer authorizes the work.

3. Furnish concrete for test specimens and transport the specimens and molds between the grade and plant as directed by the Engineer, at no additional cost to the Contracting Authority.

4. The above prices are full compensation for furnishing all tools, equipment, labor, and materials necessary for construction of the pavement in accordance with the contract documents.

5. The cost of furnishing, installing, and monitoring vibrators, as well as the vibrator monitoring device itself, is incidental to the contract unit price for PCC pavement.