

SECTION 350 CEMENT CONCRETE PAVEMENT

350-1 Description.

Construct portland cement concrete pavement in one course, on a prepared subgrade. Use either the fixed-form or the slip-form method of construction. When reinforced cement concrete pavement is specified or required, use concrete reinforced with steel bars or steel fabric, in accordance with details shown in the plans.

For aggregates, proportioning and mixing, and other provisions for the production of the concrete, meet the applicable provisions of Section 346.

Provide adequate lighting for all work done at night, including finishing, curing, and sawing joints. Unless lighting is provided for finishing, stop construction operations soon enough each day to permit finishing during daylight.

At least 20 days prior to paving, furnish the following information for the Engineer's review for specification compliance:

1. A detailed sequence and schedule of concrete placement operations including, but not necessarily limited to, width of pavement to be placed, proposed equipment, production rates, working hours, concrete hauling, and placement, curing, sawing, and sealing methods.
2. A detailed staking plan for subgrade controls including offset requirements.
3. A traffic control plan for pavement construction operations which includes provisions for the placement and maintenance of barriers required to protect the pavement from traffic for a minimum of 14 days after concrete placement.

350-2 Materials.

Meet the following requirements:

Concrete, Class I	Section 346
Curing Materials	Section 925
Embedded Items.....	Section 931
Joint Seal.....	Section 932

350-3 Equipment.

350-3.1 General: Obtain the Engineer's approval of the equipment and tools to be used for handling materials and performing all parts of the work, as to their design, capacity, and mechanical condition. Deliver the equipment to the job site sufficiently ahead of the start of construction operations to allow the Engineer to examine it thoroughly for approval.

Provide equipment of such capacity that the paver operates continuously and at a constant rate of production, with starting and stopping held to a minimum.

Equip all equipment which operates on the side forms with scraping devices to clean accumulations from the top of the forms and wheels.

350-3.2 Equipment For Trimming of Subgrade: For equipment operating on the subgrade, provide an automatically controlled subgrade trimmer. Use a machine that is capable of trimming the subgrade to proper elevation within the tolerances established herein. Provide grade controls that operate by sensing from a taut line, set true to line and grade. Erect and maintain the taut line.

350-3.3 Forms:

350-3.3.1 Form Material: Provide steel forms, except that on curves with a radius of 45 m or less, provide flexible forms, or wooden forms that bend to the required arc.

350-3.3.2 Dimensions: Use forms with a minimum length of 10 feet [3 m], except where they are used on curves having a radius between 150 and 300 feet [45 and 90 m], in which case use a form length of 5 feet [1.5 m]. Use forms with a height that is equal to the edge thickness of the pavement. Use forms with a height greater than the edge thickness, provided the outer portion of the slab is

thickened to equal the depth of the form by tapering at the rate of 1 inch of the extra thickness per foot [80 mm of the extra thickness per meter] of width. In such case, the Department will make no allowance for additional concrete. Do not use built-up forms.

350-3.3.3 Steel Forms: Use steel forms fabricated into an approved section and sufficiently strong to ensure rigidity under the impact, thrust, and weight of the heaviest equipment to be carried over the forms. Make the width of the base of the forms which is in direct contact with the soil at least equal to the height of the forms, but not less than 8 inches [200 mm]. Extend the flange braces outward on the base not less than two-thirds the height dimension of the form. Use steel forms of a thickness that is not less than 7/32 inch [5.5 mm]. When tested with a 10 foot [3.048 m] straightedge, ensure that the forms have no vertical variation in a 10 foot [3 m] length that is greater than 1/8 inch [3 mm] from a true plane of the surface on the top of the form, and no lateral variation that is greater than 1/4 inch [6 mm] from a true plane surface on the vertical face of the form. Do not use steel forms if, when tested as a simple beam with a span of 9 feet 6 inches [2.9 m] and a load equal to that exerted by construction equipment placed upon them, the deflection is more than 1/4 inch [6 mm].

350-3.3.4 Form Connections: Provide connections between adjacent sections of the form, that form a lock joint, free from vertical movement in excess of 1/8 inch [3 mm] and from horizontal movement in excess of 1/4 inch [6 mm], under the impact, thrust, and weight of the heaviest machine carried on the forms.

350-3.3.5 Defective Forms: Remove bent, twisted, or broken forms, and forms with battered top surfaces, from the work. Do not use repaired forms until they are inspected and approved by the Engineer.

350-3.3.6 Form Stakes: Provide at least three steel stakes for each 10 foot [3 m] length of form. Use stakes that are of sufficient size to prevent undue lateral movement of the form during paving operations. Fasten each of the stakes to the form by means of a suitable socket attached to the form. Equip each stake socket with steel wedges for securely keying the forms to the stakes. Locate a stake not more than 12 inches [300 mm] from the end of each section. Do not use forms with broken or badly worn sockets.

350-3.3.7 Form Tampers: Use adequate mechanical form tampers, capable of thoroughly compacting the soil under the forms, except when the forms rest on a cement-treated subgrade.

350-3.4 Spreader: Provide a mechanical spreader that is independently powered and capable of spreading the mixed concrete on the subgrade over the entire width and depth of the strip being paved in a manner which will prevent segregation of the materials. Use a spreader designed and constructed to permit the concrete to be struck-off to a uniform thickness.

350-3.5 Strike-Off, Consolidation, and Finishing for Fixed-Form Construction: Provide equipment for these operations that consists of a self-propelled unit, or units, that perform the following functions by mechanical means, in the sequence indicated:

- (1) Strike-off.
- (2) Vibratory Consolidation.
- (3) Screeding.
- (4) Floating.

Use equipment that is fully and accurately adjustable to produce a pavement meeting project requirements. Use equipment that is equipped with a double screed and is capable of operating in a consistent and smooth manner under all conditions of use.

350-3.6 Slip-Form Paver: Provide a slip-form paver that is self-propelled and equipped to spread, strike-off, consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the equipment, in such a manner that a minimum amount of hand-finishing will be necessary to provide a dense and homogeneous pavement. Ensure that all of this equipment is of such dimensions and arrangement as to cover the full width of the pavement strip being laid. Use equipment that is adjustable as to crown and superelevation and that can shape and compact the concrete into a dense and stable mass,

to the required cross-section. Ensure that the crown adjustment is readily controllable for accuracy in crown transitions.

Operate the paver on tracks having sufficient contact area to prevent track slippage under load. Ensure that the length of ground contact per track and the arrangement of tracks are adequate to meet the straightedge and other riding-quality requirements specified.

Accomplish screeding by either: (1) oscillating screeds, (2) an extrusion device, or (3) a combination of both.

If necessary, in order to produce a pavement of the required cross-section and meeting the surface requirements, equip the slip-form paver with traveling side forms of sufficient dimension and strength and of proper shape to support the concrete laterally for a sufficient length of time during placing and finishing.

If using trailing forms, provide forms that are rigidly supported laterally.

Equip the slip-form paver with automatic guidance and grade controls which operate by sensing from a taut line set true to line and grade. Erect and maintain the taut line.

Do not use automatic grade controls on the paver when the tracks of the slip-form paver are operating on econcrete base or previously placed concrete pavement. The Engineer may waive the use of automatic grade controls on the paver when the entire width of the tracks of the slip-form paver are operating on a subgrade which has been consistently trimmed to a tolerance of 1/8 inch [3 mm] above or below true grade as established by the taut line set for that purpose.

The Engineer may allow variation from any specific feature of the slip-form paver as detailed above, provided the industry has generally accepted the proposed variation as an improved feature.

350-3.7 Vibratory Units: Consolidate the concrete for the full width of the strip being placed with either surface pan type or internal type vibrators.

For the surface vibrators, use a frequency of not less than 3,500 impulses per minute. For internal type vibrators, use a frequency of not less than 5,000 impulses per minute for tube vibrators and not less than 7,000 impulses per minute for spud vibrators. When using spud-type internal vibrators adjacent to forms, either hand-operated or attached to spreaders or finishing machines, use a frequency of not less than 3,500 impulses per minute. Measure the frequency of internal vibrators in plastic concrete. Mount spud vibrators such that the free tip trails, and space spud vibrators at a maximum interval of 30 inches [0.75 m].

Provide an amplitude of vibration with spud vibrators that is sufficient for the vibration to be perceptible on the surface of the concrete along the entire width of the strip being placed. Furnish a device for measuring and indicating the actual frequency of vibrations. Control all vibration by the forward movement of the spreader or finishing machine so that vibration automatically ceases when stopping the forward movement of the spreader.

350-3.8 Mechanical Floating Equipment: Provide equipment that consists of a supplementary self-propelled machine capable of further smoothing the concrete, removing excess mortar from the surface, and minimizing hand finishing.

Use a machine that leaves the surface of the concrete true to grade and crown and free of irregularities. If the Engineer permits adding water to assist the finishing operations, apply water as a fog spray by means of approved spray equipment.

350-3.9 Device for Application of Membrane Curing Compound: Provide equipment for applying membrane curing compound that is self-propelled and capable of uniformly applying the curing compound at the specified rate. Use equipment that continuously stirs the curing compound, by effective mechanical means, and that thoroughly atomizes the curing compound during the spraying operation so that the finished surface of the fresh concrete will not be marred. Cover the entire surface of the pavement and, with slip-form type paving, the vertical faces by a single pass of the machine. Only use spray nozzles that are equipped with appropriate wind guards to ensure uniform application.

The Contractor may use hand power-spray equipment to apply curing compound to areas where it is impracticable to operate the self-propelled equipment.

350-3.10 Equipment for Sealing Joints: Provide equipment for sealing the joints for each section of pavement. Use a heating kettle for hot-poured sealer that is of the indirect heating or double-boiler type, using oil as a heat transfer medium. Use a heating kettle that has a thermostatically controlled heat source, a built-in automatic agitator, and thermometers installed to indicate both the temperature of the melted sealing material and that of the oil bath. Use pouring equipment equipped with nozzles that discharge the seal at the bottom of the groove. Ensure that the apparatus develops sufficient pressure to extrude the joint sealer from the nozzles satisfactorily and to control the rate of application so as to completely fill the joint to within 1/4 inch [6 mm] of the surface of the pavement without spillage. Use an apparatus so constructed that it maintains the proper temperature of the sealing material for pouring, within 10°F [5°C].

350-3.11 Equipment for Paving Small or Narrow Areas: For variable width areas, other than mainline, ramps, and shoulders, the Engineer will not require the full paving train as specified for the standard run of paving. The Contractor may use such equipment as the Engineer may approve for such areas.

350-3.12 Hand Finishing Tools: Provide straightedges that have a blade length of 10 feet [3.048 m]. Use long-handled floats that have flat blades, approximately 4 feet [1.2 m] long by 5 to 8 inches [125 to 200 mm] wide, and that are designed so as to remain straight and true. Use a handle for both types of tool with a length that exceeds 1/2 the width of the strip being placed by 3 feet [1 m].

350-3.13 Texturing Machine: Provide a machine that consists of a supplementary machine capable of applying the final finish to the concrete pavement. Apply the finish by rectangular shaped spring steel tines rigidly mounted in a frame operating on an adjustable track mounted under the main frame of the machine. Use a machine that is constructed so as to provide for adjustment of the downward pressure on the tines as necessary to produce the desired finish under varying conditions of the concrete surface.

The Engineer may allow variation from any specific feature of the Texturing Machine as detailed above, provided that the Contractor can produce an equivalent final finish.

350-4 Subgrade Preparation.

Keep construction of the subgrade completed for a distance of at least 500 feet [150 m] ahead of the paving operation. Maintain the finished subgrade in a smooth, compact condition, and restore any areas which are disturbed prior to placing the concrete. Do not place concrete on a frozen subgrade.

Ensure that the subgrade is moist while placing the concrete. Uniformly apply water ahead of the paving operations, as directed by the Engineer.

Do not allow vehicles to travel on the prepared subgrade between the subgrade trimming machine and the paving operations unless specifically authorized.

Accurately trim the subgrade to the required elevation. Trim high areas to proper elevation. Fill low areas with suitable material, compacted to the specified density, or with concrete placed integrally with the pavement. When slip-form paving, include in the width to be trimmed the areas on which the tracks of the paver will operate.

Remove material planed from the subgrade before placing any concrete. The Engineer may waive the use of the planer for small or isolated areas or any areas where its use would be impracticable.

350-5 Setting Forms.

350-5.1 General: Accurately set the forms to line and grade and such that they rest firmly, throughout their entire length, upon the subgrade surface. Join forms neatly and tightly, and brace them to resist the pressure of the equipment operating on the forms. Obtain the Engineer's approval of the alignment and grade of all forms before and immediately prior to the placing of concrete.

Fill any subgrade that is below the established grade at the form line to grade with granular material, in lifts of 1/2 inch [13 mm] or less, for a distance of 18 inches [0.5 m] on each side of the pavement edge, and thoroughly compact the material. As an exception, when placing forms on a cement-treated subgrade, the Contractor may use wedging, provided that the wedging system used adequately supports the forms without causing detrimental deflection under the weight of the paving equipment.

350-5.2 Tamping: When placing forms on other than a cement-treated subgrade, adequately tamp the materials below and adjacent to the forms with form-tamping machines.

350-5.3 Advance Preparation of Forms: Keep sufficient forms on hand at all times, and set forms so that at least 500 feet [150 m] of forms on each side of the roadway will be accurately set, and maintained true to line and grade, in advance of the point where concrete is being placed. Provide sufficient forms so that it is not necessary to remove them in less than 12 hours after placing the concrete.

350-5.4 Cleaning and Oiling Forms: Thoroughly clean and oil the forms after each use and before placing concrete against them.

350-6 Protection from Weather.

Have available at the site, at all times when concrete paving operations are underway, materials for the protection of the surface and edges of the unhardened concrete. For the protection of the pavement edges, use any covering material, such as burlap, paper, or plastic sheeting material, suitable for the protection of the pavement surface.

When rain appears imminent, stop all paving operations, and have all available personnel cover the surface of the unhardened concrete with the protective covering.

During periods when the air temperature may fall below 35°F [1°C], advise the Engineer of plans for curing and protecting the fresh concrete before placing the concrete. Do not place any concrete until the Engineer has approved the proposed methods.

The Contractor is fully responsible for the quality and strength of the concrete placed in cold weather even if the Engineer approves of the provisions the Contractor employs for protecting the concrete placed during cold weather.

350-7 Placement of Reinforcement.

350-7.1 General: Where the plans call for reinforced concrete pavement, place the steel reinforcement in the pavement slab in accordance with the details shown in the plans.

Secure the reinforcement in position in advance of concrete placement or, with the Engineer's specific approval, place it in the plastic concrete by mechanical or vibratory means after spreading the concrete. At the time of the concrete placement, ensure that the reinforcing steel is free from dirt, oil, paint, grease, mill scale, and any loose or thick rust which could impair bonding of the steel with the concrete. Place the reinforcement as provided below.

350-7.2 Fabric: Place fabric reinforcement at right angles to the centerline of the pavement and accurately to the position and location shown in the plans. Lap adjacent sheets of fabric not less than 6 inches [150 mm]. Make the laps only in the longitudinal members.

350-7.3 Bars: Place bar reinforcement as shown in the plans. Securely wire together transverse and longitudinal bars at their intersections. Lap splices not less than 20 times the nominal diameter of the bar, and only in the longitudinal members.

350-8 Placing Concrete.

350-8.1 Distribution: Distribute the concrete on the subgrade to such depth that, when it is consolidated and finished, the slab thickness required by the plans will be obtained at all points and the surface will at no point be below the grade specified for the finished surface, after application of the allowable tolerance. Deposit the concrete on the subgrade in a manner which will require as little

rehandling as possible. Continuously place concrete between transverse joints without using intermediate bulkheads.

Deposit concrete as near to expansion and contraction joint assemblies as possible without disturbing them. Do not dump concrete from the discharge bucket or hopper onto an assembly without centering the bucket or hopper directly over the assembly.

350-8.2 Use of Spreader: Place concrete on the subgrade by an approved spreading device. The Engineer will not require the Contractor to use a spreader for areas where the width of slab varies, for intersections, and for small or isolated areas where it would be impractical to use a spreader. Perform the necessary hand spreading with shovels (not with rakes). Ensure that workmen do not walk in the freshly deposited concrete with earth or other deleterious substances coated on their boots or shoes.

350-8.3 Placement Widths: The Contractor may construct the pavement either in lanes as determined by the longitudinal joints shown in the plans, or for the full width in one operation. Construct the pavement to the full width of the lane or slab in a single construction operation. When constructing pavement in separate lanes, do not deviate the junction line from the true line shown on the plans by more than 1/2 inch [13 mm] at any point. Tool the edges of the junction to the radius shown in the plans.

When constructing pavement in separate lanes, place the lanes adjacent to the low edge of the pavement, as shown on the typical section, first. The Engineer will not require the Contractor to alter placement operations where superelevation reverses the pavement cross slope from that shown on the typical section.

350-8.4 Hours of Operation: Stop placing concrete in time to complete finishing operations during daylight hours, or provide adequate approved lighting.

350-8.5 Consolidation Along Forms and Joints: Thoroughly consolidate concrete against and along the faces of all forms, and along the full length on both sides of all joint assemblies, by means of hand-operated, spud-type vibrators. Do not allow vibrators to come in contact with a joint assembly, the subgrade or a side form. Do not continue vibration at any one location so long as to produce puddling or the accumulation of excessive grout on the surface.

350-9 Slip-Form Paver.

When placing concrete with a slip-form paver, operate the paver with a continuous forward movement. If for any reason it is necessary to stop the forward movement of the paver, immediately stop operation of the vibrating or tamping elements. Do not apply tractive force to the paving machine except that which is controlled from the machine.

In case of an emergency, have available for use at the project site at least 100 feet [30 m] of forms.

Do not insert steel tie-bars into the unsupported side of the freshly formed slab. The Contractor may place tie-bars into position prior to extrusion from the paver by insertion through the forms, by insertion through a temporary support form placed against the form slab, or by other means approved by the Engineer. Use a method that results in placement of the tie-bars at the specified locations with no damage or disruption of the concrete.

350-10 Striking-off, Consolidating, and Finishing Concrete.

350-10.1 General Requirements: Immediately after placing the concrete, strike-off, consolidate, and finish it to produce a finished pavement in accordance with the cross-section, width, and surface finish required by the Contract Documents. Perform the sequence of operations as follows: strike-off; vibratory consolidation; screeding; floating; removal of laitance; straightedging; and final surface finish. Except as specified, perform strike-off, consolidation, screeding, and floating by the machine method.

350-10.2 Machine Method: Operate the machine over each area of pavement as few times and at such intervals as is necessary to give proper consolidation and to leave a surface of uniform texture. Avoid excessive operation over a particular area.

Perform strike-off, consolidation, and finishing in a manner such as to avoid damage to, or misalignment of, joint assemblies, reinforcing steel, dowels, and other embedded items.

350-10.3 Hand Methods:

350-10.3.1 Conditions under which Allowed: The Contractor may use hand methods in areas of narrow width or irregular dimensions, where operation of mechanical equipment is impracticable. In the event that mechanical equipment breaks down, the Contractor may use hand methods to finish only that concrete already deposited on the subgrade when the breakdown occurred.

350-10.3.2 Strike-off and Screeding: Use a portable screed of an approved design, constructed either of metal or of other suitable material shod with metal, to strike-off and screed the concrete. Use a screed that is sufficiently rigid to retain its shape and is at least 2 feet [0.6 m] longer than the maximum width of the strip to be screeded.

In operation, move the screed forward on the forms with a combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing, and manipulate it so that neither end is raised from the side forms during the striking-off process. If necessary, repeat this until the surface is of uniform texture, true to grade and cross-section, and free from porous areas.

350-10.3.3 Consolidation: Use hand-operated spud-type vibrators to consolidate.

350-10.3.4 Floating: Use long-handled floats to float the concrete. Take the necessary care to avoid creating depressions or ridges during this operation.

350-10.4 Work Bridges: Provide work bridges or other devices necessary for access to the pavement surface for the purpose of inspection, finishing, straightedging, and performing corrective work.

350-11 Supplemental Floating.

In areas where performing machine strike-off, consolidation, and finishing, further smooth the surface of the concrete and remove the excess mortar from the surface. Carry a small amount of mortar ahead of the float device as it moves on the surface of the concrete. Operate the machine over the surface of the concrete as many times as required to obtain an acceptable surface, meeting the requirements specified herein. Waste excess mortar beyond the edge of the slab.

350-12 Final Finish.

350-12.1 Finishing: As the water sheen disappears from the surface of the pavement and just before the concrete achieves its initial set, drag a seamless length of damp burlap that extends the full width of the strip of the constructed pavement, longitudinally along the surface to produce a uniform gritty texture.

Use a burlap drag that consists of two layers of medium weight burlap with the trailing edge of the lower layer extending approximately 2 inches [50 mm] behind the upper layer. Support the burlap drag in a manner so that a length of at least 3 feet [1 m] of burlap is in contact with the pavement.

Except in areas where using hand methods to construct the pavement, support the lead end of the burlap drag by a traveling bridge. Maintain the drag clean and free from encrusted mortar. Replace the burlap with new material as necessary.

After applying the burlap drag finish, apply the final finish with the texturing machine. Control the time of applying this finish and the method of operating the texturing machine so as to minimize tearing of surface and unseating of aggregate particles.

Provide a final finish that consists of transverse grooves which are 0.08 to 0.12 inch [2 to 3 mm] in width and 0.10 to 0.15 inch [2.5 to 4 mm] in depth, spaced at random intervals between 1/2 to 1 inch [13 to 25 mm]. Operate the texturing machine in a manner that minimizes the overlapping of subsequent passes of the steel comb. Create short gaps in the grooved finish as necessary to avoid overlap between passes.

In areas of irregular dimensions or narrow widths, where operating the texturing machine is impracticable, the Contractor may apply the finish by approved hand methods that achieve the required finish with a minimum of surface tearing and unseating aggregate particles. Ensure that the surface resulting from this operation is uniform in appearance and free of irregular, rough, or porous areas.

350-12.2 Edging: After applying the final finish, but before the concrete has become nonplastic, carefully round the edges to a 1/4 inch [6 mm] radius on each side of transverse expansion joints and construction joints and along any structure extending into the pavement. Produce a well-defined and continuous radius, and obtain a smooth, dense mortar finish. Completely remove all concrete from the top of the joint filler.

Check all joints with a straightedge before the concrete has become nonplastic, and, if one side of the joint is higher than the other or the entire joint is higher or lower than the adjacent slabs, make corrections as necessary.

350-13 Curing.

350-13.1 General: After completing the finishing operations and as soon as the concrete has hardened sufficiently to not mar the surface, cover and cure the entire surface and, when the slip-form method is used, the edges of the newly placed concrete in accordance with one or more of the methods described below. In all cases in which curing requires the use of water, ensure that curing has prior right to use all water supplies. If the Contractor fails to provide sufficient curing materials to adequately cure the concrete in place in a timely manner, the Engineer will order an immediate suspension of concreting operations. Do not leave the concrete exposed for a period in excess of 30 minutes between stages of curing or during the curing period.

Continuously cure the freshly placed concrete for a period of 72 hours, exclusive of any periods when the temperature of the surface of the concrete falls below 50°F [10°C].

350-13.2 White-Pigmented Curing Compound: Under this method, uniformly apply white-pigmented curing compound to the surfaces to be cured, in a single coat, continuous film, at the minimum rate of 0.005 gal/ft² [0.2 L/m²], by a mechanical sprayer.

At the time of use, thoroughly mix the compound until the pigment is uniformly dispersed throughout the vehicle.

Do not apply curing compound during periods of rainfall. Do not apply curing compound to the inside faces of joints to be sealed. Should the film become damaged from any cause within the required curing period, repair the damaged portions immediately with additional compound. If using side forms, upon their removal, immediately coat the sides of the slabs exposed to provide a curing treatment equal to that provided for the surface.

350-13.3 Burlap Mats: Under this method, cover the surfaces to be cured with burlap mats. Thoroughly saturate the mats with water before placing them. Use mats of such dimensions that as laid they extend to at least 2 feet [0.6 m] beyond the edges of the strip of concrete placed. Place and weigh down the mats so as to cause them to remain in intimate contact with the surface being cured, throughout the curing period. Maintain the mats fully moist and in position for the entire portion of the required burlap curing period.

350-13.4 Removal of Forms: Do not remove forms from freshly placed concrete until it has set for at least 12 hours. Remove forms carefully so as to avoid damage to the pavement. After removing the forms, immediately cure the sides of the slab in the same manner as the surface of the pavement.

350-14 Surface Requirements.

After curing, remove the curing material (except for the impervious coating), and thoroughly test the surface for pavement surface smoothness in accordance with 352-4(c). Plainly mark all variations from the required tolerances. Where pavement surfaces do not meet the smoothness requirements, the Engineer will require corrective work and retesting to ensure conformity.

Eliminate high spots exceeding 1/8 inch in 10 feet [3.2 mm in 3 m], but not in excess of 0.3 inch in 25 feet [7.6 mm in 7.6 m], by grinding either with an approved machine or with a carborundum brick and water. Do not use bush-hammering or other destructive means for removing irregularities. As directed by the Engineer, retexture corrected high areas to give skid resistance comparable to the surrounding area.

Provide grinding equipment with a power driven self-propelled machine that is specifically designed to grind portland cement concrete pavement, with a minimum of a 3 foot [1 m] wide grinding head and diamond impregnated grinding blades. Produce, by grinding, a pavement surface that is true to grade and uniform in appearance with a longitudinal line type texture. Provide a line type texture that contains parallel longitudinal corrugations that present a narrow ridge corduroy type appearance. Ensure that the peaks of ridges are approximately 1/32 inch [0.8 mm] higher than the bottoms of the grooves with approximately 60 evenly spaced grooves per foot [300 mm].

Operate all milling, cutting, or grinding equipment to produce a reasonably uniform finished surface without spalling the pavement joints within corrected areas. The Engineer will not require extra grinding to eliminate minor depressions in order to provide 100% texturing of the pavement surface. Maintain the cross slope of the pavement as shown in the plans. Repair all joint seals destroyed by grinding at no expense to the Department.

Remove and replace any area of pavement which, after grinding, still shows a deviation in excess of the allowable tolerance. Ensure that the area removed and replaced is the full length between transverse joints and the full width of the lane involved.

Saw the area to be removed to a smooth vertical surface. Clean the face of the adjacent (hardened) concrete, and coat it with an epoxy bonding compound before placing the replacement concrete.

Bear the costs of all surface corrections required and of all required removal and replacement of defective surface concrete.

350-15 Joints.

350-15.1 General: Construct joints at the locations and in accordance with the details shown in the Design Standards, Index No. 305 and the Contract Documents.

350-15.2 Longitudinal Joints:

350-15.2.1 Longitudinal Construction Joints: Where the pavement is poured in strips less than the full width of the pavement, construct longitudinal construction joints in accordance with the details shown in the plans. Where keyways are required, the Contractor may form them by placing an insert of the proper shape along the inside face of the side form or, when using the slip form method of paving, by an approved extrusion device. Use a method that produces a keyway of the shape and at the location indicated in the plans.

350-15.2.2 Longitudinal Lane-tie Joints: Construct longitudinal lane-tie joints within the limits of a strip of pavement, in accordance with the details shown in the plans. Construct the plane of weakness by sawing a groove in the hardened concrete. Complete sawing within 72 hours after placing the concrete.

350-15.2.3 Tie Bars and Bolt Assemblies: Place deformed steel tie bars or tie bolt assemblies at the required depth, parallel to the finished surface, at right angles to the joint and at the uniform spacing specified or required in the plans. Place them in the plastic concrete using approved equipment, or rigidly support them on the subgrade by approved devices capable of preventing displacement prior to placing of the concrete. Do not paint or coat the bars with any material before placing them in the concrete.

If placing tie bars along a longitudinal construction joint using the method of inserting bars with a 90 degree bend in the edge of the plastic concrete and after the concrete hardens straightening these bars, use Grade 40 [Grade 300] reinforcing steel for such tie bars. Replace any bar broken while being straightened in an approved manner.

350-15.2.4 Longitudinal Shoulder Joints (Concrete to Asphalt): Construct a continuous joint by sawing a groove into the asphalt pavement at the abutment with the concrete pavement. Produce a groove that is 3/4 inch [19 mm] wide and 3/4 inch [19 mm] deep, after sawing and cleaning.

Seal the joint with hot-poured type sealant.

350-15.3 Transverse Joints:

350-15.3.1 Transverse Construction Joints: Construct transverse construction joints at the end of all pours and at other locations where the paving operations are stopped for as long as 30 minutes. Do not place construction joints, however, within 10 feet [3 m] of any other transverse joint or within 10 feet [3 m] of either end of a section of pavement. If sufficient concrete has not been placed to form a slab at least 10 feet [3 m] long, remove the excess concrete, back to the last preceding joint. Form the joints by placing a wood or metal bulkhead accurately and securely in place, in a plane perpendicular to the profile and centerline of the pavement. Install dowel bars at the construction joints. Saw or form construction joints, in a manner similar to contraction joints, so that a groove will be formed for holding the joint sealing compound.

350-15.3.2 Transverse Contraction Joints: Construct transverse contraction joints at the interval indicated in the plans consisting of planes of weakness created by sawing a groove in the surface of the hardened concrete. Place the groove perpendicular to the surface of the pavement. Install load-transfer devices in transverse contraction joints.

Ensure that the sawing equipment does not damage the pavement, and saw the transverse contraction joints as soon as the pavement has hardened to the degree that tearing and raveling are not excessive and before uncontrolled shrinkage cracking begins.

Accomplish the joint sawing in two steps. Make the initial cut 1/8 inch [3 mm] wide by a depth at least 1/3 of the pavement thickness, and in general when the concrete is between 4 and 12 hours old. Make a second saw cut, to provide the joint dimensions indicated in the plans, as soon as there is no danger of further raveling.

In cases where a strip of pavement is being placed immediately adjacent to a previously constructed strip of pavement, construct transverse contraction joints using extreme care to time sawing so as to prevent uncontrolled cracks.

Repair any uncontrolled cracks at no expense to the Department by removing and replacing the pavement across the full width of all affected lanes or shoulders and to the nearest transverse joint in each direction.

After the final sawing, clean the joint, install the bond breaker, and seal the joint.

350-15.3.3 Transverse Expansion Joints: Form transverse expansion joints using preformed joint filler, and provide them with dowel load transfer, in accordance with the details shown on the Design Standards, or in the plans.

Form the joints during the placing of the concrete, by securely staking a metal bulkhead accurately in place at the joint location or by other methods which will securely brace and support the joint filler. Where using approved devices to keep the expansion joint filler and dowels securely in place, the Engineer will not require a bulkhead. Protect all transverse expansion joints at the bottom and side edges by a sheet metal strip as specified in 931-2.1 and as shown on the Design Standards.

Cut the filler to the crown and shape of the slab cross-section and extended it to the subgrade. After installation, ensure that the top is not less than 1 inch [25 mm], and not more than 1.25 inches [30 mm], below the finished surface. Furnish the joint filler in lengths not less than the lane widths being poured, except that the Engineer will not require lengths greater than 12 feet [3.5 m]. Where more than one section is allowed and used in a joint, securely lace or clip the sections together.

Place the filler normal to the pavement surface. Stake the assembly into position in such a way as to hold the assembly securely in position throughout construction. Ensure that the assembly is true to the line prescribed, subject to a tolerance of 1/4 inch [6 mm] in the width of the slab.

Obtain the Engineer's approval of the assembly and its installation before placing any concrete against it. Obtain the Engineer's approval of the cross-section and length of the stakes.

When laying the pavement in partial width slabs, place transverse joints in the succeeding slab in line with the like joints in the first slab. In the case of widening existing pavement, place transverse joints in line with like joints in the existing pavement or as otherwise shown in the plans.

350-15.4 Load-Transfer Devices: Provide dowel load-transfer devices in all transverse joints. Firmly hold dowel bars in a position parallel to the surface and the centerline of the slab, by approved steel supports and spacers of a type shown in the plans. The Engineer may approve the use of dowel bar supports or assemblies other than those specifically detailed in the plans. Allow the dowels to be free to move in one slab as the concrete contracts and expands. Paint the free end of each dowel with one coat of approved zinc rich paint (listed on the Qualified Products List), and grease it with an approved lubricant, to prevent the concrete from bonding to the dowel. Provide the free end of expansion joint dowels with the closest fitting metal cap or sleeve, equipped with a stop to prevent closing during placement operations. Maintain a clearance of 1 inch [25 mm] between the closed end of the cap and the dowel to accommodate future slab movement.

Position each dowel such that its final deviation from parallel to the surface of the pavement and parallel to the longitudinal centerline of the pavement does not exceed 1/2 inch [13 mm]. Position each dowel such that its final deviation from being centered on the joint does not exceed 2 inches [50 mm]. Position each dowel such that at no point in its length does it deviate from the surface of the pavement as shown in the plans in excess of 1 inch [25 mm].

Provide the Engineer with confirmation of the location of the dowel bars. The Contractor shall confirm that the paving operation has not displaced the dowels from their required positions. Perform confirmation checks daily for the first two days of the paving operation and weekly thereafter.

350-15.5 Expansion Joints Around Structures: Form expansion joints by placing premolded expansion joint material about all structures and features projecting through, into or against the pavement. Ensure that such joints are 1/2 inch [13 mm] in width.

350-15.6 Cleaning Joints and Cracks:

350-15.6.1 Cleaning Joints in New Pavement:

350-15.6.1.1 Sawed Joints: Immediately after sawing the joints which require sealing, completely remove the resulting slurry from the joint and the immediate area by flushing with a jet of water under pressure and by using other tools as necessary.

After flushing, blow out the joints with compressed air. After the flushed joints have dried, sandblast the joint faces to thoroughly remove all foreign material. Perform sandblasting in two passes, once for each face.

Patch all spalled edges with an epoxy compound. Immediately prior to joint seal installation, clean the joints using compressed air to remove all traces of debris and dust within and on the joint surfaces.

350-15.6.1.2 Non-Sawed Joints: Thoroughly clean joints which require sealing of all foreign material for the full depth of the seal installation.

With the exception of slurry removal due to sawing, meet the cleaning requirements as specified for sawed joints.

350-15.6.2 Cleaning Joints in Existing Pavement: Remove all existing joint-sealing material and foreign material for the full depth of the new joint seal by sawing, wire brushing, sandblasting, or other methods approved by the Engineer.

Remove any existing sealant or parting strip material below the tape or backer rod bond breaker and replace it with additional bond breaker. When conditions require removal and replacement with additional bond breaker below the new joint seal, obtain the Engineer's approval of the type of bond breaker and its installation procedure. Perform cleaning by any method or combination of methods, as detailed in the plans.

Flush the joint with a pressurized jet of water, and use other tools as necessary, to remove loose remnants and debris.

After flushing, blow out the joints with compressed air. After the flushed joints have dried, sandblast the joint faces to thoroughly remove all foreign material. Perform sandblasting in two passes, once for each face.

Patch all spalled edges with an epoxy compound.

Immediately prior to joint seal installation, clean the joints using compressed air to remove all traces of debris and dust within and on the joint surfaces.

350-15.6.3 Cleaning Random Cracks in Existing Pavement: Do not begin cleaning random cracks in existing pavement until all other concrete pavement repairs have progressed to the point where those operations will not adversely affect the installation of the new seal.

Cut the random cracks to be repaired and sealed into grooved joints to the depth and width detailed in the plans. Clean the joints as specified in 350-15.6.2.

350-15.7 Sealing Joints and Cracks: Seal joints in new pavement before allowing any traffic or construction equipment on the pavement. Complete sealing within 72 hours (weather permitting) of sawing.

When using silicone and non-silicone sealants in the transverse and longitudinal joints, respectively, always use the silicone sealants first to prevent contamination at the intersection of the joint faces. Remove non-silicone sealant 1 foot [300 mm] in each direction from the transverse joints, and replace it with silicone sealant.

350-15.7.1 Hot-Poured Type Sealant: When the plans require hot poured sealant for specific joints, fill the joint thoroughly, without trapping air, ensuring the sealant is recessed below the pavement surface as required, and control the pouring rate to avoid spilling of sealant onto the adjacent pavement surface. If any spilling of sealant occurs, immediately remove and clean the entire surplus amount from the pavement surface. Place poured material when the ambient air temperature is 50°F [10°C] or greater.

350-15.7.2 Low Modulus Silicone Sealant: Use low modulus silicone sealant of either Type A (non-self-leveling silicone sealant), or Type B and/or Type C (self-leveling silicone sealant). Because Type A will not flow into the proper shape under its own weight, install and tool it so that the sealant is in firm contact with the joint faces and is formed into the appropriate shape as specified. Types B and C will normally flow into the proper shape without tooling. Exercise care to provide the required depth of recess above the sealant surface and below the pavement surface. Install the silicone sealant at temperatures above 40°F [5°C].

350-16 Thickness Determinations.

350-16.1 Core Borings: After completing the concrete pavement, including any corrective work to meet ride requirement, drill cores from the pavement to determine the actual thickness. When the Department is ready to core the finished pavement for thickness, provide traffic control, coring equipment, and operator to obtain the cores. The Engineer will select the coring locations and make the acceptance measurements. Take borings at random intervals and at various points on the cross-section so that each test boring represents an area not exceeding 2,500 yd² [2,000 m²].

Replace the portions of the pavement removed by the borings at no expense to the Department.

350-16.2 Method of Calculating Average Thickness: The Department will determine the average thickness of pavement from the length of all cores taken as indicated above and will calculate it as follows:

(a) The Department will not take into account in the calculation any areas of pavement which are left in place, but for which no payment will be made.

(b) When the thickness as measured by the cores is more than 1/2 inch [13 mm] greater than the specified thickness, the Department will consider it in the calculation as the specified thickness plus 1/2 inch [13 mm].

(c) The Department will calculate the average thickness for the entire job as a unit.

350-17 Deficient Thickness.

350-17.1 General: The Department will not pay for any pavement which is more than 1/2 inch [13 mm] less than the specified thickness. When the pavement contains no longitudinal construction joint, the Department will not pay for the area of such pavement that is the product of the full width of the strip placed as a unit times the sum of the distances each way from the short core or cores to the cores on each side which show measurements within the tolerance limits. When the pavement contains longitudinal construction joints, for the width, the Department will use the width between longitudinal construction joint and the edge of pavement.

350-17.2 Deficient Pavement Requiring Removal: The Engineer will evaluate areas of pavement found deficient in thickness by more than 1/2 inch [13 mm] and if, in his judgment, the deficient area is sufficient to seriously impair the anticipated service life of the pavement, the Contractor shall remove such areas and replace them with concrete of the thickness shown in the plans. The Department will not pay for the area of pavement removed or for the materials or labor involved in its removal. When removing a section of pavement, remove the full length between transverse joints.

350-17.3 Deficient Pavement Left in Place: If the Engineer determines that the deficiency will not seriously impair the anticipated service life of the pavement, the Contractor may elect to leave the pavement in place, but shall receive no compensation for the area of pavement.

350-17.4 Additional Borings: If the Contractor believes that the number of cores taken is not sufficient to indicate the thickness of the pavement, he may request that the Engineer select additional boring locations. The Department will deduct the cost of these additional borings from any sums due the Contractor, unless such borings indicate that the pavement within the questioned area is of specified or greater thickness.

350-18 Opening Pavement to Traffic.

Except as provided below, keep the pavement closed to traffic for a minimum period (exclusive of days when surface temperature of the concrete falls below 50°F [10°C]) of 14 calendar days after placement of the concrete. As an exception to the above, when Type III cement is used, the Engineer will reduce this minimum required period to 48 hours. The Engineer may permit opening of a section of pavement to traffic at an earlier time provided that representative test beams, made in accordance with AASHTO T 23 and tested in accordance with AASHTO T 97, indicate a flexural strength of at least 550 psi [3.75 MPa]. Cure these test beams in a manner identical to the corresponding section of pavement.

Protect the pavement from all traffic, including construction operations, until the specified period of time has elapsed. Provide protection that includes the erection and maintenance of signs, lights, barricades, etc., the construction and removal of temporary pavement, bridges, crossovers, etc., and the use of flagmen as may be necessary. Arrange the protective measures so as not to interfere with traffic in lanes being utilized for required maintenance of traffic.

Before opening the pavement to traffic, construct an earth berm along each edge. Build the berm to the full height of the pavement and at least 18 inches [0.5 m] wide, and sufficiently compact it to prevent underwash of the pavement. Maintain the berm until completing the final shoulders.

350-19 Method of Measurement.

350-19.1 Concrete Pavement: The quantities to be paid for will be the plan quantity, in square yards [square meters], of Plain Cement Concrete Pavement and of Reinforced Cement Concrete Pavement, omitting any areas not allowed for payment under the provisions of 350-17.3 and adjusted for average thickness as provided herein.

For purposes of payment, the average thickness of pavement will determine the final pay quantities for this pavement as follows:

The area of pavement represented by the difference between the calculated average thickness and the specified thickness will be converted into equivalent square yards [square meters] of specified thickness pavement, and the quantity thereby obtained will be added to, or deducted from, the quantity of pavement to be paid for, subject to the limitation that the maximum average of over-thickness permitted in the adjustment of the quantity of pavement to be paid for will be 1/4 inch [6 mm].

Where the plans call for cement concrete pavement that is to be covered with asphalt concrete surface course, payment will be made for the total thickness of the combination as Plain Cement Concrete Pavement.

In such cases, price and payment will also include all costs of the asphalt concrete surface course.

Reinforcing steel, placed and accepted, will be measured and paid for as provided in Section 415.

350-19.2 Joints and Cracks: The Contractor shall include the cost for Cleaning and Sealing Joints in the cost of the newly constructed pavement for: (1) transverse and longitudinal joint construction for new pavement; and (2) abutting joints between existing pavement and new pavement.

For replacing joint seals and sealing random cracks in existing portland cement concrete pavement, the quantity to be paid for will be as specified below:

(a) The length of pavement joint that have been satisfactorily cleaned and sealed in existing portland cement concrete pavement, as determined by field measurement along the joints, will be paid for at the Contract unit price per foot [per meter] for Cleaning and Resealing Joints.

(b) The length of random cracks in existing portland cement concrete pavement that have been satisfactorily cut, cleaned, and sealed, as determined by field measurement along the joints, will be paid for at the Contract unit price per foot [per meter] for Cleaning and Sealing Random Cracks.

350-20 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including any preparation of the subgrade not included in the work to be paid for under another Contract item; all transverse and longitudinal joint construction, including tie-bars and dowel bars; the furnishing of test specimens; repair of core holes; and all incidentals necessary to complete the work.

Payment will be made under:

Item No. 350- 1-	Plain Cement Concrete Pavement - per square yard.
Item No. 2350- 1-	Plain Cement Concrete Pavement - per square meter.
Item No. 350- 2-	Reinforced Cement Concrete Pavement - per square yard.
Item No. 2350- 2-	Reinforced Cement Concrete Pavement - per square meter.
Item No. 350-72-	Cleaning and Resealing Joints - per foot.
Item No. 2350-72-	Cleaning and Resealing Joints - per meter.
Item No. 350-78-	Cleaning and Sealing Random Cracks - per foot.
Item No. 2350-78-	Cleaning and Sealing Random Cracks - per meter.