415 Concrete Pavement

415.1 Description

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

415.2 Materials

415.2.1 Concrete

(1) Furnish grade A concrete conforming to 501 as modified for class I pavement concrete in 715. Provide QMP for class I pavement concrete as specified in 715.

(2) Furnish high early strength concrete under the HES bid items.

(3) Maintain a uniform consistency in consecutive batches of concrete. Use the following slumps for the technique used:

SLIP-FORMED	NOT SLIP-FORMED
2.5 inches or less	4 inches or less

415.2.2 Reinforcement

(1) Furnish steel reinforcement conforming to 505.2.4. 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 ASTM D8139. When constructing headers or providing slip form expansion, furnish expansion joint filler conforming to AASHTO M153, AASHTO M213, or ASTM D8139. Place material 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 factory-punched holes 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 poly-alpha-methylstyrene (PAM) liquid curing compound conforming to ASTM C309, type 2, class B as modified here in 415.2.4.

(2) 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/m^2.
- Loss of water in 72 hours does not exceed 0.40 kg/m^2.
- 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 time.

415.2.6 Joint Filler

(1) Furnish a hot-poured elastic joint sealer according to ASTM D6690 type II.

415.3 Construction

415.3.1 General

(1) Use handling, weighing, batching, mixing, and hauling equipment and procedures conforming to 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, truck aprons, 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 an opaque 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 impracticable 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 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 nonconforming. 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 honeycombed 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) 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 quantity of concrete in front of the screed sufficient to fill voids or low areas. Do not allow excessive concrete accumulation 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 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 pavement has cured sufficiently to avoid damaging the concrete. The contractor may remove individual forms sooner to saw transverse joints. Fill surface voids as soon as practicable after form removal using a well-mixed grout composed of one part 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.

(2) For intersections, plan and locate points necessary to establish the horizontal position of transverse and longitudinal joints to prevent uncontrolled cracking. Submit a joint layout design to the engineer at least 7 calendar days before paving each intersection. Do not lay out joints until the engineer has reviewed the joint layout design. Mark the location of concrete joints in the field. Follow the concrete pavement jointing plan details making adjustments as required to fit field conditions. For unique project circumstances not covered in the plan details, review the joint layout plan with the engineer.

(3) Use construction joints as dictated by contractor operations to join together work at locations where the plans show 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.

(4) 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.

(5) 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.

(6) 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.

(7) 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.

(8) The contractor may temporarily hand tool joints to reduce 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 multilane 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 by doing one of the following:

- Set a header board to support 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 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 impracticable 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 impracticable, 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 where the engineer directs or allows.

415.3.8.3.2 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

(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

415.3.10.1 Smoothness

(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.

415.3.10.2 Ride Quality

(1) Provide QMP for concrete pavement ride quality as specified in 740.

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 as specified in 415.3.12.2. Use PAM except, use curing compound conforming to 501.2.8 on pavement that will get an overlay under the contract.

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

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 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 gives 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 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 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 501.2.8, except for color and reflectance. 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 protective material in place until the concrete conforms to opening criteria specified in 415.3.15. If removing 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 as specified in 415.3.15. 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 psi. 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
Grade A general purpose concrete Without blended cements or field-added supplementary cementitious materials	4
Grade A general purpose concrete With blended cements or field-added supplementary cementitious materials	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 WTM R100 and test the cylinders according to WTM 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 WTM 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 or thicker. The department will accept pavement thickness based on the results of department-performed acceptance testing conforming to:

Magnetic Pulse Induction..... WTM E3209
Probing ..... WTP C-002
Preplacement Measurement..... WTP C-003

415.3.16.2 Pavement Units

415.3.16.2.1 Basic Units

(1) Basic unit is defined as a slip formed, single lane, with a minimum lane width of 10 feet. Width is 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.

415.3.16.2.2 Special Units

(1) Establish special units for areas of fillets, intersections, gaps, gores, shoulders, ramps, truck aprons, pavement lanes less than 10 feet wide and other areas not included in basic units.

415.3.16.3 Test Plate Locations

(1) Place department-furnished test plates. Within 5 business days after paving, enter the sequential number and associated position data into MRS available at:

http://www.atwoodsystems.com/

(2) Maintain plate location markings for 10 business days after paving.

415.3.16.4 Acceptance Testing

415.3.16.4.1 Basic Units

415.3.16.4.1.2 Magnetic Pulse Induction

(1) The department will measure thickness within 10 business days of paving. Upon completion of the project thickness testing, the department will provide the test results to the contractor within 5 business days.

(2) The department will establish a project reference plate at the start of each paving stage. The department will notify the contractor of project reference plate locations before testing. The department will measure the project reference plate before each day of testing.

(3) If the random plate test result falls within 80 to 50 percent pay range specified in 415.5.2, the department will measure the second plate in that unit. The department will notify the contractor immediately if the average of the 6 readings fall within the 80 to 50 percent pay range.

(4) If an individual random plate test result is more than 1 inch thinner than contract plan thickness, the department will measure the second plate in that unit. If both plates are required to be measured, then all six thickness measurements will be averaged for that unit. If the average of the six measurements is more than 1 inch thinner than contract plan thickness, the pavement is unacceptable.

415.3.16.4.2 Special Units

415.3.16.4.2.1 Magnetic Pulse Induction

(1) The department will measure thickness within 10 business days of paving. Upon completion of the project thickness testing, the department will provide the test results to the contractor within 5 business days.

(2) Department will establish a project reference plate at the start of each paving stage. Project reference plate will be measured before each day of testing. Department will notify the contractor of project reference plate locations before testing.

(3) If the random plate test result falls within 80 to 50 percent pay range specified in 415.5.2, the department will measure the second plate in that unit. The department will notify the contractor immediately if the average of the 6 readings fall within the 80 to 50 percent pay range.

(4) If an individual random plate test result is more than 1 inch thinner than contract plan thickness, the department will measure the second plate in that unit. If both plates are required to be measured, then all six thickness measurements will be averaged for that unit. If the average of the six measurements is more than 1 inch thinner than contract plan thickness, the pavement is unacceptable.

415.3.16.4.2.2 Probing

(1) The department will measure slip form special units during concrete placement. Upon completion of the project thickness testing, the department will provide the test results to the contractor within 5 business days.

(2) The department will probe 2 random locations within the special unit. The average of the two readings is the reported thickness measurement for the special unit.

415.3.16.4.2.3 Preplacement Measurement

(1) The department will measure non-slip form special units before concrete placement.

(2) Correct the thickness until conforming by reshaping the base aggregate before the placing pavement.

415.3.17 Concrete Crack Repair

(1) The engineer will inspect concrete pavement 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.

415.3.20 Filling Joints

(1) Fill joints in concrete pavement, not requiring tining under 415.3.8, and in the adjacent curb and gutter with filler conforming to 415.2.6 as soon as practicable after the engineer inspects them.

(2) Clean joints of laitance, curing compound, and other contaminants before filling. Saw construction joints at least 3/4 inches deep before filling. Sawing is not required for tooled joints in curb and gutter. Sandblast or waterblast exposed joint faces using multiple passes as required to clean joints surfaces of material that might prevent bonding. Blow clean and dry with oil-free compressed air immediately before filling.

(3) Heat filler to the manufacturer's recommended pouring temperature in an engineer-approved double boiler with the space between the inner and outer shells filled with oil or other engineer-approved heat transfer medium. Ensure that the heating kettle is equipped with a mechanical agitator, positive temperature control, and an engineer-approved thermometer. Do not operate the heating kettle on concrete without insulation or a heat shield to protect the concrete surface. If applying only a small amount of filler, the engineer may allow alternate heating equipment.

(4) Do not heat above the maximum safe temperature the filler manufacturer recommends. Discard over-heated material.

(5) Maintain a uniform filler temperature within the manufacturer's recommended working range throughout the filling operation. Cease filling if the temperature in the applicator falls more than I0 F below the manufacturer's recommended pouring temperature.

(6) Completely fill joints without overflowing so that the finished filler is approximately flush with the adjoining surfaces after shrinking. If one pass gives unsatisfactory filling, use 2 passes making sure that at least half of the required filler is poured on the first pass. Make the second pass as soon as practicable after the first pour attains maximum shrinkage but not later than an hour after the first pour.

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 and Concrete Truck Apron bid items by the square yard acceptably completed, based on the pay limits the plans show.

(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.

(4) The department will measure Concrete Pavement Joint Filling by the square yard acceptably completed, measured as the concrete pavement area plus the length times nominal width of adjacent curb and gutter.

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
415.0210	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
415.2000 - 2050	Concrete Truck Apron (inch)	SY
415.4100	Concrete Pavement Joint Filling	SY

(2) Payment for the Concrete Pavement and Concrete Truck Apron bid items is full compensation for providing pavement; for preparing the foundation, unless provided otherwise; for placing thickness plates; and for thickness coring and filling core holes as required under 415.3.16.4. 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 415.3.10. The depatment will pay seperately for coloring concrete as required for roundabout truck aprons.

(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.

(6) Payment for Concrete Pavement Joint Filling is full compensation for filling concrete pavement joints; for filling adjacent curb and gutter joints; and for sawing.

415.5.2 Adjusting Pay for Thickness

(1) The department will adjust pay for pavement thickness under the Nonconforming Thickness Concrete Pavement administrative item as follows:

FOR PAVEMENT THINNER THAN PLAN THICKNESS BY:	PERCENT OF THE CONTRACT UNIT PRICE
> 1/4 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 415.3.16.4, the department will direct the contractor to either:

1. Remove and replace unacceptable concrete pavement to the nearest joint with new concrete pavement of conforming thickness. The department will pay once for the area at the full contract price.
2. If the unacceptable pavement is less than 100 LF, the department may allow the concrete to remain in place without payment 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 424. 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 materials including dowel bars; drilling in tie and dowel bars; and 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 + $1700)

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.