

**DIVISION 400
PAVEMENTS
SECTION 401
PLANT MIX PAVEMENTS-GENERAL**

DESCRIPTION

401.01 These specifications include general requirements that are applicable to all types of hot mix asphalts irrespective of gradation of aggregate, kind and quantity of asphalt cement, or pavement use. Deviations from these general requirements will be indicated in the specific requirements for each type.

This work consists of one or more courses of asphalt mixture constructed on a prepared foundation per these specifications and the specific requirements of the type under contract, and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established.

MATERIALS

401.02 Composition of Mixtures. The asphalt plant mix shall be composed of a mixture of aggregate, filler or additives if required and approved, asphalt cement, and reclaimed material if permitted and used.

(a) *Mix Design.* The Contractor shall submit the following to the Engineer:

- (1) A proposed hot mix asphalt mix design prepared per Colorado Procedure 52, including a proposed job-mix gradation for each mixture required by the Contract, which shall be wholly within the Master Range Table in subsection 703.04 before the tolerances shown in Section 401 are applied. The weight of lime shall be included in the total weight of the material passing the 75 μm (No. 200) sieve.
- (2) The name of the refinery supplying the asphalt cement and the source of the anti-stripping additive.
- (3) A sufficient quantity of each aggregate for the Department to perform the tests specified in Section 3.2.1 of CP 52.

The Contractor's proposed job-mix formula for each hot mix asphalt grading will be tested by the Department utilizing materials actually produced and stockpiled for use on the project.

The job-mix formula for each mixture shall establish a single percentage of aggregate passing each required sieve size, a single percentage of asphalt cement to be added to the aggregate, and a single temperature for the mixture at the discharge point of the plant.

When Laboratory tests indicate that a proposed job-mix formula complies with the specifications as revised for the project, a Form 43 shall be executed between the Engineer and the Contractor to establish the job-mix formula.

After the Form 43 is executed, and all materials are available on the project, the Contractor shall notify the Engineer a minimum of one working day in advance of beginning production of the hot mix asphalt. Any changes in the Form 43 will require the same notification unless otherwise approved by the Engineer.

(b) *Mixtures Furnished to the Project.* After the job-mix formula is established, all mixtures furnished for the project shall conform thereto within the ranges of tolerances listed in Table 401-1.

Table 401-1
***TOLERANCES FOR HOT MIX ASPHALT**

*Hot Mix Asphalt - Item 403, Gradations	
#Passing the 9.5 mm (3/8 inch) and larger sieves	± 6%
#Passing the 4.75 mm (No. 4) and 2.36 mm (No. 8) sieves	± 5%
#Passing the 600 μm (No. 30) sieve	± 4%
#Passing the 75 μm (No. 200) sieve	± 2%
Asphalt Content	± 0.3%
Asphalt Recycling Agent	± 0.2%

Table 401-1 Notes: *When 100% passing is designated, there shall be no tolerance. When 90 - 100% passing is designated, 90% shall be the minimum; no tolerance shall be used.

#These tolerances apply to the Contractor's Process Control Testing.

The job-mix formula for each mixture shall be in effect unless modified in writing on Form 43.

Should a change in sources of materials be made, a new job-mix formula shall be established before the new material is used. This new job-mix formula shall be in effect until modified by the Engineer. Requests made in writing by the Contractor for changes in the job-mix formula will be considered. The job-mix formula may be changed by the Engineer if the change will produce a mixture of equal or better quality and will:

1. Permit better utilization of available material, or
2. Result in a saving in cost to the Department through an adjustment in unit price.

Tests for cleanliness, abrasion loss, and percent of fractured faces will be made on representative samples of aggregate taken during production or from the stockpiles.

Hot mix asphalt (HMA) will be tested for moisture susceptibility by the Department per Table 401-2. If a sample fails to meet the criteria shown in Table 401-2, the Contractor shall take corrective action before being permitted to continue production. If proper corrective action cannot be readily determined, the Engineer will suspend the use of such material until Laboratory tests indicate that the corrective measures taken by the Contractor will provide material that is in compliance.

If one or more samples fail to meet the requirements of Table 401-2, material from the area represented by the failing sample will be evaluated as follows:

If the area represented by the failing sample contains 2,000 tons of the new pavement or less, then the result for the failing sample shall be considered a lot of one and will be evaluated according to the formulas and procedures in subsection 105.03.

If the area represented by the failing sample contains more than 2,000 tons of the new pavement, then the material from the area represented by the failing sample will be sampled and tested according to the following method:

Pavement samples for possible moisture susceptibility testing will be taken at a minimum frequency of once every 2,000 tons throughout the project. The Engineer will observe the sampling, take possession of the samples, and retain these samples for possible testing. Sample size shall be a minimum of 20 pounds. If a 10,000-ton sample fails, then the four 2,000-ton samples from the area represented by that failing 10,000-ton sample will be tested for moisture susceptibility. The 10,000-ton result and the four 2,000-ton results will be considered a lot of five and will be evaluated according to the formulas and procedures in subsection 105.03. If less than four retained samples are on hand because the 10,000-ton sample represents less than 8,000 tons of hot mix asphalt, the price adjustment will be based on the test results from the retained samples on hand plus the test result from the 10,000-ton sample.

For the above evaluation, the “F” factor used in calculating P factors shall be 2.5. The P value shall be applied to price of the HMA item. If asphalt cement is not paid for separately, the price reduction shall be multiplied by 0.60. Lottman P values will not be combined with Pay Factors for other elements determined per Process Control/Owner Acceptance (PC/OA) specifications.

**Table 401-2
HMA MOISTURE SUSCEPTIBILITY
TEST FREQUENCY/CRITERIA**

Grading	Test Procedure	Minimum Test Result	Sampling Frequency
All Gradings	CP L-5109 Method B	70	One per 10,000 tons or fraction (minimum)

401.03 Aggregates. Aggregates shall meet the applicable requirements of subsection 703.04.

401.04 Mineral Filler. Mineral filler shall meet the requirements of subsection 703.06.

401.05 Hydrated Lime. Hydrated lime shall meet the requirements of subsection 712.03.

401.06 Asphalt Cements. The type and grade of asphalt cement will be specified in the Contract.

The asphalt cement shall meet the applicable requirements of Section 702.

CONSTRUCTION REQUIREMENTS

401.07 Weather Limitations and Placement Temperatures. Hot mix asphalt shall be placed only on properly prepared unfrozen surfaces that are free of water, snow, and ice. The hot mix asphalt shall be placed only when both the air and surface temperatures equal or exceed the temperatures specified in Table 401-3 and the Engineer determines that the weather conditions permit the pavement to be properly placed and compacted.

**Table 401-3
PLACEMENT TEMPERATURE LIMITATIONS IN °F**

Compacted Layer Thickness in inches	Minimum Surface and Air Temperature °F Top Layer	Minimum Surface and Air Temperature °F Layers Below Top Layer
< 1 1/2	60	50
1 1/2 - < 3	50	40
3 or more	45	35

Table 401-3 Notes: Air temperature is taken in the shade. Surface is defined as the existing base on that the new pavement is to be placed.

If the temperature falls below the minimum air or surface temperatures, paving shall stop. The Contractor shall schedule the work so that no planed or recycled surface is left without resurfacing for more than 10 calendar days during the period specified in Table 401-4, below. The Contractor shall immediately place a temporary hot mix asphalt layer on any surface that has been planed or recycled and cannot be resurfaced per the above temperature requirements within 10 calendar days after being planed or recycled. The minimum thickness of the temporary hot mix asphalt layer shall be 2 inches. The Contractor shall perform the process control required to assure adequate quality of the hot mix asphalt used in the temporary layer. All applicable pavement markings shall be applied to the temporary layer surface. The Contractor shall maintain the temporary layer for the entire period that it is open to traffic. Distress that affects the ride, safety, or serviceability of the temporary layer shall be immediately corrected to the satisfaction of the Engineer. The temporary hot mix asphalt layer shall be removed when work resumes.

**Table 401-4
PERIODS REQUIRING OVERLAY OF TREATED SURFACES**

Location by Elevation	Period That Planned or Recycled Surfaces Must be Overlaid within 10 Days
All areas below and including 7000 feet	October 1 to March 1
All areas above 7000 feet up to and including 8500 feet	September 5 to April 1
All areas above 8500 feet	August 20 to May 15

401.08 Asphalt Mixing Plant. The asphalt mixing plant shall be capable of producing a uniform material, have adequate capacity, and be maintained in good mechanical condition. Defective parts shall be replaced or repaired immediately if they adversely affect the proper functioning of the plant or plant units, or adversely affect the quality of the hot asphalt plant mix.

Dust, smoke, or other contaminants shall be controlled at the plant site to meet all air quality requirements per subsections 107.01 and 107.24.

Acceptable safety equipment shall be provided by the Contractor to accommodate sampling and testing.

Hot asphalt plant mix shall not be stored longer than nine hours, unless additional protective measures are used and approved.

When hot asphalt plant mix is obtained from a commercial plant, the Contractor shall make arrangements for approved laboratory facilities at the plant site for testing hot asphalt paving mixtures. The plant laboratory shall meet the requirements of subsection.

401.09 Hauling Equipment. Trucks used for hauling asphalt mixtures shall have tight, clean, smooth metal beds thinly coated with a minimum amount of paraffin oil, lime solution, or other approved release agent. Petroleum distillates such as kerosene or fuel oil will not be permitted. Each truck shall have a cover of canvas or other suitable material to protect the mixture from the weather.

401.10 Asphalt Pavers. Self-propelled asphalt pavers shall be provided and equipped with an activated screed assembly, heated, if necessary, capable of spreading and finishing the asphalt plant mix material in lane widths applicable to the typical section and thicknesses shown in the Contract. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of asphalt plant mix material in widths shown in the Contract.

The paver's receiving hopper shall have sufficient capacity for a uniform spreading operation and shall have an automatic distribution system that will place the mixture uniformly in front of the screed.

The screed or strike-off assembly shall produce the specified finished surface without tearing, shoving, or gouging the mixture.

The paver shall include an approved longitudinal paver wedge system to create a sloped SafetyEdge_{SM} as shown on the plans. The wedge system shall be attached to the screed and shall compact the HMA to a density at least as dense as the compaction imparted to the rest of the HMA layer by the paving screed. The system shall provide a sloped SafetyEdge_{SM} equal to 32 degrees plus or minus 5 degrees measured from the pavement surface cross slope extended. A single plate strike off shall not be used. The system shall be adjustable to accommodate varying paving thicknesses. The Engineer may allow the Contractor to use handwork for short sections or to saw cut the sloped SafetyEdge_{SM} after paving operations are completed in areas such as transitions at driveways, intersections, interchanges.

The Contractor shall submit the proposed paver wedge system for approval at the Pre-construction Conference. The Engineer may require proof that the system has been used on previous projects with acceptable results or may require a test section constructed before the beginning of work to demonstrate that it creates an acceptable wedge shape and compaction. Paving shall not begin until the system is approved in writing by the Engineer. The SafetyEdge_{SM} may be constructed on each lift of HMA or on the full-specified plan depth on the final lift. The finished shape of the SafetyEdge_{SM} shall extend for the full depth of the asphalt pavement or for the top 5 inches whichever is less.

The paver shall be capable of operating at forward speeds consistent with uniform and

continuous laying of the mixture. Stop and go operations of the paver shall be avoided.

The asphalt paver shall be equipped with a means of preventing the segregation of the coarse aggregate particles from the remainder of the asphalt plant mix when that mix is carried from the paver hopper back to the paver augers. The means and methods used shall be approved by the paver manufacturer and may consist of chain curtains, deflector plates, or other such devices and any combination of these.

The following specific requirements shall apply to the identified asphalt pavers:

- (1) Blaw-Knox asphalt pavers shall be equipped with the Blaw-Knox Materials Management Kit (MMK).
- (2) Cedarapids asphalt pavers shall be those that were manufactured in 1989 or later.
- (3) Caterpillar asphalt pavers shall be equipped with deflector plates as identified in the December 2000 Service Magazine entitled "New Asphalt Deflector Kit {6630, 6631, 6640}".

Before the start of using the paver for placing plant mix, the Contractor shall submit for approval a full description in writing of the means and methodologies that will be used to prevent asphalt paver segregation. Use of the paver shall not commence before receiving approval from the Engineer.

The Contractor shall supply a Certificate of Compliance that verifies that the approved means and methods used to prevent asphalt paver segregation have been implemented on all pavers used on the project.

Pavers shall be equipped with automatic screed controls with sensors capable of sensing grade from an outside reference line and maintaining the screed at the specified longitudinal grade and transverse slope. The sensor shall be constructed to operate from either or both sides of the paver and shall be capable of working with the following devices:

- (1) Ski-type device at least 30 feet in length.
- (2) Short ski or short shoe.
- (3) At least 5,000 feet of control line and stakes.

The type or types of devices to be furnished shall be as provided in the Contract.

The controls shall be capable of maintaining the screed at the specified transverse slope within plus or minus 0.1 percent.

Manual operation will be permitted for constructing irregularly shaped and minor areas.

If the automatic controls fail or malfunction the equipment may be operated manually for the remainder of the normal working day, provided specified results are obtained.

If the Contractor fails to obtain and maintain the specified surface tolerances, the paving operations shall be suspended until satisfactory corrections, repairs, or equipment replacements are made.

Placement of hot mix asphalt on a waterproofed bridge deck shall be accomplished with equipment that will not damage the membrane or protective covering.

401.11 Tack Coat. When ordered by the Engineer or specified in the Contract, a tack coat shall be applied between pavement courses and paid for per Section 407.

401.12 Surface Conditioning. Irregularities in the existing pavement or base shall be brought to uniform grade and cross section.

Before placing tack coat and beginning overlay work, the surface to be tack coated shall be swept to remove accumulations of loose gravel and debris.

Asphalt plant mix shall be placed only on properly constructed surfaces that are free from substances that would adversely affect the pavement quality.

Contact surfaces of curbing, gutters, manholes, and other structures shall be painted with a uniform coating of asphalt cement before placing asphalt mixture against them.

401.13 Preparation of Asphalt Cement. The asphalt cement shall be heated to the specified temperature without local overheating and shall be continuously supplied to the mixer at a uniform temperature within the specified range.

401.14 Preparation of Aggregates. Heating and drying of the aggregates shall be accomplished without damaging the aggregate.

When hydrated lime is used it shall be added to the aggregate per one of the following methods:

- (a) *Lime Slurry Added to Aggregate.* The hydrated lime shall be added to the aggregate in the form of a slurry and then thoroughly mixed in an approved pugmill. The slurry shall contain a minimum of 70 percent water by weight.
- (b) *Dry Lime Added to Wet Aggregate.* The dry hydrated lime shall be added to the blended aggregate wetted a minimum of 2 percent above the surface saturated dry condition (SSD) as shown on the Form 43, and then thoroughly mixed in an approved pugmill. The Engineer will not require the Contractor to increase the moisture above 5 percent total, although the Contractor may elect to do so if the added water is necessary to meet the minimum Lottman specification (See Table 401-2).

The Contractor may request that the 2 percent above SSD requirement be waived, provided the requirements of CPL 5150 have been met. If the HMA fails to meet the minimum TSR requirements defined in Table 401-2 at any point during production, the Contractor shall immediately be required to add the minimum amount of moisture as defined above.

The lime-aggregate mixture may be fed directly into the hot plant after mixing or it may be stockpiled for not more than 90 days before introduction into the plant for mixing with the asphalt cement. The hydrated lime may be added to different sized aggregates and stockpiled, by adding 75 percent of the lime to the aggregate passing the 4.75 mm (No. 4) sieve and 25 percent to the aggregate retained on the 4.75 mm (No. 4) sieve.

In order to ensure the required lime and water quantities are introduced, lime and water feed for lime operation shall have control systems that change introduction rates in conjunction with changes in plant mix production. The control systems shall be documented in the Contractor's PC Plan.

When a test for aggregate percent moisture falls below the required minimum, the Contractor will receive a warning. When two consecutive tests for aggregate percent

moisture fall below the required minimum, a follow up test will immediately be performed. A failure on the follow up test will result in suspension of work. Production will remain suspended until the source of the problem is identified and corrected. Each time production is suspended, corrective actions shall be proposed in writing by the Contractor and approved in writing by the Engineer before production may resume.

401.15 Mixing. The dried aggregates and asphalt shall be combined in the mixer in the quantities required to meet the job-mix formula.

The materials shall be mixed until the aggregate is completely and uniformly coated, and the asphalt is uniformly distributed throughout the aggregate.

The minimum temperature of the mixture when discharged from the mixer and when delivered for use shall be as shown in Table 401-5:

**Table 401-5
HMA MINIMUM DISCHARGE/DELIVERY TEMPERATURES**

Asphalt Grade	Minimum Mix Discharge Temperature, °F*	Minimum Delivered Mix Temperature, °F#
PG 58-28	275	235
PG 64-22	290	235
PG 76-28	320	280
PG 64-28	320	280
PG 70-28	320	280
PG 58-34	300	280

Table 401-5 Notes: *The maximum mix discharge temperature shall not exceed the minimum discharge temperature by more than 30 °F.

Delivered mix temperature shall be measured behind the paver screed.

Hot mix asphalt mixture shall be produced at the lowest temperature within the specified temperature range that produces a workable mix and provides for uniform coating of aggregates (95 percent minimum per AASHTO T 195), and that allows the required compaction to be achieved.

Storing or holding of asphalt mixture will be permitted provided the characteristics of the mixture are not altered. If storing or holding of the mixture causes segregation, excessive heat loss, or adversely affects the quality of the finished product, corrective action shall be taken. Unsuitable mixture shall be disposed of at the Contractor's expense.

When placing hot asphalt mixture over bridge decks covered by waterproofing membrane, the minimum temperature of the mixture when rolling operations begin shall be 250 °F. The job-mix formula temperature may be increased up to 30 °F to obtain this temperature.

401.16 Spreading and Finishing. Asphalt pavers shall be used to distribute the mixture to the established grade and required thickness over the entire width or partial width as practicable.

The longitudinal joint in both a new pavement and an overlay pavement layer shall offset the joint in the layer immediately below by 6 inches. In every pavement layer, the longitudinal joints shall not be constructed in the wheel paths. The Contractor shall submit a longitudinal joint and pavement marking plan three days before the Pre-paving Conference. The plan shall show the location and configuration of the proposed longitudinal joints and pavement markings and shall detail the methods to be used to field establish a control line. The Contractor shall use a continuous string line to delineate every longitudinal joint during paving operations. All exposed string line shall be picked up and disposed of at the end of each day's paving. Paving shall not commence until the plan has been approved in writing by the Engineer. The joints in the top layer of pavement shall be located as follows unless otherwise approved in writing by the Engineer:

1. For 2-lane roadways, offset 6 to 12 inches from the center of pavement and from the outside edge of travel lanes.
2. For roadways of more than 2 lanes, offset 6 to 12 inches from lane lines and outside edge of travel lanes.

Longitudinal joints shall not cross the centerline, lane line, or edge line unless approved by the Engineer.

Where paving operations are on the present traveled roadway, the Contractor shall arrange paving operations so there will be no exposed longitudinal joints between adjacent travel lanes at the end of a day's run. With the approval of the Engineer, the Contractor may leave an exposed longitudinal joint conforming to the following:

1. When the thickness of the pavement course being placed is 1.5 inches or less a vertical exposed longitudinal joint may be constructed.
2. When the thickness of the pavement course being placed is greater than 1.5 inches the joint shall be constructed according to one of the following:
 - A. The entire joint shall be tapered 3:1 or flatter. A Taper steeper than 3:1 shall be considered vertical.
 - B. The top portion of the longitudinal joint may be vertical. The vertical portion shall be a maximum of 1.5 vertical inches. The remainder of the joint, below the vertical portion, shall be tapered 3:1 or flatter.

On areas where the use of mechanical spreading and finishing equipment is impracticable, the mixture shall be dumped, spread, raked, screeded, and luted by hand tools to the required compacted thickness and grades.

Production of the mixture shall be maintained so pavers can be used in echelon to place the wearing course in adjacent lanes.

The asphalt mixture shall be transported and placed on the roadway without segregation. All segregated areas behind the paver shall be removed immediately upon discovery. The segregated material shall be replaced with specification material before the initial rolling has taken place. If more than 50 square feet of segregated pavement is ordered removed and replaced in any continuous 500 linear feet of paver width laydown, operations shall be discontinued until the source of the segregation has been found and corrected.

If at any time, the Engineer observes segregated areas of pavement, they will notify the Contractor immediately.

After rolling, segregated areas will be delineated by the Engineer and evaluated as follows:

1. The Engineer will delineate the segregated areas to be evaluated and inform the Contractor of the location and extent of these areas within two calendar days, excluding weekends and holidays, of placement.
2. In each segregated area or group of areas to be evaluated, the Contractor shall take five 10-inch cores at random locations designated by the Engineer. Per CP 75, the Contractor shall also take five 10-inch cores at random locations designated by the Engineer in non-segregated pavement adjacent to the segregated area. These cores shall be within 30 feet of the boundary of the segregated area and in the newly placed pavement. The coring shall be in the presence of the Engineer and the Engineer will take immediate possession of the cores. The Contractor may take additional cores at the Contractor's expense.
3. Gradation of the aggregate of the cores will be determined by CDOT per CP 46.
4. The core aggregate gradations from the segregated area will be compared to the core aggregate gradations of the corresponding non-segregated area.
5. Two key sieves of the core gradations from the segregated area will be compared to the core gradations from the corresponding non-segregated area to determine the difference. If differences for both key sieves exceed the allowable difference specified in the table below, the area is segregated.

**Table 401-6
SEGREGATION DETERMINATION**

Mix Grading	Key Sieves	Allowable Difference, %
SX	2.36 mm (#8), 4.75 mm (#4)	9
S	2.36 mm (#8), 4.75 mm (#4)	9

6. Segregated areas in the top lift shall be removed and replaced, full lane width, at the Contractor's expense. The Engineer may approve a method equivalent to removal and replacement that results in a non-segregated top lift. Segregated areas, in lifts below the top lift that are smaller than 50 square feet per 100 linear feet of lane width shall be corrected by the Contractor at the Contractor's expense in a manner acceptable to the Engineer. Segregated areas larger than 50 square feet per 100 linear feet of lane width in any lift shall be removed and replaced, full lane width, by the Contractor at the Contractor's expense.

If the area is determined to be segregated, the coring shall be at the expense of the Contractor. If the area is determined to be non-segregated, the Engineer will reimburse the Contractor \$2,000 for obtaining the 10 cores.

The Engineer will perform a systematic segregation check per CP 58 as early in the project as is feasible to determine if temperature segregation problems exist. Temperature segregation will be of concern on the project if, across the width of the mat, temperatures vary by 25 °F or more. Densities will not need to be taken in the systematic segregation check. The Engineer will discuss the temperature findings of the systematic segregation check with the Contractor.

The Engineer may evaluate the HMA for low density due to temperature segregation whenever industry best practices, as detailed on Form 1346, are not being followed or the Engineer suspects temperature segregation is occurring. The Engineer will first meet with the Contractor to discuss the paving practices that are triggering the temperature investigation. Areas across the mat, excluding the outside 1 foot of both edges of the mat, that are more than 25 °F cooler than other material across the width may be marked for density testing. Material for temperature comparison will be evaluated in 3-foot intervals behind the paver across the width of the mat. The material shall be marked and tested per CP 58. If four or more areas within a lot of 500 tons have densities of less than 93 percent of the material's maximum specific gravity for SMA mixes or less than 92 percent of the material's maximum specific gravity for all other HMA mixes, a 5 percent price disincentive will be applied to the 500-ton lot. The 500-ton count begins when the Engineer starts looking for cold areas, not when the first cold area is detected. This price disincentive will be in addition to those described in Sections 105 and 106. Only one area per delivered truck will be counted toward the number of low-density areas. Temperature segregation checks will be performed only in areas where continuous paving is possible.

401.17 Compaction. The hot mix asphalt shall be compacted by rolling. Both steel wheel and pneumatic tire rollers will be required. The number, weight, and type of rollers furnished shall be sufficient to obtain the required density while the mixture is in a workable condition. Compaction shall begin immediately after the mixture is placed and be continuous until the required density is obtained. When the mixture contains unmodified asphalt cement (PG 58-28 or PG 64-22) or modified (PG 58-34), and the surface temperature falls below 185 °F, further compaction effort shall not be applied unless approved, provided the Contractor can demonstrate that there is no damage to the finished mat. If the mixture contains modified asphalt cement (PG 76-28, PG 70-28 or PG 64-28) and the surface temperature falls below 230 °F, further compaction effort shall not be applied unless approved, provided the Contractor can demonstrate that there is no damage to the finished mat.

Warm Mix Asphalt compaction requirements shall conform to CP 59.

All roller marks shall be removed with the finish rolling. Use of vibratory rollers with the vibrator on will not be permitted during surface course final rolling and will not be permitted on any rolling on bridge decks covered with waterproofing membrane.

SMA shall be compacted to a density of 93 to 97 percent of the daily theoretical maximum specific gravity, determined according to CP 51. All other HMA shall be compacted to a density of 92 to 96 percent of the daily theoretical maximum specific gravity, determined according to CP 51. If more than one theoretical maximum specific gravity test is taken in a day, the average of the theoretical maximum specific gravity results will be used to determine the percent compaction. Field density determinations will be made per CP 44 or 81.

The longitudinal joints shall be compacted to a target density of 92 percent of the theoretical maximum specific gravity. The tolerance shall be plus or minus 4 percent. The theoretical maximum specific gravity used to determine the joint density will be the average of the daily theoretical maximum specific gravities for the material that was placed on either side of the joint. Density (percent relative compaction) will be determined per CP 44.

The Contractor shall obtain one 6-inch diameter core at a random location within each

longitudinal joint sampling section for determination of the joint density. The Contractor shall mark and drill the cores at the location directed by the Engineer and in the presence of the Engineer. The Engineer will take possession of the cores for testing. The Contractor may take additional cores at his own expense. Coring locations shall be centered on the visible line where the joint between the two adjacent lifts abuts the surface. The center of all joint cores shall be within 1 inch of this visible joint line. Core holes shall be repaired by the Contractor using materials and methods approved by the Engineer. PC and OA joint coring shall be completed within five calendar days of joint construction.

Longitudinal joint coring applies to all pavement layers. When constructing joints in an echelon paving process, the joints shall be clearly marked to ensure consistent coring location. In small areas, such as intersections, where the Engineer prescribes paving and phasing methods, the Engineer may temporarily waive the requirement for joint density testing.

Incentive or disincentive payment determined for joint density per subsection 105.05 will apply to the HMA on each side of the joint. If a layer of pavement has joints constructed on both sides, incentive or disincentive payment for each of those joints will apply to one half of the pavement between the joints.

Along forms, curbs, headers, walls, and all other places not accessible to the rollers, the mixture shall be thoroughly compacted with mechanical tampers.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective, shall be immediately removed and replaced with fresh hot mixture, and compacted to conform to the surrounding area.

The Contractor shall construct a compaction pavement test section (CTS) for each job mix where 2,000 or more tons are required for the project. The CTS will be used to evaluate the number of rollers and the most effective combination of rollers and rolling patterns for achieving the specified densities. Factors to be considered include, but are not limited to, the following:

- (1) Number, size, and type of rollers.
- (2) Amplitude, frequency, size and speed of vibratory rollers.
- (3) Size, speed, and tire pressure of rubber tire rollers.
- (4) Temperature of mixture being compacted.
- (5) Roller patterns.

The CTS shall be constructed according to the following procedures:

The CTS shall be constructed to provide the nominal layer thickness specified. The first 500 tons of hot mix asphalt on the project location shall constitute the CTS. The production and placement rates of the CTS shall closely approximate the anticipated production and placement rates for the remainder of the Contract.

Compaction of the CTS shall commence immediately after the hot mix asphalt has been spread and shall be continuous and uniform over the entire CTS. For the CTS, compaction shall continue until no discernible increase in density is obtained by additional compactive efforts. All compaction shall be completed before the surface temperature of the mixture drops below 185 °F.

Approved types of rollers shall be used to achieve the specified density. The Contractor shall determine what methods and procedures are to be used for the compaction operation. The

compaction methods and procedures shall be used uniformly over the entire last 200 tons. The Contractor shall record the following information and a copy of this data shall be furnished to the Engineer.

- (1) Type, size, amplitude, frequency, and speed of roller.
- (2) Tire pressure for rubber tire rollers, and whether the pass for vibratory rollers is vibratory or static.
- (3) Surface temperature of mixture behind the laydown machine and subsequent temperatures and densities after each roller pass.
- (4) Sequence and distance from laydown machine for each roller, and number of passes of each roller to obtain specified density.

Two sets of random cores shall be taken within the last 200 tons of the CTS. Each set shall consist of seven random cores. The Engineer will determine the coring locations using a stratified random sampling process. The locations of these cores will be such that one set can serve as a duplicate of the other. One set of these cores shall be immediately submitted to the Engineer. This set will be used for determining acceptance of the CTS and determining density correction factors for nuclear density equipment. Densities of the random samples will be determined by cores according to CP 44. Density correction factors for nuclear density equipment will be determined according to CP 81. Coring shall be performed under CDOT observation. Coring will not be measured and paid for separately but shall be included in the work. For SMA, a CTS is not used. The Contractor shall follow the requirements for the demonstration control strip per the Revision of Section 403, Stone Matrix Asphalt Pavement.

The CTS meets requirements if the Quality Level of the random samples is greater than or equal to 75. The Quality Level will be determined according to CP 71. Once constructed and accepted, the CTS shall remain in place and become part of the hot mix asphalt on the project.

When the Quality level is less than 75 the Contractor shall construct an additional test section, utilizing different rollers, or roller positions, or roller patterns as required. A written proposal detailing the changes in methods and procedures that will be used to obtain density is to be submitted to the Engineer for review before constructing the additional test section.

If the Quality Level of a CTS is less than 75 and greater than or equal to 44, the Engineer may accept the material at a reduced price per Section 105.

If the Quality Level of a CTS is less than 44, the Engineer may:

- (1) Require complete removal and replacement with specification material at the Contractor's expense.
- (2) Where the finished product is found to be capable of performing the intended purpose and the value of the finished product is not affected, as determined by the Engineer, permit the Contractor to leave the material in place with a pay factor, but not more than 75 percent of the bid price.

Each CTS shall be 500 tons. If in-place densities of the CTS, as determined by nuclear density equipment before determining density of the cores, meet the CTS density requirements, the Contractor may begin production paving and continue to place hot mix asphalt pavement under the following conditions:

- (1) The period during which the Contractor continues to pave without test results from cores shall not exceed one workday.
- (2) Construction proceeds at the Contractor's risk. If correlation with the cores reveals that the densities do not meet the CTS requirements, the hot mix asphalt pavement placed subsequently will be subject to price reduction or removal and replacement.

After production paving work has begun, a new Roller Pattern shall be demonstrated when a change in the compaction process is implemented.

All additional costs associated with construction of the CTS shall be at the Contractor's expense. The hot mix asphalt placed in the CTS will be paid for per subsection 401.22, at the contract price for the hot mix asphalt.

401.18 Joints. Placing of the hot mix asphalt shall be continuous, and rollers shall not pass over the unprotected end of a freshly laid mixture. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. A coat of asphalt cement shall be applied to contact surfaces of all joints just before additional mixture is placed against the previously compacted material. Location and configuration of longitudinal joints shall be per subsection 401.16.

401.19 Pavement Samples. The Engineer may take samples of the compacted pavement at random locations on the project for testing. Where samples have been taken, new material shall be placed and compacted by the Contractor to conform with the surrounding area.

401.20 Surface Smoothness. The roadway surface smoothness shall be tested per subsection 105.07.

METHOD OF MEASUREMENT

401.21 Hot mix asphalt and asphalt cement will be measured by the ton. Batch weights will not be permitted as a method of measurement. The tonnage shall be the weight used in the accepted pavement. Deduction will not be made for the weight of asphalt cement in the mixture.

BASIS OF PAYMENT

401.22 All work performed and measured as described above will be paid for as provided in the respective sections for each type specified.

If there is no pay item for asphalt cement of the type specified it will not be measured and paid for separately but shall be included in the work.

Water used in the mixing plant, per subsection 401.14, to bring the lime-aggregate mixture to approved moisture content will not be measured and paid for separately but shall be included in the work.

Facilities for testing hot asphalt plant mix at the site of the commercial plant will not be paid for separately but shall be included in the work.

When asphalt cement is a separate pay item, the amount of asphalt cement contained in reclaimed asphalt pavement (RAP) material will not be measured or paid for but shall be included in the work.

Coring for in-place density, coring for longitudinal joint density, core hole repair, and associated expenses will not be paid for separately but shall be included in the work. Traffic control for this work will be paid for per the contract.

All costs of the temporary hot mix asphalt layer required according to subsection 401.07, maintenance and removal of the temporary pavement layer, temporary pavement marking, and traffic control will not be paid for separately but shall be included in the work.

All costs associated with the construction of the SafetyEdgeSM specified in subsection 401.10 will not be paid for separately but shall be included in the work.

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SECTION 403 HOT MIX ASPHALT

DESCRIPTION

403.01 This work consists of constructing one or more courses of hot mix asphalt (HMA) on a prepared base per these specifications, and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established.

The asphalt pavement shall be composed of a mixture of aggregate, filler if required, and asphalt cement.

Hot Mix Asphalt (Patching) consists of those quantities required for the replacement of unstable corrugated areas in the existing pavement, pipe trenches, areas removed for curb and gutter forms, areas between the curb and gutter or sidewalk and the existing paved parking lots, and areas designated on the plans. These quantities will be restricted to small areas that require hand placement methods and where conventional paving equipment cannot be utilized.

MATERIALS

403.02 The materials shall conform to the requirements of subsections 401.02 through 401.06.

CONSTRUCTION REQUIREMENTS

403.03 The construction requirements shall be as prescribed in subsections 401.07 through 401.20.

Areas to be patched shall be excavated and squared to a neat line, leaving the sides of the excavation vertical. Before placement of the patch, the exposed sides of the existing pavement shall be thoroughly coated with emulsified asphalt (slow-setting). Hot mix asphalt shall then be placed and compacted in succeeding layers not to exceed 3 inches in depth.

METHOD OF MEASUREMENT

403.04 Hot mix asphalt will be measured as prescribed in subsection 401.21.

BASIS OF PAYMENT

403.05 The accepted quantities of hot mix asphalt will be paid for per subsection 401.22, at the contract unit price per ton for the asphalt mixture.

Payment will be made under:

Pay Item	Pay Unit
Hot Mix Asphalt (Grading___)	Ton
Hot Mix Asphalt (Grading___) (Asphalt)	Ton
Hot Mix Asphalt (Patching) (Asphalt)	Ton

403.05

Aggregate, asphalt cement, asphalt recycling agent, additives, hydrated lime, and all other work necessary to complete each hot mix asphalt item will not be paid for separately but shall be included in the unit price bid.

Excavation, preparation, and tack coat of areas to be patched will not be measured and paid for separately but shall be included in the work.

SECTION 405 HEATING AND SCARIFYING TREATMENT

DESCRIPTION

405.01 This work consists of recycling the top portion of the existing asphalt pavement as shown in the Contract, by cleaning, heating, scarifying, redistributing, re-leveling, compacting, and rejuvenating the existing asphaltic material.

MATERIALS

405.02 Asphalt rejuvenating agent shall meet the requirements of subsection 702.02(f).

CONSTRUCTION REQUIREMENTS

405.03 Weather limitations shall be as provided in subsection 401.07. Before commencing heating and scarifying operations, the pavement shall be cleaned of all loose material. Power brooms shall be supplemented by hand brooming and use of other tools as required to bring the surface to a clean, suitable condition free of deleterious material.

Equipment used to heat and scarify the asphalt surface shall meet the following requirements:

- (1) Capable of uniformly applying heat under totally insulated, enclosed hoods to produce radiant heat.
- (2) Self-propelled and capable of scarifying to the depth specified.
- (3) Capable of covering a minimum of 750 square yards per hour while heating the existing surface to the extent that it will be remixed by the scarifiers to a depth not less than specified.

The heating operation shall extend at least 4 inches beyond the width of scarifying on both sides. When a pass is made adjacent to a previously placed mat, the longitudinal seam shall extend at least 2 inches into the previously placed mat. The temperature of the scarified material shall be between 200 and 300 °F when measured immediately behind the scarifier. The scarified material shall be distributed and leveled by a paving machine. The paving machine shall be capable of screeding the full width of the scarified material to produce a uniform cross section as shown in the Contract.

While the scarified material is still hot and before it is placed by the paving machine, an application of asphalt rejuvenating agent shall be applied as specified.

The asphalt surface shall be compacted immediately after it has been distributed and leveled, and while it is still workable. Two rollers shall be used to compact the scarified material. A steel wheel roller shall be used first to provide breakdown rolling, followed by a pneumatic tire roller with a minimum weight of 12 tons, to complete compaction to 92 to 96 percent of maximum theoretical density. When the mixture surface temperature falls below 165 °F, no further compaction effort shall be done unless approved. A minimum of 24 hours shall elapse before an asphalt pavement overlay is applied to the scarified pavement.

405.04

The weight per cubic foot of the existing asphalt surface shall be determined per AASHTO T 166. Scarification depth will be acceptable when the moving average of a minimum of three consecutive random tests per hour indicates that the required amount per square foot, based on the weight per cubic foot of the existing asphalt surface, has been scarified. Testing shall be performed by the Contractor in lots of three per hour, or as often as necessary to maintain process control.

The longitudinal surface smoothness of the roadway before and after heating and scarifying shall be tested per subsection 105.07(f).

METHOD OF MEASUREMENT

405.04 Heating and scarifying treatment will be measured by the square yard of work completed and accepted.

BASIS OF PAYMENT

405.05 The accepted quantities of heating and scarifying treatment will be paid at the contract unit price per square yard for heating and scarifying treatment, and shall include cleaning, heating, scarifying, redistributing, re-leveling, and compacting the existing asphalt surfacing.

Payment will be made under:

Pay Item	Pay Unit
Heating and Scarifying Treatment	Square Yard

Asphalt rejuvenating agent will be measured and paid for per Section 411.

SECTION 406 COLD ASPHALT PAVEMENT (RECYCLE)

DESCRIPTION

406.01 This work consists of pulverizing the existing asphalt surfacing to the depth shown on the plans, mixing a recycling agent and water, if required, with the pulverized material, then spreading and compacting the mixed material.

MATERIALS

406.02 The recycling agent shall be either a high float emulsified asphalt (polymerized) or emulsified recycling agent meeting the requirements of subsection 702.02(e).

The pulverized material shall meet the following gradation requirements:

**Table 406-1
COLD ASPHALT PAVEMENT (RECYCLE)
PULVERIZED MATERIAL GRADATION REQUIREMENTS**

Sieve Size	Percent Passing
31.5 mm (1 1/4 inch)	100
25.0 mm (1 inch)	90-100

The sealing emulsion shall be high float emulsion (diluted), emulsified asphalt (SS), or approved equal.

CONSTRUCTION REQUIREMENTS

406.03 Weather Limitations. Daily recycling operations shall not begin until the atmospheric temperature is 55 °F and rising. Recycling operations shall be discontinued when the temperature is 60 °F and falling. Recycling operations shall not be performed when the weather is foggy or rainy, or when weather conditions are such that the proper mixing, spreading, compacting, and curing of the recycled material cannot be accomplished. Cold recycled pavement damaged by precipitation shall be reprocessed or repaired by methods approved by the Engineer, at the Contractor's expense.

The construction of cold recycled pavement will not be allowed from September 16 through May 14 unless otherwise approved. The Contractor's Progress Schedule shall show the methods to be used to comply with this requirement.

406.04 Milling. The existing asphalt surfacing shall be cold recycled in a manner that does not disturb the underlying material in the existing roadway.

Adjacent recycling passes shall overlap at the longitudinal joint a minimum of 4 inches.

The beginning of each day's recycling operation shall overlap the end of the preceding recycling operation a minimum of 100 feet unless otherwise directed.

Any fillet of fine, pulverized material that forms adjacent to a vertical face shall be removed before spreading the mixed material, except that such fillet adjacent to existing pavement that will be removed by a subsequent overlapping milling operation need not be removed. Vertical cuts in the roadway shall not be left overnight.

406.05 Mixing. When commencing recycling operations, the recycling agent shall be applied to the pulverized material at the initial design rate determined by the Materials Laboratory, based on samples obtained by the Department before construction. The exact application rate of the recycling agent will be determined and may be varied as required by existing pavement conditions. An allowable tolerance of plus or minus 0.2 percent of the initial design rate or directed rate of application shall be maintained at all times.

A representative of the recycling agent supplier shall be present on the project during recycling operations until an acceptable production sequence is established as determined by the Engineer.

The Contractor may add water to the pulverized material to facilitate uniform mixing with the recycling agent. Water may be added before or concurrently with the recycling agent, provided that this water does not adversely affect the recycling agent.

406.06 Spreading. Recycling and placing recycled material shall be at a rate sufficient to provide continuous operation of the paving machine. If paving operations result in being excessively behind or in excessive stopping of the paving machine, as determined by the Engineer, recycling operations shall be suspended. Recycling may resume when the Contractor can synchronize the rate of recycling with the capacity of the paving machine.

If segregation occurs behind the paver, the Contractor shall make changes in equipment, operations, or both to eliminate the segregation.

406.07 Compacting and Finishing. After the recycled material has been spread, traffic, including Contractor's equipment, shall not be allowed on the recycled material until it starts its initial break as determined by the Engineer. However, if precipitation is imminent, compaction may proceed to seal the surface from additional moisture.

Initial rolling shall be performed with one or more pneumatic tire rollers and be continued until no displacement is observed. Final rolling to eliminate pneumatic tire marks and achieve the required density shall be done by steel wheel rollers either in static or vibratory mode. The use of vibratory rollers shall be approved by the Engineer. If rollers are used in the vibratory mode, vibration shall be at low amplitudes to prevent transverse cracks.

The recycled material shall be compacted to a minimum of 100 percent of the density of a laboratory specimen compacted per CP 53. If the area tested fails to meet the required density, the area shall be reworked until it attains 100 percent compaction. The frequency of density testing for project acceptance will be one per 5,000 square yards. The Engineer will perform one CP 53 for calculation of the percent relative compaction with each field density taken.

Rollers shall not be started or stopped on uncompacted recycled material. Rolling shall be accomplished so that starting and stopping will be on previously compacted cold recycled pavement or existing pavement.

Any type of rolling resulting in cracking, movement, or other types of pavement distress shall be discontinued until the problem is resolved.

After the recycled material has been compacted, traffic, including the Contractor's equipment, shall not be permitted on the cold recycled pavement for at least two hours, unless otherwise approved.

Before placing the sealing emulsion or hot mix asphalt overlay, the cold recycled pavement shall be allowed to cure until the free moisture is reduced to 1 percent free moisture or less, by total weight of mix. Free moisture will be measured according to CP 57. After the free moisture content of the cold recycled pavement has reached the acceptable level, the hot mix asphalt overlay or sealing emulsion, if required, shall be placed. However, unless otherwise approved by the Engineer, the cold recycled pavement shall be covered with a minimum thickness of 2 inches of hot mix asphalt within 10 calendar days after it is laid and compacted. The sealing emulsion, if required, shall be applied to the surface at an approximate rate of 0.025 to 0.10 gallons per square yard. The sealing emulsion shall be applied when the Engineer determines that it is necessary to prevent raveling (progressive separation of aggregate particles).

Damage caused by the Contractor to the cold recycled pavement shall be repaired at Contractor's expense, as directed, before placing any hot asphalt surfacing. Soft areas that are not caused by the Contractor or weather shall also be repaired before placing the hot mix asphalt.

406.08 Recycling Train. The Contractor shall furnish a self-propelled machine capable of pulverizing the existing asphalt surfacing to the depth shown on the plans, in one pass. The machine shall have a minimum rotor cutting width of 12 feet. The rotor cutting width selected for the project shall allow for the longitudinal joint to be offset from the longitudinal joint of the layer placed above by at least 6 inches. The longitudinal joint shall not fall in the wheel path. The machine shall have standard automatic depth controls and maintain a constant cutting depth. The machine shall also have screening and crushing capabilities to reduce or remove oversize particles before mixing with recycling agent. Oversize particles shall be reduced to size by crushing.

The machine shall perform continuous weight measurement of the pulverized material interlocked with the recycling agent metering device so the required recycling agent content will be maintained. Positive means shall be provided for calibrating the weight measurement device and the recycling agent metering device.

A positive displacement pump, capable of accurately metering the required quantity of recycling agent at rates as low as 4 gallons per minute, shall be used to apply the recycling agent. The interlock system shall allow addition of the recycling agent only when pulverized material is present in the mixing chamber. Each mixing machine shall be equipped with a meter capable of registering the rate of flow and the total amount of recycling agent introduced into the mixed material.

The recycling agent shall be applied through a separate mixing machine capable of mixing the pulverized material and the recycling agent to a homogeneous mixture and placing the mixture in a windrow. The mixture shall be placed in a windrow in a manner that prevents segregation.

406.09 Paver. The recycled material shall be placed with a self-propelled asphalt paver meeting the requirements of subsection 401.10, except that the screed shall not be heated. The mixed material shall be spread in one continuous pass, without segregation, to the lines and grades established on the plans.

When a pick-up machine is used to feed the windrow into the paver hopper, the pick-up machine shall be capable of picking up the entire windrow to the underlying materials.

406.10 Compactors. Rollers shall be steel wheel, pneumatic tire, vibratory or combination of these types. The number and weight of rollers shall be sufficient to obtain the required compaction while the recycled material is in a workable condition, except that each pneumatic tire roller shall be 30 tons' minimum weight.

406.11 Smoothness. The longitudinal surface smoothness of the roadway before and after cold recycling shall be tested by the Contractor per subsection 105.07.

METHOD OF MEASUREMENT

406.12 In-place cold recycled pavement will be measured by the square yard of paved surface actually recycled, complete in place and accepted.

Repair of cold recycled pavement will be measured by the square yard of paved surface repaired and accepted.

BASIS OF PAYMENT

406.13 The accepted quantity of in-place cold recycled pavement will be paid for at the contract unit price per square yard.

Payment will be made under:

Pay Item	Pay Unit
Cold Asphalt Pavement (Recycle)	Square Yard

Repair of Cold Asphalt Pavement (Recycle) Square Yard

Asphalt materials will be measured and paid for per Section 411.

Water will not be measured and paid for separately but shall be included in the work.

Repair of cold recycled pavement damaged by the Contractor or by weather will not be measured and paid for separately but shall be included in the work.

Overlaps of preceding recycling operations will not be measured and paid for separately but shall be included in the work.

**SECTION 407
PRIME COAT, TACK COAT, AND
REJUVENATING AGENT**

DESCRIPTION

407.01 This work consists of preparing and treating an existing surface with asphalt material, and blotter material if required, per these specifications and in conformity with the lines shown on the plans or established.

MATERIALS

407.02 Asphalt Material. The type and grade of asphalt material for prime and tack coating will be specified in the Contract.

The asphalt material for all coatings shall meet the applicable requirements of Section 702. The asphalt material for prime and tack coating may be conditionally accepted at the source. The rejuvenating agent shall be accepted before loading into the distributor.

407.03 Blotter Material. Blotter material for prime coating shall consist of aggregate base course conforming to the requirements specified for base course aggregate on the project.

Blotter material for rejuvenating agent shall consist of dry, gritty sand conforming to the fine aggregate gradation of Table 703-2, or as approved.

Blotter material may be accepted in the stockpile at the source or at the roadway before placement.

CONSTRUCTION REQUIREMENTS

407.04 Weather Limitations. Prime coat and tack coat shall not be applied under the following conditions:

- (1) When the surface is wet.
- (2) When weather conditions would prevent the proper construction of the prime or tack coat.

407.05 Equipment. The Contractor shall provide equipment for heating and uniformly applying asphalt material and blotter material.

The distributor and equipment shall be capable of uniformly distributing asphalt material at even temperature and uniform pressure on variable widths of surface up to 15 feet at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard. The allowable variation from any specified rate shall not exceed plus or minus 0.02 gallon per square yard. Distributor equipment shall include a tachometer, pressure gauges, accurate volume measuring devices or a calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically.

The distributor for rejuvenating agent shall also be equipped with the following:

- (1) Heating facilities with controls to reach a temperature of 130 °F.
- (2) Circulating system to maintain proper mixture of the rejuvenating agent.

407.06 Preparation of Surface. Preparation of the surface to be treated shall include all work necessary to provide a smooth, dry, uniform surface. The work shall include patching, brooming, shaping to required grade and section, compaction, and removal of unstable corrugated areas.

The edges of existing pavements that are to be adjacent to new pavement shall be cleaned to permit the adhesion of asphalt materials.

407.07 Application of Asphalt Material. Asphalt material shall be applied by a pressure distributor in a uniform and continuous spread. When traffic is maintained, not more than $\frac{1}{2}$ of the width of the section shall be treated in one application, or sufficient width shall be left to adequately handle traffic. Care shall be taken so the application of asphalt material at the junctions of spreads is not in excess of the specified quantity. Excess asphalt material shall be removed or distributed as directed.

Skipped areas or deficiencies shall be corrected. Asphalt material shall not be placed on any surface where traffic will travel on the freshly applied material.

The rate of application, temperatures, and areas to be treated shall be approved before application of the coating.

407.08 Application of Blotter Material. If, after the application of the prime coat or rejuvenating agent the asphalt material fails to penetrate and the roadway must be used by traffic, blotter material shall be spread in the quantity required to absorb excess asphalt material.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

407.09 Asphalt material will be measured and paid for per Section 411.

Blotter material will not be measured and paid for separately but shall be included in the work.

Payment for patching will be made at the contract unit price for the various items used for patching.

SECTION 408 JOINT AND CRACK SEALANT

DESCRIPTION

408.01 This work consists of furnishing and placing an approved hot poured joint and crack sealant in properly prepared cracks in asphalt pavements. Cracks with a width greater than 1/8 inch and less than 1 inch are to be filled with this material.

MATERIALS

408.02 Materials for hot poured joint and crack sealant shall meet the requirements of subsection 702.04.

Using a mixture of different manufacturers' brands or different types of sealant is prohibited.

CONSTRUCTION REQUIREMENTS

408.03 Immediately before applying hot poured joint and crack sealant, the cracks shall be cleaned of loose and foreign matter to a depth approximately twice the crack width. Cleaning shall be performed using a hot compressed air lance. This lance shall be used to dry and warm the adjacent asphalt immediately before sealing. Direct flame dryers shall not be used.

These Cracks shall be filled with hot poured joint and crack sealant flush with the pavement surface. Immediately following the filling of the crack, excess sealant shall be leveled off at the wearing surface by squeegee, a shoe attached to the applicator wand, or other suitable means approved by the Engineer. The squeegeed material shall be centered on the cracks and shall not exceed 3 inches in width or 1/16 inch in depth.

The sealant material shall be heated and applied according to the manufacturer's recommendations. The equipment for heating the material shall be an indirect heating type double boiler using oil or other heat transfer medium and shall be capable of constant agitation. The heating equipment shall be capable of controlling the sealant material temperature within the manufacturer's recommended temperature range and shall be equipped with a calibrated thermometer capable of plus or minus 5 °F accuracy from 200 to 600 °F. This thermometer shall be located so the Engineer can safely check the temperature of the sealant material. Overheating of the sealant material will not be permitted.

The face of the crack shall be surface dry, and the air and pavement temperatures shall both be at least 40 °F and rising at the time of sealant application.

Sealant material picked up or pulled out after being placed shall be replaced at the Contractor's expense. The Contractor shall have blotter material available on the project in the event it is required to prevent tracking or pulling. If required, blotter material shall be approved by the Engineer and placed at the Contractor's expense.

METHOD OF MEASUREMENT

408.04

408.04 Hot poured joint and crack sealant will be measured by the ton of material used. The Engineer may require the weighing of equipment for determination of actual quantities of material used.

BASIS OF PAYMENT

408.05 The accepted quantities will be paid for at the contract unit price per ton.

Payment will be made under:

Pay Item	Pay Unit
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Hot Poured Joint and Crack Sealant	Ton
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All materials, equipment, and costs incidental to the preparation of the surface before application of the hot poured joint and crack sealant will not be paid for separately but shall be included in the work.

SECTION 409 CHIP SEAL

DESCRIPTION

409.01 This work consists of furnishing and applying asphalt emulsion and cover coat material on an existing surface, per these specifications and in conformity with the lines shown on the plans or established. When rejuvenating agent or emulsified asphalt is used as a fog seal, cover coat material will not be required.

MATERIALS

409.02 Asphalt Emulsion. Emulsified asphalt shall be polymerized or latex modified and shall be rapid set or medium set conforming to the requirements of subsection 702.02(b).

Rejuvenating agent shall conform to the requirements of subsection 702.02(f).

409.03 Cover Coat Material. Cover coat material shall meet the requirements of subsection 703.05 for the type specified. The material will be accepted at the spreader.

CONSTRUCTION REQUIREMENTS

409.04 Weather Limitations. Asphalt emulsion shall not be applied on a damp surface, when either the air or pavement surface temperature is below 70 °F, or when weather conditions would prevent the proper construction of the chip seal.

409.05 Equipment. The following equipment or its equivalent shall be used:

- (1) Asphalt distributor and equipment shall be capable of uniformly distributing asphalt emulsion at even temperature and uniform pressure on variable widths of surface up to 15 feet at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard. The allowable variation from any specified rate shall not exceed plus or minus 0.02 gallon per square yard. The distributor's spreading capabilities shall be computer controlled or it shall be calibrated to conform to the distributor manufacturer's procedure before applying the emulsified asphalt. Distributor equipment shall include a tachometer, pressure gauges, accurate volume measuring devices or a calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump, and full circulation spray bars adjustable laterally and vertically. Distributors shall be equipped with an automatic heater capable of maintaining the asphalt emulsion at the manufacturer's recommended application temperature or at 140 °F, whichever is higher.
- (2) A rotary power broom.
- (3) A minimum of two pneumatic tire rollers that weigh at least 10 tons each.
- (4) One self-propelled aggregate spreader of approved design supported by at least four wheels equipped with pneumatic tires on two axles. The aggregate spreader shall be capable of applying the larger cover coat material to the surface ahead of the smaller cover coat material and shall have positive controls, so the required quantity of material is deposited uniformly over the full width of the asphalt emulsion. Other types of aggregate spreaders may be used provided they accomplish equivalent results and are approved.

409.06 Preparation of Surface. The entire surface that is to receive a chip seal shall be cleaned of loose sand, dust, rock, mud, and all other debris that could prevent proper adhesion of the asphalt coating. The cleaning shall be accomplished by power broom, scraping, blading, or other approved measures. Chip sealing operations shall not be started until the surface is approved.

409.07 Applying Asphalt Emulsion. Asphalt emulsion shall be applied by a pressure distributor in a uniform, continuous spread and within the temperature range specified. The distributor's spreading capability shall be computer controlled or calibrated to conform to the distributor manufacturer's procedure before applying the emulsified asphalt. If streaking occurs, the distributor operation shall be stopped immediately until the cause is determined and corrected. Streaking is alternating, narrow, longitudinal areas of excessive and then insufficient quantities of asphalt emulsion. The quantity of asphalt emulsion per square yard may vary from the rate shown in the Contract, as directed. A strip of building paper, at least 3 feet in width and with a length equal to that of the spray bar of the distributor plus 1 foot shall be used at the beginning of each spread. If the distributor does not have a positive cut-off, the paper shall be used at the end of each spread. The paper shall be removed and disposed of in a satisfactory manner. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Skipped areas and deficiencies shall be corrected. Junctions of spreads shall be carefully made to assure a smooth riding surface.

The length of spread of asphalt emulsion shall not be in excess of the area that trucks loaded with cover coat material can immediately cover.

The spread of asphalt emulsion shall not be more than 6 inches wider than the width covered by the cover coat material from the spreading device. Under no circumstances shall operations proceed so asphalt emulsion will be allowed to chill, set up, dry, or otherwise impair retention of the cover coat.

The distributor shall be parked so that asphalt emulsion will not drip on the surface of the traveled way.

409.08 Application of Cover Coat Material. Immediately following the application of the asphalt emulsion, cover coat material shall be spread in quantities as designated. The spreading rate may vary from the rate shown in the Contract when approved. Spreading shall be accomplished so the tires of the trucks or aggregate spreader do not contact the uncovered and newly applied asphalt emulsion.

The cover coat material shall be moistened with a sufficient amount of water to reduce the dust coating of the aggregate before spreading. The cover coat material shall not contain free moisture as evidenced by drain down in the delivery truck bed.

Immediately after the cover coat material is spread, deficient areas shall be covered with additional material. Rolling shall begin immediately behind the spreader and shall continue until three complete coverages are obtained. Rolling shall be completed the same day the asphalt emulsion and cover coat materials are applied.

The completed roadway surface shall be lightly broomed the following morning to remove any excess material, without removing any embedded material. The Contractor shall conduct additional brooming if so directed.

A fog seal shall be applied to the surface of the completed chip seal at the rate of 0.11 plus or minus 0.04 gallon per square yard of diluted emulsion when directed. The fog seal shall have a 3:2 emulsion to water dilution rate. The application rate and the dilution rate may be changed by the Engineer.

METHOD OF MEASUREMENT

409.09 Chip seal will be measured by the number of tons, cubic yards, or square yards of the designated type of cover coat aggregate.

BASIS OF PAYMENT

409.10 The accepted quantities of chip seal will be paid for at the contract price per ton, cubic yard, or square yard for cover coat material.

Payment will be made under:

Pay Item	Pay Unit
Cover Coat Material (Type___)	Ton
Cover Coat Material (Type___) (Lightweight)	Cubic Yard
Cover Coat Material (Type __)	Square Yard

Asphalt emulsion, including the asphalt emulsion used for fog seal, will be measured and paid for per Section 411.

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SECTION 411 ASPHALT MATERIALS

DESCRIPTION

411.01 This work consists of furnishing asphalt materials of all types and the application of these materials per these specifications and details shown on the plans.

MATERIALS

411.02 All asphalt materials shall conform to the requirements of Section 702.

The type and grade of asphalt material will be specified in the Contract. The grade may be changed one step by the Engineer at no change in unit price except as provided for under subsection 104.02.

Emulsion used for seal coat will be identified as rapid setting or medium setting emulsion and conform to the requirements of subsection 702.02.

CONSTRUCTION REQUIREMENTS

411.03 Asphalt materials shall be fortified when required by the Contract with an additive of an approved type. Additive shall be uniformly blended with asphalt materials at the refinery, or through an approved in-line blender as specified in the Contract.

Asphaltic application methods that result in the discoloration of concrete structures, concrete curbs, and concrete gutters will not be permitted. Coatings shall be applied so as to cause the least inconvenience to traffic and to permit one-way traffic. Traffic will be permitted to travel on fresh asphalt material when it can be accomplished without pickup or tracking of the asphalt material.

Asphaltic materials used as fuel or lubricant shall be stored separately.

Emulsified asphalt for tack coat shall be diluted before use as shown in the Contract or as directed.

METHOD OF MEASUREMENT

411.04 Asphalt cement will be measured by the ton by one of the following methods as determined by the Engineer:

- (1) The pay quantity of asphalt cement will be determined by multiplying the total accepted tons of paving mix by the weighted average of all asphalt content percentages obtained from the field acceptance tests for that item, or
- (2) The pay quantity of asphalt cement will be determined from the invoices for the asphalt cement delivered to the job corrected by tank stabs.

Emulsified asphalt and liquid asphaltic materials will be measured by the gallon.

The pay quantity for emulsified asphalt shall be the number of gallons before dilution with water.

Concentrated asphalt rejuvenating agent will be measured by the gallon before any water is added.

Emulsified asphalt used for seal coat will be measured by the actual number of tons placed and accepted. The pay quantity of emulsified asphalt will be determined from the invoices of emulsified asphalt delivered to the project, corrected by any weight of remaining emulsion in the distributor truck or tanker at the conclusion of the project. The Engineer may elect to calculate the remaining weight in a distributor by use of the average specific gravity of materials delivered, or by tank stabs. The average specific gravity for this calculation will be as determined by Central Laboratory Testing. If tank stabs are to be utilized for this measurement, the Contractor's Process Control Plan shall include appropriate information for calculations on the distributor used on the project. This calculation will be limited to less than 4,000 gallons of material. All other material shall require weigh back for proper calculation of payment. The weight shall be determined by certified scales per Section 109. This will also be monitored and documented by daily distributor gauge readings and yield calculations. All proposed methods of weighing materials, calibrating distributor rates and monitoring the yields shall be included in the Process Control Plan per Section 409.

Diluted emulsified asphalt used for fog seal on chip seals will be measured by the actual number of tons of asphalt before dilution with water. Correction for the final diluted emulsion at the conclusion of a project will assume a 3:2 emulsion to water dilution rate, and the water subtracted from the weight of the remaining product unless otherwise approved.

BASIS OF PAYMENT

411.05 The accepted quantities, measured as provided above, will be paid for at the contract unit price per ton or gallon as the case may be, for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Asphalt Cement (___)	Ton
Emulsified Asphalt (___)	Gallon
Emulsified Asphalt (Rapid-Setting) (Polymerized)	Ton
Emulsified Asphalt (Medium-Setting) (Polymerized)	Ton
Liquid Asphaltic Material (___)	Gallon
Asphalt Rejuvenating Agent	Gallon
Recycling Agent	Gallon

High float emulsified asphalt (polymerized) or emulsified recycling agent used in Item 406, Cold Asphalt Pavement (Recycle) will be paid for by the gallon under the pay item Recycling Agent.

Water used to dilute emulsified asphalt or asphalt rejuvenating agent will not be paid for separately but shall be included in the work.

**SECTION 412
PORTLAND CEMENT
CONCRETE PAVEMENT**

DESCRIPTION

412.01 This work consists of constructing a pavement composed of Portland Cement Concrete on a prepared subgrade or base course per these specifications and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established.

MATERIALS

412.02 Materials shall meet the requirements of the following subsections:

Fine Aggregate	703.01
Coarse Aggregate	703.02
Portland Cement	701.01
Fly Ash	701.02
Water	712.01
Air-Entraining Admixtures	711.02
Joint Sealant with Backer Rod	705.01
Curing Materials	711.01
Reinforcing Steel	709.01
Chemical Admixtures	711.03
Dowel Bars and Tie Bars	709.03

CONSTRUCTION REQUIREMENTS

412.03 Classification. Concrete shall conform to the requirements for Class P concrete as specified in Section 601. Fast track concrete pavement is accelerated Class P concrete.

412.04 Proportioning. Proportioning shall conform to the requirements of subsection 601.05.

412.05 Batching. Batching shall conform to the requirements of subsection 601.06.

The Contractor shall provide a Process Control Plan (PCP) to minimize voids in the concrete pavement, such as clay balls, mud balls and other deleterious materials. It shall also identify the Contractor's method for ensuring that the provisions of the PCP are met. This PCP shall be submitted to the Engineer at the Pre-construction Conference. Paving operations shall not begin until the Engineer has approved the PCP. This PCP shall identify and address issues affecting the quality of aggregates incorporated into the concrete mix including but not limited to:

- (1) Washing aggregates.
- (2) Inspection at the pits, plants and aggregate storage areas.
- (3) Base or floor of pits, plants and aggregate storage areas.
- (4) Inspection of truck beds.

- (5) Methods and frequency of aggregate testing.
- (6) Training of operators, haulers and inspectors in regard to aggregate quality.
- (7) Plant site selection and layout.
- (8) Grizzlies and screens on conveyors.
- (9) Stabilization of haul roads and construction accesses.

When the Engineer determines that any element of the approved PCP is not being implemented, the paving shall stop, the cause shall be identified and corrected by the Contractor before paving operations resume.

412.06 Mixing. Mixing shall conform to the requirements of subsection 601.07.

412.07 Equipment. Equipment and tools shall be capable of handling materials, performing the work, producing a product of specified quality, and shall be approved. The equipment shall be at the job site sufficiently ahead of the start of paving operations to be examined and approved.

- (a) *Hauling Equipment.* Concrete may be hauled and placed with non-agitator equipment. Bodies of non-agitating equipment shall be smooth, mortar tight containers, and shall be capable of discharging the concrete at a controlled rate without segregation.
- (b) *Consolidating and Finishing Equipment.* Concrete shall be spread, struck-off and finished by mechanical equipment, either from fixed forms or by slip form method, unless otherwise permitted.

The Contractor shall use an approved longitudinal paver wedge system to create a sloped SafetyEdge_{SM}. The Contractor shall modify the paver screed to create a SafetyEdge_{SM} that meets the final cross-section shown on the plans. The system shall provide a sloped SafetyEdge_{SM} equal to 32 degrees plus or minus 5 degrees measured from the pavement surface cross slope extended. There may be areas where it is not possible to place the SafetyEdge_{SM} in conjunction with mainline paving but where the SafetyEdge_{SM} is required, such as transitions at driveways, intersections, interchanges, etc. In these areas the Engineer may allow the Contractor to use handwork for short sections or to saw cut the sloped SafetyEdge_{SM} after paving operations are completed.

The Contractor shall submit the proposed paver wedge system for approval at the Pre-construction Conference. The Engineer may require proof that the system has been used on previous projects with acceptable results or may require a test section constructed before the beginning of work to demonstrate that it creates an acceptable wedge shape. Paving shall not begin until the system is approved in writing by the Engineer. The finished shape of the SafetyEdge_{SM} shall extend for the full depth of the concrete pavement or for the top 5 inches whichever is less.

The full width and depth of concrete requiring a finishing machine shall be consolidated by a single pass of an approved internal vibrator. Internal vibrators shall be operated within a frequency range of 4,000 to 8,000 vibrations per minute (VPM). Vibrators shall not be operated in a manner to cause a separation of the mix materials, either a downward displacement of large aggregate particles or an accumulation or laitance on the surface of the concrete. Avoidance of separation of the mix may require reduction in the vibrator frequency when forward motion of the paver is reduced.

Paving machine operations shall stop if any vibrator fails to operate within specifications. Vibration shall be stopped whenever forward motion of the paver is stopped.

The use of surface vibrators shall be approved by the Engineer before use. Surface vibrators shall be operated within a frequency range of 3,500 to 6,000 VPM.

An electronic monitoring device displaying the operating frequency of each individual internal vibrator shall be required for mainline pavement exceeding 600 feet in length. The monitoring device shall have a readout display near the operator's controls visible to the paver operator and to the Engineer. It shall operate continuously while paving and shall display all vibrator frequencies with manual or automatic sequencing among all individual vibrators. If a vibrator monitor fails to function properly, a handheld device may be used until the monitor is repaired. The Contractor shall measure the vibrations of each vibrator at least once an hour. The vibrator monitor repair must be made within 48 hours.

The depth of penetration into the concrete pavement slab of internal vibrators shall be between the surface and mid slab and passing above any reinforcing steel. An operating position-locking device shall be provided so that no part of the vibrating unit can be lowered to the extent that it will come in contact with reinforcing steel or tie bars while paving.

Vibrators shall have a minimum eccentric diameter of 1 1/2 inches or as approved by the Engineer. Horizontal spacing of vibrators shall not exceed the manufacturer's recommendations and shall not exceed 18 inches from center to center. The longitudinal axis of the vibrator body shall be mounted approximately parallel to the direction of paving. Vibrators shall meet or exceed the following specifications at manufacturers design frequency of 10,000 VPM:

- (1) Amplitude (peak to peak) 0.070 inch.
- (2) Centrifuge force 1,200 pounds.

Within the frequency range, the Contractor shall adjust the frequency to provide optimum consolidation for the mix and placement conditions.

If any vibrator ceases to function properly, the paving operation shall be stopped immediately and not resumed until the faulty vibrator has been repaired or replaced. Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies by means of vibrators inserted in the concrete. Vibrators shall not come in contact with or cause displacement of the joint load transfer devices, subgrade, or side forms and shall not interfere with placement of reinforcing steel.

Any variation from the above method must have prior written approval from the Engineer. The Contractor's documentation shall include evidence that the proposed method of consolidation will provide equal or better consolidation than the method described above.

- (c) *Concrete Saw.* When sawed joints are required, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at a rate that will control cracking. The Contractor shall provide at least one standby concrete saw in good working order at all times. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job during concrete placement.

Wastewater generated from concrete saw operations shall be contained and disposed of

per subsection 107.25.

(d) *Test Bridge.* The Contractor shall furnish a movable bridge that conforms to subsection 601.15(g) for use by the Department.

412.08 Preparation of Subgrade. After the roadbed has been graded and compacted, the subgrade shall be trimmed to the correct elevation and slope. For slip form paving, the elevation and slope of the trimmer shall be automatically controlled from outside reference lines established for this purpose. The trimmed subgrade shall extend at least 2 feet beyond each edge of the proposed concrete pavement when forms are used and at least 1 foot outside the track width of finishing, curing, and tining equipment for slip form operations. Any work required beyond the planned roadbed necessary to support the Contractor's paving equipment or hauling vehicles, will not be paid for separately, but shall be included in the work.

The subbase or base course shall be brought to the specified cross section. High areas shall be trimmed to the proper elevation. Low areas in untreated bases may be filled and compacted to a condition similar to that of the surrounding grade or filled with concrete integral with the pavement. Low areas in treated bases shall be filled with concrete integral with the pavement. The finished grade shall be maintained in a smooth and compacted condition until the pavement is placed.

Untreated subgrade or base course shall be uniformly moist during concrete placement. If it becomes too dry, the untreated subgrade or base course shall be sprinkled without forming mud or pools of water.

412.09 Limitations of Placing Concrete. Limitations on the placing of concrete shall conform to subsections 601.12 (b) and (c), and 412.15.

412.10 Placing Concrete. The concrete shall be uniformly deposited on the grade in a manner that requires as little re-handling as possible. Concrete for areas that contain load transfer devices shall not be dumped directly from the hauling vehicles onto the grade. Concrete shall be placed by an approved placer spreader machine. Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them but shall not be dumped from the discharge bucket or hopper onto a joint assembly unless the discharge is well centered on the joint assembly. Necessary hand spreading shall be done with Shovels, not rakes. Workers shall not walk-in freshly mixed concrete with footwear coated with earth or foreign substances. All footprints in the fresh concrete shall be vibrated and finished flush with the adjacent surface.

Construction equipment other than standard paving equipment will not be allowed to handle plastic concrete in advance of the paver in the roadway without approval.

Where concrete is placed adjacent to a newly constructed lane of pavement with the concrete paving equipment operating on the newly constructed pavement, the concrete shall have attained a minimum compressive strength of 2,000 psi before commencing paving. Determination that the concrete has reached 2,000 psi shall not relieve the Contractor of the responsibility for protecting the pavement.

Any concrete or foreign material that falls on or is worked into the surface of a completed slab shall be removed immediately.

Following placement, the concrete shall be struck off to conform to the cross section shown on

the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the plans or established.

The Contractor shall provide a MIT-Scan-2, which is manufactured by MIT GmbH.

The Contractor shall ensure the MIT-Scan-2 is calibrated for the specific dowel bar size or load transfer device being placed and is operating within the manufacturer's tolerances. The Contractor shall also ensure that the operator of the MIT-Scan-2 is fully competent in the use of the device. The Contractor shall supply the serial number of the device to be used on the project.

412.11 Test Specimens. The Contractor shall furnish the concrete necessary for casting test cylinders and performing air and slump tests.

412.12 Finishing. The sequence of operations shall be strike-off and consolidation, floating, and final surface finish.

Water shall not be added to the surface of the concrete to assist in finishing operations. The surface shall be finished to a uniform texture, true to grade and cross section, and free from porous areas. When the finishing machine, either form, slip form, or hand finishing method, leaves a surface that is not acceptable, the operation shall stop, and corrective action shall be taken. Inability of the finishing machine to provide an acceptable surface finish, after corrective action, will be cause for requiring replacement of the finishing machine.

Wastewater generated from concrete finishing operations shall be contained and disposed of per subsection 107.25.

(a) Hand Finishing. Hand finishing shall be minimized wherever possible. The Engineer shall be notified beforehand finishing work and the proposed hand finished work shall be addressed in the Process Control Plan for concrete finishing. Unless otherwise specified, hand finishing methods will be permitted only under the following conditions. Hand finished concrete shall be struck off and screeded with a portable screed that is at least 2 feet longer than the maximum width of the slab to be struck off. It shall be sufficiently rigid to retain its shape. Concrete shall be thoroughly consolidated by hand vibrators. Hand finishing shall not be allowed after concrete has been in-place for more than 30 minutes or when initial set has begun unless otherwise approved by the Engineer. Finishing tools made of aluminum shall not be used.

The Contractor shall provide a Process Control Plan (PCP) to ensure that proper hand finishing is accomplished per current Industry standards for concrete pavement placement. It shall also identify the Contractor's method for ensuring that the provisions of the PCP are met. The PCP shall be submitted to the Engineer at the Pre-construction Conference. Paving operations shall not begin until the Engineer has approved the PCP. The PCP shall identify and address issues affecting the quality of finished concrete pavement including but not limited to:

- (1) Timing of hand finishing operations
- (2) Methodology to place and transport concrete
- (3) Equipment and tools to be utilized
- (4) Qualifications and training of finishers and supervisors

When the Engineer determines that any element of the approved PCP is not being implemented or that hand finished concrete is unacceptable, work shall be suspended. The Contractor shall supply a written plan to address improperly placed material and how to remedy future hand finishing failures and bring the work into compliance with the PCP. The Engineer will review the plan for acceptability before authorizing the resumption of operations.

(b) *Floating*. Hand floating will be permitted only as specified in subsection 412.12 (a). The Contractor shall not use floats made of aluminum.

(c) *Final Finish and Stationing*. The final surface of the pavement shall be uniformly textured with a broom, burlap drag, artificial turf or diamond ground in order to obtain the specified texture depth. The Contractor shall submit the proposed method of PCCP texturing at the Pre-construction Conference for approval by the Engineer. Surface imperfections resulting from the texturing operation shall be corrected by the Contractor at no additional cost.

Broom, burlap drag, or artificial turf texture shall be installed within 15 minutes after strike-off, or as pavement conditions allow.

Diamond grinding shall be performed using diamond blades mounted on a self-propelled machine designed for diamond grinding and texturing concrete pavement. The equipment shall have a positive means of vacuuming the grinding residue from the pavement surface, leaving the surface in a clean, near-dry condition. Diamond grinding shall not occur until the concrete has attained strength of at least 2,500 psi.

The diamond grinding process shall produce a pavement surface that is true to grade and uniform in appearance. The grooves shall be evenly spaced. Any ridges on the outside edge next to the shoulder, auxiliary, or ramp lanes greater than 3/16-inch high shall be feathered out to the satisfaction of the Engineer in a separate, feather pass operation.

The pavement surface after diamond grinding shall have no depressions or misalignment of slope in the longitudinal direction exceeding 1/8 inch in 12 feet when measured with a 12-foot straightedge placed parallel to the centerline. All areas of deviation shall be reground at no additional cost.

Stationing shall be stamped into the outside edge of the pavement, as shown on the plans.

412.13 Joints. Joints shall be constructed of the type, dimensions, and at locations required by the Contract. When a joint is saw cut more than 3 inches from the designated location, the pavement shall be removed and replaced to the nearest correct joints. When portions of concrete pavement are removed and replaced, the portion removed shall be the full width of the lane and length of the affected slabs. This corrective action shall be at the Contractor's expense.

Immediately after sawing, the sawed joints shall be flushed with water to remove any saw residue, and the saw residue shall be completely removed from the surface of the pavement. This residue shall be removed by approved methods.

All equipment other than saws shall be kept off the pavement until the sawing is complete.

After the proper curing period, the sawed joint shall be thoroughly cleaned and immediately sealed per subsection 412.18.

(a) *Construction Joints* Construction joints shall be slightly tooled while the concrete is plastic and later sawed to the dimensions specified in the Contract. The tooling shall not exceed the width of the sawed joint at any point.

In the event tie bars cannot or are not placed in plastic state concrete, then the tie bars shall be placed according to the following minimum requirements:

Holes with a diameter 1/4 inch greater than the bar diameter shall be drilled laterally into the hardened concrete slabs at one half the slab depth, 36 inches on center, 15 to 16 inches deep. Each hole shall be cleaned out with compressed air using a wand attachment that fits into the hole and is long enough to reach to the back of the hole. Each hole shall be brushed out with a stiff bristled cylindrical brush that is at least 1/4 inch larger than the diameter of the hole. Each hole shall be blown out with compressed air a second time using a wand attachment that fits into the hole and is long enough to reach to the back of the hole. Each hole shall be blown out until there is no longer any evidence of dust, debris or loose material in the hole.

An approved epoxy shall be used and installed according to the manufacturer's instructions. Epoxy shall be placed in the back of each hole with an applicator that will reach the end of the drilled hole. A sufficient amount of epoxy shall be placed in each hole to ensure that the bar will be completely covered with epoxy. Epoxy shall be placed on the bar before inserting the bar into the hole. The bar shall be inserted into the hole using a twisting motion to facilitate covering the bar and the inside surface of the hole with epoxy minimizing voids or air pockets.

When tie bars are placed in plastic state concrete or drilled and epoxied into a construction joint, and if required by the Engineer, the Contractor shall demonstrate by testing at least 15 of the tie bars that the bar pullout resistance is at least 11,250 pounds with slippage of 1/16 inch or less. If two or more tie bars do not meet the required pullout resistance, then another 15 tie bars shall be tested. If any of the second 15 do not meet the required pullout resistance, then all remaining tie bars shall be tested. The Contractor shall perform additional pullout tests and take corrective action when and as directed. All steps taken to test bars, and to correct, repair or replace failed tie bars and the surrounding failed area shall be at the Contractor's expense. Concrete strength shall have a compressive strength of at least 2,500 psi before testing. ASTM E488 shall be used for performing pullout testing.

1. *Longitudinal Construction Joints.* Keyways and epoxy-coated, deformed steel tie bars shall be placed as specified in the Contract. Tie bars shall be placed perpendicular to the longitudinal joint by an approved method.

When adjacent lanes of pavement are constructed separately, tie bars may be bent at right angles against the edge of the first lane constructed and straightened into final position before the concrete of the adjacent lane is placed. In lieu of bent tie bars, approved two-piece connectors may be used. If the coating of epoxy coated tie bars is damaged, the bars shall be repainted with epoxy paint before placement of concrete.

2. *Transverse Construction Joints.* Transverse construction joints shall be constructed at a transverse contraction joint as specified in the Contract. Transverse construction joints shall be constructed when the concrete placement is interrupted for more than 30 minutes, or initial set is imminent. The concrete back to the preceding transverse joint shall be removed and the bulkhead placed per the requirements for a standard transverse contraction joint. Transverse construction joints shall be placed at the end of each day's placement.

(b) *Weakened Plane Joints.* Weakened plane joints shall be spaced and skewed as specified in the Contract and formed by sawing. The time of sawing shall be determined by the Contractor to prevent random cracking and raveling from the sawing. The time will depend upon weather conditions, temperature, and other factors affecting the setting of concrete. If uncontrolled cracking occurs during or before joint sawing, the Contractor shall move the sawing operation ahead and, if necessary, add additional sawing units to eliminate uncontrolled cracking.

1. Longitudinal Weakened Plane Joints. Epoxy coated deformed steel tie bars shall be inserted into the plastic state concrete after the auger. In the event the tie bars are placed behind the machine paving mold, vibration will be required during placement. Other methods of bar placement may be acceptable if the Contractor can demonstrate satisfactory performance of the alternate method. Proposals of alternate methods or additional costs associated with other methods shall be at the Contractor's expense. Tie bars shall be placed according to a method approved by the Engineer. The Contractor shall use an MIT Scan-2 to evaluate the location of tie bars that cannot be visually inspected. Each longitudinal joint located within the dowel bar test locations described in subsection 412.13 (b) 2 that were not visually inspected shall be evaluated with the MIT Scan-2. The MIT Scan-2 shall be calibrated for the tie bar size placed. The tie bars shall be located within the middle third of the slab, and a minimum of 1/2 inch below the saw cut. Tie bars shall have a minimum embedment of 12 inches on each side of the joint. The weakened plane joint shall be made by sawing in hardened concrete per the plan details.

Tie bars that are cut during sawing operations shall be replaced at the Contractor's expense. Tie bars that are located less than 2 inches above the bottom of the slab shall be replaced at the Contractor's expense. Tie bars that are not embedded a minimum of 12 inches on each side of the joint shall be replaced. When the spacing between two in-place tie bars exceeds 40 inches but less than 72 inches, a tie bar will be installed halfway between the two tie bars, unless this installation location is within 12 inches of a transverse weakened plane joint. When the spacing between two in-place tie bars exceeds 72 inches, tie bars will be installed at an even spacing not to exceed 36 inches but shall not be installed within 12 inches of a transverse weakened plane joint. The Contractor shall submit to the Engineer a method for replacing the tie bars. The Contractor shall not proceed to replace the tie bars until the method for replacement has been approved by the Engineer.

2. Transverse Weakened Plane Joints. When dowel bars are specified in the Contract, they shall be installed within the tolerances and of the size, grade, and spacing specified. Dowel bars shall be furnished in a rigid welded assembly or placed by a dowel bar insertion (DBI) machine. The center of the dowel assembly or the insertion location shall be marked on both sides of the pavement slab for reference in sawing the joint. When a DBI is used, the Contractor shall submit details and specifications of the proposed slip-form paver and DBI to the Engineer a minimum of 14 calendar days before the Concrete Pavement Pre-paving Conference. The Contractor shall detail his methodology for ensuring correct marking of dowel bar insertion points and correct sawing of the joints. The Contractor shall ensure that the slip-form paver is compatible with the DBI.

When a rigid assembly (dowel basket) is used, the rigid assembly shall be fabricated from number 1/0 wire or heavier with vertical support wires every 1 foot. The rigid assembly shall be securely fastened to the subbase and constructed to firmly hold all the dowel

bars at T/2 depth, parallel to each other and to the pavement grade and alignment. Horizontal support wires or shipping braces shall be non-deformed bars or wires with a diameter less than or equal to 0.307 inches (gauge 0 wire). The number of horizontal support wires or shipping braces shall be limited to five per rigid assembly. Shipping braces shall not be cut.

The Contractor shall perform a pull test after baskets are staked. The minimum staking method will be determined using the pullout test. The pullout test shall be performed on all dowel baskets placed in a test section and one dowel basket per day thereafter when the minimum staking method is used. The test section for determining staking method shall be the first 10 joints with dowel baskets for each base type. Each dowel basket in the test section shall withstand a minimum of 25 pounds of force when pulled vertically at three equally spaced locations along the length of the dowel basket using a fish scale, or approved equivalent. If any basket moves more than 0.5 inches, a new staking method and test section will be required.

The use of the MIT Scan-2 will be used for joint acceptance. Joint acceptance or rejection will be based on the Joint Map generated by the MIT Scan software. Should the joint map show missing or misaligned bars the Contractor will have the choice of either performing additional testing using a method approved by the Engineer or perform corrective measures. Colorado Procedure 79 in the CDOT Field Materials Manual will be used to determine if dowel bars are misaligned or missing. Dowels in rigid assemblies will be inspected by the Engineer before concrete placement for misalignment and dowel bar depth. If misalignments and dowel bar depths exceeding the rejection tolerances are found, the rigid assembly shall be reset and re-inspected. The MIT Scan-2 shall be used for determining the depth of dowel bars placed by a DBI.

See Standard Plan M-412-1 for schematic describing the measurement of each tolerance.

Joint Rejection Criteria:

- A. Any joint that does not have at least three acceptable dowel bars in each wheel path.
- B. Rotational misalignment: Bars with misalignment greater than 1.5 inches.
- C. Longitudinal (side) shift: Bars that are not embedded at least 6 inches on each side of the joint (saw-cut).
- D. Depth: Bars within the top 3 inches of the pavement or at a depth less than the saw-cut depth. Bars within the bottom 3 inches of the pavement.

Corrective Measures: The following corrective measures will be allowed for the bars or joints that are rejected.

- A. Rotational misalignment: Saw-cut the misaligned bars. Joints with less than three uncut bars in each wheel path will require the addition of dowel bars using an approved dowel bar retrofit method.
- B. Longitudinal (side) Shift and missing bars: Addition of dowel bars using an approved dowel bar retrofit method.
- C. Depth: Inadequate cover above the bar—Saw-cut the bar and install a replacement bar using an approved dowel bar retrofit method.

Inadequate cover below the bar— Addition of dowel bars using an approved dowel bar retrofit method.

Retrofitted dowel bars shall not exceed the dowel bar rejection criteria.

In addition to the above procedures, the Contractor may propose removal and replacement of the affected slabs. The Contractor shall submit his method of repair to the Engineer for approval.

The Contractor shall demonstrate his ability to place dowel bars in conformance with the specifications by placement of a test section. The test section shall be a minimum of 300 feet in length. Upon completion of the test section, the Contractor shall shut down paving operations. During the shutdown period, the Contractor shall evaluate all joints in the test section using the MIT-Scan-2 and CP-79 and submit the results to the Engineer. Paving operations shall not be restarted until the Engineer approves the test section results. The test section will be found acceptable if 100 percent of the joints are found to be acceptable. All unacceptable joints must be addressed using the above corrective measures. The Contractor may continue paving at his own risk before the test section evaluation is complete.

If the Project has less than 500 linear feet of pavement, the test section will not be required. If a Project does not have sections of continuous pavement greater than 45 linear feet, the test section will not be required.

Upon completion of the test section(s) and for each week of production, the Contractor shall prepare an electronic report generated using MagnoProof software and submit it to the Engineer at the start of each working week during production, for the previous week's work. The reports shall show the joint map generated by the MIT-Scan-2 and the joint pass/fail rating according to CP-79.

When the test section is found to be unacceptable, the Contractor shall perform corrective actions and place a second test section. If the second test section is found to be unacceptable, the Contractor shall pave no more than 500 feet per day until an acceptable test section has been achieved.

Once a test section is successfully completed, Dowel Bar Placement testing frequency shall be a minimum of one location per 1,250 linear feet of each continuous lane including climbing lanes, passing lanes, acceleration and deceleration lanes and ramps. Sections greater than 45 linear feet and less than 1,250 linear feet require a minimum one of test location. Testing locations shall be determined by a random procedure so that each area has a randomly selected transverse joint location. At each location, five consecutive joints shall be tested.

Sections of continuous pavement constructed by the project less than 45 linear feet will not require Dowel Bar Placement Testing.

When any joint exceeds the rejection criteria, joints shall be tested in each direction from the rejected joint, until two consecutive joints in each direction are found to be acceptable.

All delays or costs associated with equipment being rejected for use by the Engineer will not be paid for by the Department and will be considered a Nonexcusable Delay

per subsection 108.08 (c) 2.

When concrete shoulders or widenings are constructed subsequent to the driving lanes,

transverse weakened plane joints shall immediately be formed in the plastic concrete of these widenings to create an extension of the existing transverse joint. This tooled joint shall be formed in such a manner that it controls the cracking and shall be sawed and sealed per the above requirements.

(c) *Expansion Joints.* Prefomed joint filler expansion joints shall be constructed at all existing or proposed structures and features projecting through, into, or against the pavement and at other locations specified in the Contract.

412.14 Curing. Immediately after the finishing operations have been completed the entire surface and exposed sides of the newly placed concrete, shall be sprayed uniformly with a curing compound meeting the requirements of ASTM C309, Type 2. The ASTM C309 Type 2 curing compound shall be volatile organic content (VOC) compliant.

The curing compound shall be applied within 10 minutes after the final finish has been applied. Failure to cover the surface of the concrete within 10 minutes shall be cause for immediate suspension of the paving operations.

An initial application of curing compound shall be applied under pressure by mechanical sprayers at the rate of at least 1 gallon per 180 square feet of pavement surface. A second application of curing compound shall be applied within 30 minutes after the initial application. The second application rate shall be at least 1 gallon per 180 square feet of pavement surface. Alternatively, the Contractor may apply the curing compound in one application of at least 1 gallon per 120 square feet. Additional curing compound shall be applied as needed to ensure that 100 percent of the pavement is covered. The spraying equipment shall be fully automated, equipped with a tank agitator, and a wind guard. During application, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle and the compound shall be stirred continuously by effective mechanical means. Hand spraying of irregular widths or shapes and surfaces exposed by removal of forms will be permitted. Curing compounds shall not be applied to the inside faces of joints to be sealed.

Should the curing film become damaged from any cause, within 72 hours after concrete placement, except for concrete open to traffic, the damaged portions shall be repaired immediately with additional curing compound, payment for which shall be at the Contractor's expense.

The sides of pavement slabs shall be immediately sprayed with curing compound when the forms are removed.

412.15 Cold Weather Concrete Paving. The Contractor is responsible for the strength and quality of the concrete placed during cold weather. Before starting paving operations, the Contractor shall be prepared to protect the concrete from freezing. Maturity meters, to monitor and record time and pavement temperature, shall be installed at the time of placement when the air temperature is expected to fall below 40 °F during the next three days or as requested by the Engineer when the air temperature is expected to fall below 45 °F during the next three days. The Contractor shall maintain the temperature of the pavement at or above 40 °F until the pavement has attained a compressive strength of at least 2000 psi. The compressive strength of the concrete shall be determined by the use of maturity meters. Maturity meters shall be placed in three locations for each day's concrete paving operations. One maturity meter shall be placed in the final 15 feet of paving, and the two other maturity meters shall be

placed at locations designated by the Engineer. The maturity meter probes shall be located on the outside edge of the slab, at least 1 foot and not more than 2 feet from the edge and at mid depth of the slab. Each maturity meter shall be capable of recording the

time and temperature. The maturity meters shall remain in place until the concrete has attained a compressive strength of 2000 psi.

The Contractor shall develop maturity relationships for each mix placed during the cold weather conditions described above per CP 69:

The development of the maturity relationship is part of the trial mix and shall be submitted to the Engineer before cold weather concrete paving.

The Contractor shall provide the maturity meters and all necessary wires and connectors. The Contractor shall be responsible for the placement, protection and maintenance of the maturity meters and wires. Locations where the maturity meters are placed shall be protected in the same manner as the rest of the concrete pavement.

The following procedures shall be followed if the temperature of the concrete pavement falls below 32 °F before the concrete reaches 2,000 psi:

- (1) The Contractor will take cores at locations designated by the Engineer.
- (2) The Engineer will take immediate possession of the cores and submit the cores to a petrographer for examination per ASTM C856.
- (3) All costs associated with coring, transmittal of cores, and petrographic examination shall be borne by the Contractor regardless of the outcome of the petrographic examination.
- (4) Pavement damaged by frost as determined by the petrographic examination, shall be removed and replaced at the Contractor's expense.

412.16 Repair of Defective Concrete Pavement. Defective concrete pavement shall be repaired or replaced at the Contractor's expense. This corrective work shall be accomplished before joint sealing and final smoothness measurement. Defective concrete pavement replaced after smoothness measurement shall be retested for localized roughness. The Contractor's corrective work plan shall be approved before performing the work.

When necessary, the extent of defects will be determined by the inspection of cores drilled at the Contractor's expense. Crack depth shall be determined by taking one core at the center of the crack or as approved by the Engineer. The Contractor shall take the cores and supply to the Engineer immediately after the coring.

1. Pavement thickness (T) shall be as shown on the plans.
2. Pavement slabs with any of the following conditions are unacceptable and shall be removed and replaced:
 - A. Pavement slabs in driving lanes containing one or more cracks that are T/3 in depth or greater that separate the slab into two or more parts.
 - B. Pavement slabs in driving lanes containing one or more cracks that are 30 inches or greater in length and T/3 in depth or greater.
 - C. Pavement slabs containing honeycombed areas.
 - D. Pavement slabs containing an extreme void as defined below.
 - E. Pavement slabs containing more than one void greater in depth than half the pavement thickness.
 - F. Pavement slabs containing a cumulative surface area of moderate and severe voids, as

defined below, greater than one percent of the slab's total area.

G. Pavement slabs containing 20 or more severe voids as defined below.

Voids are defects in a slab consisting of air pockets, clay balls, or foreign materials such as cans, rags, bottles, etc. Voids may also consist of clumps of sand, cement or reinforcing fibers caused by incomplete mixing. The defect will be considered a moderate void when the largest dimension, either height, width or length is at least 1/2 inch but not more than 2 inches. The defect will be considered a severe void when the largest dimension, either height, width or length is greater than 2 inches. The defect will be considered an extreme void when the largest dimension, either height, width or length is greater than the thickness of the pavement.

When the Engineer determines that voids are at an unacceptable level, the paving shall stop, and the cause shall be identified and corrected by the Contractor before paving operations are allowed to resume.

Concrete slabs that are determined by the Engineer to be acceptable if repaired shall have voids filled using materials from the Department's Approved Products List and methods approved by the Engineer.

When portions of concrete pavement are removed and replaced, the portion removed shall be the full width of the lane and length of the affected slab. Slabs with cracks penetrating the full depth of pavement shall be removed as required above. Cracks that are 30 inches or longer and are between 1 inch and T/3 in depth shall be repaired. The Contractor shall submit in writing a plan to repair the partial depth cracks for approval by the Engineer. The Engineer will have seven calendar days to review and approve the Contractor's repair plan in writing.

Joints and cracks that are spalled shall be repaired as follows:

- (1) A saw cut at least 1 inch outside the spalled area and to a minimum depth of T/3 shall be made parallel to the joint or crack.
- (2) The concrete between the saw cut and the joint or crack shall be chipped out to solid concrete to a minimum depth of T/3.
- (3) The cavity formed shall be thoroughly cleaned.
- (4) A prime coat of epoxy-resin binder shall be applied to the dry, cleaned surface on all sides of the cavity, except the face of the joint. The prime coat shall be applied by scrubbing prime coat material into the surface with a stiff bristle brush.
- (5) Placement of portland cement concrete or epoxy-resin concrete shall immediately follow the application of the prime coat.

If the spalled area, to be repaired, abuts a working joint or a working crack that penetrates the full depth of the pavement, an insert or other bond-breaking medium shall be used to maintain the working joint or crack during the repair work.

If concrete paving exhibits the above defects for two or more days, production will be suspended. The Contractor shall submit a written plan to correct these defects. The plan shall detail, at a minimum, changes in paving procedures, materials and

equipment required to construct concrete pavement that meets the specifications. The Engineer will approve the Contractor's plan before the continuation of the concrete paving operation.

412.17 Surface Smoothness. The roadway surface smoothness shall be tested per subsection 105.07.

412.18 Sealing joints. Before installation of the backer rod or sealant, the following shall be completed:

- (1) Repair of defective pavement slabs and repair and proper curing of cracks or spalls per subsection 412.16.
- (2) Corrective work for texturing.
- (3) Corrective work for pavement smoothness per subsection 105.07.

A copy of the manufacturer's recommendations pertaining to the storage, heating and application of the sealant shall be submitted to the Engineer before commencing work. These recommendations shall be adhered to by the Contractor, with such exceptions as required by these specifications.

The Contractor shall cut the transverse and longitudinal joints to the width and depth required. The cut shall be made with a power drive saw equipped with diamond blades. The residue from sawing shall be removed from the pavement by the Contractor. The material shall be removed at the time of the sawing operation. Any damage to the concrete pavement such as spalling or fracturing shall be repaired by the Contractor as directed by the Engineer at no cost to the project. Sawing residue shall be immediately removed from all joints.

Cleaning, repairing, and proper curing of all spalls, fractures, breaks, and voids in the concrete surface of the joints shall be accomplished before installing the backer rod material or joint sealant.

The backer rod shall be placed in such a manner that the grade for the proper depth of the seal material is maintained.

The Contractor shall thoroughly clean the joint and adjacent pavement for a width of at least 1 inch on each side of the joint of all scale, dirt, dust, residue, and other foreign material that will prevent bonding of the joint sealant. This operation is to be accomplished by sandblasting or jet water-blasting on the same day as the joint sealing operation.

Immediately before the placement of backer rod material and sealant, the joints shall be cleaned using a minimum of 100 psi of compressed air. Work shall be stopped when and if it is found that there is oil or moisture in the compressed air. Work shall not resume until oil and moisture are removed from the compressed air.

Sealant shall not be placed unless the surfaces of the joint and the pavement are dry, and the weather is dry. Joint sealing will not be allowed when the air or surface temperature falls below 50 °F. Manufacturer's recommendations shall be followed if a higher temperature is recommended. Sealant shall not be placed before expiration of the sealant manufacturer's recommended concrete pavement curing period, if any.

The Contractor shall not place the sealant if there is dust, moisture, oil, or foreign material on that portion of the concrete that is to receive the backer rod or sealant.

The Contractor shall prevent smearing of the joint sealant material onto the concrete pavement driving surface. Smearred joint sealant shall be removed from the pavement before it is opened to traffic.

Sealing shall be completed before opening the pavement to traffic, unless otherwise specified or approved.

412.19 Construction by Form Method. Straight side forms shall be made of a metal having a thickness of at least $7/32$ inch and shall be furnished in sections at least 10 feet in length. Forms shall have a depth equal to or greater than the specified edge thickness of the concrete, without horizontal joint, and a base width equal to or greater than the depth of the forms. Top surface of the forms shall be set flush with the proposed concrete surface. Flexible or curved forms of proper radius shall be used for curves of 100 feet radius or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure setting so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Flange braces shall extend outward on the base at least $2/3$ the height of the form. Forms with battered top surfaces, and forms that are bent, twisted, or broken shall not be used. Repaired forms shall not be used until inspected and approved. Built-up forms shall not be used except where the total area of the pavement, of any specified thickness, on the project is less than 2,000 square yards. The top face of the form shall not vary from a true plane by more than $1/8$ inch in 10 feet, and the vertical leg shall not vary more than $1/4$ inch from vertical. The forms shall contain provisions for locking the ends of abutting form sections together tightly, and for secure setting.

Forms for bridge approach slabs or for pavement areas with irregular dimensions shall be made of metal or straight, sound timber. Forms shall be free from warp and of sufficient strength to resist springing out of shape. Forms shall be staked securely to line and grade to the satisfaction of the Engineer. All mortar and dirt shall be removed from the forms.

(a) *Setting Forms.* The foundation under the forms shall be compacted true to grade so that the form, when set, will be firmly in contact for its whole length and at the specified grade. The roadbed shall be prepared per subsection 412.08; however, where the grade at the form line is found to be below specified grade it shall be filled and thoroughly compacted to specified grade with granular material in lifts of $1/2$ inch or less. Imperfections or variations above grade shall be corrected by tamping or by trimming as necessary.

Forms shall be set sufficiently in advance of concrete placement to provide time for the Engineer to check the line and grade and allow a continuous concrete placement operation. Forms shall be staked in place and free from play or movement in any direction. The forms shall not deviate from true line by more than $1/4$ inch at any point. No excessive settlement or springing of the forms under the finish machine will be tolerated. Forms shall be cleaned and coated with a form release agent or oiled before placement of concrete.

The alignment and grade elevations of the forms shall be checked, and corrections made by the Contractor immediately before concrete placement. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

(b) *Removing Forms.* Unless otherwise provided, forms shall not be removed from freshly placed concrete until the concrete is strong enough to withstand damage when the forms are removed. After the forms have been removed, the sides of the slab shall be cured per subsection 412.14.

412.20 Construction by Slip Form Method. The subgrade shall be completed per subsection 412.08 and then checked and approved by the Engineer before installation of load transfer units, if required, and placement of concrete. Concrete shall not be placed on a subgrade that has not been approved. If any traffic uses the finished subgrade, the grade shall be checked and corrected immediately before placement of the concrete.

The concrete shall be finished with an approved, self-propelled slip form paver capable of spreading, consolidating, screeding, and finishing the freshly placed concrete with one pass of the paver. The paver shall be capable of providing a dense and homogeneous pavement with an even texture and no porous areas, and to the slope and elevation specified. The alignment and elevation of the paver shall be automatically controlled from outside reference lines established to obtain a smooth alignment and profile.

For mainline paving of Pavement Smoothness Category I roadways, as defined in Table 105-14 all slip form paving shall be accomplished by a machine capable of paving at least a 24 feet minimum width as recommended by the equipment manufacturer.

(a) *Stabilized Bases.* The Contractor is responsible for irregularities in the stabilized base and payment will not be made for overruns in concrete quantities if extra concrete is used to correct the irregularities.

(b) *Concrete Pavement Overlays.* Trimming will not be required. The Contractor shall place a bond breaker, if specified in the Contract, before placing the concrete. Payment will be made for irregularities under pay item of Furnish Concrete Pavement.

The Contractor shall furnish a machine to develop and establish a profile grade for the new pavement. The method used will be by dual slope laser mounted on a 30-foot ski. The Engineer may approve an alternative method of establishing the profile grade, if the Contractor demonstrates that equal or superior results will be achieved by the alternative method.

412.21 Determining Pavement Thickness. Pavement thickness will be determined by cores or magnetic pulse induction (MPI). The Contractor shall select the pavement thickness determination method at the Pre-paving Conference.

(a) *Pavement Thickness Using Cores.* The Contractor shall perform the process control (PC) testing for pavement thickness. A process control testing plan shall be submitted and must be approved before the start of paving. This PC testing plan shall include determining the thickness of freshly finished concrete pavement at a minimum frequency of one measurement per 1,250 linear feet of each traffic lane. All shoulders 8 feet or greater in width shall be tested as a separate traffic lane. Shoulders less than 8 feet wide shall be included in the adjacent lane. Areas such as sections of mainline pavement that are less than 1,250 linear feet long, intersections, entrances, crossovers, ramps, shall be grouped into units of 1,000 square feet or remaining fraction. A minimum of one random measurement shall be taken in each unit.

The Engineer may inspect the Contractor's PC tests at any time during the paving operations. Approval and inspection of the Contractor's PC plan and operations does not

constitute acceptance of the pavement thickness and does not relieve the Contractor of the responsibility for providing the required hardened pavement cores for project acceptance testing. The Contractor shall provide daily written reports to the Engineer listing the results of the day's PC thickness measurements.

Project acceptance (PA) testing will be the responsibility of the Engineer. PA testing consists of determining pavement thickness by measuring the length of cores taken by the Contractor from the hardened pavement as outlined below. Acceptance of the pavement thickness and price adjustment for deficient thickness will be based on project acceptance tests.

The Engineer will designate the time and location of the coring and will be present during the coring operation. The Contractor shall obtain 4-inch or 6-inch nominal diameter cores from the hardened pavement that are suitable for measuring per AASHTO T148. When the cores are removed from the pavement, the Engineer will take possession and determine their length per AASHTO T148.

The lower tolerance limit (TL) for pavement thickness shall be Plan Thickness (PT) minus 0.4 inches. This TL shall be used in the formulas in Section 105 for Incentive and Disincentive Payments (I/DP), Quality Levels (QL) and Pay Factor (PF) determinations. Any pavement thickness test value that exceeds the PT by more than 1.0 inch shall be assigned a value of PT plus 1.0 inch for the purpose of calculating the QL, PF and I/DP.

Core locations shall be determined by a random procedure so that each area has a randomly selected coring location. One core will be taken at each location.

Where the new portland cement concrete pavement (PCCP) overlays an existing roadway, cores for measuring pavement thickness shall be determined by a stratified random procedure in the longitudinal direction and by the point of minimum required thickness in the lateral direction as shown in the plans. If existing field conditions show a condition where the point of minimum thickness in the lateral direction as shown in the plans is not appropriate, the Contractor shall identify the location and extent of the area to the Engineer at least 24 hours before paving. The Engineer may exclude this area from pavement thickness measurements for incentive and disincentive payments.

Pavement thickness tests will be evaluated per subsection 105.06.

Additional cores will be taken at the direction of the Engineer as follows:

- (1) One additional core at the location of each PC or PA test that is less than PT minus 1.0 inch.
- (2) If the length of the additional core is greater than PT minus 1.0 inch, no additional actions will be taken, and the PA test core will be used to compute I/DP for the process that includes this material.
- (3) If the length of the additional core is less than PT minus 1.0 inch, the area represented by this core shall become a separate process and this core will not be used to compute an I/DP. Exploratory cores shall be taken at intervals of 15 feet or less, parallel to the centerline in each direction from the affected location until two consecutive cores are found in each direction which are not less than PT minus 1.0 inch. Four additional randomly selected cores will be taken within the area represented by these cores. The four additional cores will be used to compute an I/DP per Section 105. Cores taken at locations not randomly determined, such as process control cores will not be used to compute I/DP.

Pavement areas found to be less than PT minus 1.0 inch shall be removed and replaced at the Contractor's expense.

When the removal and replacement have been completed, four additional randomly selected cores will be taken within the area represented by this core. The four additional cores will be used to compute an I/DP per subsection 105.06. Exploratory cores will not be used to compute I/DP.

The Contractor shall repair all core holes by filling them with an approved nonshrink high strength grout.

(b) *Pavement Thickness Using MPI.* The Contractor shall perform the process control (PC) testing for pavement thickness using MPI. A process control testing plan shall be submitted and must be approved before the start of paving. This PC testing plan shall include determining the thickness of hardened concrete pavement at a minimum frequency of one measurement per 1,250 linear feet of each traffic lane. All shoulders 8 feet or greater in width shall be tested as a separate traffic lane. Shoulders less than 8 feet wide shall be included in the adjacent lane. Areas such as sections of mainline pavement that are less than 1,250 linear feet long, intersections, entrances, crossovers, ramps, etc., shall be grouped into units of 1,000 square feet or remaining fraction thereof. A minimum of one random measurement shall be taken in each unit.

The Contractor's PC test results using MPI for pavement thickness will be used for Project Acceptance (PA) and used to calculate I/DP. PC testing will be witnessed by the Engineer.

The MPI results will be considered acceptable when the range of the three individual scans is less than or equal to 0.10 inches. If the three scans are not within 0.10 inches, a second set of three scans shall be taken. The three new scans will be considered acceptable when the range of the three individual scans is less than or equal to 0.10 inches. If the second set of three scans are not within 0.10 inches, the MPI for this location will not be used. A MPI test will be the result of the average of a set of three acceptable scans at a location. The average of the set of three scans shall be rounded to the nearest 0.04 inches. If a MPI location is unable to obtain three acceptable scans, a core shall be taken and used for thickness determination and I/DP.

A test section shall be conducted to verify the calibration and correlation of the MPI pavement thickness determination at the start of PCCP operations. The test section correlation shall be established in the first 7,500 square yards of PCCP per a stratified random sampling schedule as established in CP 75. The test section correlation verification shall consist of conducting ten pavement thickness measurements by taking a core at the MPI test locations. The Contractor shall obtain 4-inch nominal diameter cores from the hardened pavement that are suitable for measuring per AASHTO T148. When the cores are removed from the pavement the Contractor shall determine their length and then the Engineer will take possession and determine their length per AASHTO T148. A verification must be run for each MPI device used on the project. The verification of any MPI device can be run at the initial verification locations. The comparison of the PC MPI measurements and hardened concrete cores shall be within 0.15 inches to be considered a valid correlation between the two test methods.

After successful completion of the thickness measurement correlation verification process, a minimum of one hardened concrete core will be taken for every 25 MPI thickness measurements for core thickness determination. When a change in thickness or process occurs, the first three MPI location shall be cored for thickness. At a minimum, one MPI test location will be cored for thickness for each pavement thickness process, or as directed by the Engineer. A core may be taken when the MPI result is in doubt. The correlation between core and MPI thickness measurements shall be verified to be within 0.15 inches at the same location. If the thickness difference between the methods exceeds 0.15 inches, the next five MPI locations will be cored. If the thickness difference between the two methods exceeds 0.15 inches on any location the contractor shall use the coring method for acceptance until the MPI is repaired or replaced and verified. Previous MPI locations shall be cored until three successive thickness differences between the two methods is equal to or less than 0.15 inches. If the MPI device is not able to be repaired or replaced within 10,000 sq yd of paving, the acceptance method will revert to coring acceptance from the last acceptable MPI measurement. A new process for pavement thickness will be started for the change in method of measurement.

The lower tolerance limit (TL) for pavement thickness shall be Plan Thickness (PT) minus 0.4 inches. This TL shall be used in the formulas in Section 105 for Incentive and Disincentive Payments (I/DP), Quality Levels (QL) and Pay Factor (PF) determinations. Any pavement thickness test value that exceeds the PT by more than 1.0 inch shall be assigned a value of PT +1.0 inch for the purpose of calculating the QL, PF and I/DP.

MPI test locations shall be determined by a random procedure so that each area has a randomly selected coring location. A MPI test plate will be installed before paving. The location of the MPI test plate shall be at least 4 feet from any dowel bar locations, tie bar location and utility box cover locations. The operator of the MPI device should use composite safety boots to not interfere with the device.

Where the new PCCP overlays an existing roadway, MPI test locations shall be determined by a stratified random procedure in the longitudinal direction and by the point of minimum required thickness in the lateral direction as shown in the plans. If existing field conditions show a condition where the point of minimum thickness in the lateral direction as shown in the plans is not appropriate, the Contractor shall identify the location and extent of the area to the Engineer at least 24 hours before paving. The Engineer may exclude this area from pavement thickness measurements for incentive and disincentive payments.

Pavement thickness tests will be evaluated per subsection 105.06. Additional cores will be taken at the direction of the Engineer at the contractor's expense as follows:

One additional core at the location of each process control (PC) test that is less than PT minus 1.0 Inch.

- (1) If the length of the additional core is greater than PT minus 1.0 inch, no additional actions will be taken, and the core test result will replace the MPI result to compute I/DP
- (2) If the length of the additional core is less than PT minus 1.0 inch the area represented by this PC test shall become a separate process and will not be used to

compute an I/DP. The thickness of the pavement in this area will be determined by taking cores. Cores shall be taken at intervals of 15 feet or less, parallel to the centerline in each direction from this location until two consecutive cores are found in each direction which are not less than PT minus 1.0 inch. The pavement found to be less than PT minus 1.0 inch shall be removed and replaced at the Contractor's expense.

When the removal and replacement have been completed, four additional randomly selected cores will be taken within the area represented by this core. The four additional cores will be used to compute an I/DP per subsection 105.06.

The Contractor shall repair all core holes by filling them with an approved non-shrink high-strength grout.

412.22 Opening to Traffic. The pavement shall not be opened to traffic until the concrete has achieved a compressive strength of 3,000 psi. Concrete compressive strength shall be determined by maturity meters. Before opening the pavement to traffic the roadway shall be cleaned, as approved.

Before placement of concrete whose strength will be determined with maturity meters, the Contractor shall provide the Engineer a report of maturity relationships per CP 69. The Contractor shall provide maturity meters and all necessary wires and connectors. The Contractor shall be responsible for the placement and maintenance of the maturity meters and wires. At a minimum a maturity meter will be placed once per day and then once per 5,000 square yards. Placement shall be as directed by the Engineer.

For placements with multiple maturity meters, the lowest compressive strength shall determine when the pavement may be opened to traffic.

If a maturity meter fails, is tampered with, is destroyed or was not placed, the section of pavement represented by the maturity meter shall remain closed to traffic for a period of 28 days. The Contractor may choose at his own expense to core the section of pavement represented by the maturity meter. Cores will be obtained and tested according to CP 65. Cores will be a minimum of 4 inches in diameter. A minimum of three cores in a two square foot area will be obtained. If the compressive strength of any one core differs from the average by more than 10 percent that compressive strength will be deleted and the average strength will be determined using the compressive strength of the remaining two cores. If the compressive strength of more than one core differs from the average by more than 10 percent, the average strength will be determined using all three compressive strengths of the cores. To open the section of pavement, the average compressive strength of the cores shall be a minimum of 3,000 psi.

METHOD OF MEASUREMENT

412.23 The quantities of Concrete Pavement, and Place Concrete Pavement to be paid for under these items will be the number of square yards completed and accepted. The width for measurement will be the width of the pavement shown on the typical cross section of the plans, including additional widening where called for, or as otherwise directed by the Engineer in writing. The length will be measured horizontally along the centerline of each roadway or ramp.

The quantity of Furnish Concrete Pavement to be paid for under this item will be the number of cubic yards of concrete delivered and accepted. The concrete volume will be based on batch

weights of the concrete converted to volumes by use of the conversion factor developed with the specific mix design. Quantities of concrete that are wasted, spilled, or used as a result of excessive thickness shall be deducted from the pay quantity. Excessive thickness shall be considered any thickness in excess of 1/2 inch greater than the specified depth that continues for a length of 200 feet or more. Yield shall be determined per AASHTO T 121. Where concrete is paid for by cubic yard batched, the pay quantities for all concrete produced with a relative yield less than 0.99 shall be corrected per the following formula:

$$\text{Corrected cubic yards} = (\text{cubic yards batched}) \cdot (\text{relative yield})$$

Reinforcement other than dowels, tie bars, and other joint material will be measured by the pound.

BASIS OF PAYMENT

412.24 General. The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Concrete Pavement (___Inch)	Square Yard
Place Concrete Pavement	Square Yard
Furnish Concrete Pavement	Cubic Yard

The price per square yard of Concrete Pavement shall be full compensation for furnishing and placing all materials, including dowels, tie bars, joint materials, texturing, sawing, finishing, and rumble strips.

The price per square yard for Place Concrete Pavement shall include everything included in the pay item, Concrete Pavement, except furnishing concrete.

The price per Cubic Yard for Furnish Concrete Pavement shall be full compensation for furnishing the concrete to the project site.

Reinforcing steel will be measured and paid for per Section 602.

Furnishing, installing, and monitoring vibrators and vibrator monitoring device will not be measured and paid for separately, but shall be included in the work for concrete pavement.

Incentive and Disincentive Payments (I/DP) will not be made on interim estimates. I/DP will be made when the concrete pavement or a major phase of the concrete pavement has been completed and all the data for computing the I/DP is available.

Furnishing, calibrating and use of maturity meters, wire and other appurtenances including the molding, curing and breaking of cylinders for calibration and placement of calibration slabs will not be measured and paid for separately, but shall be included in the work.

All costs associated with developing correlation curves used to evaluate low flexural strength results per the Contract, or as requested by the Engineer, shall be included in the work. This shall include all materials, forms, testing, equipment and labor.

(a) Where the pavement thickness is more than Plan Thickness (PT) minus 1.0 inch, I/DP for the element of pavement thickness will be applied to the contract unit price per subsections 105.06 and 412.21. I/DP for other elements will be applied to the contract unit per Section 105.

Adjustments in payment because of deviations in air content will be per subsection 601.17 using \$100 per cu. yd. for the unit bid price.

DESCRIPTION

412.25 Cross Stitching. This work consists of cross stitching longitudinal cracks and joints by directionally drilling holes in concrete pavement, injecting grout, and inserting deformed steel reinforcing bars per these specifications and the details shown on the plans. Cross stitching shall not be used for thin concrete overlays (8 inches or less).

MATERIALS

412.26 Materials for cross stitching shall be #6 or #8 deformed steel reinforcing bars, grade 60, epoxy coated, with length as specified on the plans.

Epoxy or cementitious grout shall be on the Department's Approved Products List. The epoxy shall be either an epoxy or polyester resin. The epoxy or cementitious grout shall be submitted to the Engineer for approval at least five working days in advance of the commencement of cross stitching work.

412.27 Placement. Directionally drilled holes shall be 1.000 to 1.125-inch diameter for #6 bars and 1.125 to 1.375-inch diameter for #8 bars and drilled at an angle from the horizontal designated on the plans. Holes shall be started at a distance shown on the plans on a line perpendicular to the crack/joint and shall extend through the crack/joint. Drilled holes shall be spaced on 20-inch centers and shall alternate from side to side along the full length of the crack/joint. Holes shall not be drilled within 24 inches of an existing transverse joint. Holes shall not extend through the bottom of the slab.

Drilled holes shall be blown free of drill dust, dirt, and moisture with oil and moisture-free compressed air immediately before placing the grout.

Holes shall be filled with epoxy/grout by injecting from the bottom of the hole. The Contractor shall insert the tie bar and remove excess epoxy/grout and finish flush with the pavement surface.

Pavement may be opened to traffic when the epoxy/grout is dry to the touch.

412.28 Equipment. The drill for boring the cross stitch holes shall be selected to minimize damage to the concrete surface. The drill shall be capable of low-impact operation in order to minimize spalling damage and prevent bottom breakout of the concrete pavement. The drill shall be skid or frame mounted. Handheld drilling will not be allowed.

The first ten holes shall be visually inspected to determine if the bottom of the slab has broken out and measured for length of minimum embedment. Installation of the tie bars and epoxy shall not occur until the Contractor's drilling method has been inspected and approved. After the Contractor's method has been approved, the Contractor may proceed with cross stitching so long as the method and equipment remain the same.

Drill bit changes do not require re-inspection. If the Contractor's method or equipment changes, the first 10 holes made with the new method shall be visually inspected to determine if the bottom of the slab has broken out and measured for length of minimum embedment.

BASIS OF PAYMENT

412.29 Cross stitching will be measured for payment by the number of cross stitches placed.

Payment will be made under:

Pay Item	Pay Unit
Cross Stitching	Each

The accepted quantity of drilled holes, filled with epoxy/grout and reinforcing bars will be paid for at the contract unit price per each hole drilled. Payment for deformed bars, grout, labor, materials, equipment, tools and incidentals necessary for completion of the work will not be measured and paid for separately but shall be included in the work.

DESCRIPTION

412.30 Slot Stitching. This work consists of installing tie bars across cracks in concrete pavement per these specifications and the details shown on the plans. Slot stitching shall not be used for thin concrete overlays (4 inches or less).

MATERIALS

412.31 Concrete patching material to be used as backfill shall be a product on the Department's Approved Products List. Concrete patching material shall attain an average compressive strength of at least 4,500 psi at 24 hours. Concrete patching material compressive strengths shall be tested according to ASTM C39 or ASTM C109. Concrete patching material shall provide a minimum bond strength of 1,000 psi at 24 hours, as tested by ASTM C882. Concrete patching material shall have a relative durability factor greater than 90 as tested by ASTM C666 method A. Concrete patching material shall have a maximum shrinkage of 0.13 percent at four days as tested by ASTM C157.

Steel tie bars shall be 18 inches long #6 deformed steel tie bars, grade 60, and epoxy coated.

CONSTRUCTION REQUIREMENTS

412.32 Slot Formation. Slots shall be made from multiple saw cuts made with a diamond impregnated saw blade to a depth as shown on the plans. Slots shall be approximately perpendicular to the general trend of the crack. Slots shall be 1.75 to 2.25 inches wide. Lightweight jackhammers weighing less than 35 pounds or hand tools shall be used to remove the "fins" formed by sawing. The length of the slot shall allow the tie bar to be placed at the mid-depth of the slab with a 1-inch space between the ends of the tie bar and the ends of the slot. Deviations from this method require a method statement detailing the means and methods for how the Contractor will perform the work.

The Contractor shall demonstrate slot stitching work for approval using the proposed equipment and procedures. The first five slots shall be visually inspected for bottom of the slab breakouts and minimum dimensions. Installation of tie bars and concrete patching material shall not occur until the Contractor's method has been inspected and approved.

After the Contractor's method has been approved, the Contractor shall proceed with slot stitching as long as the method and equipment remain the same. Saw blade changes do not require re-inspection. If the Contractor's method or equipment changes, the first five slots of the new method shall be visually inspected for bottom of the slab breakouts and measured for minimum dimensions. Tie bars shall be provided at locations and spacing as detailed on the plans.

Damages to the concrete pavement caused by the Contractor's operations shall be repaired at the Contractor's expense.

Slots shall be sand blasted or water blasted to remove saw slurry and blown clean with high pressure oil-free air to remove sand, water, and dust.

Tie bars shall be placed on support chairs to rest horizontal at the mid-depth of the slab.

Concrete patching material mixing, placement, placement during cold temperatures, consolidation, and curing shall be per the manufacturer's recommendations. A mix may be extended with aggregate per the manufacturer's recommendations up to 90 percent of the manufacturer's maximum extension. The maximum aggregate size shall be 3/8 inch for the extending aggregate.

Patching material shall be placed and consolidated in the slot. Patching material shall fill the space under and around the bar. Tie bars shall not be dislodged or moved out of position.

The surface of the concrete patching material shall be level with the adjacent pavement.

412.33 Opening to Traffic. The pavement shall not be opened to traffic until all tie bars have been installed at a joint and the concrete has obtained a minimum compressive strength of 3,000 psi. Pavement shall be cleaned before opening to traffic.

METHOD OF MEASUREMENT

412.34 Method of Measurement. Slot stitching will be measured for each completed and accepted tie bar complete in place.

BASIS OF PAYMENT

412.35 The accepted quantities will be paid for at the contract unit price for the pay item listed below.

Payment will be made under:

Pay Item	Pay Unit
Slot Stitching	Each

The work performed and materials furnished per this item will be paid for at the unit price bid. This price is full compensation for furnishing all materials, tools, labor, equipment and incidentals necessary to complete the work. Payment will not be made for extra work required to repair damage to the adjacent pavement that occurs during slot stitching.

DESCRIPTION

412.36 Dowel Bar Retrofit. This work consists of placing epoxy coated smooth dowel bars in transverse joints as identified on the plans. This shall be done by cutting slots into the existing concrete pavement, installing dowel bars, and filling the slots at locations as shown on the plans. The surface shall be finished as approved by the Engineer. All work, including the concrete pavement slot preparation, inserting dowel bars, filling the slot with backfill material, and finishing the surface shall be performed per these specifications and the details shown on the plans.

MATERIALS

412.37 Materials for dowel bars shall meet the requirements in subsection 709.03. Dowels shall be equipped with tight fitting, non-metallic end caps to allow 1/4-inch bar movement.

Concrete patching material to be used as backfill shall be a product on the CDOT Approved Products List. Concrete patching material shall attain an average compressive strength of at least 4,500 psi at 24 hours. Concrete patching material compressive strengths shall be tested according to ASTM C39 or ASTM C109. Concrete patching material shall provide a minimum bond strength of 1,000 psi at 24 hours, as tested by ASTM C882. Concrete patching material shall have a relative durability factor greater than 90 as tested by ASTM C666 method A. Concrete patching material shall have a maximum shrinkage of 0.13 percent at four days as tested by ASTM C157. The proposed material shall be submitted to the Engineer for approval at least five days in advance of the start of dowel bar placement. Installation of dowel bars shall not begin until approval has been received in writing from the Engineer.

CONSTRUCTION REQUIREMENTS

412.38 Slots for dowel bars shall be cut perpendicular to the transverse joint as shown on the plans by using a slot cutting machine or walk-behind saw. Slots shall be of adequate length and width to accommodate the dowel bar, as shown on the plans or as directed. The concrete in the slot shall be removed by using a lightweight jackhammer weighing a maximum of 30 pounds, or hand tools, to half slab depth. All damage to the concrete slab outside of the slot shall be repaired or replaced at the Contractor's expense. Slots shall be placed at locations shown on the plans.

Slots shall be removed of all debris and cleaned before placement of dowel bars by sandblasting or other procedure so that clean aggregate is exposed. Before placement of backfill material, each dowel bar shall be equipped with a 1/4- to 3/8-inch-thick foam core board to provide a tight seal at the joint. Dowels shall be placed on chairs so that the bar is sitting a minimum of 1/2 inch above the bottom of slot and perpendicular to the transverse joint. The chairs shall be epoxy-coated steel or plastic rigid enough to hold the dowel in place during grout placement. The existing transverse joints shall be sealed with an approved joint sealant along the bottom and sides of the slot to prevent backfill material from infiltrating the joint. The joint sealant material shall be on the CDOT Approved Products list and shall be approved by the Engineer before use.

Backfill material to be placed shall be mixed according to the manufacturer's recommendations. Once in the slot, the material shall be vibrated thoroughly so that the entire bar is encased with the consolidated material. The slot shall be slightly overfilled, and the area shall be diamond ground once the material has cured to provide a smooth pavement surface.

After grinding, transverse joints shall be sawed and sealed per subsection 412.18.

412.39 Opening to Traffic. The pavement shall not be opened to traffic until all dowel bars have been installed at a joint and the concrete has obtained a minimum compressive strength of 3,000 psi. Pavement shall be cleaned before opening to traffic.

METHOD OF MEASUREMENT

412.40 Dowel bar retrofit in concrete pavement will be measured as the actual number of dowel bars placed and accepted.

BASIS OF PAYMENT

412.41 The accepted quantities will be paid for at the contract unit price for the pay item listed below.

Payment will be made under:

Pay Item	Pay Unit
Concrete Pavement Dowel Bar Retrofit	Each

The accepted quantity of dowel bar slots cut, filled with accepted patching material, and dowel bars will be paid for at the contract unit price per each bar installed. Payment for cutting slots, support chairs, joint sealant, patching, and all labor, materials, equipment, tools and incidentals necessary for completion of the work will not be measured and paid for separately but shall be included in the work. Payment will not be made for extra work required to repair damage to the adjacent pavement that occurs during dowel bar retrofitting.

SECTION 420
GEOSYNTHETICS
DESCRIPTION

420.01 This work consists of furnishing and installing geotextiles and geomembranes for paving, impervious lining, erosion control, drainage, separators and landscape weed barrier.

MATERIALS

420.02 Geotextiles and geomembranes shall meet the applicable requirements of subsections 712.07 and 712.08 for the use intended. Geotextiles for erosion control for drainage or for separators may be Class 1, Class 2, or Class 3, conforming to subsection 712.08, if the class is not specified on the plans.

Asphalt cement binder for the paving geotextile shall be the same grade as the asphalt cement used for Item 403.

Paving geotextile shall be a minimum Class 3, conforming to subsection 712.08.

CONSTRUCTION REQUIREMENTS

420.03 Areas where the geosynthetic is to be placed shall have a uniform slope, be reasonably smooth, free from mounds and windrows, and free of any debris or projections that could damage the material.

Riprap or cobbles placed on the geosynthetic shall not be dropped from a free fall greater than 3 feet. The cushion layer or initial layer of riprap may require careful placement without free fall to avoid geosynthetic damage. Geosynthetics damaged or displaced before or during placement of overlying layers shall be replaced or repaired per the requirements of this section and to the satisfaction of the Engineer, at the Contractor's expense.

420.04 Paving. The areas to be treated shall be as designated on the plans. The pavement surface shall be broomed clean immediately before beginning the crack reduction geotextile treatment using a self-propelled power broom.

The asphalt cement binder shall be applied to the pavement surface at the rate of approximately 0.25 gallon per square yard. The exact application rate shall be as recommended by the geotextile manufacturer, and at a temperature of 300 to 350 °F. Paving geotextile shall be applied, per the manufacturer's recommendations, immediately after the application of asphalt cement binder.

Construction equipment, including dump trucks, shall not make sudden stops or starts or sharp turning movements on the geotextile. Dump trucks shall not park on the geotextile before dumping into the asphalt paver.

Traffic shall be kept off all newly placed binder and geotextile material until the asphalt surface has been placed.

The minimum temperature of the hot mix asphalt at the time compaction begins shall be 250 °F.

The Contractor shall make arrangements with the geotextile supplier to have a technician,

skilled in this paving geotextile work, present at the project site during this work to give any technical assistance needed.

420.05 Impervious Lining. Geomembranes for lining shall be loosely laid (not stretched) to avoid any rupture of the lining. If field lap joints are necessary, the joints shall be formed by lapping the edges of panels per the manufacturer's recommendations. The contact surfaces of the panels shall be cleaned to remove all dirt, dust, and other foreign materials. Sufficient cold-applied vinyl to vinyl bonding adhesive shall be applied to the contact surfaces in the joint area and the two surfaces pressed together immediately. Wrinkles in the joints shall be smoothed out.

Necessary repairs to the geomembrane shall be patched using the geomembrane material itself and cold-applied vinyl to vinyl bonding adhesive. The bonding adhesive shall be applied to the contact surfaces of both the patch and the lining to be repaired and the two surfaces pressed together immediately. Any wrinkles in the repair joints shall be smoothed out.

420.06 Erosion Control and Drainage. Geotextiles for erosion control or drainage shall be loosely laid (not stretched) with the roll direction the same as the anticipated water flow, and in a manner that avoids any rupture of the cloth.

The geotextile may be anchored in place with securing pins at 3-foot spacing along but not closer than 2 inches to all edges and to the extent necessary to prevent displacement. When shown on the plans, erosion control geotextile may be held in place using 6 inches of clean embankment with a minimum 6-inch trench at the top of the slope. Overlaps shall be at least 12 inches on slopes 3:1 and flatter, and at least 24 inches on slopes steeper than 3:1. Laps shall be made with the uphill layer on top. Sewn seams per the manufacturer's recommendations may be used in place of overlaps. Full rolls shall be used whenever possible in order to minimize the number of roll end laps. Lengths and widths of individual sheets shall be at the Contractor's option.

420.07 Geotextile Separator. The geotextile shall be unrolled as smoothly as possible on the prepared subgrade in the direction of construction traffic. The geotextile shall be placed by machinery or by hand labor. The geotextile shall not be dragged across the subgrade. Wrinkles and folds in the geotextile (not associated with roadway curves) shall be removed by stretching and staking as required. The geotextile may be held in place before placement of cover by pins, staples or piles of fill or rock. On curves, the geotextile may be folded to conform to the curve. The fold or overlap shall be in the direction of construction and held in place as prescribed above. Adjacent geotextile rolls shall be overlapped in the direction of subbase placement using the guidelines in Table 420-1. Before covering, the condition of the geotextile will be inspected by the Engineer to determine that no holes, rips or other defects exist. If any defects are observed, the section of the geotextile containing the defect shall be repaired by placing a new layer of geotextile extending beyond the defect in all directions a minimum distance equal to the overlap shown in Table 420-1. Alternatively, the defective section may be replaced.

Either sewn seams or overlaps (unsewn seams) shall be used in construction. The widths of the overlaps shall conform to Table 420-1. Sewn seams shall be per the manufacturer's recommendations.

The first lift of cover material shall be end-dumped or spread over the geotextile from the

edges of the geotextile. The height of the dumped pile shall be limited to avoid local bearing capacity failures. The first lift of cover material shall be graded to a 12-inch thickness or to top of grade whichever is less and compacted. Equipment shall not be on the treated area with less than the minimum thickness of compacted cover material over the geotextile. Small dozer equipment or front-end loader shall be used to spread the cover material.

Construction vehicles shall be limited in size and weight such that rutting in the initial lift is no deeper than 3 inches. If rut depths exceed 3 inches, the Contractor shall use a smaller size and weight of construction vehicles. Ruts shall be filled in with cover material.

Compaction of lifts shall be accomplished without damaging the geotextile.

Construction equipment shall not make turns on the first lift of cover material.

**Table 420-1
MINIMUM REQUIRED OVERLAP**

Subgrade Strength R-Value	Overlap Width (Unsewn Seam) Inches
5 - 10	30
10 - 20	24
>20	18

420.08 Landscape Weed Barrier. Landscaped and mulched areas to be covered by geotextile shall be brought to finish grade below the depth of the mulch material shown on the plans. All soil preparation shall be completed before geotextile application.

Geotextile for landscape weed barrier shall be a minimum Class 3, conforming to subsection 712.08.

The geotextile shall be rolled directly onto prepared soil in the direction of water flow. The geotextile shall be applied loosely without stretching. The top edge of the geotextile shall be buried in a 6-inch check slot at the top of the slope and stapled. When specified, metal landscape border shall be placed adjacent to check slot on the uphill side, so as not to puncture the geotextile.

Where one roll of geotextile ends and a second roll begins, the upslope piece shall be brought over the start of the second roll and overlapped per the manufacturer's recommendation. Where two or more widths of geotextile are applied side by side, they shall be overlapped per the manufacturer's recommendation. Staples shall be inserted at a 2-foot spacing along the outer edges of the geotextile where a metal border is not used.

In level planting beds, geotextile shall be secured under metal landscape border by extending the geotextile 6 inches beyond the metal landscape border and driving stakes through the geotextile.

METHOD OF MEASUREMENT

420.09 Geomembranes and geotextiles will be measured by the square yard of surface area covered, complete in place.

BASIS OF PAYMENT

420.10 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Geomembrane	Square Yard
Geotextile (Erosion Control) (Class__)	Square Yard
Geotextile (Drainage) (Class__)	Square Yard
Geotextile (Weed Barrier)	Square Yard
Geotextile (Paving)	Square Yard
Geotextile (Separator) (Class__)	Square Yard

Securing pins, staples, adhesives, sewn seams, asphalt cement, brooming, skilled technician, and other work and materials necessary for placement will not be measured and paid for separately but shall be included in the work.

