

SECTION 415 CONCRETE PAVEMENT

415.1 Description

- (1) This section describes constructing concrete pavement as well as approach slabs, alleys, and pavement gaps.

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](#) as modified for class I pavement concrete in [section 715](#). Provide QMP for class I pavement concrete as specified in [section 715](#).
- (2) Furnish high early strength concrete under the HES bid items. The contractor may use special high early strength concrete conforming to [416.2.4](#) for concrete pavement placed in conjunction with the SHES repair and SHES replacement items for repair areas 100 feet long or longer.
- (3) Maintain a uniform consistency in consecutive batches of concrete. Use the following slumps for the technique used:

SLIP-FORMED
2.5 inches or less

NOT SLIP-FORMED
4 inches or less

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 M153 or AASHTO M213 in lengths equal to the pavement lane width and of the thickness and height the plans show. Where dowel bars are required, use filler with holes factory-punched at the dowel bar locations and with a diameter not greater than 1/8 inch larger than the nominal dowel bar diameter.

415.2.4 Concrete Curing Compounds

- (1) Furnish linseed oil based and poly-alpha-methylstyrene (PAM) liquid curing compounds conforming to ASTM C309, type 2, class B as modified here in 415.2.4 and as modified for testing in [501.2.9](#).
- (2) Furnish linseed oil emulsion curing compound consisting of, by volume exclusive of the pigment, 50 +/- 4 percent linseed oil and 50 +/- 4 percent water. Ensure that the oil phase is, by weight, 80 percent boiled linseed oil and 20 percent high viscosity (Z-8) linseed oil. Modify ASTM C309 as follows:
 - Waive the drying time requirement.
- (3) Furnish curing compound with a resin consisting of 100 percent poly-alpha-methylstyrene and with, by weight, 42 percent or more total solids. Modify ASTM C309 to ensure the following:
 - Loss of water in 24 hours does not exceed 0.15 kg/m².
 - Loss of water in 72 hours does not exceed 0.40 kg/m².
 - Reflectance in 72 hours is greater than or equal to 65 percent.
 - The volatile organic compound (VOC) content does not exceed 350 g/L.

415.2.5 Concrete Pavement Gaps

- (1) Use concrete of the same mix design used for the contiguous pavement. If the engineer allows paving through the gap, use a concrete mix design that will develop 2500 psi opening strength in an engineer-approved maximum amount of time.

415.3 Construction

415.3.1 General

- (1) Use handling, weighing, batching, mixing, and hauling equipment and procedures conforming to [section 501](#). In addition proportion aggregates and cement for concrete pavement in batching plants by weight using semi-automatic or automatic batching plants.
- (2) If using ready-mixed concrete, ensure production and uniform delivery of at least 80 cubic yards per hour to support two-lane slip-form operations and at least 40 cubic yards per hour for single-lane slip-form or hand placement operations.

415.3.2 Concrete Placement and Finishing Equipment

415.3.2.1 Slip-Form Paver

- (1) Use an engineer-approved, self-propelled slip-form paver capable of consolidating, screeding, and float-finishing freshly placed concrete in one complete pass of the machine for the required thickness. Use machines equipped to internally vibrate the concrete for the full width and depth placed in a single pass as required to produce a dense, homogeneous pavement. Equip the slip-form paver with devices that accurately space and position required tie bars and that allows for automatic or manual tie bar insertion.
- (2) Ensure that paver vibration equipment is capable of producing the frequency and amplitude the paver manufacturer recommends for the placement at hand.

415.3.2.2 Hand Vibrators

- (1) Use hand-operated single spud internal vibrators capable of consolidating concrete pavement adjacent to forms, joints, or fixtures. Ensure that vibrators produce a minimum of 7000 impulses per minute.

415.3.2.3 Screeds for Formed Pavement

- (1) Use air-vibrated or mechanically-vibrated truss screeds designed for and capable of striking off fixed-form concrete pavement for the size of placement at hand.

415.3.2.4 Forms

- (1) Use clean, straight, un-warped steel forms with a vertical face as high or higher than the pavement thickness minus 1 1/2 inches. Ensure that forms have side and base supports capable of supporting finishing equipment and are sufficiently strong to resist concrete pressure without bulging.
- (2) The contractor may use wood or plastic forms for forming fillets, widened areas in intersections, curves less than 100-foot radius, and in other engineer-approved locations.

415.3.2.5 Hand Finishing Tools

- (1) Use aluminum, magnesium, or wooden hand finishing tools. Do not use steel hand finishing tools.

415.3.2.6 Concrete Saws

- (1) Use saws light enough to operate on and capable of sawing new concrete with minimal raveling, chipping, spalling, or otherwise damaging the pavement. Ensure that saws have diamond blades with functioning blade guards and are equipped with guides or other devices to control cut alignment and depth.

415.3.3 Preparing the Foundation

- (1) Prepare the base course as specified in [211.3.4](#) before placing concrete. Repair and re-compact rutted or disturbed base resulting from hauling or paving operations. The engineer may suspend paving operations if the contractor fails to repair and maintain the base course in advance of the paving operation.
- (2) Identify areas of yielding subgrade. The engineer may direct or allow EBS to correct subgrade problems as specified in [301.3.5](#).

415.3.4 Setting Forms

- (1) Set forms to the required grade and alignment. Firmly support and anchor forms in a manner that prevents movement during concrete placement. Ensure that forms are sufficiently tight to prevent loss of concrete either under or through the forms.
- (2) Immediately before placing concrete recheck the foundation as well as the grade and alignment of the forms. Ensure that the forms are not twisted. Make necessary corrections to the forms and foundation before placing concrete.

415.3.5 Reinforcement

- (1) Reinforce the concrete if and as the plans specify. Keep reinforcement clean, free of rust and scale, and supported to prevent distortion. Store reinforcement steel, received on the job, in engineer-approved storage and distribute only as needed for placement.
- (2) Protect epoxy coated steel from cumulative exposure to sunlight for more than 2 months by covering with opaque plastic sheeting or other engineer-approved material. Clear plastic shrink wrap for dowel bar bars and dowel baskets is sufficient protection for up to 4 months exposure.

415.3.6 Placing Concrete

415.3.6.1 General

- (1) Unless the engineer allows otherwise, slip-form work that is 300 feet or more in length, a minimum of 10 feet in width or greater, and a constant width. Also use slip-formed placement wherever practicable for other work unless the engineer directs or allows otherwise. In irregular areas or areas inaccessible to self-propelled slip-form paving equipment, construct the pavement using fixed forms.
- (2) Use machine methods to strike-off and consolidate the concrete. 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 wide, for transition sections on curves or at other points with variable pavement crown, and for other areas where it is not practicable to use machine methods.
- (3) Deposit concrete on the base course continuously in a manner that minimizes segregation. Place to a depth sufficiently above grade so, after consolidating and finishing, the required slab thickness is obtained and the surface conforms to the specified grade and slope.
- (4) Use two-lane placement for rural pavement unless project staging dictates single-lane paving. Delay placement of adjoining lanes until completed lanes are sufficiently cured to preclude damage to work already placed. Do not operate paving equipment on pavement not meeting the opening to service criteria specified in [415.3.15](#).
- (5) Shut down placement if paving train equipment breaks down, finishing and curing operations are delayed, or if the materials or work are non-conforming. Cover the concrete at the unfinished end of the placement to maintain moisture during temporary shutdowns. Provide construction joints if interruptions are long enough for the concrete to develop its initial set.
- (6) Check the surface of the newly placed concrete with a long-handled 10-foot or longer straightedge. Overlap successive passes by about 1/2 the straightedge length. Cut down high areas. Fill depressions immediately with freshly mixed concrete and strike off, consolidate, and refinish the concrete. Do not add water to correct surface deficiencies except in emergency cases or with engineer authorization.
- (7) Set castings and frames for manholes, catch basins, inlets, and other fixtures conforming to [611.3.3](#). Adjust to required alignment and grade while adjacent concrete is plastic. Hand vibrate concrete adjacent to fixtures to fill voids and openings between fixtures and support structures. Fill remaining voids beneath the base of these fixtures with an engineer-approved non-shrink grout before opening to traffic.

415.3.6.2 Slip-Formed Placement

- (1) Coordinate the mixing, delivering, and spreading operations to provide uniform progress. Check and adjust string lines, sensors, and other paver guidance equipment during paving to assure uninterrupted placement to the plan alignment and grade.
- (2) Advance the paving train at a slow uniform pace stopping and starting the paver as little as possible. If it is necessary to stop the forward movement of the paver, stop vibrating and tamping immediately, and restart when forward motion resumes.
- (3) Ensure that concrete is uniformly consolidated throughout its width and depth, free from honey combed areas, and has a consistent void-free closed surface.
- (4) Keep hand finishing efforts on the surface to a minimum to avoid over finishing. Hand-float the surface only as needed to produce a uniform surface and sharp corners. Do not use excess mortar to build up slab edges or round the slab corners.
- (5) Measure edge slump according to [CMM 8-70](#). Maintain an edge slump, exclusive of edge rounding, no greater than of 3/8 inch at free edges or 1/8 inch, where abutting other concrete. Correct excessive edge slump before concrete hardens and adjust operations to reduce edge slump to an acceptable level. Tool pavement edges to a 1/4-inch radius ensuring that edges are smooth and true to line.

415.3.6.3 Formed Placement

- (1) Deposit concrete as near a possible to its final location to minimize segregation. Consolidate uniformly throughout the depth and systematically across the area of the placement to produce a dense, homogeneous pavement.
- (2) Strike off with vibrating screeds unless the engineer directs or allows otherwise. Maintain a uniform amount of concrete in front of the screed sufficient to fill 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. Do not make more than 2 passes of the vibratory screed on a

given area of concrete. Coordinate forward movement of the screed with vibration frequency to optimize consolidation. Do not vibrate the concrete with the screed in a stationary position.

- (3) Augment vibrating screeds with internal vibration in front of the screed for placements over 5 inches deep. Insert single spud hand vibrators vertically in a grid pattern just long enough to bring mortar to the surface. Ensure that areas visibly affected by successive vibrator insertions overlap by 2 - 3 inches. Do not drag spud vibrators through the concrete or move concrete laterally by vibration.
- (4) Use single spud hand vibrators to consolidate the concrete adjacent to transverse construction joints and along the full length of dowel basket assemblies. Vibrate to a depth that consolidates the concrete above and below the dowel or tie bars. Vibrate along the forms as required to achieve a void-free formed edge. Do not allow vibrators to contact reinforcement, forms, or the grade during vibration.
- (5) Float the surface as needed to produce a uniform surface. Before the concrete's initial set, tool the pavement edges and along each side of transverse isolation joints, formed joints, transverse construction joints, and fixed forms to produce a true-to-line 1/4-inch radius with a smooth, dense mortar finish.
- (6) Remove forms after the pavement has cured sufficiently to avoid damaging the concrete. The contractor may remove individual forms sooner to saw transverse joints. Fill voids in the formed surface as soon as practicable after form removal using a well-mixed grout composed of one part portland cement and 3 parts fine aggregate.

415.3.7 Jointing

415.3.7.1 General

- (1) Construct joints as and where the plans show perpendicular to the pavement surface. Use construction joints as dictated by contractor operations to join together work at locations where the plan shows no joints. Join new work to existing concrete pavement using tie bars epoxied into the existing pavement as specified in [416.3.3.2](#) or dowel bars epoxied into the existing pavement as specified in [416.3.4](#). The contractor may use cast-in-place tie bars or dowel bars in construction joints of pavement placed under the contract.
- (2) Maintain the alignment of dowel bars, tie bars, and other reinforcing or embedments when placing joints. Augment machine vibration with hand vibrators if necessary to ensure complete consolidation at joints.
- (3) Test joints with a straightedge before the concrete sets. Correct if one side of the joint is higher than the other or if higher or lower than adjacent slabs. Remove any concrete, mortar, or laitance resulting from paving operations before it hardens. Remove concrete fins extending across isolation joints, doweled joints, and expansion joints after the concrete hardens.
- (4) Saw joints in a single cut to the width and depth the plans show. Begin sawing as soon as the concrete hardens sufficiently to prevent excessive raveling along the saw cut and finish before conditions induce uncontrolled cracking. Provide artificial light if sawing between sunset and sunrise.
- (5) The contractor may saw the transverse 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.
- (6) The contractor may temporarily hand tool joints to reduce the the potential for early cracking. Ensure that hand-tooled joints have a 1/4-inch radius and are smooth and true to line. Saw hand tooled joints to the plan depth as soon as practicable.

415.3.7.2 Longitudinal Joints

- (1) If the plans do not show a specific location, construct parallel to the centerline along lane edges. On two-lane pavements, construct along the pavement centerline. On multi-lane pavements, construct along traffic and taper lane edges. Make joints perpendicular to the pavement surface. Do not deviate more than 1/2 inch in 10 feet from the required line.

415.3.7.3 Transverse Joints

- (1) Extend transverse joints across the entire width of paving and through curb or median placed integrally with pavement. When the pavement abuts existing pavement, curb and gutter, or median, construct transverse joints in locations matching existing joints or cracks.
- (2) Install dowel bars as follows:
 - Within one inch of the planned transverse location and depth.
 - Within 2 inches of the planned longitudinal location.
 - Parallel to the pavement surface and centerline within a tolerance of 1/2 inch in 18 inches.

- (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:
 - Place and consolidate the pavement to full depth before inserting the dowel bars.
 - Insert the dowel bars into the plastic concrete in front of the finishing beam or screed.
 - Ensure that the installing device consolidates the concrete with no voids around the dowel bars.
 - Do not interrupt the forward movement of the finishing beam or screed while inserting the dowel bars.
 - Provide a positive method of marking the locations of the transverse joints.
- (5) Remove concrete directly above expansion joint filler, if necessary, by sawing the full width of the filler to remove concrete bridging the joint.
- (6) Form a construction joint at the end of each day's run or when an interruption long enough for the concrete to develop its initial set occurs as follows:
 - Set a header board to support tie bars or dowel bars. Use production quality concrete, hand vibrated behind the header board, and protect protruding steel from anything that might damage the bars or weaken the bond.
 - Saw back the concrete full depth to expose solid concrete then drill and epoxy in tie bars or dowel bars.

415.3.8 Surface Finishing

415.3.8.1 General

- (1) Finish the pavement surface after straightedging, after excess moisture disappears, and while it is still possible to produce a uniform striated surface texture.

415.3.8.2 Design Speed Less Than 40 MPH

- (1) Provide an artificial turf drag surface finish. Use a seamless strip of artificial turf approximately full pavement width and of sufficient length to provide approximately 2 feet of turf in contact with the pavement surface. Pull the drag with a device that allows control of the time and rate of texturing. Operate the drag in a longitudinal direction parallel with the centerline to produce a straight finish. Weight the drag as necessary to maintain contact with the pavement. Keep the drag clean and free of particles of hardened concrete.
- (2) Where it is not practicable to apply a turf finish, apply a broom finish.
- (3) Restore pavement texture damaged by rain by re-dragging the concrete while still plastic.

415.3.8.3 Design Speed - 40 MPH and Higher

415.3.8.3.1 General

- (1) Texture and tine freshly placed pavement as soon as practicable after floating. Texture with an artificial turf drag as specified in [415.3.8.2](#).
- (2) Longitudinally tine with a self-propelled tining machine. Where using a tining machine is not practicable, tine by hand. Produce uniformly deep grooves approximately 1/8 to 3/16 inch deep. Provide a finished surface free of tining defects. Complete before tining tears or unduly roughens the concrete.
- (3) For hand work, use longitudinal tining unless the engineer directs or allows otherwise.
- (4) When paving next to existing pavement and for repair work, match the existing tining direction whether using machine or hand methods. The contractor may apply transverse tining in locations where the engineer directs or allows.

415.3.8.3.2 Longitudinal Tining

Revise 415.3.8.3.2(1) to require 3/4" center-to-center tine spacing for longitudinal tining.

- (1) Use a tining machine with an automated horizontal and vertical alignment control system to ensure that tining runs straight and parallel to the longitudinal axis of the pavement. **Use a rake with individual 1/8-inch wide tines spaced uniformly 3/4 inches on center.** Do not tine, but instead apply an artificial turf drag finish, within 2 inches of a longitudinal sawed joint.

415.3.8.3.3 Transverse Tining

Revise 415.3.8.3.3(1) to require 5/8" center-to-center tine spacing for transverse tining.

- (1) Use a rake with individual 1/8-inch wide tines spaced uniformly 5/8 inches on center. For machine work, use a 10-foot rake drawn transversely across the full pavement width without overlapping passes.

415.3.9 Stamping

- (1) At the beginning of each day's run and at the end of the job, stamp the contractor's name and the year of pavement construction into the pavement. Use 2-inch numbers for the year of construction.

415.3.10 Surface Testing and Correction

- (1) Test the pavement surface at engineer-selected locations with a 10-foot straightedge or other engineer-specified device. The engineer may direct the contractor to mark and grind down areas showing high spots greater than 1/8 inch but not exceeding 1/2 inch in 10 feet. Grind until there are no deviations greater than 1/8 inch when retested with the straightedge. The engineer may direct the contractor to remove and replace areas with deviations greater than 1/2 inch in 10 feet.
- (2) Perform grinding as specified in [415.3.11](#).
- (3) If the engineer directs removal, remove an area at least 6 feet long and extending across the full lane width. Also remove adjacent pavement less than 6 feet from a transverse joint.

415.3.11 Pavement Grinding

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

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. Except as allowed under [415.3.12.3](#), apply curing compound conforming to [415.2.4](#) as specified in [415.3.12.2](#).

Revise 415.3.12.1(2) to require wax based cure on work that will be overlain and clarify that the contractor can use either linseed oil or PAM where ever a particular material is not specified.

- (2) The contractor may use either linseed oil based material or PAM except as follows:
 - Use linseed oil based material for concrete placed contiguous to or within the incorporation limits of a municipality, except the contractor may use PAM or linseed oil on freeways and associated entrance and exit ramps within municipalities.
 - Use linseed oil based material on roundabouts regardless of location.
 - Use PAM on rural pavement; the contractor may use PAM or linseed oil based material on non-pavement items in rural areas.
 - Use curing compound conforming to [501.2.9](#) for pavement that will be overlain under the contract.
- (3) 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. Seal moisture in the concrete by applying a continuous water-impermeable film on 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 practicable. The contractor may use hand-operated spraying equipment for the following:
 - Irregular, narrow, or variable width sections.
 - Re-coating applications or after form removal.
 - 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. For other surface finishes, apply the curing compound uniformly at or exceeding a minimum rate of one gallon per 200 square feet.
- (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 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.
- (2) The engineer will approve delayed application of curing compound if the contractor uses the impervious sheeting method as specified in [502.3.8.1.2](#) to protect freshly placed concrete from rain damage, protect adjacent property from overspray damage, or to otherwise accommodate specific job conditions. Apply linseed oil based or PAM curing compound immediately after removing the impervious sheeting.

415.3.13 Cold Weather Concreting

415.3.13.1 General

- (1) The contractor is responsible for the quality of the concrete placed in cold weather. Take 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.
- (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. Do not resume concreting operations until an ascending air temperature in the shade and away from artificial heat reaches 30 F. 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. Maintain the temperature of the concrete at or above 50 F 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 frozen or containing 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 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 and 80 F 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.

415.3.13.2 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 [415.3.15](#). The contractor may provide clear, black, or white polyethylene sheeting conforming to the requirements, except for color and reflectance, specified in [501.2.9](#). 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 within the next 24 hours, arrange to have available a sufficient quantity of straw or hay to protect concrete that has yet to conform to the opening criteria specified in [415.3.15](#). 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 [415.3.15](#).

PREDICTED OR ACTUAL AIR TEMPERATURE	MINIMUM EQUIVALENT LEVEL OF PROTECTION
22 to <28 F	single layer of polyethylene
17 to <22 F	double layer of polyethylene
<17 F	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 [415.3.15](#). 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.

415.3.14 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) Protect the pavement against both public traffic and construction activities. Repair or replace, as the engineer directs, pavement damaged by traffic or otherwise damaged before acceptance.
- (3) Arrange to have available materials for protecting the unhardened concrete against rain damage. If rain is imminent, cover unhardened concrete immediately with plastic or other engineer-approved material secured along pavement edges. Provide drainage as required to protect the work.

415.3.15 Opening to Service

415.3.15.1 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 to service as are used to allow opening of pavement 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. 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. 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, accumulate equivalent curing days at a reduced rate. For a daily average ambient temperature of:
 1. 60 F or more; accumulate one equivalent curing day per calendar day.
 2. 40 to less than 60 F ; accumulate 0.6 equivalent curing day per calendar day.
 3. Less than 40 F; accumulate 0.3 equivalent curing day per calendar day.
- (4) The contractor may operate concrete saws and lightweight profilers 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.

415.3.15.2 Opening Strength

415.3.15.2.1 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:
 - Of the same mix design as the test location.
 - Cured under similar or more desirable conditions.

- 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.

415.3.15.2.2 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 T23 and test the cylinders according to AASHTO T22.

415.3.15.2.3 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 T24.

415.3.15.2.4 Maturity Method

- (1) Conform to the concrete maturity method requirements of [502.3.10.1.3.3](#).

415.3.16 Tolerance in Pavement Thickness

415.3.16.1 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 validate contractor data before determining pay adjustments. The department will determine areas with deficient thickness by coring.
- (3) Within 5 business days after probing, submit the thickness data electronically using the department's materials reporting system (MRS) software available at:

<http://www.atwoodsystems.com/iibv2/default.cfm>

415.3.16.2 Definitions

- (1) Interpret these terms, used to describe thickness within 415.3.16, as follows:

Conforming Greater than or equal to the plan thickness minus 1/8 inch.

Nonconforming Greater than or equal to the plan thickness minus 1 inch but less than the plan thickness minus 1/8 inch.

Unacceptable Less than the plan thickness minus 1 inch.

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.

415.3.16.3 Pavement Units

- (1) Divide the pavement into basic units 250 feet long, measured along the pavement centerline. Treat fractional units less than 250 feet but greater than or equal to 100 feet long as a whole basic unit. Include fractional units less than 100 feet 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, and other areas not included in basic units. Also establish special units for shoulders, ramps, and other long areas of constant cross section less than 10 feet wide. Limit the size of special units to a maximum of 350 square yards.

415.3.16.4 Contractor Quality Control Tests

415.3.16.4.1 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 as the plan thickness plus 1/4 inch.

415.3.16.4.2 Probing Method

Revise 415.3.16.4.2(1) to clarify that adjacent lanes paved in a single pass are probed at the same longitudinal location.

- (1) Randomly select a longitudinal location and probe at 2 engineer-approved transverse locations per basic unit. Probe basic units in adjacent lanes paved in a single pass at the same longitudinal location. The engineer may approve or change probing locations at the engineer's discretion.
- (2) Conduct probing tests according to [CMM 8-70](#).

415.3.16.4.3 Alternate Methods

- (1) The contractor may employ an engineer-approved alternate method 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. Include a brief description of the alternate method as a part of the MRS submittal.

415.3.16.5 Validating Contractor Quality Control Test Procedures

- (1) The engineer will periodically observe the contractor to ensure that the contractor is testing properly.

415.3.16.6 Verification Tests

- (1) The department will probe one or more randomly selected units out of each 10 units the contractor defines. The engineer may increase the verification testing frequency to ensure that the pavement thickness is conforming.
- (2) Provide the engineer with the probing device used for contractor quality control testing and access to the contractor's work bridge. The engineer will validate the accuracy of the device before using that device to conduct verification testing.
- (3) For basic units, the engineer will select a longitudinal location at random and designate the transverse positions for 2 probings in each lane at that location. For special units, the engineer will designate 2 randomly selected probing locations. Place plates on the base at the engineer-designated locations.
- (4) The engineer will record actual individual measurements and calculate the average thickness for each unit. In computing the average thickness for verification tests, the engineer will use the plan thickness plus 1/4 inch for measurements in excess of the plan thickness by more than 1/4 inch. The engineer will provide the results of these tests to the contractor immediately.
- (5) 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.
- (6) 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 [415.3.16.7](#) to determine the final thickness of the affected pavement.
- (7) 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 [415.3.16.10](#).

415.3.16.7 Resolving Disputes

- (1) The department will base resolution of a disputed thickness on coring. The engineer will perform dispute resolution coring according to AASHTO T24 and will evaluate it according to AASHTO T148. The

department and the contractor will share equally costs associated with dispute resolution coring, except costs for filling the holes with concrete or mortar.

415.3.16.8 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.

415.3.16.9 Nonconforming Areas

- (1) If the final thickness of a basic unit is nonconforming, the department will make the pay adjustment for that unit contingent upon the final thickness of the next basic unit in that lane. If the location for the next required random probing series is within 125 feet 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 basic unit is conforming, the department will not assess any pay adjustments for either basic unit. If the final thickness of the next basic unit is nonconforming or unacceptable, the department will adjust the pay for both basic units. The department will continue pay adjustment for each succeeding basic unit until the contractor produces a basic unit with conforming final thickness.
- (3) If the final thickness of a special unit is nonconforming, the department will adjust the pay for that unit.

415.3.16.10 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 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 T24. The engineer will evaluate the results according to AASHTO T148. Fill core holes with concrete or mortar. Bear all costs associated with the coring and core filling operations.

415.3.17 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 [415.3.15](#) 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.

415.3.18 Pavement Gaps

- (1) Construct gaps using either doweled or tied construction joints. Locate construction joints and joints within the gap ensuring that the resulting slab lengths are greater than or equal to 6 and less than or equal to 15 feet long. Alternatively, if the engineer approves, the contractor may pave continuously through the gap using concrete conforming to [415.2.5](#).

415.3.19 Approach Slabs

- (1) Unless the engineer directs otherwise, the contractor may construct the approach slab before, at the time of, or after constructing the roadway pavement.
- (2) The contractor may use built-up forms instead of full depth metal side forms. Place reinforcing steel as the plans show. Employ engineer-approved methods to support bar steel and dowel bars in their plan position during concrete placing and finishing.

415.4 Measurement

- (1) The department will measure the Concrete Pavement and Concrete Alley 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 of one square yard or less as measured in the plane of the pavement surface.
- (2) The department will measure the Concrete Pavement Approach Slab bid items by the square yard acceptably completed, based on the width and length the plans show or the engineer directs.

Revise 415.4 to clarify that the department measures gaps separately for each roadway.

- (3) The department will measure Concrete Pavement Gaps as each individual gap acceptably completed including eliminated gaps the engineer allows the contractor to pave through, **measured separately for each roadway**. The department will measure multiple gaps at one **roadway location** as required to conform to contract staging provisions, but not solely to accommodate the contractor's means and methods.

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:

<u>ITEM NUMBER</u>	<u>DESCRIPTION</u>	<u>UNIT</u>
415.0060 - 0199	Concrete Pavement (inch)	SY
415.0210	Concrete Pavement Gaps	Each
415.0310	Concrete Alley	SY
415.0410	Concrete Pavement Approach Slab	SY
415.1080 - 1199	Concrete Pavement HES (inch)	SY
415.1310	Concrete Alley HES	SY
415.1410	Concrete Pavement Approach Slab HES	SY

- (2) Payment for the Concrete Pavement bid items is full compensation for providing pavement; for preparing the foundation, unless provided otherwise; for replacing frozen or frost damaged concrete as required in [415.3.13](#); for determining opening strength; for measuring pavement thickness including thickness coring except as specified in [415.3.16.7](#); and for filling core holes. Payment also includes providing tie bars and dowel bars within concrete placed under the contract. The department will pay separately for tie bars and dowel bars used to connect the work to concrete not placed under the contract under the Drilled Tie Bars and Drilled Dowel Bars bid items as specified in [416.5](#). The department will not pay for removal and replacement of pavement not meeting the surface smoothness tolerances specified in [415.3.11](#).
- (3) Payment for Concrete Pavement Gaps is full compensation for providing pavement gaps. If the engineer allows paving through a gap, the department will pay the full contract price for each gap eliminated. Payment for furnishing and placing concrete material is included under Concrete Pavement.
- (4) Payment for the Concrete Pavement Approach Slab bid items is full compensation for providing the approach slab; and for bar steel reinforcement, dowel and tie bars, and jointing materials.
- (5) The department will pay for engineer-approved EBS to correct subgrade problems beyond the contractor's control as specified in [301.5](#).

415.5.2 Adjusting Pay for Thickness

- (1) For nonconforming pavement thinner than plan thickness minus 1/8 inch and subject to pay adjustment, as specified in [415.3.16](#), 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
> 1/8 inch but <= 1/2 inch	80
> 1/2 inch but <= 3/4 inch	60
> 3/4 inch but <= 1 inch	50

- (2) If the department determines areas of pavement have unacceptable final thickness, as specified in [415.3.16.10](#), the engineer will direct the contractor to either:

1. Remove and replace with concrete pavement of conforming thickness. The department will pay for the replaced 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, according to [CMM 4-24](#). 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; drilling in tie and 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 follows:

Total Reimbursement = (unit price x repair area + \$1600)

Shared Reimbursement = 1/2 of the total reimbursement amount

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