SECTION 415 CONCRETE PAVEMENT

415.1 Description

(1) This section describes constructing a concrete pavement, with or without reinforcement, on a prepared foundation.

415.2 Materials

415.2.1 Concrete

(1) Furnish grade A, A2, A3, A-FA, A-S, A-S2, A-T, A-IS, or A-IP, air-entrained concrete conforming to section 501. Furnish high early strength concrete if the plans show or the special provisions require. If the contract does not specify high early strength concrete, the contractor may, at no expense to the department, use high early strength concrete.

415.2.2 Reinforcement

(1) Furnish steel reinforcement conforming to section 505. Furnish dowel bars and tie bars as the plans show and conforming to 505.2.6.

415.2.3 Expansion Joint Filler

(1) Furnish expansion joint filler conforming to AASHTO M 153 or AASHTO M 213.

(2) Furnish the filler in lengths equal to the width of the pavement lanes, and to the thickness and height that the plans show. If dowel bars are required, use filler with clean-cut punched holes, not greater than 1/8 inch (3 mm) larger in diameter than the nominal size of the dowel bar the plans require.

415.2.4 Concrete Curing Agents

(1) Furnish liquid curing compound conforming to AASHTO M 148, type 2, except for water retention testing. The department will conduct water retention tests according to AASHTO T 155, except as follows:

1. The department will not seal the edges of the specimen.
2. The department will apply the curing compound at one gallon per 200 square feet (0.20 L/m^2) of surface or at the manufacturer's recommended rate whichever is greater.

(2) Furnish polyethylene sheeting conforming to AASHTO M 171 for white opaque polyethylene film.

(3) Furnish burlap conforming to AASHTO M 182, class 3 or 4. The contractor may use 2 layers of class 1 or class 2 instead of one layer of class 3 or class 4.

(4) Furnish polyethylene-coated burlap conforming to AASHTO M 171 for white burlap-polyethylene sheets.

415.2.5 Calcium Chloride

(1) Furnish calcium chloride for use in concrete for pavements as follows:

1. For use in solid form or on the job preparation of admixture solutions, conform to AASHTO M 144, type S, grade 1 or grade 2.
2. For admixture delivered in premixed solution form, conform to AASHTO M 144, type L, in a concentration of approximately 30 percent.

415.2.6 Epoxy Grout

(1) Furnish epoxy grout consisting of a 2-component epoxy material of contrasting colors and conforming to AASHTO M 235, grade 3 - non-sagging consistency, type IV epoxy, except as modified below:

1. Use class B material for mid-depth slab temperatures between 41 F and 61 F (5 C and 16 C).
2. Use class C material for mid-depth slab temperatures between 61 F (16 C) and the highest temperature allowed by the manufacturer of the product.

(2) Bond strength, tensile strength, and elongation testing is not required.

(3) Achieve a minimum compressive yield strength of 5000 pounds per square inch (34.5 MPa) at 8 hours for special high early strength concrete, or at 3 days for grades A, C, and E concrete. Test according to AASHTO M 235 and ASTM D 695, with the following restrictions:

1. Mold and cure compressive test specimens in cylinders with a one-inch (25 mm) nominal diameter.
2. Machine specimen ends square to produce a final specimen length of 2 inches (50 mm).

(4) Submit to the engineer, before using the epoxy grout, a manufacturer's certification, include test reports from a qualified independent laboratory, showing that the product conforms to all above requirements. Clearly identify the temperature classes and compressive strength cure times for which the product is certified.

415.2.7 Weighing, Batching, Mixing, and Hauling Equipment

(1) Conform to section 501.

415.3 Construction

415.3.1 Equipment

415.3.1.1 Concrete Spreader

(1) Use a self-propelled machine with sufficient power and traction to spread and strike off the concrete to the desired cross section. If constructing slip-formed pavement, operate the spreader on wheels or crawler tracks. If constructing fixed-formed pavement, operate the spreader on the forms.

(2) Use a spreader equipped with a power-driven device that spreads the concrete uniformly between the tracks or forms, and capable of striking off in the longitudinal direction of the slab, at any required elevation. Use one or more of the following spreading devices:

- Reciprocating blade.
- Screw conveyor.
- Belt conveyor.

(3) The engineer may approve the use of mechanically operated concrete spreaders of other designs, if capable of uniform distribution and minimal segregation.

415.3.1.2 Concrete Finishing Machine

(1) Use an engineer-approved, self-propelled slip-form paving machine designed to consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the machine to minimize the necessary hand finishing to produce a dense, homogeneous pavement. Use machines equipped to vibrate the concrete for the full width and depth of the course placed in a single pass, and designed and constructed so no spreading or appreciable slumping of the concrete occurs. Use a concrete spreader, conforming to 415.3.1.1, ahead of a slip-form paver that cannot otherwise satisfactorily spread, consolidate, or finish the concrete. Equip the slip-form paver with a mechanical device that accurately spaces and positions the required tie bar reinforcement and that allows satisfactory mechanical or manual tie bar insertion.

(2) Use a self-propelled finishing machine for formed concrete pavement with sufficient power and traction to move at a uniform speed without slipping. Use a screeding and troweling type machine equipped with at least 2 oscillating transverse screeds, adjustable for tilt and crown, and designed to both strike off and consolidate the concrete.

(3) If using a finishing machine to both spread and strike off the concrete, equip it to spread the concrete uniformly with a minimum of segregation and to strike off the concrete at the required elevation.

(4) The contractor may use finishing machines that do not conform to these requirements but are specifically designed for finishing concrete pavement or bridge decks to finish minor amounts of concrete pavement with the engineer's written permission. These machines must produce equivalent results including adequate consolidation by internal vibration and an acceptable finish.

415.3.1.3 Paving Vibrators

(1) For full width consolidation of concrete pavement, use either the surface pan vibrator or the internal vibrator with either immersed tube or multiple spuds. Obtain the engineer’s approval of the vibratory equipment. Use vibrators that do not come in contact with the forms or joint assemblies. Operate surface pan type vibrators at a minimum frequency of 4000 impulses per minute. Operate internal type vibrators at a minimum frequency of 5000 impulses per minute for tube vibrators and 7000 for spud vibrators.

(2) To consolidate concrete pavement that is adjacent to forms, joints, or fixtures, use single spud type internal vibrators, either hand operated or attached to spreaders or finishing machines. Operate the vibrator at a minimum frequency of 7000 impulses per minute.

(3) Use vibrators capable, when operated according to the manufacturer's recommendations and 415.3.11.2, of thoroughly and uniformly consolidating the concrete for its full width and depth.

415.3.1.4 Float Finishers for Formed Pavement

(1) Use an engineer-approved longitudinal or transverse type float finisher adjustable to conform to the required crown and grade, and capable of producing the required surface finish.

(2) If using a mechanical longitudinal float, use a rigidly constructed, self-propelled machine operating on the forms, equipped with a power-driven floating screed. Ensure that the screed oscillates longitudinally with respect to the pavement during its transverse travel across the pavement.

(3) If using a transverse float finisher, use a float, consisting of a rigid frame carried on wheels that ride on the forms, attached to and propelled by a finishing machine or by a machine designed for the purpose. Provide a transverse cutting screed or screeds, and a transverse smoothing float suspended from and guided by the frame.

(4) If allowed to use manually operated floats instead of mechanical floats, use rigidly constructed floats. Provide floats at least 10 feet (3 m) in length with a base at least 6 inches (150 mm) in width.

415.3.1.5 Tube Float

(1) A tube float consists of a suitable tube mounted on a self-propelled unit. Use a tube adjustable in either diagonal direction, up or down, and to the required pavement crown.

415.3.1.6 Forms

(1) Unless specified otherwise, only use steel side forms of an engineer-approved cross section, constructed to ensure rigidity under impact, thrust, and mass of the equipment operating on them. For each 10-foot (3 m) section, secure at least 3 flange braces to the base and the vertical member, and fit not less than 3 stake pockets with pin anchoring keys. Use forms with a vertical face height of not less than the specified edge thickness of the pavement and a base width of 8 inches (200 mm) or more. Furnish the ends of each section with devices for interlocking the sections to form a rigid and secure joint. Use straight and true forms that, when tested with a 10 foot (3 m) straightedge, do not vary more than 1/8 inch (3 mm) along the top and no more than a 1/4 inch (6 mm) along the face. Discard, or repair and straighten bent or damaged forms to conform to these tolerances.

(2) Use built-up forms, as the engineer allows, consisting of regular pavement forms fitted on the bottom, in an engineer-approved manner, with metal or wood plates. Use full-length plates at least 8 inches (200 mm) wide.

415.3.2 Foundation

(1) Prepare the foundation according to section 211. Before placing concrete, repair and re-compact rutted or disturbed areas of the foundation resulting from hauling or paving operations as specified in section 211. If the contractor fails or neglects to perform the required repair of damaged foundation, the engineer may suspend paving operations until the contractor performs satisfactory reconditioning of the foundation.

415.3.3 Setting Forms

(1) Set forms to the required grade and alignment. Cut the foundation under the forms true to grade and make firm, so the form is firmly in contact for its whole length and at the desired grade. Correct any foundation that, at the form line, is below established grade. Fill the foundation to grade in lifts of one inch (25 mm) or less, for a distance of 18 inches (500 mm) on each side of the base of the form, and re-roll and tamp. Correct imperfections and variations above grade by tamping or by cutting, as necessary. Always tamp the material under the forms thoroughly after setting the form. The engineer will shut down operations if observing any settlement or springing of forms under the finishing equipment.

(2) Use at least 3 pins for each 10-foot (3 m) length to stake forms. Use pins of a length that, if driven in place, are firm and rigid, and prevent movement in the forms. Drive pins into the stake pockets of the forms, and securely fasten the forms to each pin with adequate locking devices. Join the form sections with a locked joint that is free from play or movement in any direction.

(3) Check that forms conform to alignment and grade, and make necessary corrections before placing the concrete. If a form has been disturbed, reset and recheck the form.

(4) Set and maintain forms, to the extent practical, for at least 1200 square yards (1000 m^2) of pavement before the point of placing concrete. Clean and oil forms before each use.

(5) Use built-up forms instead of full-depth side forms if the total area of concrete pavement of any specified thickness on a project is less than 200 square yards (1700 m^2).

(6) Use wood side forms for forming fillets, widening strips at intersections, curves of less than 100 foot (30 m) radius, and where the use of metal paving forms is impractical. Provide wood forms made from sound lumber, free from cracks or other blemishes, surfaced at least on the concrete face and top edge and, except for forming curves of less than 100 foot (30 m) radius, of not less than 2 inch (50 mm) nominal stock. Do not allow the variation of the top of forms from a true plane to exceed 1/8 inch (3 mm). Do not allow the variation of the face of forms from a true plane to exceed 1/4 inch in 10 feet (6 mm in 3 m).

(7) Use flexible or curved forms of proper radius for curves of 100 feet (30 m) radius or less. For flexible or curved forms, use either wood or metal of ample strength to produce completed work conforming to the alignment, grade, and surface tolerance required. Place and stake, insofar as it is practical, as specified for steel forms in 415.3.1.6 and 415.3.3 and as the engineer approves.

415.3.4 Handling, Measuring, and Batching Materials

(1) Conform to section 501 and the additional requirements specified here in 415.3.4.

(2) Proportion aggregates and cement for concrete pavement in batching plants by weight. Use semi-automatic or automatic batching plants on contracts involving 15 000 square yards (12 500 m^2) or more of concrete pavement.

(3) On contracts involving less than 15 000 square yards (12 500 m^2) if furnishing a semi-automatic or automatic plant, provide a plant conforming to the pertinent requirements of 501.3.4.

415.3.5 Mixing

(1) Conform to section 501.

415.3.6 Consistency

(1) Maintain a uniform consistency in consecutive batches of concrete. Perform slump tests according to AASHTO T 119. Use the following slumps for the technique used:

SLIP-FORMED	NOT SLIP-FORMED
2.5 inches or less	4 inches or less
(65 mm) or less	(100 mm) or less

(2) The contractor need not test slump for slip-formed work except as the engineer requests.

415.3.7 Placing Concrete

415.3.7.1 General

(1) Deposit concrete on the foundation from the mixer or hauling equipment across the full width of the pavement in a manner that minimizes required spreading and minimizes segregation in the concrete mix.

(2) Distribute concrete to a depth sufficiently above grade so, after consolidating and finishing, the required slab thickness is obtained at all points and the surface conforms to the specified grade and slope.

(3) Adjust and set castings and frames for manholes, catch basins, inlets, and other fixtures to the required alignment and grade while the adjacent concrete is still plastic.

(4) Provide internal vibration for concrete placed against the faces of fixtures to prevent the formation of voids and to fill openings between the bases of the fixtures and their support structures.

(5) The contractor may set the castings and frames for manholes, catch basins, and inlets, on a full bed of mortar and adjust to the required alignment and grade before placing concrete. The contractor may also use an engineer-approved non-shrink pressure grout to fill all remaining voids beneath the base of these fixtures before opening the adjacent pavement to traffic.

(6) Continuously place concrete between transverse joints, do not use intermediate bulkheads. If a temporary shutdown occurs, cover the concrete at the unfinished end of the slab with wet burlap. Install a construction joint if an interruption exceeds 30 minutes or is long enough that the concrete deposited attains its initial set. Do not place sections of pavement less than 10 feet (3 m) in length between joints.

(7) If constructing continuously reinforced pavement, install the construction joint header as specified for transverse joints in 415.3.9.2. After installing the header, wait 8 hours before resuming concrete placement, unless the engineer directs otherwise.

(8) Immediately repair any damage to the slab resulting from header removal or subsequent operations.

(9) Discontinue concrete placement if finishing equipment breaks down, the time sequence of finishing and curing operations is not kept, or if materials, work quality, or the resultant product are substandard.

(10) Deposit concrete at joint installations so as not to displace or disarrange the installations. Completely fill the joint assemblies with concrete. Simultaneously place concrete on both sides of expansion joints. Deposit the concrete at and in advance of contraction joint assemblies to preclude the formation of segregated or laitance-bearing concrete in the assembly.

(11) Unless specified otherwise, place pavement of rural cross section to its full plan width in a single construction operation. For pavement constructed directly on open graded base, the contractor may place pavement to a single lane width in a single operation.

(12) Do not place temporary gaps in continuously reinforced pavement unless the contract specifies or the engineer directs. If unable to pave the gap beforehand, use additional reinforcement as specified for placing continuous pavement reinforcement in 415.3.8.2 and stabilize the concrete temperature in the free ends of the pavement by applying a double layer of burlap to the pavement surface for a distance of 200 feet (60 m) from each free end. Keep the burlap wet and in place for at least 24 hours just before paving the gap and until the curing time has expired for the newly placed adjacent pavement.

(13) Make the longitudinal construction joint between lanes or sections less than or equal to 1/2 inch in 10 feet (13 mm in 3 m) from the true line. Edge the joint to a 1/4-inch (6 mm) radius.

(14) Only place concrete in a subsequent lane if capable of avoiding damage to the previously constructed lane. When placing concrete adjacent to previously constructed pavement, provide that part of the equipment supported on the existing pavement with protective pads, crawler tracks, or rubber-tire wheels and operate a sufficient distance from the edge of the pavement to avoid breaking the pavement edge. Do not operate this equipment on the pavement surface until opening to service as specified in 415.3.17.

(15) Exclude equipment, other than paving equipment as specified above, from the previously constructed lane or lanes until, as specified for opening to service in 415.3.17, after the expiration of the required number of days or until attaining the required strength.

(16) If moving or operating paving equipment on concrete bridge decks, asphaltic pavement or surfacing, or concrete pavements, employ appropriate means to prevent damage to the bridge decks or pavements.

415.3.7.2 Pavement Constructed with Ready-Mixed Concrete

(1) Facilities for the production and delivery of ready-mixed concrete shall ensure placement at a uniform rate of not less than 80 cubic yards (60 m^3) per hour, unless performing single-lane construction.

(2) As practical, use delivery vehicles operating outside the lane or lanes being placed to deposit the concrete on the prepared subgrade. If the engineer allows the delivery vehicle to operate in the lane in which the concrete is being placed, provide means to satisfactorily correct irregularities and to restore the foundation as necessary before placing concrete. If placing fixed-formed pavement, operate a subgrade planer just ahead of the deposited concrete. If using slip-form methods, use engineer-approved methods or equipment to restore the subgrade satisfactorily.

415.3.7.3 Formed Pavement

(1) Vibrate placed concrete along the faces of forms to prevent voids.

(2) Use single or multiple spud vibrators to consolidate the concrete along the full length of all transverse joint assemblies. Vibrate to a depth that consolidates the concrete above and below the dowel bars and assembly, unless installing dowel bars using engineer-approved machine methods during placement. If spud vibrators are an integral part of the paver, set them to clear the dowel bar assembly and ensure they are capable of consolidating the concrete to full depth.

(3) Use hand vibrators on concrete adjacent to all transverse construction joints.

(4) Vibrate along forms, fixtures, and joints according to 415.3.1.3. Do not allow vibrators to contact a joint assembly, the grade, or a side form. Vibrate the concrete adjacent to joint assemblies to preclude displacing the dowels or other parts of the assembly. Do not operate the vibrator in one location for longer than required to bring grout to the surface of the immediate area. Immediately fill all voids or rock pockets of more than casual occurrence, found after removing the forms, with a well-mixed grout, composed of one part portland cement and 3 parts fine aggregate. Finish these areas to the true surface of the edge of the pavement slab.

415.3.7.4 Slip-Formed Pavement

(1) Coordinate the mixing, delivering, and spreading operations to provide uniform progress. Stop and start the paver as little as possible.

(2) Vibrate concrete adjacent to transverse construction joints with hand vibrators.

415.3.8 Reinforcement

415.3.8.1 General

(1) Reinforce the concrete if and as the plans specify. Keep reinforcement clean and free from rust scale, straight and free from distortion. Store all reinforcement steel, received on the job, in engineer-approved storage and distribute only as needed for immediate placement.

415.3.8.2 Placing Continuous Pavement Reinforcement

(1) Place the bar steel reinforcement after properly preparing the subgrade. Place the longitudinal bars on top of the transverse bars and firmly tie or fasten together at each intersection. Support the assembled bars on bar chairs at a depth the plans show. Bar chairs are subject to the engineer's approval. They shall be sufficient in strength and number to hold the steel reinforcement in position during construction.

(2) Splice longitudinal bars by lapping, as the plans show, and firmly tie or fasten together. Arrange splices as the plans show. Install additional steel reinforcement, as the plans show at construction joints.

(3) Protect all bar steel reinforcement left protruding from the slab for any extended period from deterioration caused by exposure.

(4) Do not bend bar steel reinforcement or subject to loading or forces that distort the steel or weaken the bond to the concrete.

(5) Tie coated bars using a procedure, equipment, and materials that do not damage or cut the coating. Use one or more of the following materials to tie coated bars:

- Engineer-approved plastic or nonmetallic material.
- Stainless steel wire.
- Nylon, epoxy, or plastic-coated wire.

415.3.9 Jointing

415.3.9.1 Longitudinal Joints

(1) Construct longitudinal joints as and where the plans show. If the plans do not show a specific location, construct parallel to the centerline along lane edges. On two-lane pavements, construct them along the pavement centerline. On multi-lane pavements, construct them along traffic and taper lane edges. Make joints perpendicular to the pavement surface. Do not deviate more than 1/2 inch in 10 feet (13 mm in 3 m) from the required line. Longitudinal joints may consist of construction joints where new work joins existing work. Saw all other longitudinal joints.

(2) Saw joints within 36 hours after placing concrete. If covering the pavement for cold weather protection, the contractor may delay sawing to avoid early exposure to freezing conditions.

(3) Tie new work to existing concrete pavement using tie bars driven into the existing pavement. Use only cast-in-place tie bars in construction joints of pavement placed under the contract.

415.3.9.2 Transverse Joints

(1) Construct as specified in the plan details. Construct contraction, construction, or expansion joints at the locations the contract specifies, or as the engineer directs.

(2) Unless the plans show otherwise or the engineer directs, install all transverse joints perpendicular to the pavement surface and continuous through adjacent lanes and contiguous curb & gutter.

(3) Hold dowel bars in the correct position and alignment using an engineer-approved device during construction. Do not allow bonded longitudinal bars or reinforcement to extend across transverse expansion or contraction joints. The contractor need not cut dowel basket tie wires.

(4) If using a mechanical device to install dowel bars, conform to the following:

1. Place and consolidate the pavement to full depth before inserting the dowel bars.
2. Insert the dowel bars into the plastic concrete in front of the finishing beam or screed.
3. Ensure that the installing device consolidates the concrete with no voids around the dowel bars.

4. Locate the dowel bars within one inch (25 mm) of the planned transverse location and depth.
5. Locate the dowel bars within 2 inches (50 mm) of the planned longitudinal location.
6. Place dowel bars parallel to the pavement surface and centerline within a tolerance of 1/2 inch in 18 inches (13 mm in 450 mm).
7. Do not interrupt the forward movement of the finishing beam or screed while inserting the dowel bars.
8. Provide a positive method of marking the locations of the transverse joints.

(5) For expansion joints, use joint filler conforming to 415.2.3 and extending from the foundation to 1/2 inch (13 mm) below the finished pavement surface, with its respective edges conforming to the contour of the subgrade and the pavement surface. Use material with factory-punched holes for and at the exact location of the dowel bars. During installation, protect the upper edge of the filler with an engineer-approved tight-fitting, removable metal channel cap having flanged edges of not less than 1 1/2 inches (38 mm) in depth. Upon completion of the finishing operations and after the concrete has set sufficiently, remove the cap, and round the edges of the joint with an engineer-approved edging tool.

(6) Form a construction joint by setting a header board securely in place at the end of each day's run or when an interruption in the concreting operation of 30 minutes or more occurs. Design and set the header board to accommodate proper placement of the tie bars or reinforcement.

(7) Use only production quality concrete in the header. Do not deposit segregated concrete carried ahead by the screed of the finishing machine at the header. While placing and finishing the concrete at the header, protect the steel projecting beyond the header from spilled concrete. Protect the steel from all loadings or forces that might displace or bend the steel or weaken the bond with the concrete. Use hand vibrators to consolidate the concrete against the header or concrete face at the transverse construction joint to prevent the formation of voids or rock pockets.

(8) If placing continuously reinforced pavement, design the header board for ready disassembly. Keep the header in place for at least 8 hours, unless the engineer allows otherwise. Secure, support, and protect the reinforcement steel immediately beyond the joint and before the next splice to preclude movement until after removing the header and completing the subsequent concrete placement.

(9) Upon removal of side forms, completely remove all struts or fins of concrete extending across the joint.

(10) Complete the sawing of contraction joints for each day's pour by approximately midnight of the same day if normal or rapid concrete setting conditions prevail. If cool weather or other conditions cause retarded setting of the concrete, delay sawing for as long as the engineer directs, to preclude tearing of the concrete adjacent to the joint, or cracking of the concrete during the sawing. Provide artificial light if joint sawing after daylight hours.

(11) Saw the joints, in a single cut, to the width and depth the plans show, as soon as the saw can be operated without damaging the concrete and before random cracking occurs. The contractor may temporarily hand tool joints to prevent premature cracking. Permanently saw all hand tooled joints to the plan depth as soon as possible. The engineer may direct the contractor to saw joints by the skip method, wherein every third joint is sawed as soon as possible. Following this skip sawing, make the cuts of the remaining intermediate joints as soon as possible.

415.3.10 (Vacant)

415.3.11 Consolidating and Finishing

415.3.11.1 General

(1) Sequence operations as follows: strike-off, consolidation, screeding, float finishing, straightedging, and final surface finish.

(2) Use the machine method of strike-off and consolidation. The contractor may, if the engineer allows, use hand methods for areas with variable slab width, for strips or lanes of pavement uniformly less than 10 feet (3 m) wide, for transition sections on curves or at other points with variable pavement crown, and for other areas if impractical to use machine methods. Immediately clean finishing equipment and tools after use, and maintain them in satisfactory condition during use.

415.3.11.2 Strike-Off and Consolidation - Machine Methods

415.3.11.2.1 General

(1) Strike off and screed the concrete, as soon as placed, with engineer-approved machine equipment. Strike off and screed to the crown and cross section the plans show and to an elevation slightly above grade so

that, when properly consolidated and finished, the surface of the pavement shall be at the required grade elevation and free from porous areas.

(2) Unless the plans show otherwise, construct pavements on curves as a plane surface with a unidirectional cross slope. Transition from the normal crown section to the unidirectional slope and back to the normal crown section smoothly over the distance the engineer specifies. Prepare the foundation surface parallel to the pavement surface to yield the required pavement thickness throughout the curve and transition.

(3) Make available ample personnel and equipment to maintain the strike-off, consolidation, and finishing operations within their proper time sequence. If the delivery rate of concrete is so great that, strike-off and consolidation cannot be performed, within the proper time sequence by one finishing machine, reduce the rate of production, or use an additional spreader or finishing machine. Provide and make available hand strike-off equipment in case of finishing machine breakdowns, to strike off and consolidate concrete in place on the grade, and to complete the operations to a construction joint.

415.3.11.2.2 Fixed-Form Pavement

(1) Make as many passes, at the necessary intervals, with the machine as required to take advantage of concrete conditions, provide proper consolidation, and leave a uniform surface, true to grade and contour. Avoid prolonged operations over any given area. Use a device attached to the machine to keep the top of the forms free of accumulations of concrete or other materials. Maintain the forms so the travel of the machine is true without lifting, wobbling, or other variation that affects a precise finish. Carry a uniform load of concrete on the forward screed on the first trip or strike-off movement extending a minimum of 4 inches (100 mm) above the planned pavement surface. Operate the machine so it does not overrun the forward limit of the puddled concrete, or pass over partially filled areas.

(2) Stop the machine when the forward screed is approximately 12 inches (300 mm) from a preinstalled transverse expansion joint. Remove all excess concrete and aggregate ahead of the screed and on the joint, and shovel forward of the joint. Lift the forward screed, and bring it directly above the joint, set it down and continue screeding operations. Lift the second screed over the joint if it is close enough to push the excess mortar in front of it onto the joint. Do not lift the screeds over the joint on subsequent passes of the finishing machine. Take care to avoid depositing segregated coarse aggregate on top of the joint or immediately between the joint and the screed.

(3) Carry a sufficient amount of concrete forward of the first screed to fill low areas that are apparent after the machine’s first strike-off movement. Maintain continuity of the forward movement of the machine. Make the last trip for a given area a continuous run of at least 40 linear road feet (12 m) of pavement. Delay the last trip of the finishing machine until after correcting irregularities in settlement or differentials in shrinkage in the freshly laid concrete. Do not delay an excessive period that causes tearing or marring of the surface results.

(4) The contractor may use vibratory equipment, conforming to 415.3.1.3, to consolidate the concrete, except for continuously reinforced pavement. Consolidate continuously reinforced pavement by vibration. Use the slump specified in 415.3.6 for vibratory consolidation. Perform vibratory consolidation after strike-off of the concrete and before the screeding. Strike off concrete consolidated by vibration to a level that ensures that the finishing machine operates properly. Unless the engineer directs otherwise, vibrate a given area of concrete with a single pass of the vibrator, while moving in a forward direction.

(5) Adjust external type vibrators, if operating, so the entire length of the pan is in contact with the concrete. Operate internal type vibrators submerged at the proper depth to preclude displacing any reinforcement.

415.3.11.2.3 Slip-Formed Pavement

(1) Maintain continuous operation of the paver if depositing, spreading, consolidating, and finishing. Minimize starting and stopping the paver. Vibrate the concrete, either externally or internally, with sufficient intensity to consolidate it throughout its entire width and depth. Use vibrators conforming to 415.3.1.3. If it is necessary to stop the forward movement of the paver, stop vibrating and tamping immediately, and restart when forward motion resumes. Use the slump as specified in 415.3.6.

415.3.11.3 Striking-Off and Consolidating By Hand

(1) Do not strike-off or consolidate concrete by hand without the engineer's permission. Strike-off and screed concrete as soon as placed, to the crown and cross section the plans show, and to an elevation above grade that results in the required grade elevation after consolidating and finishing the pavement surface.

(2) Consolidate the concrete using internal type spud vibrators.

(3) Use an engineer-approved screed, of sufficient rigidity to retain its shape, constructed of either metal or other suitable material, and at least 2 feet (600 mm) longer than the slab being struck off. Move the screed forward with a combined longitudinal and transverse shearing motion and without raising either end from the side forms during the striking-off process. Repeat this action, if necessary, until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

(4) The contractor may use surface type vibratory screeds for hand strike-off and to supplement internal vibration. Do not over vibrate if using the internal spud vibrator and the vibratory screed. If using vibratory screeds, first spread and partially level the concrete with shovels, a straightedge or other means, allow sufficient material above the forms for consolidation, then operate the vibrator with the screed moving forward, sliding on the forms, with a uniform amount of concrete in front of it for the full width of the pour. Maintain a sufficient amount of concrete, during operations, in front of the screed to fill all voids or low areas. Do not allow excessive amounts of concrete to accumulate in front of the screed, causing the concrete to surge under the screed, or produce ridges or waves in the surface. Unless the engineer directs otherwise, do not make more than 2 passes of the vibratory screed on a given area of concrete. Perform the second pass of the screed with a small roll of concrete in front of it to smooth out any irregularities in the surface. Regulate the speed of the forward movement of the screed, and the speed of the vibrator, to produce the best results. Do not vibrate the concrete with the screed in a stationary position. After vibratory screed consolidation, finish the concrete.

415.3.11.4 Float Finishing for Fixed-Formed Pavement

(1) Perform the float finish after completing finishing machine operations. Use an engineer-approved mechanically operated float, of either longitudinal or transverse type, to float the concrete surface smooth. Finish the pavement to the required cross section, elevation, and surface smoothness, or by hand-operated floats, if the engineer allows.

(2) If using a mechanical longitudinal float, adjust the screed so that it operates in the plane and cross section of the pavement surface with a small amount of mortar carried ahead of the screed. Operate the machine in its forward movement so the screed in its transverse travel passes over each section of the pavement at least 2 times, or as the engineer directs. Do not operate for a prolonged period over a given area. Stop the machine at apparent low areas and back up slightly, bring fresh concrete from the puddle, spread, consolidate and level with hand tools, then continue operations.

(3) If using a transverse type mechanical float-finisher, adjust the suspended screeds and float-pans to conform to the required grade and crown of the pavement, and operate to produce a smooth, dense concrete surface, free of waves or porous areas. If using the float-finisher attached to or towed by a finishing machine equipped with engineer-approved screeds, perform float finishing while performing the delayed or last trip of screeding operations as specified in 415.3.11.2.

(4) If the finishing machine obtains a satisfactory surface on minor amounts of concrete pavement, the engineer may not require the use of separate mechanical float finishers.

(5) If the engineer allows hand methods of float finishing, use longitudinal floats operated from footbridges or long-handled smoothing lutes or floats. Remove high spots, fill depressions with fresh concrete from the puddle, and continue floating operations until producing a satisfactory surface.

415.3.11.5 Straightedging

(1) Test the slab surface, while the concrete is still plastic, for trueness with a 10-foot (3 m) straightedge. Furnish and use an accurate 10-foot (3 m) straightedge with a handle at least 3 feet (1 m) longer than 1/2 the width of the slab. Place the straightedge at the center of the slab, with the blade parallel to the centerline and pull slowly and uniformly to the edge. Hold the straightedge in successive positions, parallel to the road centerline, in contact with the surface, and go over the whole area from one side of the slab to the other as necessary. Advance along the road in successive stages that do not exceed 1/2 the length of the straightedge. Fill any depressions immediately with freshly mixed concrete, and strike off, consolidate, and refinish the concrete. Also, strike off and refinish all projections.

(2) Continue straightedge testing and refloating until the entire surface is free from observable deviations or irregularities and the slab is the required grade and contour.

(3) The contractor may use a tube float to accomplish the testing and floating procedure instead of the above straightedging procedure if it can obtain equivalent results.

(4) Use only minimal amounts of water, if the engineer allows, for operating the tube float and correcting deficiencies found in straightedging.

415.3.11.6 Final Surface Finish

415.3.11.6.1 General

(1) Perform the final finish after the straightedging or tube floating, and after all excess moisture disappears, and while it is still possible to produce a uniform striated surface texture.

415.3.11.6.2 Design Speed Less Than 40 MPH

(1) Unless otherwise specified, provide a final finish with an engineer-approved artificial turf drag. Use a drag made of molded polyethylene with synthetic turf blades approximately 0.85 inches (20 mm) long and containing approximately 7200 individual blades per square foot (77 500 blades per m^2). Use a seamless strip of artificial turf approximately full pavement width and of sufficient size that during the finishing operation approximately 2 feet (600 mm) of turf, measured parallel to the pavement centerline, is in contact with the pavement surface. Pull the drag with an engineer-approved device that allows control of the time and rate of texturing. Operate the drag in a longitudinal direction to produce a finish acceptable to the engineer. Weight the drag as necessary to maintain contact with the pavement. Keep each drag clean and free of particles of hardened concrete. Replace the drag as necessary to produce the desired finish.

(2) If the engineer agrees that it is not practical to apply an artificial turf drag, apply a broom finish to small areas of urban pavement and to concrete driveways and other miscellaneous areas.

(3) Restore pavement texture damaged by rain by re-dragging the concrete while still plastic.

415.3.11.6.3 Design Speed - 40 MPH and Higher

415.3.11.6.3.1 General

(1) Texture and tine freshly placed pavement as soon as it is practical after floating.

(2) Texture with an artificial turf drag as specified in 415.3.11.6.2.

(3) Tine with a self-propelled tining machine. Where using a tining machine is not practical, tine by hand. Produce uniformly deep grooves approximately 1/8 to 3/16 inch (3 mm to 5 mm) deep. Provide a finished surface free of tining defects. Complete before tining tears or unduly roughens the concrete.

(4) For machine work, the department encourages the contractor to use longitudinal tining, however, the contractor may select either transverse or longitudinal tining. For hand work, use transverse tining.

415.3.11.6.3.2 Transverse Tining

(1) For machine work, use a 10-foot (3.022 m) rake constructed with individual 1/8 inch (3 mm) tines randomly spaced as specified in CMM 5-35-100. Draw the rake transversely across the full pavement width without overlapping passes.

(2) For hand work, use a rake with individual 1/8 inch (3 mm) tines randomly spaced between 3/8 of an inch (10 mm) and 2 1/4 inches (57 mm).

(3) For rural pavements, the department encourages the contractor to tine at a 1:6 skew, left side forward. Unskewed transverse tining is also acceptable. The contractor may select either skewed or unskewed tining, but must use that pattern exclusively throughout the project. For urban pavements use unskewed tining.

415.3.11.6.3.3 Longitudinal Tining

(1) Use a tining machine with an automated alignment control system to assure that all tining runs straight and parallel to the longitudinal axis of the pavement. Use a rake with individual 1/8 inch (3 mm) tines spaced uniformly with a clear spacing between tines of 3/4 inches (19 mm).

415.3.11.7 Joint Finishing and Edging

(1) Lift metal channel caps for prefabricated expansion joints until the top edge is above the pavement surface. Lift the caps only after the concrete is shaped, consolidated, straightedged, and surface finished, and set to preserve the width and shape of the joint without slump of adjacent concrete. Remove excess concrete and float, edge, and finish the surface along each side of the joints. Remove these temporary joint devices without disturbing the adjacent concrete.

(2) Test construction or expansion joints with a straightedge before the concrete sets, and correct if one side of the joint is higher than the other, or if higher or lower than the adjacent slabs.

(3) Remove any concrete, mortar, or laitance resulting from paving operations, at construction joints, before it hardens, and clean the joint.

(4) Edge the slab, expansion joints, and construction joints to a 1/4-inch (6 mm) radius. Provide finished edges of the slab and joints that are smooth and true to line.

(5) At the beginning of each day's run and at the end of the job, stamp into the pavement, in 2 inch (50 mm) letters, the contractor's name and the year of pavement construction.

415.3.11.8 Surface Testing and Correction

415.3.11.8.1 Ten-Foot Straightedge

(1) Test the pavement surface at engineer-selected locations with a 10-foot (3 m) straightedge or other engineer-specified device. The engineer may direct the contractor to mark and grind down those areas showing high spots greater than 1/8 inch (3 mm) but not exceeding 1/2 inch (13 mm) in 10 feet (3 m) until the area or spot’s elevation no longer shows surface deviations greater than 1/8 inch (3 mm) when retested with the straightedge. If the departure from correct cross section or profile exceeds 1/2 inch in 10 feet (13 mm in 3 m), the engineer may direct the contractor to remove and replace the pavement at no expense to the department.

415.3.11.8.2 (Vacant)

415.3.11.8.3 Pavement Grinding and Removal

(1) Perform grinding with an engineer-approved device specifically designed for pavement grinding having diamond blades uniformly spaced with at least 50 blades per linear foot (300 mm). Perform additional light grinding as necessary to provide a neat rectangular area of uniform appearance. Perform the grinding parallel with the centerline. Do not use a bush hammer or other impact device.

(2) Do not remove any area or section, required to be removed under 415.3.11.8.1, less than 10 feet (3 m) in length or less than the full width of the lane involved. If it is necessary to remove and replace a section of pavement, also remove and replace remaining portions of the slab adjacent to the joints less than 10 feet (3 m) in length.

(3) Complete required grinding or replacement before determining the pavement thickness.

415.3.11.8.4 Edge Slump Tolerance

(1) If constructing pavement by the slip-form method, the engineer will allow an edge slump tolerance of 3/8 inch (10 mm), exclusive of edge rounding, at locations with no adjacent concrete construction; and an edge slump tolerance of 1/8 inch (3 mm), exclusive of edge rounding, at locations with adjacent concrete construction. Correct edge slump in excess of these requirements before the concrete hardens.

415.3.12 Curing Concrete

415.3.12.1 General

(1) Maintain adequate moisture throughout the concrete mass to support hydration until the concrete develops sufficient strength to open it to service. Cure all concrete by one or a combination of the following methods:

1. Impervious coating.
2. Impervious sheeting.
3. Continuous wet cure.
4. Alternate method the engineer approves.

(2) If the contractor does not cure concrete as specified in this subsection, the engineer may suspend concrete placement operations.

415.3.12.2 Impervious Coating Method

(1) After finishing operations, and as soon as the free water disappears, spray the concrete surface with a uniform coating of curing compound conforming to curing agent requirements specified in 415.2.4. Seal moisture in the concrete by applying a continuous water-impermeable film on all exposed concrete surfaces.

(2) Provide sufficient agitation while spraying to ensure uniform consistency and dispersion of pigment within the curing compound during application.

(3) Apply the curing compound with an engineer-approved self-propelled mechanical power sprayer whenever practical. The contractor may use hand-operated spraying equipment for the following:

1. Irregular, narrow, or variable width sections.
2. Re-coating applications or after form removal.
3. Special applications the engineer approves.

(4) For tined surfaces, apply the curing compound uniformly at or exceeding a minimum rate of one gallon per 150 square feet (0.27 L/m^2). For all other surface finishes, apply the curing compound uniformly at or exceeding a minimum rate of one gallon per 200 square feet (0.20 L/m^2).

(5) If the curing compound coating is damaged within 72 hours after application, immediately recoat the affected area. If removing forms within 72 hours after placing the concrete, coat newly exposed surfaces within 30 minutes after form removal.

415.3.12.3 Impervious Sheeting Method

(1) After finishing the concrete and allowing it to harden enough to prevent excessive marring, immediately cover all exposed concrete surfaces with one or a combination of the following impervious sheeting materials:

1. Polyethylene sheeting conforming to 415.2.4.
2. Polyethylene-coated burlap conforming to 415.2.4. Pre-wet the polyethylene-coated burlap and place the uncoated side against the concrete.
3. If the engineer approves, insulated curing blankets with an impervious coating.
4. Alternate impervious sheeting materials as the engineer approves.

(2) Provide enough sheeting material to cover all exposed edges, with enough excess to enable use of weights or anchors to hold the material securely in place. Provide 12 inches (300 mm) or more overlap between adjacent pieces of sheeting. Place the sheeting material in direct contact with all exposed concrete surfaces.

(3) Maintain the sheeting material in place until the concrete conforms to the opening criteria specified in 415.3.17. If temporary removal is required to remove forms or perform other necessary work, re-cover all exposed concrete as quickly as practical, or as the engineer directs.

(4) If the engineer approves, the contractor may reuse sheeting materials that are in serviceable condition.

415.3.12.4 Continuous Wet Cure Method

(1) After finishing the concrete and allowing it to harden enough to prevent excessive marring, immediately spray or fog the exposed surfaces of the concrete to keep it moist until the concrete achieves the opening criteria specified in 415.3.17. The contractor may apply a layer of thoroughly wetted burlap to protect the surface from the mechanical impact of the spray.

(2) If there is evidence the curing water causes concrete surface erosion, the engineer will immediately suspend spraying or fogging. Remedy the conditions causing erosion or switch to another curing method.

(3) If ambient temperatures are predicted to fall below 40 F (4 C) within the next 24 hours, suspend continuous wet curing and switch to another curing method.

415.3.12.5 Alternate Curing Methods

(1) If the contractor requests, the engineer may approve the use of alternate materials or curing methods. If the engineer requests, supply technical specifications, test results, or performance records to support the proposed alternative method.

415.3.13 Accelerated Hardening of Concrete

(1) If placing concrete pavement as specified under 415.3.15 and if the engineer allows, the contractor may add calcium chloride to the mix to accelerate concrete hardening. Do not exceed the manufacturer's recommended maximum dosage. If the engineer requests, provide a written copy of the manufacturer's dosage recommendations.

(2) Add calcium chloride, in solution, by an engineer-approved procedure to the batch ingredients while placing them in the mixer. Provide sufficient water in the job-mixed solutions to dissolve the calcium chloride completely, and ensure that the solution is of a uniform and known concentration. Reduce the quantity of mixing water by the quantity of solution used. Use positive means, a method by which the

quantity added cannot vary appreciably from the target value, to introduce the correct quantity of calcium chloride into the mixer.

415.3.14 Removing Forms

(1) Do not remove forms from the concrete pavement until it sets for at least 6 hours. The contractor may remove individual sections sooner to allow sawing of transverse joints. Carefully remove the forms in a manner to preclude damaging the pavement. Do not drop or stack forms on pavement less than 7 days old.

415.3.15 Cold Weather Concreting

415.3.15.1 General

(1) The contractor is responsible for the quality of the concrete placed in cold weather. Take all precautions necessary to prevent freezing of the concrete until it has developed sufficient strength to open it to service. Remove and replace frozen or frost damaged concrete at no expense to the department.

(2) Unless the engineer issues written permission to continue, suspend concreting operations if a descending air temperature in the shade and away from artificial heat falls below 35 F (2 C). Do not resume concreting operations until an ascending air temperature in the shade and away from artificial heat reaches 30 F (-1 C). The engineer may require the contractor to measure the concrete temperature, at the point of placement, if the ambient air temperature falls below 40 F (4C). Maintain the temperature of the concrete at or above 50 F (10 C) at the point of placement.

(3) If necessary to maintain placement temperature, the contractor may heat the water, aggregates, or both. Uniformly heat, with steam or by other means, aggregates that are frozen or contain frost. Accurately control the temperature of the mixing water as it is heated. Do not allow the temperature of either the mixing water or the aggregates to exceed 100 F (38 C) when placed together with the cement in the mixer. Control the temperature of the water and the aggregates so that the temperature of the concrete discharged from the mixer is between 50 F (10 C) and 80 F (27 C) inclusive.

(4) Do not heat the cement, add salt or chemical admixtures to the concrete mix to prevent freezing, or place concrete on a frozen base or subgrade.

415.3.15.2 Protective Covering

(1) Arrange to have available a sufficient quantity of material to provide thermal protection for concrete that has yet to conform to the opening criteria specified in 415.3.17. The contractor may provide clear, black, or white polyethylene sheeting conforming to the requirements, except for color and reflectance, specified in 415.2.4. The engineer may allow other curing materials with suitable water resistance, strength, and insulating properties.

(2) If the national weather service forecast for the construction area predicts temperatures of less than 17 F (-8 C) within the next 24 hours, arrange to have available a sufficient quantity of straw or hay to protect all concrete that has yet to conform to the opening criteria specified in 415.3.17. If the engineer approves, the contractor may use other materials placed to the thickness necessary to provide the same insulating protection as the required thickness of loose, dry straw or hay.

(3) At any time of the year, if the national weather service forecast for the construction area predicts freezing temperatures within the next 24 hours, or when freezing temperatures actually occur, provide the minimum level of thermal protection specified below for concrete that has yet to conform to the opening criteria specified in 415.3.17.

PREDICTED OR ACTUAL AIR TEMPERATURE	MINIMUM EQUIVALENT LEVEL OF PROTECTION
22 to <28 F (-6 to <-2 C)	single layer of polyethylene
17 to <22 F (-8 to<-6 C)	double layer of polyethylene
<17 F (<-8 C)	6" of loose, dry straw or hay between 2 layers of polyethylene

(4) Place protective material as soon as the concrete is finished and sets sufficiently to prevent excessive surface marring. Maintain the protective material in place until the concrete conforms to the opening criteria specified in 415.3.17. If necessary to remove the coverings to saw joints or perform other required work, and if the engineer approves, the contractor may remove the covering for the minimum time required to complete that work.

415.3.16 Protecting Concrete

(1) Erect and maintain suitable barricades and, if necessary, provide personnel to keep traffic off the newly constructed pavement until it is opened for service. Conform to 104.6 for methods of handling and facilitating traffic.

(2) If it is necessary to provide for traffic across the pavement, construct suitable and substantial crossings to bridge over the concrete at all locations the plans or contract designate, at no expense to the department. Span the concrete pavement without transmitting load to the pavement. Make available the required materials for temporary crossings at the site, before placing the pavement. Construct them, as soon as it is practical, after placing and finishing the pavement. Keep the crossing in service to keep traffic off the pavement for a period specified in 415.3.17.

(3) Instead of the above temporary crossings, leave gaps in the pavement to provide for the passage of traffic, if the engineer allows. Pave these gaps after routing the cross traffic over the contiguous ends of the pavement previously constructed.

(4) Repair or replace all parts of the pavement damaged by traffic or otherwise damaged before its acceptance, at no expense to the department, in a manner satisfactory to the engineer. Protect the pavement against both public traffic and the traffic caused by employees and agents.

(5) Furnish materials for protecting the unhardened concrete against rain damage. If rain is imminent, cover the unhardened concrete immediately with paper, plastic film, or other suitable material, and planks or forms placed along slip-formed pavement edges.

(6) Ensure all ditches and drains provide effective drainage.

415.3.17 Opening to Service

415.3.17.1 General

(1) Maintain moisture, temperature, and physical protection for concrete until it develops sufficient strength to open it to service. The engineer will use the same criteria to allow opening of non-pavement concrete items to service as are used to allow opening of pavement items to traffic.

(2) The engineer will allow the contractor to open pavement to construction and public traffic when the concrete attains a verified compressive strength of 3000 pounds per square inch (20.7 MPa). Absent compressive strength information, the engineer may allow the contractor to open pavement after the following minimum times, as adjusted for changes in the ambient air temperature on the project:

APPLICATION	EQUIVALENT CURING DAYS
High early strength concrete	3
General purpose concrete (grades A, A2, and A3)	4
General purpose concrete (grades A-FA and A-IP)	5
General purpose concrete (grades A-S, A-S2, A-IS, and A-T)	7

(3) The equivalent curing day is based on a daily average ambient temperature of 60 F (16 C). The daily average ambient temperature is the average of the high and low engineer recorded temperatures on the project site for each day. If this daily average ambient temperature falls below 60 F (16 C), accumulate equivalent curing days at a reduced rate. For a daily average ambient temperature of:

1. 60 F (16 C) or more; accumulate one equivalent curing day per calendar day.
2. 40 to less than 60 F (4 to <16 C); accumulate 0.6 equivalent curing day per calendar day.
3. Less than 40 F (4 C); accumulate 0.3 equivalent curing day per calendar day.

(4) The contractor may operate concrete saws and profilographs on concrete that does not conform to these opening criteria. If the engineer approves, the contractor may operate other necessary light equipment on concrete that does not conform to these opening criteria. The engineer may suspend or delay operations that injure the surface or otherwise damage the concrete. Clean the surface before allowing traffic of any kind on the pavement.

415.3.17.2 Opening Strength

415.3.17.2.1 General

(1) Determine opening strength and provide the engineer with the information required to verify that strength by one or a combination of the following methods:

1. Compressive strength testing of cylinders.
2. Maturity method.

3. Compressive strength testing of cores.

(2) The resulting opening strength, after engineer verification, will apply to concrete on the same project conforming to the following criteria:

1. Of the same mix design as the test location.
2. Cured under similar or more desirable conditions.
3. Placed on or before the test location.

(3) If direct compressive strength test results and maturity data are not available, the engineer may estimate compressive strength based on test results of concrete of the same mix design placed contiguously under similar conditions on the same project.

415.3.17.2.2 Compressive Strength Testing of Cylinders

(1) Submit the compressive strength test results to the engineer for verification. Compute the opening strength as the average of compressive strength test results for 2 cylinders. If the strength of a cylinder is less than 90 percent of the required strength, the engineer will reject the resulting average. Field cure cylinders under conditions similar to those prevailing for the pavement they represent. Fabricate cylinders according to AASHTO T 23 and test the cylinders according to AASHTO T 22.

415.3.17.2.3 Compressive Strength Testing of Cores

(1) Submit core test results to the engineer for verification. Determine opening strength from the compressive strength of cores obtained and tested according to AASHTO T 24.

415.3.17.2.4 Maturity Method

(1) Conform to the concrete maturity method requirements of 502.3.10.1.3.3.

415.3.18 Tolerance in Pavement Thickness

415.3.18.1 General

(1) Construct the plan thickness. The department will determine pavement thickness based on an acceptance program that considers the results of the following:

1. Contractor quality control tests.
2. Validation of contractor quality control test procedures.
3. Verification tests.
4. Dispute resolution process.

(2) The department will use contractor probing of the freshly placed concrete as the primary method for determining thickness. The department will base acceptance and payment on the contractor's quality control tests until shown through the validation, verification, or dispute resolution process that the contractor's test results are in error. The department will record the contractor’s required quality control test measurements and make them part of the permanent project record.

(3) The department will determine areas with deficient thickness by coring.

415.3.18.2 Definitions

(1) Interpret these terms, used to describe thickness within 415.3.18, as follows:

Conforming	Greater than or equal to the plan thickness minus 3/8 inch (10 mm).
Nonconforming	Greater than or equal to the plan thickness minus 1 inch (25 mm) but less than the plan thickness minus 3/8 inch (10 mm).
Unacceptable	Less than the plan thickness minus 1 inch (25 mm).
Measured thickness	The thickness determined as the average of the contractor quality control measurements taken for a pavement unit.
Final thickness	The thickness determined after validation, verification, and resolution of disputes for an area of pavement.

415.3.18.3 Pavement Units

(1) Divide the pavement into basic units 250 feet (80 m) long, measured along the pavement centerline. Treat fractional units less than 250 feet (80 m) but greater than or equal to 100 feet (30 m) long as a

whole basic unit. Include fractional units less than 100 feet (30 m) long as a part of a contiguous basic unit.

(2) The basic unit is one lane wide, measured from the pavement edge to the adjacent longitudinal joint; from one longitudinal joint to the next; or between pavement edges if there is no longitudinal joint.

(3) Establish special units for areas of fillets, intersections, gaps, ramps, and other special areas not included in basic units.

415.3.18.4 Contractor Quality Control Tests

415.3.18.4.1 General

(1) Determine the measured thickness of a pavement unit by one of the following methods:

1. For a basic unit containing no unacceptable areas, the average of the 2 required contractor probings made within that unit.
2. For a special unit containing no unacceptable areas, the average of the available measurements made within that unit as agreed upon by the engineer.
3. For units containing unacceptable areas, the average thickness of the remaining portion of that unit not defined as unacceptable. Base this determination on adjacent required tests and, if the engineer agrees, include additional measurements the contractor may provide.

(2) In computing the measured thickness for a unit, consider individual measurements in excess of the plan thickness by more than 1/4 inch (6 mm) as the plan thickness plus 1/4 inch (6 mm).

415.3.18.4.2 Probing Method

(1) Make 2 probings for each basic unit. Perform both probings at a single longitudinal location selected at random. Perform individual probings at transverse locations as agreed upon by the engineer. The engineer may approve or change probing locations at the engineer's discretion.

(2) Conduct all probing tests as specified in CMM 4-25-70.

415.3.18.4.3 Alternate Methods

(1) The contractor may employ an alternate method, agreeable to the engineer, to determine the measured thickness of special units. Measure the depth of a special unit at a minimum of 2 locations as the engineer approves. The department will record contractor measurements and a brief description of the method employed and make them part of the permanent project record.

415.3.18.5 Validating Contractor Quality Control Test Procedures

(1) The engineer will periodically observe the contractor to ensure that the contractor' is testing properly. At the engineer’s request, bring the probing assembly to the edge of the pavement for the engineer to validate the accuracy of the contractor's recorded measurements.

415.3.18.6 Verification Tests

(1) The engineer will use probing to verify the acceptability of pavement thickness and will direct these tests at least once for each 1/2 day of paving. The engineer may increase the verification testing frequency to ensure that the pavement thickness is conforming.

(2) The engineer will select a longitudinal location at random and designate the transverse positions for 2 probings in each lane of pavement at that location. Perform the probing as specified in CMM 4-25-70. The engineer will be present and observe both the plate placement and probing of the freshly placed concrete.

(3) The engineer will record the individual measurements and calculate the average thickness for each lane. In computing the average thickness for verification tests, the engineer will record measurements in excess of the plan thickness by more than 1/4 inch (6 mm) as the plan thickness plus 1/4 inch (6 mm). The engineer will provide the results of these tests to the contractor immediately.

(4) If verification tests indicate conforming thickness, the engineer will accept the final thickness as equal to the contractor's measured thickness for the affected pavement.

(5) If verification tests indicate nonconforming or unacceptable thickness and the contractor's tests do not, the engineer and the contractor will jointly investigate that discrepancy immediately. If this investigation does not lead to a mutually agreeable explanation of the discrepancy, either the engineer or the contractor may invoke the dispute resolution provisions as specified in 415.3.18.7 to determine the final thickness of the affected pavement.

(6) If the engineer and the contractor agree that the pavement is unacceptable, the engineer will determine the extent of the unacceptable area as specified in 415.3.18.10.

415.3.18.7 Resolving Disputes

(1) The department will base resolution of a disputed thickness on coring. The engineer will perform dispute resolution coring according to AASHTO T 24 and will evaluate it according to AASHTO T 148. The department and the contractor will share equally costs associated with dispute resolution coring, except costs for filling the holes with concrete or mortar.

415.3.18.8 Conforming Areas

(1) If the final thickness of a pavement unit is conforming, the engineer will not require more measurements and the department will not adjust pay under 415.5.2. If the final thickness is consistently less than the plan thickness, adjust the operation to construct the plan thickness.

415.3.18.9 Nonconforming Areas

(1) If the final thickness of a pavement unit is nonconforming, the department will make the pay adjustment for that unit contingent upon the final thickness of the next unit in that lane. If the location for the next required random probing series is within 125 feet (40 m) of the first test location, the contractor may select and document a new random location to provide space for corrective action.

(2) If the final thickness of the next unit is conforming, the department will not assess any pay adjustments for either unit. If the final thickness of the next unit is nonconforming or unacceptable, the department will adjust the pay for both units. The department will continue pay adjustment for each succeeding unit until the contractor produces a unit with conforming final thickness.

415.3.18.10 Unacceptable Areas

(1) The pavement is unacceptable if one or more of the following is true:

1. An individual required contractor probe measurement is unacceptable.
2. The outcome of an investigation of a discrepancy between contractor and verification test results indicates a unacceptable final thickness.
3. A dispute resolution core is unacceptable.

(2) The engineer will direct the contractor to core the hardened concrete to determine the extent of the unacceptable area. Take cores at points approximately 20 feet (6 m) in each direction of the unacceptable measurement on a line parallel to the centerline or longitudinal axis of the unit. Continue coring in each direction until locating a core that is not unacceptable. The engineer will determine the limits of the unacceptable area, at each end, by drawing lines across the unit of pavement midway between the location of the last 2 cores.

(3) Perform coring according to AASHTO T 24. The engineer will evaluate the results according to AASHTO T 148. Fill core holes with concrete or mortar. Bear all costs associated with the coring and core filling operations.

415.3.19 Concrete Crack Repair

(1) The engineer will inspect concrete pavement and ancillary concrete for transverse cracking, twice, as follows:

1. After attaining opening strength as specified in 415.3.17 but before opening to construction or public service.
2. Before opening to public service or before partial acceptance as defined in 105.11.1, whichever comes first.

(2) The engineer will determine if a transverse crack needs repair and the type of repair needed. Repair the cracked concrete as the engineer directs.

415.4 Measurement

(1) The department will measure the Concrete Pavement bid items by the square yard acceptably completed, measured using the centerline length and the width from outside to outside of completed pavement, but limited to the width the plans show or the engineer directs. The department will include fillets for widened sections, or at drain basins and similar locations, placed monolithic with the pavement. The department will not deduct for fixtures with an area, in the plane of the pavement surface, of one square yard (1 m^2) or less.

(2) The department will measure Concrete Pavement Continuous Reinforcement, composed of steel bars, by the square yard of pavement with reinforcement incorporated and acceptably completed. The department will not deduct the areas for clearances called for adjacent to the edges of the slab or joints.

415.5 Payment

415.5.1 General

(1) The department will pay for measured quantities at the contract unit price under the following bid items:

ITEM NUMBER	DESCRIPTION	UNIT
415.0060 - 0199	Concrete Pavement (inch)	SY
415.1080 - 1199	Concrete Pavement HES (inch)	SY
415.5105	Concrete Pavement Continuous Reinforcement	SY

(2) Payment for the Concrete Pavement and Concrete Pavement HES bid items is full compensation for preparing the foundation, unless provided otherwise; for furnishing, hauling, preparing, placing, curing, and protecting the concrete: for jointing and joint materials, dowels, and tie bars, unless provided otherwise; for measuring opening strength including fabricating and testing cylinders, obtaining and testing cores, and evaluating maturity; for measuring pavement thickness, except as specified in 415.3.18.7; and for filling all core holes. Payment does not include compensation for furnishing reinforcement.

(3) Payment for Concrete Pavement Continuous Reinforcement is full compensation for furnishing and installing reinforcement and for coating.

415.5.2 Adjusting Pay for Thickness

(1) For nonconforming pavement thinner than plan thickness minus 3/8 inch (10 mm) and subject to pay adjustment, as specified in 415.3.18, the department will adjust pay under the Nonconforming Thickness Concrete Pavement administrative item as follows:

FOR PAVEMENT WITH A FINAL THICKNESS THINNER THAN PLAN THICKNESS BY:	PERCENT OF THE CONTRACT UNIT PRICE
> 3/8 inch (10 mm) but <= 1/2 inch (13 mm)	80
> 1/2 inch (15 mm) but <= 3/4 inch (19 mm)	60
> 3/4 inch (19 mm) but <= 1 inch (25 mm)	50

(2) If the department determines that areas of pavement have unacceptable final thickness, as specified in 415.3.18.10, the engineer will direct the contractor to either:

1. Remove and replace with concrete pavement of conforming thickness. The department will pay for the unacceptable area at the full contract price.
2. Leave the concrete in place. The department will not pay for the unacceptable area.

415.5.3 Adjusting Pay for Pavement Crack Repairs

(1) The engineer will allocate responsibility and costs for crack repairs, mobilization for traffic control, and traffic control devices, as specified in CMM 5-35-160. The department will adjust pay under the Crack Repair Concrete Pavement administrative item.

(2) Pay adjustment for crack repair costs, based on the total repair area in a single panel, includes mobilization for the repair work; sawing; removing pavement; furnishing and placing all materials including dowel bars; and all incidentals. The department will adjust pay for contiguous repair areas in adjacent panels separately. The engineer will compute the pay adjustment for repair costs as the contract unit price for concrete pavement, multiplied by the appropriate multiplier as follows:

FIXED AMOUNT MULTIPLIER PER PANEL FOR FULL OR PARTIAL REPLACEMENT

REPAIR AREA in square yards (m^2)	SHARED REIMBURSEMENT MULTIPLIER	TOTAL REIMBURSEMENT MULTIPLIER
18 (15) or greater	60	120
12 (10) to < 18 (15)	54	108
6 (5) to < 12 (10)	48	96
< 6 (5)	42	84

FIXED AMOUNT MULTIPLIER PER PANEL FOR ALTERNATE REPAIRS

REPAIR TECHNIQUE	SHARED REIMBURSEMENT MULTIPLIER	TOTAL REIMBURSEMENT MULTIPLIER
Retrofit dowels	15	30
Rout and seal	0	0
Seal only	0	0
Do no repair	0	0

(3) The department will adjust pay for traffic control devices and mobilization for traffic control separately.