DIVISION 500 – CONCRETE PAVEMENT

SECTION 501 – QC/QA PORTLAND CEMENT CONCRETE PAVEMENT, PCCP

501.01 Description

This work shall consist of QC/QA portland cement concrete pavement, PCCP, placed on a prepared subgrade or subbase in accordance with 105.03.

501.02 Quality Control

The mixture for PCCP shall be produced by a qualified plant in accordance with ITM 405, transported, and placed in accordance with a QCP. The QCP shall be prepared and submitted in accordance with ITM 803, for PCCP. The QCP shall contain a plan for placing PCCP in cold weather, as defined in 501.15. The cold weather plan shall, at a minimum, provide details to address changes in materials, concrete batching and mixing processes, construction methods, curing, temperature monitoring, and protection of in-situ PCCP. Temperature monitoring shall consist of monitoring the surface temperature of the PCCP by use of a thermometer. The thermometer shall be capable of recording and maintaining a record of the day, time, and temperature every 15 minutes around the clock. The thermometer shall be located 6 in. in from the edge of the PCCP.

The QCP shall be submitted to the Engineer a minimum of 15 days prior to commencing PCCP paving operations. Work shall not begin until written notice has been received that the QCP was accepted by the Engineer.

An ACI-Certified Concrete Field Testing Technician, Grade I, shall be on site to direct all sampling and testing.

A common testing facility shall be provided for both production control and acceptance testing.

MATERIALS

501.03 Materials

Materials shall be in accordance with the following:

Admixtures	912.03
Concrete Coarse Aggregate, Class AP	904.03, ITM 226
Fine Aggregate, Size No. 23	904.02
Coal Ash	901.02
Liquid Membrane Forming Compound	912.01(e)
Portland Cement	901.01(b)*
Rapid Setting Patch Materials	901.07
Silica Fume	901.04

Slag Cement.....901.03
Water.....913.01
* Type IS-A and Type IP-A blended cements shall not be used.

501.04 Concrete Mix Design

The CMDS shall be in accordance with 501.05. The CMDS shall be submitted to the DTE. The CMDS shall be submitted a minimum of seven calendar days prior to the trial batch utilizing the Department provided spreadsheet and shall include the following:

1. a list of all ingredients
2. the source of all materials
3. the fine to total aggregate ratio
4. the gradation of the aggregates
5. the absorption of the aggregates
6. the SSD bulk specific gravity of the aggregates
7. the specific gravity of each SCM
8. the batch weights
9. the names of all admixtures
10. the admixture dosage rates and the manufacturer's recommended range.

The aggregate blend submitted on the CMDS shall produce an optimized aggregate gradation in accordance with the Department provided spreadsheet. The aggregate blend shall consist of, at a minimum, one concrete coarse aggregate and one fine aggregate, size No. 23. One additional Class A intermediate-sized coarse aggregate may be included if approved by the Engineer.

The CMDS shall be used to conduct a trial batch in accordance with 501.06. Upon completion of the trial batch, the Contractor shall update the submitted CMDS to include the Contractor's and the Engineer's trial batch test results on the Department provided spreadsheet a minimum of three business days prior to production. Production shall not commence until the DTE has issued the concrete mix design for production, CMDP.

A CMDP may be changed or adjusted in accordance with the following:

(a) Change in Materials

Any of the following changes to a CMDP shall require a new CMDS to be submitted to the DTE, referencing the original CMDP:

1. cement source or type
2. SCM source or type
3. coarse aggregate source or type
4. admixture type.

A trial batch shall be conducted in accordance with 501.06, or verification of the new CMDS may be made during the first day of production by tests conducted by the Contractor and the Engineer. Acceptance test results may be used for the Engineer's verification tests. Production may continue until flexural strength tests are completed, provided all other properties are in accordance with 501.06. The test results shall be submitted to the DTE utilizing the Department provided spreadsheet no later than one day after the flexural strength test results are complete. If the test beams indicate a modulus of rupture that is not in accordance with 501.06, production shall stop and all PCCP constructed with the new CMDS will be considered as a failed material and will be reviewed in accordance with 105.03. If all properties are in accordance with 501.06, the DTE will issue the CMDP.

(b) Adjustments to Materials

Any of the following adjustments to a CMDP shall require a new CMDS to be submitted to the DTE, referencing the original CMDP:

1. admixture source
2. admixture product of the same type and from the same source designated in the original CMDP
3. fine aggregate source
4. target unit weight due to change in aggregate properties
5. fine to total aggregate ratio in excess of ±3% from the value designated by the original CMDP.

The new CMDS shall be submitted to the DTE utilizing the Department provided spreadsheet a minimum of one business day prior to production. A trial batch or verification testing will not be required. Production shall not commence until the DTE has issued the CMDP.

(c) Other Adjustments

Other adjustments in a CMDP to any of the following will be allowed and DTE notification prior to use will not be required:

1. admixture dosage rate
2. fine aggregate to total aggregate ratio within ±3% of the value designated by the original CMDP.

A CMDP in accordance with either 501.05 or 502.04 from a previous contract may be submitted to the DTE for consideration for use on the current contract. The DTE will notify the Contractor when the review is complete and if the previously used CMDP can be used on the current contract.

501.05 Concrete Mix Criteria

The CMD shall contain at least one, but not more than two SCMs, and produce workable concrete mixtures having the following properties:

Minimum total cementitious content ..... 450 lb/cu yd
Allowable amount of single SCM,
% of total cementitious, by weight..... 25.0 – 40.0%*
Allowable amount of two SCMs,
% of total cementitious, by weight..... 25.0 – 40.0%**
Minimum portland cement content..... 275 lb/cu yd
Allowable amount of silica fume as SCM,
% of total cementitious content..... 3.0 – 7.0%**
Maximum allowable water/cementitious ratio
of concrete mixture with coal ash as SCM 0.440
Maximum allowable water/cementitious ratio
of concrete mixture with slag cement as SCM..... 0.450
Target air content..... 7.0%
Minimum modulus of rupture ..... 570 psi at 7 days

* Binary binder systems shall contain either coal ash or slag cement combined with a cement. If blended cement is used, it shall be either a Type IP ($25 \leq X \leq 40$) or Type IS ($25 \leq X \leq 40$) or Type IL. Blended cements, except for Type IL, shall not be combined with plant added slag cement or coal ash to create a binary binder system. When using a Type IL blended cement, plant addition of coal ash or slag cement will be allowed. The limestone dust in Type IL cement will not be considered in calculating the amount of SCM.

** Ternary binder systems shall contain two SCMs such as coal ash and slag cement, or coal ash and silica fume, or slag cement and silica fume, combined with a cement. If a blended cement is used, it shall not be combined with a plant added SCM of the same type of SCM to create a ternary system. For example: a Type IP shall not be combined with plant-added coal ash and slag cement. When using a Type IL blended cement, the plant addition of both coal ash and slag cement will be allowed. The limestone dust in Type IL cement will not be considered in calculating the amount of SCM. Silica fume shall only be an SCM component of a ternary binder system. If a blended cement is used, silica fume shall only be an SCM component of the ternary system.

Absorption tests shall be performed on the fine aggregate in accordance with AASHTO T 84 and on the coarse aggregate in accordance with AASHTO T 85. Absorption test results for a particular size of aggregate that differ by more than 1.0 percentage point from the Department's source value shall be investigated. The Contractor shall report any differences that exceed 1.0% to the Department. The Contractor's results shall be used when calculating the water/cementitious ratio.

Hand placed paving operations meeting the requirements of 508.04(c) shall utilize concrete having a ternary binder system that contains silica fume as one of the SCMs when the ambient temperature is below 50°F during placement or when the ambient temperature will fall below 50°F before the opening to traffic strength is attained. Concrete with a ternary binder system containing silica fume as one of the SCMs, may be used in any approved method of pavement placement without restriction. Placement

operations that involve form riding equipment in accordance with 508.04(b), may use a binary CMDP, without restriction.

Water reducing admixture Type A, or water reducing and retarding admixture Type D, may be used in PCCP. However, admixture Type A shall not be used in conjunction with admixture Type D.

501.06 Trial Batch

A trial batch shall be produced and tested by the Contractor's ACI-Certified Concrete Field Testing Technician, Grade I, to verify that the CMDS meets the concrete mix criteria. An ACI-Certified Concrete Field Testing Technician, Grade I, shall be on site to direct all sampling and testing. Concrete produced at a plant shall be batched within the proportioning tolerances of 508.02(b). Concrete batched in a laboratory shall be in accordance with ASTM C192. The Engineer will test the trial batch and provide the Contractor with the results. The trial batch shall be of sufficient quantity to allow the Contractor and the Engineer to perform all required tests from the same batch. Trial batch concrete shall not be used for more than one test, except the concrete used for the unit weight may be used to conduct the air content test. The air content shall be 5.5% to 10.0%. The plastic unit weight shall be within ±3.0% from the target plastic unit weight of the CMDS. The water/cementitious ratio shall be within ±0.015 of the target value of the CMDS and shall not exceed the maximum amount allowed for the appropriate mix in accordance with 501.05. The flexural strength shall be determined by averaging a minimum of two beam breaks and shall be a minimum of 570 psi.

Test results shall be added to the Department provided spreadsheet and submitted to the DTE in accordance with 501.04. Adjustments to the target unit weight and the target water/cementitious ratio may be made.

The box test shall be performed in accordance with AASHTO T 396. The overall void rating shall be 2.25 or less. If the overall void rating is greater than 2.25, the trial batch may be subject to rejection.

501.07 Lots and Sublots

Lots will be defined as 7,200 sq yds of PCCP. Lots will be further subdivided into sublots of 2,400 sq yds of PCCP within a lot. Partial sublots of 480 sq yds or less will be added to the previous sublot. Partial sublots greater than 480 sq yds constitute a full sublot. Partial lots of one or two sublots constitute a full lot.

Lots and sublots will be numbered and tested for a given pay item regardless of the number of CMDs used and will be closed out at the end of the paving season or construction phase.

501.08 Acceptance

Acceptance of PCCP will be based on the results of modulus of rupture, air content, unit weight, water/cementitious ratio, and thickness measurements obtained

by the Engineer in accordance with 505. The Engineer will randomly select the location within each sublot for sampling in accordance with ITM 802.

The random sample per sublot shall be of sufficient quantity to perform all required tests and obtained in accordance with AASHTO R 60. Concrete and necessary labor for sampling shall be furnished as required by the Engineer. The test results of the sublots for each lot will be averaged and shall be in accordance with 501.05 and 501.06, except the lot average for thickness shall be in accordance with 501.26. Test results are to be shared in a timely manner.

Test or Determination	Frequency	Test Method	Precision
7-Day Flexural Strength	two beams per sublot	AASHTO T 97	modulus of rupture, rounded to the nearest 5 psi
Air Content	one test per sublot	AASHTO T 152 or ASTM C173	0.1%
Unit Weight	one per sublot	AASHTO T 121	0.1 lb/cu ft
Water/Cementitious Ratio	one per two lots	ITM 403	0.001
Thickness	two per sublot	ITM 404	0.1 in.

Rounding will be in accordance with 109.01(a).

If an acceptance sample is not available to represent a sublot, all test results of the previous sublot will be used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

CONSTRUCTION REQUIREMENTS

501.09 General

Equipment for PCCP shall be in accordance with 508.

501.10 Preparation of Subgrade

The subgrade shall be shaped to the required grade and section, free from all ruts, corrugations, or other irregularities, and uniformly compacted in accordance with 207.

501.11 Preparation of Subbase

Subbase, if required, shall be placed and shaped to the required grade and section in accordance with 302. Construction traffic shall not be allowed on the aggregate drainage layer of the subbase, except where PCCP placement is restricted. Exceptions shall be submitted for approval.

501.12 Placement

Placement of PCCP shall be by the slipformed or formed methods with equipment specified in 508.04. The subgrade or subbase shall be uniformly moist at the time of PCCP placement. Excessively dry subgrade or subbase shall be sprinkled with water.

501.13 Process Control

The Engineer and the Contractor will jointly review the operations to ensure compliance with the QCP. Continuous violations of compliance with the QCP will result in suspension of paving operations.

501.14 Concrete Mixing and Transportation

Concrete shall be mixed and delivered by one of the following:

(a) Central mixed concrete shall be completely mixed in a stationary mixer and transported in a truck agitator, truck mixer at agitating speed, or non-agitating equipment.

(b) Shrink mixed concrete shall be partially mixed in a stationary mixer and the mixing completed during transportation in a truck mixer.

(c) Transit mixed concrete shall be completely mixed in a truck mixer.

The batch ticket for contract dedicated plants and delivery tickets for ready mix plants shall include the assigned CMDP number. The tickets shall be delivered to the Engineer.

When the concrete temperature is 90°F or above, discharge from non-agitating equipment shall be completed within 30 minutes of mixing the water, cement, and aggregates. For concrete temperature below 90°F, discharge from non-agitating equipment shall be completed within 45 minutes of mixing the water, cement, and aggregates. The concrete temperature shall be measured in accordance with ASTM C1064 at the point of delivery.

A watertight cover shall be used for a truck agitator and non-agitating equipment. The concrete shall be incorporated into the paving equipment within 15 minutes of discharge by the truck mixer, truck agitator, or non-agitating equipment.

Discharge from a truck agitator or a truck mixer shall be completed within 90 minutes of mixing the water, cement, and aggregates.

Concrete shall be uniformly mixed when delivered to the job site. The Engineer may conduct additional testing to verify uniformity of the mixture. Additional testing will consist of slump tests taken in accordance with AASHTO T 119 at approximately the 1/4 and 3/4 points of a load. If the slumps differ by more than 1 in. when the average slump is 3 in. or less, or by more than 2 in. when the average slump is greater than 3 in., paving operations may be suspended while the mixing process is jointly reviewed and problems resolved by the Engineer and the Contractor.

Wash water shall not be used as a portion of the mixing water.

When concrete is delivered in transit mixers, additional water to increase the workability of a load may be added within 45 minutes of initial mixing per the QCP. Any addition of water shall be noted on the batch ticket and shall not occur as a continuing operation.

501.15 Weather Limitations

PCCP shall be placed when the ambient temperature is 32°F or rising. It shall not be placed on frozen subgrade or subbase.

When the ambient temperature is at or below 40°F during PCCP placement, the cold weather plan shall be followed as outlined in the QCP in accordance with 501.02.

Continuous temperature monitoring and recording shall be initiated for the day's production when the ambient temperature is at or below 38°F at any time during placement for that day. Once monitoring has started, it shall continue uninterrupted until the opening to traffic strength, in accordance with 501.23, has been achieved. A record of the temperature monitoring shall be furnished to the Engineer when the opening to traffic strength has been achieved.

Prior to attaining opening to traffic strengths in accordance with 501.23, sufficient means shall be taken to prevent the PCCP from freezing.

501.16 Placing Concrete

The batches shall be deposited uniformly requiring minimal rehandling. The plastic concrete shall not be segregated during placement. Dowel bars and assemblies shall not be displaced during placement of concrete.

Concrete shall be thoroughly consolidated against the faces of all forms or adjacent concrete surfaces. Hand placed concrete shall be thoroughly consolidated with the use of a vibrator. Vibrators shall not be operated in any one location to avoid bringing excessive mortar to the surface. Vibrators shall not come in contact with dowel bar assemblies, subgrade, subbase, or forms.

Concrete shall be placed around manholes or similar structures in accordance with 720.

The Contractor shall be responsible for the protection of the existing joints from the intrusion of fresh concrete mortar and for any damage to existing pavement caused by the operation of mechanical equipment. Concrete materials that fall on or are worked into the joints or surface tines of an existing slab, shall be removed immediately.

Concrete shall not be mixed, placed, or finished when the natural light is insufficient, unless an adequate artificial lighting system is operated in accordance with the QCP.

The Contractor shall always have sufficient materials available for the protection of unhardened PCCP from the effects of rain. Covering material such as burlap or polyethylene sheeting shall be provided. When rain appears imminent, paving operations shall stop. All available personnel shall be used to cover the PCCP.

501.17 Blank

501.18 Joints

Joints shall be in accordance with 503.

501.19 Finishing

PCCP shall be finished in accordance with 504.

501.20 Curing

PCCP shall be cured with a white pigmented liquid membrane forming compound selected from the QPL of Liquid Membrane Forming Curing Compounds. Alternative methods of curing shall be as approved by the Engineer. Curing shall be in accordance with 504. For formed PCCP, the sides of the PCCP shall be cured immediately after the forms are removed.

501.21 Form Removal

Forms may be removed as soon as the PCCP has hardened sufficiently to prevent edge spalling or other damage. Form pullers shall not be supported on the PCCP during form removal operations.

501.22 Pavement Inspection

The Contractor and the Engineer will conduct an inspection of the new PCCP for any damage, including freezing or random cracks. The inspection and all necessary repairs shall be completed prior to opening the pavement to non-construction traffic. All random, full-depth cracks in the PCCP shall be corrected in accordance with 503.06. All other damage shall be repaired by approved methods.

501.23 Opening to Traffic

The Contractor shall be responsible for controlling the opening of the PCCP to construction and non-construction traffic and include the procedures in the QCP. Pavement inspection will be completed in accordance with 501.22.

PCCP may be opened to construction vehicles, equipment, and traffic when the flexural strength of the test beams indicates a modulus of rupture of 550 psi or greater. ITM 402 may be used as an alternate method to determine the flexural strength. If adequate strengths are not achieved, an investigation by the Engineer and the Contractor will be conducted to determine if the PCCP is deficient. Resolutions for all deficiencies will be developed at the completion of the investigation. Cracks and joints shall be sealed in accordance with 503.05 and the PCCP cleaned prior to opening to traffic.

501.24 Pavement Corrugations

Pavement corrugations shall be in accordance with 606.

501.25 Pavement Smoothness

Pavement smoothness will be accepted by means of an inertial profiler, a 16 ft straightedge, or a 10 ft straightedge as described below.

(a) Inertial Profiler with Smoothness Pay Adjustments

When a pay item for Inertial Profiler, PCCP is included in the contract, the Contractor shall furnish, calibrate, and operate an approved inertial profiler in accordance with ITM 917 for the acceptance of longitudinal smoothness on the mainline traveled way, including adjacent acceleration or deceleration lanes, where both of the following conditions are met:

1. The posted speed is greater than 45 mph.

2. The traveled way width and slope are constant and is at least 0.5 mi in length.

The profiles and International Roughness Index, IRI, results including areas of localized roughness shall become the property of the Department. The inertial profiler shall remain the property of the Contractor.

The project area will be divided into individual smoothness sections measuring 0.1 mi in length for each lane. The paving exceptions and areas exempt from inertial profiler operation will be in accordance with ITM 917.

If the posted speed limit for an entire smoothness section is less than or equal to 45 mph, the section will be exempt from Inertial Profiler operation and the smoothness within the section will be accepted in accordance with 501.25(b).

If the posted speed limit is greater than 45 mph for a portion of a smoothness section and is less than or equal to 45 mph for the remainder, the section smoothness acceptance will be as follows:

1. By inertial profiler for the portion of the section with a posted speed limit greater than 45 mph.

2. In accordance with 501.25(b) for the portion of the section with a posted speed limit less than or equal to 45 mph.

(b) 16 ft Straightedge

The Contractor shall furnish and operate a 16 ft straightedge in accordance with 306.03(d) and as described below. The 16 ft straightedge shall be used to measure smoothness along the direction of mainline traffic.

Locations on the pavement surface scraped by the straightedge shall be marked. The pavement shall be corrected in accordance with 501.25(e) to meet the required tolerance. For existing utility and manhole castings that required no grade adjustment, the tolerance may be adjusted after being reviewed and approved by the Engineer.

For contracts which include the Inertial Profiler, PCCP pay item, the 16 ft straightedge or the Inertial Profiler simulating the 16 ft straightedge shall be used to measure longitudinal smoothness at the following locations:

1. All mainline traveled way lanes shorter than 0.5 mi.
2. All mainline traveled way lanes at locations exempted from inertial profiler operation in accordance with ITM 917.
3. All mainline traveled way lanes within smoothness sections with posted speed limits less than or equal to 45 mph throughout the entire section length.
4. All tapers.
5. All ramps.
6. All turn lanes, including bi-directional left turn lanes shorter than 0.5 mi.
7. All acceleration and deceleration lanes associated with ramps with posted speeds of 45 mph or less.
8. All shoulders.
9. All intersections with significant change in cross slope.

For contracts where the inertial profiler is not used for smoothness acceptance, the 16 ft straightedge shall be used to measure longitudinal smoothness. Measurement with the 16 ft straightedge shall include the above locations, all mainline traveled way lanes and ramps with posted speeds greater than 45 mph, and on ramp acceleration or deceleration lanes.

(c) 10 ft Straightedge

The 10 ft straightedge will be in accordance with 306.03(d). The 10 ft straightedge will be used to check transverse slopes across traveled way lanes and shoulders, approaches, and crossovers. When the 10 ft straightedge is used, the pavement variations shall be corrected to 1/8 in. or less.

(d) Areas of Localized Roughness, ALR

At locations where the inertial profiler is used, all areas having a localized

roughness in excess of 160 in./mi utilizing continuous IRI with a 25 ft window shall be corrected subject to approval by the Engineer. After ALRs have been identified, a grinding simulation shall be performed to estimate whether the ALR can be corrected to an IRI value of less than 160 in./mi with no more than a 1/4 in. maximum grind depth at any spot. If such correction is not possible, then an ALR with an IRI value of less than 190 in./mi can remain uncorrected if approved by the Engineer, and an ALR with an IRI value greater than 190 in./mi shall require full depth removal and replacement of sufficient area to meet specifications.

In addition, if there is only one ALR in any two-lane mile section, then no smoothness correction will be required if the ALR does not exceed 190 in./mi and the overall smoothness in accordance with 501.25(d) of the two-lane mile section does not require any corrective action. A two-lane mile section will start one mile before the ALR and end one mile after the ALR in order that all two-lane mile sections will have, at most, one ALR each.

(e) Smoothness Section Correction

Pavement smoothness variations outside specified tolerances shall be corrected by grinding with a groove type cutter or by replacement. Grinding will not be allowed until the PCCP is 10 days old and flexural strength testing yields a modulus of rupture of 550 psi or greater. The grinding of the pavement to correct the profile shall be accomplished in either the longitudinal or the transverse direction. The PCCP texture after grinding shall be uniform. If the grinding operation reduces the tining grooves to a depth of less than 1/16 in. and the longitudinal length of the removal area exceeds 15 ft, or two or more areas are within 30 ft of each other, the PCCP shall be retextured in accordance with 504.03.

The width of the corrected area may be partial or full lane width, depending on the respective wheel path profiles. After the corrective action is complete, the inertial profiler shall be operated throughout the entire affected smoothness section to verify the adequacy of the corrective action.

At locations where the 16 ft straightedge is used, the pavement variations shall be corrected to 1/4 in. or less.

501.26 Pavement Thickness

PCCP thickness shall be determined after all corrective grinding. The Contractor shall obtain cores at the locations determined by the Engineer in accordance with ITM 802. Cores, 4 in. in diameter, shall be taken in the presence of the Engineer for the full depth of the PCCP. The Engineer will take immediate possession of the cores. Cores shall not be taken within 6 in. of the edge of pavement, within 3 in. of longitudinal joints, within 2 ft of D-1 contraction joints, or within 5 ft of a transverse construction joint. Cores shall be taken and measured in accordance with ITM 404.

All core holes shall be filled with PCC or rapid setting patch material within 24 h of drilling.

The width of PCCP, subject to review in accordance with 105.03, shall be the width of pavement lane in which the deficiency occurs. Pavement that has been replaced shall be investigated for thickness.

The thickness of the PCCP for each sublot shall be the average lengths of both cores from the sublot. Calculations shall be to the nearest 0.1 in.

501.27 Tolerance

Plastic unit weight, water/cementitious ratio, modulus of rupture, and air content measurements will be performed during PCCP operations.

(a) Plastic Unit Weight

Sublots shall not vary by more than ±3.0% from the target unit weight. A stop paving order will be issued if the plastic unit weight exceeds ±3.0% from the target plastic unit weight. Paving operations shall not resume until satisfactory changes are made or an alternate CMDP is used.

Calculations for the plastic unit in lb/cu yd will be made and reported to the nearest figure in the tenth.

(b) Water to Cementitious Ratio

The weekly water to total cementitious materials ratio shall not vary more than ±0.030 of the target value or exceed the maximum allowed for the appropriate mixture in accordance with 501.05. A stop paving order will be issued if the test results exceed these values. Paving operations shall not resume until satisfactory changes are made or an alternate CMDP is used.

Calculations for water to cementitious ratio will be made and reported to the nearest figure in the third decimal place.

(c) Flexural Strength

Average lot values for modulus of rupture of 570 psi and above shall be achieved. Price adjustments for values outside the tolerance limits will be in accordance with 501.28.

Calculations for modulus of rupture in psi will be made and reported to the nearest 5.0 psi.

(d) Air Content

The average lot air content values shall not vary more than -1.2% to +2.2% from the 7.0% target air content. The range of sublot air content values shall not exceed 2.5%. Price adjustments for values outside the tolerance limits or range will be in accordance with 501.28.

Calculations for air content percentage will be made and reported to the nearest figure in the first decimal place.

501.28 Pay Factors

When the PCCP measurements for air content, air content range, modulus of rupture, smoothness, and thickness exceed the allowable tolerances, pay factors will be determined. The pay factors will be used to calculate a quality assurance adjustment quantity for the lot.

The adjustment for modulus of rupture, air content, air content range, thickness, and smoothness will be calculated as follows:

$$q = L \times U \times (P - 1.00)$$

where:

q = quality assurance adjustment quantity
L = lot quantity
U = unit price for QC/QA-PCCP, $/sq yd
P = pay factor.

For sublot thickness determination:

$$q_T = l_T \times U \times (P - 1.00)$$

where:

q_T = quality assurance adjustment quantity
l_T = sublot quantity for thickness
U = unit price for QC/QA-PCCP, $/sq yd
P = pay factor.

The quality assurance adjustment points for smoothness, Qs, will be calculated in accordance with 501.28(d).

The total quality assurance adjustments will be calculated as follows:

$$Q_T = \Sigma (q_{T1} + q_{T2} + q_{T3}), \text{ and}$$

$$Q = \Sigma (q_F + q_A + q_R + Q_T) + Q_S$$

where:

Q = total quality assurance adjustment quantity
Q_S = quality assurance adjustment for smoothness
q_F = lot quality assurance adjustments for modulus of rupture from flexural strength testing
Q_T = lot quality assurance adjustments for thickness
q_A = lot quality assurance adjustments for air content
q_R = lot quality assurance adjustments for range.

If the Contractor is not required to remove the pavement or take other corrective actions, quality assurance adjustments of the lot will be assessed as determined by the Department's Division of Materials and Tests.

(a) Modulus of Rupture

When test results for modulus of rupture from flexural strength testing exceed the allowable tolerance, a pay factor will be assessed as follows:

1. Lots

LOT AVERAGE MODULUS OF RUPTURE	
Psi	Pay Factors
570 and above	1.00
565 – 569	0.98
560 – 564	0.96
555 – 559	0.94
550 – 554	0.92
545 – 549	0.89
540 – 544	0.86
535 – 539	0.83
525 – 534	0.78
515 – 524	0.72
514 or less	*
* The PCCP will be reviewed and a determination rendered as a failed material in accordance with 105.03. The PCCP may be subject to removal and replacement or left in place with reduced or no payment.	

2. Sublots

If an individual sublot value is less than 500 psi, the PCCP will be reviewed and a determination rendered as a failed material in accordance with 105.03. For a sublot completely removed, the sublot test value from the replacement sublot will replace the original test value.

(b) Air Content

When test results for air content exceed the allowable tolerance or range, a pay factor will be assessed as follows:

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1. Lots

LOT AVERAGE AIR CONTENT	
Percent, %	Pay Factors
> 9.8	*
9.7 – 9.8	0.85
9.5 – 9.6	0.95
9.3 – 9.4	0.99
5.8 – 9.2	1.00
5.7	0.93
5.6	0.90
5.5	0.85
5.4	0.79
< 5.4	*
* The PCCP will be reviewed and a determination rendered as a failed material in accordance with 105.03. The PCCP may be subject to removal and replacement or left in place with reduced or no payment.	

LOT RANGE FOR AIR CONTENT	
Percent, %	Pay Factors
0.0 – 2.5	1.00
2.6 – 3.0	0.99
3.1 – 3.5	0.97
> 3.5	*
* The PCCP will be reviewed and a determination rendered as a failed material in accordance with 105.03. The PCCP may be subject to removal and replacement or left in place with reduced or no payment.	

2. Sublots

If a sublot value is less than 5.5% or greater than 10.0%, the PCCP will be reviewed and a determination rendered as a failed material in accordance with 105.03.

For a sublot completely removed, the sublot test value from the replacement sublot will replace the original test value.

(c) Thickness

When test results for pavement thickness do not meet the specified thickness, a pay factor will be assessed as follows:

SUBLOT PAY FACTORS FOR THICKNESS	
Average Core Depth, ACD Design Depth, DD	
ACD minus DD	Pay Factor
> +0.5 in.	1.05
+0.3 in. to +0.5 in.	1.02
±0.2 in.	1.00
−0.3 in. to −0.5 in.	0.96
−0.6 in. to −0.7 in.	0.90
−0.8 in. to −1.0 in.	0.80
< −1.00 in.	*
* The PCCP will be reviewed and a determination rendered as a failed material in accordance with 105.03. The PCCP may be subject to removal and replacement or left in place with reduced or no payment.	

(d) Smoothness

Smoothness pay adjustments will only be applied when the smoothness is measured by an inertial profiler in accordance with 501.25(a).

The Mean Roughness Index, MRI, will be determined utilizing a fixed interval for each lane for each 0.1-mile section of paving. The MRI for a 0.1-mile section is the average of the IRI of the two-wheel paths. A Quality Assurance Pay Factor, PFs, for smoothness will apply to the planned thickness of the PCCP. The quality assurance adjustment for each section will be calculated by the following formula:

$$qs = (PFs - 1.00) \times A \times U$$

where:

qs = quality assurance adjustment for smoothness for one section
PFs = pay factor for smoothness
A = area of the section, sq yd
U = unit price for the material, $/sq yd.

The quality assurance adjustment for smoothness, Qs, for the contract will be the total of the quality assurance adjustments for smoothness, qs, on each section by the following formula:

$$Qs = \sum qs$$

When smoothness is measured by an inertial profiler, payment adjustments will be made for any 0.1-mile section based on the initial MRI generated and in accordance with the following table. The MRI pay factors for smoothness will be determined prior to any required smoothness correction in accordance with 510.25(d). Smoothness

correction, if required, shall be in accordance with 501.25(d). For any 0.1-mile sections containing transverse construction joints that are required as per the planned maintenance of traffic, the pay factors for smoothness may be determined after corrective action at the discretion of the Contractor. Regardless of the tabulated value, the maximum pay factor for a smoothness section where corrective action has been performed will be 1.00.

PAY FACTORS FOR SMOOTHNESS Posted Speed greater than 45 mph	
MRI, in./mi	Pay Factor, PF_s
over 0 to 35	1.08
over 35 to 40	1.07
over 40 to 45	1.05
over 45 to 50	1.03
over 50 to 55	1.02
over 55 to 60	1.01
over 60 to 70	1.00
over 70 to 75	0.99
over 75 to 80	0.98
over 80 to 85	0.96
over 85 to 90	0.95
over 90	PF_s will be 0.95 and the section shall be corrected to 90 or less.

501.29 Contractor Disputing Acceptance Test Results

(a) PCCP Materials

If the Contractor does not agree with the acceptance test results, a request may be made in writing for additional testing of that sublot or lot. The request shall include applicable QC test results showing acceptable quality results and shall be submitted within five calendar days of receipt of the Department's written results for that lot. The request will be reviewed in accordance with 105.03.

1. Modulus of Rupture

Disputes over the acceptance test results will not be considered unless QC test results for modulus of rupture obtained from flexural strength testing indicate greater than a 50 psi difference between the Department's and the Contractor's test results. Once additional testing has been approved, the Contractor shall obtain cores, as directed, in the presence of the Engineer.

The Engineer will determine the location of the cores within the disputed sublots and adjacent sublots using the same CMD. The location of the cores will be at the center of a lane at the acceptance sample location. Cores shall not be taken over dowels or within 5 ft of a header. Two cores shall be taken in each sublot for the full depth of

pavement and shall be 4 in. in diameter. All core holes shall be filled with portland cement concrete within 24 h of drilling. If adjacent sublots were produced using different CMDs, the matter will be reviewed as a failed material in accordance with normal Department practice.

Each core will be tested for split tensile strength in accordance with ASTM C496. The cores will be submerged in lime saturated water prior to testing for a minimum of 40 h.

The average core split tensile strength will be determined for the disputed sublots and adjacent sublots. Modulus of rupture will be calculated as follows:

$$F_D = S_D \times \left[\frac{F_{A1}}{2S_{A1}} + \frac{F_{A2}}{2S_{A2}} \right]$$

where:

F_D = modulus of rupture of the disputed sublot
F_{A1} = modulus of rupture of the previous adjacent sublot
F_{A2} = modulus of rupture of the subsequent adjacent sublot
S_D = split tensile strength of the disputed sublot
S_{A1} = split tensile strength of the previous adjacent sublot
S_{A2} = split tensile strength of the subsequent adjacent sublot.

2. Air Content

Disputes over the acceptance test results will not be considered unless QC test results indicate greater than a 0.5% difference between the Department's and the Contractor's tests. Once additional testing has been approved, the Contractor shall obtain core as directed in the presence of the Engineer.

The Engineer will determine the location of the core within the disputed sublot. The location of the core will be at the center of a lane at the acceptance sample location. A core shall not be taken over dowels or within 5 ft of a header. One 4 in. diameter full depth core shall be taken from the pavement for each sublot disputed. All core holes shall be filled with PCC or rapid setting patch material within 24 h of drilling.

The air content for a sublot will be the hardened concrete air content determined from the core in accordance with ITM 401. When ACBF aggregates are used, the hardened concrete air content will be determined in accordance with ASTM C457.

(b) Smoothness

The Department will perform annual QA reviews of a portion of each Contractor's MRI results in accordance with ITM 917. The Contractor's results will be compared to the Department's. The Department will notify the Contractor of unacceptable results in a timely manner. If the Contractor disputes the results, the Department will allow a dispute period of 14 days during which time the Contractor shall submit a written

request and additional MRI results for Department review. If the Contractor's additional MRI results do not agree with the Department's results, the Contractor shall perform a side-by-side evaluation. The Department's results will be utilized for smoothness payment in place of the Contractor's results unless the Contractor's additional MRI results are determined to be acceptable for payment. Sections where corrective action has taken place prior to the Department's data collection will utilize the Contractor's initial results prior to corrective action for payment.

501.30 Method of Measurement

QC/QA-PCCP will be measured by the square yard of the thickness specified. The area of QC/QA-PCCP will be the planned width of the pavement multiplied by the length of the pavement, or as directed in writing. The width of the pavement will be as shown on the typical cross-section of the plans. The length of the pavement will be measured parallel to the surface of the pavement along the centerline of the roadway or ramp, excluding paving exceptions as shown on the plans.

Milled pavement corrugations will be measured in accordance with 606.02.

501.31 Basis of Payment

The accepted quantities of QC/QA-PCCP will be paid for at the contract unit price per square yard for the thickness specified, complete in place.

Payment for furnishing, calibrating, operating the inertial profiler, and furnishing IRI profile information will be made at the contract lump sum price for Inertial Profiler, PCCP.

Furnishing and operating the 16 ft straightedge shall be included in the cost of other pay items within this section.

Adjustments to the contract payment due to measurements for modulus of rupture, thickness, air content, range and smoothness will be included in a quality assurance adjustment pay item in accordance with 109.05.1.

Milled pavement corrugations will be paid for in accordance with 606.03.

Payment for pavement thickness determinations will be made at the contract lump sum price for coring, PCCP. A change order in accordance with 109.05 will be developed to adjust the cost of coring when the final QC/QA-PCCP quantity differs from the bid quantity by more than 2,400 sq yds. This adjustment covers the cost of cores for the adjusted quantity of QC/QA-PCCP. The adjustment, plus or minus, will be based on the difference in the number of sublots, rounded to the nearest full sublots, times $100.

Payment will be made under:

Pay Item	Pay Unit Symbol
Coring, PCCP	LS
Inertial Profiler, PCCP	LS
QC/QA-PCCP, _____ in. thickness	SYS

The cost of trial batch demonstrations shall be included in the cost of PCCP.

The price of Inertial Profiler, PCCP will be full compensation regardless of how often the inertial profiler is used or how often the IRI is determined.

The cost of corrections for pavement smoothness and retexturing shall be included in the cost of QC/QA-PCCP.

The cost of coring and refilling of the pavement holes for disputes shall be included in the cost of QC/QA-PCCP.

The cost of temperature monitoring and recording during cold weather placement shall be included in the cost of QC/QA-PCCP.

Traffic control for disputes shall be supplied with no additional payment.

Removal and replacement of QC/QA-PCCP damaged by freezing shall be with no additional payment.

SECTION 502 – PORTLAND CEMENT CONCRETE PAVEMENT, PCCP

502.01 Description

This work shall consist of portland cement concrete pavement, PCCP, placed on a prepared subgrade or subbase in accordance with 105.03.

MATERIALS

502.02 Materials

Materials shall be in accordance with the following:

Admixtures	912.03
Concrete Coarse Aggregate, Class AP	904.03, ITM 226
Fine Aggregate, Size No. 23	904.02
Coal Ash	901.02
Liquid Membrane Forming Compound	912.01(e)
Portland Cement	901.01(b)
Rapid Setting Patch Materials	901.07
Silica Fume	901.04

Slag Cement.....901.03
Water.....913.01

502.03 Concrete Mix Design

A concrete mix design submittal, CMDS, shall be in accordance with 502.04. The CMDS shall be submitted to the DTE. The CMDS shall be submitted a minimum of seven calendar days prior to production utilizing the Department provided spreadsheet and shall include the following:

(a) a list of all ingredients
(b) the source of all materials
(c) the fine to total aggregate ratio
(d) the absorption of the aggregates
(e) the SSD bulk specific gravity of the aggregates
(f) the specific gravity of all SCMs
(g) the batch weights
(h) the names of all admixtures
(i) the admixture dosage rates and the manufacturer's recommended range.

The aggregate blend on the CMDS may produce an optimized aggregate gradation in accordance with the Department provided spreadsheet. If an optimized aggregate gradation is used, it shall consist of, at a minimum, one concrete coarse aggregate and one fine aggregate, No. 23. One additional Class A or higher intermediate-sized coarse aggregate may be included if approved by the Engineer.

The absolute volume of the mix design shall be 27.0 cu ft at the design air content of 6.5%.

Production shall not commence until the DTE has issued the concrete mix design for production, CMDP.

Any of the following changes or adjustments to a CMDP shall require a new CMDS to be submitted to the DTE, referencing the original CMDP. The new CMDS shall be submitted to the DTE utilizing the Department provided spreadsheet a minimum of one business day prior to production.

Production shall not commence until the DTE has issued the CMDP.

(a) Cement source or type.
(b) SCM source or type.
(c) Aggregate source or type.
(d) Admixture source or type.
(e) Addition or deletion of an admixture.
(f) Proportioning of the concrete in accordance with 502.04 as follows:

1. cement content or cement reduction

2. SCM to cement substitution ratio
3. target water/cementitious ratio
4. proportion of aggregate by weight exceeding ±2%.

A CMDP in accordance with either 501.05 or 502.04 from a previous contract may be submitted to the DTE for consideration for use on the current contract. The DTE will notify the Contractor when the review is complete and if the previously used CMDP can be used on the current contract.

502.04 Concrete Mix Criteria

Chemical admixtures Type A, Type B, Type C, Type D, Type E, and Type F may be allowed if shown on the CMDP. The supplied concrete mix shall include one of the following water reducing admixtures: Type A, Type D, Type E, or Type F.

(a) Portland Cement Concrete

The CMD shall produce workable concrete mixtures, with the minimum amount of water, and having the following properties.

Targets for the CMD:

Portland cement content	564 lb/cu yd[A]
Minimum water/cementitious ratio	0.340[B]
Maximum water/cementitious ratio	0.435[B]
Maximum portland cement reduction for slag cement replacement	30%
Slag cement/portland cement substitution ratio	1.00 by weight
Maximum cement reduction for coal ash replacement	20%
Coal ash/portland cement substitution ratio	1.25 by weight
Air Content	6.5%
Minimum modulus of rupture	570 psi at 7 days[C]
Relative Yield	1.00

Field Acceptance Properties:

Minimum water/cementitious ratio	0.320[B]
Maximum water/cementitious ratio	0.450[B]
Slump, formed	2 to 6 in.
Slump, slipformed	1.25 to 3 in.
Air Content	5.0% to 8.0%
Minimum modulus of rupture	570 psi at 7 days[C]
Relative Yield	0.98 to 1.02

[A] The target cement content during production shall not be adjusted from the value stated on the CMDP.

[B] The water cementitious ratio during production shall not deviate more than 0.020 from the target stated in the CMDP and shall not fall outside the limits above.

[C] Beams shall be standard cured in a water tank in accordance with AASHTO T 23 and 505.01(a). The water does not need to be saturated with calcium hydroxide.

Class C concrete in accordance with 702 using Class AP coarse aggregate may be substituted in PCCP.

Blended portland pozzolan cements, coal ash, or slag cement may only be incorporated in the concrete mix when the ambient temperature is above 50°F during the entire placement period. If Type IP, Type IP-A, Type IS, or Type IS-A cements are to be used, the minimum portland cement content shall be increased to 598 lb/cu yd. The use of coal ash or slag cement will not be allowed when blended cement types IP, IP-A, IS, or IS-A are used.

(b) High-Early Strength Concrete

Patching concrete in accordance with 506.04(b) shall be used.

502.05 Job Control

Control of PCCP for air content, slump, or relative yield will be determined from tests performed by the Engineer in accordance with 505. Concrete and necessary labor for sampling shall be furnished as required by the Engineer. Testing will be in accordance with the Frequency Manual.

The Engineer will notify the Contractor when test results for air content, slump, or relative yield are outside the requirements of 502.04. Rounding will be in accordance with 109.01(a). The Contractor shall adjust the mixture such that it is in accordance with 502.04.

CONSTRUCTION REQUIREMENTS

502.06 General

Equipment for PCCP shall be in accordance with 508.

Aggregate stockpiles shall be located in well drained areas to prevent the soil from pumping into and contaminating the aggregate that is to be used in PCCP. Stockpiles shall be built in layers not to exceed 6 ft. Upper layers shall be prevented from spilling onto the lower layers.

Aggregate stockpiles shall be worked to minimize segregation and maintain uniform moisture content. Aggregates which have become contaminated shall not be used.

The water measuring device will be checked under actual working conditions or at any other time deemed necessary. All labor and equipment required for calibrating and checking shall be furnished.

The volume of the batched concrete shall not exceed the manufacturer's standard

rating for the concrete mixer.

502.07 Preparation of Subgrade

The subgrade shall be shaped to the required grade and section, free from all ruts, corrugations, or other irregularities, and uniformly compacted in accordance with 207. Surfaces on which a mixture is placed shall be free from objectionable or foreign materials at the time of placement.

502.08 Preparation of Subbase

Subbase, if required, shall be placed and shaped to the required grade and section in accordance with 302. Construction traffic shall not be allowed on the aggregate drainage layer of the subbase, except where PCCP placement is restricted. Exceptions shall be submitted for approval.

502.09 Placement

Placement of PCCP shall be by the slipformed or formed methods with equipment specified in 508.04. The subgrade or subbase shall be uniformly moist at the time of PCCP placement. Excessively dry subgrade or subbase shall be sprinkled with water.

If the slip-form method is used the subgrade or subbase shall firmly support the paving equipment to construct the specified alignment and grade. The slip-form paver shall be operated with as nearly a continuous forward movement as possible. If it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped. Edge slump of PCCP shall not exceed 1/4 in.

When the slip-form method is used, the Contractor shall have metal or wood forms available for protection of the PCCP edges should excessive edge slump occur.

If forms are used, they shall be firmly supported by the subbase or subgrade for the entire length of the form at the specified alignment and grade. The alignment of the forms shall not deviate more than 1/4 in. in the horizontal direction from the planned PCCP width for tangent sections.

Forms shall be staked into place with a minimum of three pins for each 10 ft section. A pin shall be placed at each side of every joint. Form sections shall be locked tightly and be free from play or movement in any direction. No excessive settlement or springing of forms under the finishing machine will be allowed. Forms shall be cleaned and oiled prior to the placing of concrete.

Forms shall be kept a minimum of 500 ft ahead of concrete placement when distance allows. Any material displaced during form setting operations shall be thoroughly compacted. If material under the forms becomes unstable before concrete is placed, the forms shall be removed, the grade corrected, and the forms reset.

502.10 Concrete Mixing and Transportation

Concrete mixing and transportation shall be completed by central mixed, shrink

mixed, or transit mixed methods. The minimum batch of concrete shall be 2 cu yds. When the concrete temperature is 90°F or above, discharge from non-agitating equipment shall be completed within 30 minutes of mixing the water, cement, and aggregates. For concrete temperature below 90°F, discharge from non-agitating equipment shall be completed within 45 minutes of mixing the water, cement, and aggregates. The concrete temperature will be measured in accordance with ASTM C1064 at the point of delivery. Discharge from a truck agitator or a truck mixer shall be completed within 90 minutes of mixing the water, cement, and aggregates.

Concrete shall be uniformly mixed when delivered to the job site. Batch tickets for each load of PCC shall indicate the weight of cement, SCM, aggregates, volume or weight of water, and the type and volume of admixtures. The weight of the cement shall be within 1% of the CMDP, the saturated surface dry weight of the aggregates shall be within 2% of the CMDP, and the volume or weight of water shall be within 1% of the required amount.

The Engineer may conduct additional testing to verify uniformity of the mixture. Additional testing will consist of slump tests taken in accordance with AASHTO T 119 at approximately the 1/4 and 3/4 points of a load. If the slumps differ by more than 1 in. when the average slump is 3 in. or less, or by more than 2 in. when the average slump is greater than 3 in., paving operations may be suspended while the mixing process is jointly reviewed and problems resolved by the Engineer and the Contractor.

Wash water shall not be used as a portion of the mixing water.

When concrete is delivered in transit mixers, additional water to increase the workability of a load may be added within 45 minutes of initial mixing. Any addition of water shall be noted on the batch ticket and shall not occur as a continuing operation.

Stationary mixers shall be operated at the manufacturer's recommended drum speed. Batches shall not exceed the nominal capacity of the mixer.

(a) Central Mixed Concrete

Central mixed concrete shall be completely mixed in a stationary mixer and transported in a truck agitator, truck mixer at agitating speed, or non-agitating equipment.

Mixing for central mixed concrete shall be no less than 60 s per batch. The mixing time shall be measured from the time all cement and aggregates are in the drum. The batch shall be so discharged into the mixer that some of the water enters in advance of the cement and aggregates. All required water shall be in the drum by the end of the first quarter of the specified mixing time.

If a truck mixer or truck agitator is used for transportation, the concrete shall be agitated at the agitation speed designated by the manufacturer.

(b) Shrink Mixed Concrete

Shrink mixed concrete shall be partially mixed in a stationary mixer and the mixing completed at the plant in a truck mixer.

The time in a stationary mixer for shrink mixed concrete may be reduced to approximately 30 s. Mixing shall then be completed in a truck mixer at the plant by 50 to 100 revolutions of the drum at the mixing speed designated by the manufacturer. Agitation during transportation shall be at the agitation speed designated by the manufacturer.

(c) Transit Mixed Concrete

Transit mixed concrete shall be completely mixed and transported in a truck mixer.

Mixing for a truck mixer loaded to rated capacity shall be 70 to 100 revolutions of the drum at the mixing speed, but not less than the number of revolutions recommended by the manufacturer. Discharge shall be completed prior to 300 revolutions of the drum.

502.11 Weather Limitations

PCCP shall not be placed on a frozen subgrade or subbase. PCCP operations shall not begin until the ambient temperature is 35°F and rising. PCCP operations shall be discontinued when the ambient temperature is descending and is 40°F or below. PCCP operations may occur outside these temperatures when authorized in writing. Regardless of placement temperature, sufficient means shall be taken to prevent the PCCP from freezing prior to attaining opening to traffic strengths in accordance with 502.18. Any PCCP damaged by freezing shall be removed and replaced.

When concreting is authorized during cold weather, the aggregates may be heated by either steam or dry heat prior to being placed in the mixer. The apparatus used shall heat the mass uniformly and prevent the occurrence of overheated areas which might damage the materials. Unless authorized, the temperature of the mixed concrete shall not be less than 50°F and not more than 80°F at the time of placement.

When the water or the aggregates are heated, they shall be a minimum of 70°F or a maximum of 150°F. When either aggregates or water are heated to above 100°F, they shall be combined in the mixer before the cement is added.

502.12 Placing Concrete

The batches shall be deposited uniformly requiring minimal rehandling. The plastic concrete shall not be segregated during placement. Rakes shall not be used to handle plastic concrete. Dowel bars and assemblies shall not be displaced during placement of concrete. Plastic concrete shall not be contaminated with earth or other foreign matter.

Concrete shall be thoroughly consolidated against the faces of all forms or adjacent concrete surfaces. Hand placed concrete shall be thoroughly consolidated with the use of a vibrator. Vibrators shall not be operated in any one location to avoid bringing excessive mortar to the surface. Vibrators shall not come in contact with dowel bar assemblies, subgrade, subbase, or forms.

Concrete shall be placed around manholes or similar structures in accordance with 720.

The Contractor shall be responsible for the protection of the existing joints from the intrusion of fresh concrete mortar and for all damage to existing pavement caused by the operation of mechanical equipment. Concrete materials that fall on or are worked into the joints or surface tines of an existing slab shall be removed immediately.

Concrete shall not be mixed, placed, or finished when the natural light is insufficient, unless an artificial lighting system in accordance with 702.26 is operated.

The Contractor shall always have sufficient materials available for the protection of unhardened PCCP from the effects of rain. Covering material such as burlap or polyethylene sheeting shall be provided. When rain appears imminent, paving operations shall stop. All available personnel shall be used to cover the PCCP.

502.13 Joints

Joints shall be in accordance with 503.

502.14 Finishing

PCCP shall be finished in accordance with 504.

502.15 Curing

PCCP shall be cured with a white pigmented liquid membrane forming compound selected from the QPL of Liquid Membrane Forming Curing Compounds. Alternative methods of curing shall be as approved by the Engineer. Curing shall be in accordance with 504. For formed PCCP, immediately after the forms are removed, the sides of the PCCP shall be cured.

502.16 Form Removal

Forms may be removed as soon as the PCCP has hardened sufficiently to prevent edge spalling or other damage. Form pullers shall not be supported on the PCCP during form removal operations.

502.17 Pavement Inspection

The Contractor and the Engineer will conduct an inspection of the new PCCP for any damage, including freezing or random cracks. The inspection and all necessary repairs shall be completed prior to opening the pavement to non-construction traffic. All random, full-depth cracks in the PCCP shall be corrected in accordance with

503.06. All other damages shall be repaired by approved methods.

502.18 Opening to Traffic

PCCP may be opened to equipment and traffic when the flexural strength of the test beams indicates a modulus of rupture of 550 psi or greater. ITM 402 may be used as an alternate method to determine the flexural strength. If adequate strengths are not achieved, an investigation by the Engineer and the Contractor will be conducted to determine if the PCCP is deficient. Resolutions for all deficiencies will be developed at the completion of the investigation. Prior to opening to traffic, cracks and joints shall be sealed in accordance with 503.05 and the PCCP shall be cleaned.

502.19 Pavement Corrugations

Pavement corrugations shall be in accordance with 606.

502.20 Pavement Smoothness

Pavement smoothness will be in accordance with 501.25 except inertial profiler requirements will not apply.

502.21 Pavement Thickness

PCCP thickness shall be determined after all corrective grinding. The Contractor shall obtain cores at the locations determined by the Engineer in accordance with ITM 802. Cores, 4 in. in diameter, shall be taken in the presence of the Engineer for the full depth of the PCCP. The Engineer will take immediate possession of the cores. Cores shall not be taken within 2 ft of the edge of PCCP, over dowels, or within 5 ft of a transverse construction joint. Cores shall be taken and measured in accordance with ITM 404. All core holes shall be filled with PCC or rapid setting patch material within 24 h of drilling.

If a core measurement reveals that the pavement is more than 1/2 in. deficient in thickness, additional cores shall be drilled at 20 ft intervals on each side of the original core. These additional cores shall be on a line which passes through the original core and parallel to the centerline of the pavement. The drilling shall continue in both directions at 20 ft intervals until two successive cores indicate a thickness deficiency of 1/2 in. or less, or where cores can no longer be drilled in the new PCCP.

If a core indicates a thickness deficiency of more than 1 in. and two cores drilled adjacent at 20 ft intervals indicate a thickness deficiency of not more than 1 in., additional cores shall be drilled at 5 ft intervals on each side of the initial core. The drilling shall continue in both directions at 20 ft intervals until two successive cores indicate a thickness deficiency of 1/2 in. or less, or where cores can no longer be drilled in the new PCCP.

When a single core indicates a thickness deficiency of more than 1 in., or if two or more adjacent cores indicate a thickness deficiency of more than 1/2 in., the investigation will be expanded to include adjoining PCCP. The additional cores shall be taken from the adjoining traffic lanes or shoulders at the same station at which the

first core or cores indicated the deficiency, whether the lane was paved at the same time or not.

The width of PCCP, subject to review in accordance with 105.03, shall be the width of pavement lane in which the deficiency occurs. Pavement that has been replaced shall be investigated for thickness.

(a) Sections

The quantity of PCCP for each pay item will be defined as a section. The section will be divided into subsections of 1,200 sq yds. Sections less than 1,200 sq yds shall not be cored. A minimum of one core shall be drilled at a random location within each subsection. A section greater than or equal to 1,200 sq yds shall have a minimum of four cores drilled. Partial subsections shall not be cored unless otherwise directed. Widening of 3 ft or less shall not be cored unless otherwise directed.

Formed drives shall not be cored unless otherwise directed. Verification of the required pavement depth on formed drives shall be checked in the presence of the Engineer prior to pouring, by making stringline measurements every 10 ft across the width of the drive. Any location deficient in thickness by 1/4 in. or more shall be corrected prior to placing PCCP.

(b) Average PCCP Thickness

The thickness of the PCCP for each section shall be the average lengths of all cores from the section. However, no cores shall be included from areas for which no payment will be made. Where PCCP has been removed and replaced, the initial core lengths will be discarded and the core lengths of the replaced PCCP will be substituted. Any core measurements exceeding the specified PCCP thickness by more than 1/2 in. will be recorded as the specified PCCP thickness plus 1/2 in. Calculations shall be to the nearest 0.1 in.

(c) PCCP Adjusted Payment

If the average PCCP thickness is equal to or greater than the specified thickness, no adjustments will be made. If an average PCCP thickness is less than the specified thickness by up to 1/2 in., payment for that section will be adjusted in accordance with the following:

$$Q_T = Q \times U \times (1 - M^2/S^2)$$

where:

Q_T = quality assurance assessment for thickness
Q = placed quantity of the PCCP section
M = average PCCP thickness of the section
S = specified PCCP thickness of the section
U = unit bid price.

(d) PCCP Non-Payment

Where two adjacent cores indicate a thickness deficiency of more than 1/2 in., no payment will be made unless the PCCP is removed and replaced. Payment for PCCP with non-adjacent cores indicating a thickness deficiency of more than 1/2 in. will be in accordance with 502.21(c).

The limits of non-payment shall extend from deficient core to the transverse joint location nearest the first additional core indicating a thickness deficiency of less than 1/2 in.

(e) PCCP Removal

Where two adjacent cores indicate a thickness deficiency of more than 1 in., the PCCP shall be removed and replaced. Non-adjacent cores indicating a thickness deficiency of more than 1 in. do not require removal and replacement.

The limits of removal and replacement shall extend from the deficient core to the transverse joint location nearest the first additional core indicating a thickness deficiency of less than 1/2 in.

502.22 Method of Measurement

PCCP will be measured by the square yard of the thickness specified. The area of PCCP will be the planned width of the pavement multiplied by the length of the pavement, or as directed in writing. The width of the pavement will be as shown on the typical cross-section of the plans. The length of the pavement will be measured parallel to the surface of the pavement along the centerline of the roadway or ramp, excluding paving exceptions as shown on the plans.

Milled pavement corrugations will be measured in accordance with 606.04.

502.23 Basis of Payment

The accepted quantities of PCCP will be paid for at the contract unit price per square yard for the thickness specified, complete in place.

Adjustments to the contract payment with respect to thickness will be included in a quality assurance adjustment pay item in accordance with 109.05.1.

Milled pavement corrugations will be paid for in accordance with 606.05.

Payment will be made for portland cement content of more than 564 lb/cu yd when ordered in writing. Additional payment for the quantity used will be at the net unit price of portland cement as shown by certified vouchers for the quantity used in accordance with 109.05.

Payment for pavement thickness determinations will be made at the contract lump sum price for coring, PCCP in accordance with 501.31. A change order in accordance with 109.05 will be developed to adjust the cost of PCCP when the final PCCP quantity

differs from the bid quantity by more than 2,400 sq yds. This adjustment covers the cost of cores for the adjusted quantity of PCCP. The adjustment, plus or minus, will be based on the difference in the number of subsections, rounded to the nearest full subsection, times $100.

Payment will be made under:

Pay Item	Pay Unit Symbol
PCCP, _____ in thickness	SYS

No additional payment will be made for PCCP which has an average thickness above that shown on the plans.

The cost of trial batch demonstrations shall be included in the cost of PCCP.

The cost of corrections for pavement smoothness and retexturing shall be included in the cost of PCCP.

Removal and replacement of PCCP found to be deficient or damaged by freezing shall be completed with no additional payment.

The cost of coring and refilling of the pavement holes for disputing original test results and traffic control expenditures related to coring operations shall be included in the cost of PCCP.

SECTION 503 – PCCP JOINTS

503.01 Description

This work shall consist of the construction of joints in PCCP, placing dowel bar assemblies and joint sealing operations in accordance with 105.03.

MATERIALS

503.02 Materials

Materials shall be in accordance with the following:

Bridge Expansion Joint Type PCF	906.07(c)
Chemical Anchor System	901.05
Concrete, Class A	702
Dowel Bars	910.01(b)10
Epoxy Coated Reinforcing Bars	910.01(b)9
Hot Poured Joint Sealant	906.02(a)2
Joint Filler	906.01
Joint Materials	906

PCC Sealer/Healers 901.06
Reinforcing Bars 910.01
Support Devices .....910.01(b)11
Threaded Tie Bar Assembly.....910.01(b)2

Tie bars shall be epoxy coated reinforcing bars.

Bent tie bars shall be deformed billet steel in accordance with 910.01 and ASTM A615, Grade 40.

The epoxy coating on the bent and straight tie bars shall be protected in accordance with 703.04.

CONSTRUCTION REQUIREMENTS

503.03 Joints

Joints shall be constructed in accordance with the type, dimensions, and locations shown on the plans or as directed. All joints shall be perpendicular to the subgrade.

Longitudinal joints shall be parallel to the centerline. The longitudinal joint shall not deviate from the true line shown on the plans by more than 1/4 in. Transverse joints shall be at right angles to the centerline and be continuous for the full width of the pavement.

All joints shall be cut to the required dimensions and sealed. All sawed joints shall be made by sawing equipment in accordance with 508.07 and shall be in accordance with the following.

(a) Type D-1 Contraction Joint

Type D-1 contraction joints shall be created by sawing slots in the pavement unless alternative methods are approved. The sawed contraction joint spacing shall be as shown on the plans or as directed, but shall not exceed 18 ft.

The saw cut shall commence as soon as the concrete has hardened sufficiently to enable sawing without raveling, usually 2 to 12 h after placement. All joints shall be saw cut through the edges of the pavement to the required depth before uncontrolled shrinkage cracking takes place. The sawing operations shall be carried on during day and night, regardless of weather conditions. The sawing of a joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discontinued if a crack develops ahead of the saw. Formed contraction joints may be used where conditions make sawing impractical.

The width of the saw cut will be measured for specification compliance at the time of the sawing operations. Slurry or saw residue remaining in the slot shall be immediately flushed with water. Construction traffic shall not be allowed on the PCCP after the saw cut until the joint is sealed.

The sawed slot shall be cleaned to remove all foreign matter from the entire depth of cut. Joint sealing shall be in accordance with 503.05.

(b) Longitudinal Joint

Longitudinal joints shall be created by sawing slots in the pavement unless alternative methods are approved. The longitudinal joint spacing shall be as shown on the plans or as directed, but shall not exceed 14 ft. Tie bars shall be placed by mechanical equipment in accordance with 508.04(a), or rigidly secured in place.

Longitudinal joints shall be cut to the depth, width, and line shown on the plans. The longitudinal joint slots shall be sawed concurrently with the D-1 contraction joint slots. If random cracking occurs ahead of sawing, the sawing operations shall be discontinued in that area. The sawed joint shall be cleaned as specified in 503.03(a). Joint sealing shall be in accordance with 503.05.

Longitudinal joints may be replaced with longitudinal construction joints when approved by the Engineer.

(c) Transverse Construction Joints

Transverse construction joints shall be constructed when there is an interruption of more than 30 minutes in the PCCP placement operations. A transverse construction joint located at a D-1 contraction joint shall be in accordance with 503.03(a), except the initial saw cut shall be omitted. All other transverse construction joints shall be located at least 6 ft from an adjacent D-1 contraction joint.

Tie bars for transverse construction joints may be placed in the plastic or hardened concrete. A header board with openings for tie bars shall be used when placing tie bars in plastic concrete. The header board shall be rigid and accurately set to grade. Tie bars placed in hardened concrete shall be retrofitted in accordance with 503.03(g).

(d) Longitudinal Construction Joint

The longitudinal construction joint spacing shall be as shown on the plans or as approved. Tie bars shall be placed by mechanical equipment in accordance with 508.04(a) or other approved methods. Longitudinal construction joint saw cuts may be made as soon as the PCCP has sufficiently hardened.

Longitudinal construction joints shall be cut to the depth, width, and line shown on the plans. Construction traffic shall not be allowed on the PCCP after the saw cuts are made until the joints are sealed. Joint sealing shall be in accordance with 503.05.

Bent tie bar spacing shall be adjusted to prevent interference with the D-1 contraction joints. Bent tie bars shall not be omitted. Bent tie bars shall be replaced with retrofitted tie bars when more than one tie bar breaks within 30 ft during straightening.

The longitudinal construction joint for shoulder widths 4 ft or less may be replaced by a longitudinal joint with tie bars. If the construction joint is eliminated, the mainline

and shoulder shall be constructed at the same time.

(e) Terminal Joints

A terminal joint of the type specified shall be constructed at the locations as shown on the plans.

The embankment shall be shaped to the required grade and section, free from all ruts, corrugations, or other irregularities, and uniformly compacted in accordance with 203. The embankment shall be finished within a tolerance of 1/2 in. from the grade as shown on the plans. The subgrade shall be prepared as shown on the plans and in accordance with 207. The sleeper slab shall be placed on top of the prepared subgrade.

1. Terminal Joint, Type PCCP

Terminal joint, Type PCCP, shall consist of a sleeper slab, polyethylene bond breaker, Type PCF bridge expansion joint, and JRCP transition slabs. The polyethylene bond breaker shall be an approved polyethylene sheeting having a thickness of 6 mils or greater. The portion of the sleeper slab on which the polyethylene bond breaker is to be placed shall be finished to a smooth trowel finish. The Type PCF bridge expansion joint shall be in accordance with 724 and as shown on the plans. The concrete and placement for JRCP transition slabs shall be in accordance with 502 and as shown on the plans. Steel reinforcement shall be epoxy coated and placed in accordance with 703. The metal chairs, spacers, clips, wire, or other mechanical means used for fastening or holding reinforcement in place shall be epoxy coated.

2. Terminal Joint, Type HMA

Terminal joint, Type HMA, shall consist of a sleeper slab, concrete lug, polyethylene bond breaker, and Type PCF bridge expansion joint. The polyethylene bond breaker shall be an approved polyethylene sheeting having a thickness of 6 mils or greater. The portion of the sleeper slab on which the polyethylene bond breaker is to be placed shall be finished to a smooth trowel finish. A Type A construction joint shall be constructed as shown on the plans. The Type PCF bridge expansion joint shall be in accordance with 724 and as shown on the plans.

The saw cut shall be sealed with hot poured joint sealant in accordance with 906.02(a)2.

(f) Expansion Joints

Expansion joints shall be constructed at the locations shown on the plans and shall consist of joint filler.

The joint filler shall be shaped to the subgrade, parallel to the surface, and be full width of the pavement. Damaged or repaired joint filler shall not be used.

The joint filler shall be held in a position which is normal to the surface. Finished joints shall deviate no more than 1/4 in. in the horizontal alignment from a straight line. There shall be no offsets between adjacent sections when the joint filler consists

of more than one section. No plugs of concrete shall be within the expansion joint.

(g) Retrofitted Tie Bars

Retrofitted tie bars shall be secured at right angles to the pavement with a chemical anchor system in accordance with the manufacturer's recommendation. The chemical anchor system shall be injected to the back of the hole to eliminate air pockets prior to inserting the bar. The quantity of material injected shall be sufficient to disperse the material along the entire length of the bar and completely fill the annular space. After the anchor system has been injected, the bar shall be fully inserted using a back-and-forth twisting motion, leaving the proper length exposed. If it is necessary to use a hammer to seat the bar, the exposed end shall be protected with a wood block.

When a capsule type chemical anchor system is used, the capsules shall be conditioned as per the manufacturer's installation instructions, if required, and placed at the back of the hole. The number of capsules shall be sufficient to disperse the material along the entire length of the bar and completely fill the annular space. After the capsules have been placed the bar shall be fully inserted in accordance with the manufacturer's installation instructions.

(h) Expansion Joint with Load Transfer

Expansion joints with load transfer shall be constructed at the locations shown on the plans. The joint shall be an assembly of dowel bars, expansion caps, and joint filler components as shown on the plans. The components shall be supported in accordance with 503.04(a).

Damaged or repaired joint filler shall not be used. The joint filler shall be held in a position which is normal to the surface and secured in place. The bottom of the joint filler shall be set firmly in place. The top of the joint filler shall be parallel to the pavement surface and be the full width of the pavement. The expansion joint assembly shall be held in place in accordance with 503.04(g). Finished joints shall deviate no more than 1/4 in. in the horizontal alignment from a straight line. There shall be no offsets between adjacent sections when the joint filler consists of more than one section. No plugs or leakage of concrete shall be allowed to occur through the joint filler or into the air gap of expansion caps.

The expansion joint opening shall be sealed with hot poured joint sealant in accordance with 906.02(a)2.

503.04 Dowel Bar Assemblies

The dowel bar assemblies shall be in accordance with the following:

(a) The dowel bars shall be supported by an approved welded wire assembly which shall hold the bars rigid during placement of the PCCP. The wire for the welded assembly shall be in accordance with ASTM A1064. The maximum angle of deviation shall not exceed 1 in 48 units during placement.

(b) The assembly shall have two continuous parallel spacer bars and two continuous parallel bearing members of size W 7.5 or greater. One spacer bar shall be located at or near each end of the dowel. Alternate ends of dowels shall be welded to a spacer bar so that the dowels remain parallel to each other and enable sliding movement in the joint. The free ends of each dowel shall be retained securely in place by means of wire loops.

(c) Suitable struts or tie wires shall be provided to hold the assembly in correct position during installation. The tie wires shall be size W 7.5 or smaller and there shall be a maximum of five tie wires for each dowel bar assembly.

(d) The assembly shall have an upright support welded to the spacer bar and a continuous bearing member at the end of each dowel.

(e) If the upright support consists of a single vertical wire, the support shall be size W 7.5 or greater wire. Otherwise, the support shall be 1/4 in. or greater in diameter.

(f) At the time of placement, dowel bars shall be free of dirt, loose rust, or scale. If the Engineer suspects the epoxy coating has been damaged by exposure to ultraviolet light, a sample will be obtained and will be tested in accordance with 910.01(b)9.

(g) The dowel bar assembly shall be held securely in place during placing, consolidating, and finishing the PCCP by means of metal pins. Pins used on granular subbase shall penetrate a minimum of 12 in. below the dowel bar assembly. Pins shall be size W 7.5 or greater wire and shall be provided with a hook or arm welded to the pin so that it shall secure the assembly in place. A minimum of eight pins shall be used for each 10, 11, or 12 ft section of assembly. A minimum of 10 pins shall be used for assembly sections greater than 12 ft and less than or equal to 16 ft.

(h) Dowel bars shall be coated with a bond breaking material and the coating shall be evident at the time of placement of the PCCP.

(i) Dowel bars shall be placed 6 in. from the edges of the pavement and spaced at 1 ft on center across the joint.

503.05 Sealing Cracks and Joints

All joints and cracks in the PCCP shall be cleaned and sealed with hot poured joint sealant in accordance with the sealant manufacturer's recommendations. Water

blasting shall not be applied under pressure which may damage the concrete. All cracks and joints shall be sealed prior to discontinuing work for the winter.

503.06 Random Crack Remediation

Random cracks shall be corrected.

(a) Transverse

Random transverse cracks shall be corrected by PCCP replacement. The replacement shall be full lane width and a minimum of 6 ft in length. Transverse PCCP removal limits shall be perpendicular to the centerline and shall include the entire random crack. Load transfer for the replacement PCCP shall be obtained by using dowel bars and retrofit epoxy coated tie bars. PCCP replacement areas shall have dowel bars which match contraction joints in any adjacent panels. All remaining panels shall be a minimum of 6 ft in length.

(b) Longitudinal

Random longitudinal and skewed cracks within 18 in. of a longitudinal joint shall be routed and sealed. All longitudinal saw cuts in areas of random cracks shall be sealed with a sealer/healer or a bonding agent in accordance with ASTM C881, Grade 1.

Random longitudinal and skewed cracks outside 18 in. of a longitudinal joint shall be corrected by PCCP replacement in accordance with 503.06(a).

503.07 Method of Measurement

D-1 contraction joints, expansion joint with load transfer, and terminal joints will be measured by the linear foot as measured along the centerline of the joint. The sleeper slab, reinforcing bars, bond breaker, sealants for the terminal joint will not be measured. When required, removal of an existing terminal joint or sleeper slab will not be measured.

JRCP will be measured by the square yard of the thickness specified. Reinforcing bars, the metal chairs, spacers, clips, wire, or other mechanical means used for fastening or holding reinforcement in place in the JRCP will not be measured.

Retrofitted tie bars will be measured by the number of units installed. Type PCF bridge expansion joints, joint fillers, and joint sealants will not be measured.

503.08 Basis of Payment

D-1 contraction joints, expansion joint with load transfer, and terminal joints will be paid for at the contract unit price per linear foot, complete in place.

JRCP will be paid for at the contract unit price per square yard of the thickness specified, complete in place.

Retrofitted tie bars will be paid for at the contract unit price per each, complete in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
D-1 Contraction Joint	LFT
Expansion Joint with Load Transfer	LFT
Jointed Reinforced Concrete Pavement, ____ in. thickness	SYS
Retrofitted Tie Bars	EACH
Terminal Joint, Type _____	LFT

The cost of furnishing and placing all materials, not specified as a pay item, shall be included in the cost of PCCP.

The cost of reinforcing bars, metal chairs, spacers, clips, wire, or other mechanical means used for fastening or holding reinforcement in place shall be included in the cost of the JRCP.

For D-1 contraction joints, the cost of dowels, dowel bar assemblies, backer rod, joint sealants, and all necessary incidentals shall be included in the cost of D-1 contraction joints.

For the construction of expansion joints, the cost of dowels, dowel bar assemblies, expansion caps, joint filler, joint sealants, and all necessary incidentals shall be included in the cost of the expansion joint with load transfer.

The cost of the sleeper slab, reinforcing bars, bond breaker, Type PCF bridge expansion joint, joint sealant, and all necessary incidentals shall be included in the cost of the terminal joint. When required, removal of an existing terminal joint and sleeper slab shall be included in the cost of the terminal joint.

The cost of retrofitted tie bars or PCCP replacement used to repair damaged PCCP due to fault or negligence, remediation of random cracking, or the replacement of broken deformed bars shall be included in the cost of the PCCP.

SECTION 504 – PCCP FINISHING AND CURING

504.01 Description

All PCCP surfaces shall be finished and cured in accordance with the following.

MATERIALS

504.02 Materials

The materials shall be in accordance with the following:

Curing Materials.....912.01

CONSTRUCTION REQUIREMENTS

504.03 Finishing and Surface Texturing

(a) Finishing

PCCP shall be finished with equipment in accordance with 508.04. The operations shall be controlled so that an excess of mortar and water is not worked to the top. Long-handled floats may be used to smooth and fill in open textured areas in the PCCP.

Hand methods of finishing may be used when finishing equipment breaks down or in tight working areas where field conditions limit the use of mechanical devices. Hand placed concrete shall be further finished by means of a longitudinal float or a transverse smoothing float in accordance with 508.08(a).

The edges of formed PCCP adjacent to HMA or compacted aggregate shall be tooled. A continuous radius with a uniform smooth dense mortar finish shall be produced.

(b) Surface Texturing

The PCCP surface shall be textured with a double thickness burlap drag or a minimum 4 ft wide turf drag followed by tining oriented either longitudinal or transverse to the direction of travel as specified herein, all before the PCCP permanently sets. The PCCP surface of mailbox approaches and private and commercial driveways shall be broom finished before the PCCP permanently sets.

Tining the textured surface shall be completed using a mechanical device in accordance with 508.06. The Contractor shall oversee the tining operation to ensure the forming of straight, uniform grooves in the textured, plastic PCCP surface without tearing the concrete surface, without allowing the tine groove edges to slump at the edges, and without bringing pieces of the coarse aggregate to the top of the PCCP surface. Wander and overlap of the tining, and any wavy pattern in the tining shall be prevented. Presence of wander, overlap, or wavy pattern in the tining will be cause for retexturing.

For tight working areas, form work, and where field conditions such as small or irregularly shaped areas limit the use of mechanical devices, as determined by the Engineer, the Contractor may request to use a hand tool that is in accordance with 508.06 and has tines and spacing in accordance with 504.03(b)1 or 2 below, as applicable for the application.

Texturing and curing operations may be performed by a single machine subject to satisfactory performance.

1. Longitudinal Tining

Tining shall be in the longitudinal direction, parallel with the direction of travel, on all PCCP that is uniform in width, including mainline and shoulders. Tining shall be completed using a mechanical device in accordance with 508.06 that has 1/8 in. wide tines, spaced at 3/4 in. center-to-center, and produces a uniform, nominal depth tine groove 1/8 in. ±1/16 in. deep in the plastic PCCP. The mechanical device shall be able to tine the full width of the PCCP in one operation. Tining shall be completed prior to the application of curing materials. String line or other controls for line and grade shall be used to ensure straight tining parallel with the direction of travel. Tining shall not be performed within 3 in. of pavement edges or longitudinal joints.

2. Transverse Tining

Tining shall be in the transverse direction, perpendicular to the direction of travel, on PCCP on all approaches, ramps, tapered areas, and gore areas. Tining shall be completed using a mechanical device in accordance with 508.06 that has 1/8 in. wide tines, spaced center-to-center as follows: 3/8 in., 9/16 in., 5/8 in., 7/16 in., 3/8 in., 1/2 in., 9/16 in., 5/8 in., 7/16 in., 3/8 in., 13/16 in., 1/2 in., and produces a uniform, nominal depth tine groove 1/8 in. ±1/16 in. deep in the plastic PCCP. The tining pattern shall be repeated across the PCCP surface perpendicular to the direction of travel.

(c) Retexturing

Areas of PCCP which are not finished and textured in accordance with the requirements herein shall be corrected by retexturing. Retexturing shall be done in the same longitudinal or transverse direction as the orientation of the existing tining. It shall consist of cutting longitudinal or transverse grooves in the PCCP surface by means of saw blades or other approved devices. The grooves shall be spaced in accordance with 504.03(b)1 or 2 above as appropriate. The PCCP surface, after cutting, shall not be polished.

504.04 Curing

Curing materials shall be applied to exposed surfaces and sides of newly placed PCCP within 30 minutes after the finishing operations have been completed, or as soon as marring of the concrete does not occur. Paving operations shall be immediately suspended if sufficient curing materials are not available on site.

When forms are used, the edges of the pavement shall be cured immediately upon removal of the forms. The edges shall be covered with curing materials equal to the material used on the surface or banked with soil 12 in. wide or greater.

When conditions arise which prevent immediate application of curing materials, the paving operation shall be suspended and the PCCP shall be kept wet with a fine spray of water. The fine spray of water shall continue until application of curing materials resumes.

When blended portland pozzolan cements, coal ash, or slag cement are used in the concrete mix, the average ambient temperature must be above 50°F for the curing

period. The average temperature shall be calculated based on hourly temperature measurements taken at the jobsite or from published weather station data within 10 miles of the jobsite. If the temperature restrictions are not met during placement or during the required curing period, curing shall continue and the PCCP shall not be opened to traffic until the strength requirements are met.

If liquid membrane forming compounds are used as the curing method and open to traffic strength has been achieved, the road may be opened to traffic and the 96 h stipulation stated below will not apply. Except when liquid membrane forming compounds are used, curing shall be continuous for 96 h unless a longer period is ordered. Curing shall be in accordance with the following.

(a) Liquid Membrane Forming Compounds

The curing compound shall be mixed thoroughly within 1 h before use. The application shall be a minimum spreading rate of 1 gal. of liquid coating for every 150 sq ft of concrete surface. Curing compound shall be applied to provide a uniform, solid, white opaque coverage on all surfaces, similar to a white sheet of paper.

All concrete cured by this method shall receive two applications of the curing compound. The first application shall be applied immediately after surface water has disappeared and surface texturing has been applied. If formwork has been used, both applications of curing compound shall be applied immediately after the formwork is removed. The second application shall be applied after the first application has set.

The curing compound may be warmed in a water bath during cold weather at a temperature not exceeding 100°F. Thinning with solvents will not be allowed. Non-uniform film rates will result in the discontinuance of that application method.

A new coat of curing compound shall be applied to areas damaged by rain or other means during the curing period. The recoating shall be applied as soon as possible and at a rate equal to that specified for the original coat.

(b) Double Burlap

The PCCP shall be covered with wet burlap laid directly on the surface and kept wet with a fine spray of water. This initial burlap shall receive an additional covering of wet burlap no later than 9:00 a.m. the day following its placement. The two layers of burlap shall be kept wet for the required curing period.

(c) Waterproof Covers

The PCCP shall be kept wet with a fogged spray of water or be covered with wet burlap laid directly on the surface and kept wet with a fine spray of water. The PCCP shall receive a cover no later than 9:00 a.m. the day following its placement. If white burlap polyethylene sheets are used, the burlap side shall be wet or the surface of the concrete thoroughly wetted just prior to the blanket being placed.

The covers shall be weighted down on each edge and shall be as wide as the full

width of the pavement being cured. Adjoining covers shall overlap 12 in. or more and the laps held securely in place.

Covers may be reused provided they are airtight. All torn covers shall be repaired with patches. All units not in accordance with these requirements shall not be used. The covers shall remain in place for the required curing period.

504.05 Method of Measurement

Finishing and curing operations will not be measured for payment.

504.06 Basis of Payment

The cost of finishing the PCCP surface furnishing and placing curing materials shall be included in the cost of the PCCP. Retexturing shall be at no additional cost to the Department.

SECTION 505 – TESTS AND PROCEDURES

505.01 Test Methods and Procedures

The following test methods and procedures shall be used with exceptions as listed below.

Air Test	AASHTO T 152* or ASTM C173**
Flexural Strength	AASHTO T 97*
Making and Curing Specimens	AASHTO T 23*
Sampling Fresh Concrete	AASHTO R 60
Sieve Analysis of Aggregates	AASHTO T 27
Slump	AASHTO T 119
Specific Gravity and Absorption, Coarse Aggregate	AASHTO T 85
Specific Gravity and Absorption, Fine Aggregate	AASHTO T 84
Thickness of PCCP	ITM 404
Unit Weight and Relative Yield	AASHTO T 121*
Water/Cementitious Ratio	ITM 403

* The concrete shall be consolidated by the method of internal vibration in beam forms or in an aluminum measure or air meter bowl, as appropriate for the test.

** If slag aggregate is used, the method and procedure for the test shall be in accordance with ASTM C173.

The chosen method of concrete consolidation shall be the same for all concrete test specimens.

(a) Exceptions to AASHTO T 23

The exceptions to AASHTO T 23 for making and curing specimens in the field

shall be as follows:

1. Non-watertight beam forms, molds, will be allowed.

2. After 24 h the molded specimens are taken to the storage location and removed from the molds.

3. Field stored beams will not require 24 ±4 h lime water soak prior to time of testing.

(b) Exceptions to AASHTO T 97

The exceptions to AASHTO T 97 for conducting a flexural test on concrete beams shall be as follows:

1. The beam size shall be measured to the nearest 1/16 in.

2. The test result shall be discarded when the break occurs outside the middle 1/3 of the beam.

(c) Exceptions to AASHTO T 121

The exceptions to AASHTO T 121 for determining the unit weight of concrete shall be as follows:

1. Weight shall be determined to the nearest 0.01 lb.

(d) Exceptions to AASHTO R 60

The exceptions to AASHTO R 60 for sampling fresh concrete shall be as follows:

1. Where job conditions dictate, the entire sample may be obtained from one portion of the load.

(e) Exceptions to AASHTO T 152

The exceptions to AASHTO T 152 for determining the air content in portland cement concrete shall be as follows:

1. The sample for aggregate correction factor shall be prepared in accordance with 7. The aggregate correction factor shall be determined in accordance with 9.4 and read directly from the meter.

2. The aggregate correction factor test shall be rerun for confirmation if the test result for gravel is greater than 0.4% or if the test result for crushed stone is greater than 0.6%.

3. For aggregates indicating a high correction factor, the aggregate may be washed from the concrete sample and used to determine the correction factor.

SECTION 506 – PCCP PATCHING

506.01 Description

This work shall consist of the removal and replacement of jointed plain PCCP or jointed reinforced PCCP in accordance with 105.03.

MATERIALS

506.02 Materials

Materials shall be in accordance with the following:

Admixtures	912.03
Calcium Chloride, Type L	913.02
Chemical Anchor System	901.05
Coarse Aggregate, Class A or Higher, Size No. 11	904.03
Concrete Coarse Aggregate, Class AP	904.03, ITM 226
Dowel Bar Assemblies	503.04
Dowel Bars	910.01(b)10
Fine Aggregate, Size No. 23	904.02
Coal Ash	901.02
Joint Fillers	906.01[A]
Joint Sealing Materials	906.02(a)2
Portland Cement	901.01(b)
Rapid Hardening Hydraulic Cement	901.01(d)
Silica Fume	901.04
Slag Cement	901.03
Water	913.01

[A] A flexible foam expansion joint material meeting the requirements of ASTM D5249, Type 2 may also be used for the retrofit pressure relief joint. If the flexible foam expansion joint is used, the basis for use will be a Type C certification in accordance with 916.

Coarse aggregate for partial depth patching shall be size No. 11. Coarse aggregate for full depth patching shall be size No. 8. Coarse aggregate for patches shall be dolomite, limestone, or gravel.

Retrofitted tie bars shall be No. 5 or No. 6 epoxy coated reinforcing bars in accordance with 910.01(b)9.

The rapid hardening hydraulic cement or calcium sulfoaluminate, CSA, cement type selected shall be a type shown in ASTM C1600 that will enable opening to traffic in accordance with the contract requirements. Food grade citric acid may be used as an organic retarding admixture in concrete utilizing CSA cement. The use and strength of food grade citric acid, or any other admixture, shall be approved in writing by the manufacturer of the CSA cement. The basis for use for the food grade citric acid will be visual inspection.

A bonding agent shall be selected from the QPL of Non-Vapor Barrier Type Bonding Agents.

506.03 Concrete Mix Design

A CMDS shall be in accordance with 506.04. The CMDS shall be submitted to the DTE. The CMDS shall be submitted a minimum of seven calendar days prior to the trial batch utilizing the Department provided spreadsheet and shall include the following:

(a) a list of all ingredients, including the type of CSA cement, if applicable
(b) the source of all materials
(c) the fine to total aggregate ratio
(d) the gradation of the aggregates
(e) the absorption of the aggregates
(f) the SSD bulk specific gravity of the aggregates
(g) the specific gravity of all SCMs
(h) the batch weights
(i) the names of all admixtures
(j) the admixture dosage rates and the manufacturer's recommended range.

The aggregate blend on the CMDS may produce an optimized aggregate gradation in accordance with the Department provided spreadsheet. If an optimized aggregate gradation is used, it shall consist of, at a minimum, one concrete coarse aggregate and one fine aggregate, No. 23. One additional Class A or higher intermediate-sized coarse aggregate may be included if approved by the Engineer.

The absolute volume of the mix design shall be 27.0 cu ft at the design air content of 6.5%.

The CMDS shall be used to conduct a trial batch in accordance with 506.05. Upon completion of the trial batch, the Contractor shall update the submitted CMDS to include the Contractor's and the Engineer's trial batch test results on the Department provided spreadsheet a minimum of three business days prior to production. Production shall not commence until the DTE has issued the concrete mix design for production, CMDP.

A CMDP in accordance with 506.04 from another contract in the current or previous calendar year may be submitted to the DTE for consideration for use on the current contract. The DTE will notify the Contractor when the review is complete and if the previously used CMDP can be used on the current contract.

A CMDP may be changed or adjusted in accordance with the following:

(a) Change in Materials

Any of the following changes to a CMDP shall require a new CMDS to be submitted to the DTE, referencing the original CMDP.

1. Cement source or type.
2. SCM source or type.
3. Coarse aggregate source or type.
4. Admixture type.

A trial batch shall be conducted in accordance with 506.05.

(b) Adjustments to Materials

Any of the following adjustments to a CMDP shall require a new CMDS to be submitted to the DTE, referencing the original CMDP.

1. Admixture source.
2. Admixture product of same type and from same source designated in the original CMDP.
3. Fine aggregate source.
4. Fine to total aggregate ratio in excess of ±3% from the value designated by the original CMDP.
5. Increase in cement content from amount designated in the original CMDP.

The new CMDS shall be submitted to the DTE utilizing the Department provided spreadsheet a minimum of one business day prior to production. A trial batch or verification testing is not required. Production shall not commence until the DTE has issued the CMDP.

(c) Other Adjustments

Adjustments to the admixture dosage rate for a CMDP will be allowed and DTE notification and review prior to use is not required.

506.04 Concrete Mix Criteria

The design flexural strength of each CMDP shall be set such that the minimum opening to traffic strength is achieved at an age consistent with the work schedule, including any lane closure restrictions.

Chemical admixtures Type A, Type B, Type C, Type D, Type E, and Type F may be allowed if shown on the CMDP. The supplied concrete mix shall include one of the following water reducing admixtures: Type A, Type D, Type E, Type F, or Type G.

Type C admixtures or calcium chloride, Type L, shall not be used in conjunction with Type III portland cement. Calcium chloride, Type L, may only be used in mixes for non-reinforced PCCP and for mixes in accordance with 506.04(a).

Blended portland pozzolan cements, coal ash, or slag cement may only be

incorporated in the concrete mix when the ambient temperature is above 50°F during the entire placement period. If Type IP, Type IP-A, Type IS, or Type IS-A cements are to be used, the minimum portland cement content shall be increased to 598 lb/cu yd. The use of coal ash or slag cement will not be allowed when blended cement types IP, IP-A, IS, or IS-A are used.

The Contractor may use either portland cement or CSA cement in the concrete. Coal ash or slag cement may also be used.

If concrete has a permeability of 900 coulombs or less at 56 days, the acceptable range of air content will be 0 - 6.0%. Verification of this property for a mix design will be determined by testing specimens cast at the trial batch. Testing will be done per AASHTO T 23, Section 10.1 Standard Cure conditions.

The CMD shall produce workable concrete mixtures having the following targets and field acceptance properties.

(a) Patches Less than or Equal to 15 ft in Length

The Contractor shall use either concrete as described below or concrete in accordance with 506.04(b). If concrete in accordance with 506.04(b) is used, 506.12(b) shall be used for the minimum open to traffic strength.

Targets for the CMD:

Minimum portland cement content	564 lb/cu yd[A]
Maximum portland cement content	752 lb/cu yd[A]
Minimum CSA cement content	564 lb/cu yd[A, B]
Maximum CSA cement content	658 lb/cu yd[A, B]
Minimum water/cementitious ratio (Type I or Type IL)	0.340[C]
Maximum water/cementitious ratio (Type I or Type IL)	0.400[C]
Minimum water/cementitious ratio (Type III or Type CSA)	0.340[C]
Maximum water/cementitious ratio (Type III or Type CSA)	0.435[C]
Maximum coal ash or slag cement addition	30% of the cement content[B]
Maximum silica fume addition	7% of the cementitious content
Air Content	6.5%
Minimum modulus of rupture	400 psi at 24 h
Minimum modulus of rupture	550 psi at 3 days[D]
Relative Yield	1.00

Field Acceptance Properties:

Minimum water/cementitious ratio (Type I or Type IL)	0.320[C]
Maximum water/cementitious ratio (Type I or Type IL)	0.420[C]
Minimum water/cementitious ratio (Type III or Type CSA)	0.340[C]
Maximum water/cementitious ratio (Type III or Type CSA)	0.450[C]
Slump	2 to 6 in.
Air Content	5.0% to 8.0%
Minimum modulus of rupture	550 psi at 3 days[D]
Relative Yield	0.98 to 1.02

[A] The cement content shall not be adjusted from the target stated on the CMDP during production.

[B] Coal ash or slag cement shall not be used in combination with CSA cement unless approved in writing by the manufacturer of the CSA cement.

[C] The water/cementitious ratio shall not deviate more than 0.020 from the target stated in the CMDP and shall not fall outside the limits shown.

[D] Beams shall be standard cured in a water tank in accordance with AASHTO T 23 and 505.01(a). The water does not need to be saturated with calcium hydroxide.

When a calcium chloride solution is added, the maximum amount of solid calcium chloride contained in solution shall not exceed 2% of the total batch weight of cement. If the ambient temperature is above 80°F, the maximum amount of solid calcium chloride contained in solution shall not exceed 1% of the total batch weight of cement.

(b) Patches Greater than 15 ft in Length

The Contractor shall use either concrete as described below, or portland cement concrete in accordance with 502.04(a). If concrete in accordance with 502.04(a) is used, a trial batch will not be required.

Targets for the CMD:

Minimum portland cement content (types I, IL or III)	564 lb/cu yd[A]
Maximum portland cement content (types I, IL, or III)	752 lb/cu yd[A]
Minimum CSA cement content	564 lb/cu yd[A, B]
Maximum CSA cement content	658 lb/cu yd[A, B]
Minimum water/cementitious ratio (Type I or Type IL)	0.340[C]

Maximum water/cementitious ratio
(Type I or Type IL)..... 0.400[C]
Minimum water/cementitious ratio
(Type III or Type CSA)..... 0.340[C]
Maximum water/cementitious ratio
(Type III or Type CSA)..... 0.435[C]
Maximum coal ash or slag cement addition..... 30% of the cement content[B]
Maximum silica fume addition..... 7% of the cementitious content
Air Content 6.5%
Minimum modulus of rupture ..... 425 psi at 24 h
Minimum modulus of rupture ..... 550 psi at 3 days[D]
Relative Yield 1.00

Field Acceptance Properties:
Minimum water/cementitious ratio
(Type I or Type IL)..... 0.320[C]
Maximum water/cementitious ratio
(Type I or Type IL)..... 0.420[C]
Minimum water/cementitious ratio
(Type III or Type CSA)..... 0.340[C]
Maximum water/cementitious ratio
(Type III or Type CSA)..... 0.450[C]
Slump..... 2 to 6 in.
Air Content ..... 5.0% to 8.0%
Minimum modulus of rupture ..... 550 psi at 3 days[D]
Relative Yield ..... 0.98 to 1.02

[A] The target cement content during production shall not be adjusted from the value stated on the CMDP.

[B] Coal ash or slag cement shall not be used in combination with CSA cement unless approved in writing by the manufacturer of the CSA cement.

[C] The water cementitious ratio during production shall not deviate more than 0.020 from the target stated in the CMDP and shall not fall outside the limits above.

[D] Beams shall be standard cured in a water tank in accordance with AASHTO T 23 and 505.01(a). The water does not need to be saturated with calcium hydroxide.

506.05 Trial Batch

A trial batch shall be produced and tested by the Contractor's ACI-Certified Concrete Field Testing Technician, Grade I, to verify that the CMDS is in accordance with the concrete mix criteria. Concrete produced at a plant shall be batched within the proportioning tolerances of 502.10. An ACI-Certified Concrete Field Testing

Technician, Grade I shall be on site to direct all sampling and testing. The trial batch shall be produced at the plant prior to production.

A sufficient number of flexural strength test beams shall be made and will be tested to demonstrate that opening to traffic strength is achieved at an age consistent with the proposed range of usage of the mixture. At a minimum, flexural strength gain will be determined at the target opening to traffic times and at the specified 24 h and 3 day targets as specified by the respective mix criteria. The Engineer will test the concrete's air content, determine the water/cementitious ratio, and prepare and test flexural beams. The flexural strength will be determined by averaging a minimum of two beam breaks. The Department will provide the apparatus to test the beams for flexural strength.

Personnel shall be provided to assist the Department in casting, curing, and testing the beams. The Engineer will provide the Contractor the results of the tests. The Contractor shall submit, along with the CMDS, all supporting test results for approval to the DTE prior to placing concrete. The supporting test results shall be signed by the technician and include air content, slump, relative yield, water/cementitious ratio, and the flexural strengths at the targets listed in 506.04(a) or 506.04(b).

Maturity in accordance with ITM 402 may be used as an alternate method to determine the flexural strength for opening to traffic.

A trial batch will not be required when the total quantity of full depth patching requires less than 10 cu yds of material per contract.

The trial batch shall be of sufficient quantity to allow the Engineer to perform all required tests from the same batch. Trial batch concrete shall not be used for more than one test, except concrete used to measure relative yield may also be used to measure air content.

506.06 Job Control

Control of PCCP for air content, relative yield, and flexural strength beams will be determined from tests performed by the Engineer in accordance with 505. Concrete and necessary labor for sampling shall be furnished as required by the Engineer. Testing for air content and relative yield will be on the first load of the day and once per every 50 cu yds.

(a) Beams for Validation of CMDP

At least one set, consisting of two beams per set, will be made once per every 150 cu yds of concrete placed and tested for compliance with either the 3-day or 7-day flexural strength requirements in accordance with 506.04(b) or 502.04(a) respectively, for the purpose of CMDP validation. Air content and relative yield will be measured on each sample of concrete from which beams are made.

Beams for validation shall be placed on the concrete pavement or shoulder

adjacent to the patch and cured in a similar manner as the patch in accordance with 505.01(a) until patch area is open to traffic. At which point the beams shall be relocated off-site and standard cured in accordance with AASHTO T 23, Section 10.1.2 with the exception that the water does not need to be saturated with calcium hydroxide until the 3-day or 7-day time period has elapsed.

Failure of the validation beams to meet or exceed the 3-day or 7-day flexural strength requirements specified herein will result in the use of the CMDP being suspended until the Department concludes an investigation into why the failure occurred. If the CMDP is subsequently shown to be acceptable, another set of validation beams will be tested on the next use of the CMDP.

(b) Beams for Opening to Traffic

Additional beams shall be cast for the purpose of opening to traffic for concrete meeting the requirements of 506.04(a) or 506.04(b). Such beams shall be cast from sampling the last load to finish the patching operations for the day's production for each of the concrete mixes used. Beams for opening to traffic shall be placed on top of a concrete patch that they represent and cured in a similar manner as the patch.

The Engineer will notify the Contractor when test results for air content, relative yield, or flexural strength are outside the requirements of 506.04. Rounding will be in accordance with 109.01(a).

CONSTRUCTION REQUIREMENTS

506.07 General

Patch areas shown on the plans or marked by the Engineer as greater than 15 ft in length may be subdivided. If a patch is subdivided, concrete mix in accordance with 506.04(b) shall be used in all portions of the patch and the requirements for opening to traffic will be in accordance with 506.12(b).

506.08 PCCP Removal

PCCP removal areas will be marked. The Contractor may saw cut the patch areas prior to removing the patch. When the lane is subject to intermittent closures, the saw cutting shall occur no more than 24 h prior to removing the patch.

Vertical saw cuts around the perimeter of the removal areas shall be made in the PCCP and shall be full depth. Transverse cuts that define the ends of the patch shall be straight and perpendicular to the centerline. In no case shall the transverse joint be over-cut into the adjacent pavement. Following the saw cutting, the concrete that remains in the corners of the patch area shall be removed by pneumatic hammers that do not damage the adjacent PCCP or shoulders. Pneumatic hammers shall not exceed 45 lb.

PCCP removal areas shall not remain open overnight. Shoulders or adjacent PCCP damaged during the removal shall be repaired as directed.

(a) Partial Depth Removal

The saw cut shall be a minimum of 1 in., to a maximum of 1/3 of the thickness of the existing pavement. Removal of all unsound concrete to a minimum depth of 2 in. shall be by hand chipping tools or handheld mechanically driven equipment. Mechanical hammers shall not be heavier than a nominal 45 lb class. Mechanically driven tools shall be operated at a maximum angle of 45° from the PCCP surface. If the saw cut face is damaged, a parallel saw cut 1 in. outside the initial saw cut shall be made and the concrete in this area shall be removed by hand chipping.

In lieu of using hand chipping tools or handheld mechanically driven equipment, a milling machine may be used. If a milling machine is used it shall be one that does not damage the adjacent pavement.

If reinforcing bars are encountered during the removal operation, the patch shall be changed to a full depth patch in accordance with 506.08(b). Wire mesh reinforcement exposed during the removal operations shall be removed.

If concrete is exposed below 1/3 of the thickness of the existing pavement, the patch shall be changed to a full depth patch in accordance with 506.08(b).

Partial depth cavities shall be thoroughly sandblasted and, just prior to placing new concrete, cleaned of all dust, chips, and water. The air lines for sandblasting and air cleaning shall be equipped with oil traps to prevent contamination of the surfaces.

(b) Full Depth Removal

After the full depth saw cut is completed, vehicle mounted removal equipment may be used to remove the concrete provided this equipment does not damage the adjacent sound concrete.

Removal areas in the same lane which are closer than 10 ft shall require the PCCP between these areas to be removed and replaced. If a transverse joint is located within the removal area, the limits of removal shall be as shown on the plans.

Full depth saw cutting and removal shall be extended at the direction of the Engineer until sound PCCP is encountered to allow the drilling and installation of dowel bars for load transfer. Removal operations shall not damage the existing PCCP that is sound and is to remain in place.

Existing subbase shall be completely removed. Before removing any type of asphalt treated, cement treated, or concrete subbase, the Contractor shall saw cut the outline of the removal area using a power-driven saw with a diamond blade. The Contractor shall cut the asphalt treated subbase at least 2 in. deep on a neat line perpendicular to the subbase surface. The Contractor shall cut the cement treated subbase or concrete subbase full depth.

506.09 Concrete Mixing and Transportation

(a) For Patches Less than or Equal to 15 ft in Length

Concrete batching tolerances, mixing, and transportation shall be in accordance with 502.10 and the following. Discharge from non-agitating equipment shall be completed within 30 minutes of mixing the water, cement, aggregates, and calcium chloride solution. Discharge from a truck agitator or a truck mixer shall be completed within 90 minutes of mixing the water, cement, and aggregates or within 30 minutes of the addition of calcium chloride solution. If the location of the plant is such that this time limit cannot be met, the calcium chloride solution shall be added to the concrete in a transit mixer at the site and the concrete shall then be mixed for an additional 40 revolutions prior to discharge.

1. Central Mixed Concrete

Central mixed concrete shall be in accordance with 502.10(a).

2. Shrink Mixed Concrete

Shrink mixed concrete shall be in accordance with 502.10(b).

3. Transit Mixed Concrete

Transit mixed concrete shall be in accordance with 502.10(c).

(b) For Patches Greater than 15 ft in Length

For patches containing portland cement, the mixing and transportation shall be in accordance with 502.10. If concrete containing CSA cement is used, it may be batched and mixed in a mobile volumetric mixer meeting the requirements of 722.09, regardless of the patch length. Calibration of the mobile mixer shall be in accordance with 722.13. Alternatively, a mixer from a CSA cement supplier may be used, if approved by the Engineer.

506.10 Weather Limitations

PCCP patches shall not be placed on frozen subgrade, subbase, or PCCP.

506.11 Placing Concrete

The concrete shall be placed level to the adjacent PCCP and consolidated by internal vibration. The concrete shall be hand finished in accordance with 504. Texturing and tining are not required if the PCCP is to be resurfaced with HMA or diamond ground in accordance with 507.06.

The PCCP patch shall be cured with liquid membrane forming curing compound in accordance with 504.04(a). In addition to applying liquid membrane forming curing compound, if the ambient temperature is below 55°F at the time of placement, polyethylene film shall be placed over the patch and covered with a 4 in. layer of rigid or flexible insulation and firmly anchored. Otherwise, polyethylene film, insulation, or any other covering shall not be used. Small dimension lumber weighted with sandbags may be used, but large objects such as rocks or concrete blocks shall not be used.

Covering with polyethylene film or any other covering does not replace the requirement to use liquid membrane forming curing compound.

The PCCP patch shall be inspected in accordance with 502.17.

For patches which are not to be overlaid and have a length greater than 20 ft, pavement smoothness will be in accordance with 501.25 except inertial profiler requirements will not apply.

(a) Partial Depth

A non-vapor barrier type bonding agent shall be applied to the vertical and horizontal surfaces prior to placing concrete. Coated surfaces shall be protected from contaminants such as dust and dirt. Contaminated surfaces shall be recleaned and recoated. The bonding agent and concrete shall be placed in accordance with the bonding agent manufacturer's recommendations. The recommended time limits will be strictly enforced.

Existing joint openings within the patch shall be maintained for the full depth of the patch by preformed joint fillers or forms. After the patch has cured, these joints shall be sawed and sealed in accordance with 503.

(b) Full Depth

Subgrade treatment and subbase shall be constructed as shown on the plans.

Dowel bars shall be installed to provide load transfer from the adjoining PCCP to the patch. The diameter of the drilled holes shall be no more than 1/8 in. greater than the diameter of the dowel bar. Dowel bars shall be placed parallel to the pavement surface and to the longitudinal joint. Dowel alignment tolerances shall be as shown on the plans.

Dowel holes shall be drilled using hydraulic, electric, or pneumatic percussion drills without spalling or damaging the existing concrete. Drills shall be capable of independent adjustment of each drill shaft in the horizontal and vertical direction. The device used to drill dowel holes shall be slab-riding and be capable of drilling a minimum of three holes at a time. The drilled holes shall be free of dust, moisture, and grease prior to installation of the dowel bars. The chemical anchor system shall be injected to the back of the hole to eliminate air pockets prior to inserting the dowel bar.

The quantity of material injected shall be sufficient to disperse the chemical anchor material along the entire length of the dowel bar and completely fill all voids around the bar. Application of the chemical anchor system by buttering it onto the dowel bar will not be allowed.

After the anchor system has been injected, the dowel bar shall be fully inserted in the hole using a back-and-forth twisting motion, leaving the proper length exposed. If

it is necessary to use a hammer to seat the dowel bar, the exposed end shall be protected with a wood block.

A lightweight plastic, clear or semi-transparent grout retention ring shall be installed after each dowel bar is inserted into the hole. The grout retention ring shall be pushed flush to the vertically sawn concrete surface and shall be used to help retain the chemical anchor system in the dowel hole.

Retrofit tie bars shall be installed in accordance with 503 and as shown on the plans. The tolerance for horizontal and vertical translation shall be the same as for dowel bars.

Joint filler and grout retention rings shall be placed and installed at the pressure relief joint as shown on the plans. Oversized holes shall be drilled in the joint filler no more than 1/2 in. over the dowel bar diameter and at a spacing to match the installed dowel bars. The oversized holes are to allow a tolerance for ease of installation of the joint filler up against the sawed face without interference with the dowel bars. The joint filler shall be attached to the sawed face without wrinkles or buckling.

Joint filler material with vertical slits or cuts will be rejected. Grout retention discs shall be installed to make the annular space between the dowel and the oversized hole mortar-tight. The joint material may be spliced along vertical joints that are joined and sealed with tape. The joint material shall not be spliced in the horizontal direction. An alternate method of installing a joint filler that has a mortar tight seal around the dowel bar may be used if approved by the Engineer.

All patches longer than 15 ft shall be placed in accordance with 502.12 and shall have joints in accordance with 503. Dowel bars shall be installed within the boundaries of the patch at a spacing as shown on the plans or as approved by the Engineer.

Patches longer than 15 ft shall be finished in accordance with 504. Patches longer than 15 ft, constructed with concrete containing portland cement, shall be cured in accordance with 504.04(a) unless ambient air and concrete temperatures warrant following the requirements in 506.11.

Patches constructed in accordance with 506.04(b) and containing CSA cement shall be water cured in accordance with 702.22(a)1 except that soaker hoses will not be required. Water curing shall be initiated after finishing and as soon as the concrete patch can support the wet covering. Water curing shall be maintained for a minimum of 1 1/2 h and shall be removed no sooner than 1 h before the patch is opened to traffic.

Concrete shall be placed around manholes or similar structures in accordance with 720.

Sawing and sealing of transverse joints may be omitted when the existing PCCP is to be overlaid as part of the contract.

506.12 Opening to Traffic

For purposes of this section, traffic shall include construction vehicles, construction equipment, and all non-construction vehicles. Any construction vehicle or equipment that may damage the PCCP shall not be used on the PCCP unless adequate protection is provided. Joint cutting saws may be operated on the PCCP as determined by the Contractor.

(a) For Patches Less than or Equal to 15 ft in Length

A patch may be opened to traffic in accordance with the following when calcium chloride is used in accordance with 506.04(a).

T	H	HT	T	H	HT
40 - 42°F	30	26	61 - 63°F	14	9
43 - 45°F	27	23	64 - 66°F	14	9
46 - 48°F	24	21	67 - 69°F	14	8
49 - 51°F	21	19	70 - 72°F	14	7
52 - 54°F	19	16	73 - 75°F	14	6
55 - 57°F	16	14	above 75°F	14	5
58 - 60°F	16	11			

T = Lowest ambient temperature during placement, or the temperature of concrete at time of delivery, whichever is lower.
H = Time in hours to open to traffic.
HT = Time in hours to open to traffic when the average daily traffic is less than 10,000.

PCCP patches with calcium chloride may be opened to traffic sooner than specified in the above table if test beams indicate a modulus of rupture of 300 psi or greater. ITM 402 may be used as an alternative method to determine the flexural strength.

When other admixtures or admixture systems are used, the PCCP patches may be opened to traffic when flexural strength tests indicate a modulus of rupture of 300 psi or greater. ITM 402 may be used as an alternate method to determine flexural strength.

(b) For Patches Greater than 15 ft in Length

Traffic shall not be allowed on the PCCP until a modulus of rupture from flexural strength testing in accordance with the appropriate value in the table below is achieved. The modulus of rupture will be determined by averaging two beams.

Concrete Mix in accordance with:	Minimum Modulus of Rupture, psi
502.04(a)	550
506.04(b)	425

506.13 Method of Measurement

Partial depth patching and full depth patching will be measured by the square yard.

D-1 contraction joints and retrofitted tie bars used in PCCP patching will be measured in accordance with 503.07.

When subgrade treatment is specified, it will be measured in accordance with 207.05.

New subbase will be measured in accordance with 302.08.

PCCP removal, subbase removal, concrete, finishing, curing, and sawing and sealing of joints will not be measured for payment.

Retrofit pressure relief joints, retrofit contraction joints, non-vapor barrier bonding agent, anchored dowel bars installed at the beginning and end of the patch, individual dowel bars, joint fillers, joint materials, drilling holes for dowel bars, grout retention rings, and chemical anchor systems will not be measured for payment.

506.14 Basis of Payment

PCCP patching will be paid for at the contract unit price per square yard for the type of patching required.

D-1 contraction joints and retrofitted tie bars used in PCCP patching will be paid for in accordance with 503.08.

Subgrade treatment will be paid for in accordance with 207.06.

New subbase will be paid for in accordance with 302.09.

Partial depth patches which have been directed to be full depth will be paid for at the contract unit price per square yard for PCCP patching, partial depth, plus 80% of the contract unit price per square yard for PCCP patching, full depth.

Payment will be made under:

Pay Item	Pay Unit Symbol
PCCP Patching, Full Depth	SYS
PCCP Patching, Partial Depth	SYS

The cost of PCCP removal, subbase removal, concrete, finishing, curing, and sawing and sealing of joints shall be included in the cost of PCCP patching.

The cost of retrofit pressure relief joints, retrofit contraction joints, non-vapor

barrier bonding agent, anchored dowel bars installed at the beginning and end of the patch, individual dowel bars, joint fillers, joint materials, drilling holes for dowel bars, grout retention rings, and chemical anchoring system shall be included in the cost of PCCP patching.

The cost of corrections for pavement smoothness and retexturing shall be included in the cost of PCCP patching.

Repair or replacement of adjacent PCCP or shoulder damaged by the Contractor shall be made at no additional cost to the Department.

SECTION 507 – PCCP RESTORATION

507.01 Description

This work shall consist of cleaning and sealing of joints and cracks, patching, profiling, underseal, and retrofit load transfer in accordance with 105.03.

MATERIALS

507.02 Materials

Materials shall be in accordance with the following:

Asphalt Binder, PG 58S-28	902.01(a)
Dowel Bars	910.01(b)10
Fine Aggregates, Size No. 23 or No. 24	904.02
Joint Sealing Materials	906.02
Rapid Setting Patch Materials	901.07

Dowel bars and dowel bar assemblies shall be in accordance with 503.04.

CONSTRUCTION REQUIREMENTS

507.03 Cracks

Sealing and filling operations shall not be conducted on a wet surface, when the ambient temperature is below 40°F, or when other unsuitable conditions exist, unless approved by the Engineer.

(a) Routing, Cleaning, and Sealing

Cracks in PCCP shall be routed and cleaned when specified. Cracks shall be routed with a routing machine capable of cutting a uniform shape to form a reservoir not exceeding 3/4 in. wide with a minimum depth of 3/4 in. The operation shall be coordinated such that routed materials do not encroach on pavement lanes carrying traffic and all routed materials are disposed of in accordance with 104.07. The cracks shall be cleaned with compressed air or by other suitable means. Air compressors shall be capable of producing a minimum air pressure of 100 psi. Water blasting shall not be utilized.

Cracks shall be sealed with hot poured joint sealant in accordance with the manufacturer's recommendations within 1/4 in. below the surface. A distributor in accordance with 409.03 shall be used with an indirect-heat double boiler kettle and mechanical agitator. The hot poured joint sealant shall be placed utilizing a "V" shaped wand tip, to allow the penetration of the materials into the cracks.

Application of hot poured joint sealant shall be completed without covering existing pavement markings. When traffic is to be maintained within the limits of the section, temporary traffic control measures in accordance with 801 shall be used. Treated areas shall not be opened to traffic until the hot poured joint sealant has set.

(b) Cleaning and Filling

The cracks shall be cleaned by blowing with compressed air or by other suitable means when specified. Air compressors shall be capable of producing a minimum air pressure of 100 psi. Water blasting shall not be utilized.

Cracks shall be filled with asphalt material. The cracks shall be completely filled or overbanded not to exceed 5 in., or as required. Asphalt material shall be placed utilizing a "V" shaped wand tip, to allow the penetration of the materials into the cracks. The filled cracks shall be covered with sufficient fine aggregate or other suitable material to prevent tracking of the asphalt material. All excess cover material shall be removed from the pavement within 24 h, when directed.

Application of asphalt material shall be completed without covering existing pavement markings. When traffic is to be maintained within the limits of the section, temporary traffic control measures in accordance with 801 shall be used. Treated areas shall not be opened to traffic until the asphalt material has set.

507.04 Joints

Sealing and filling operations shall not be conducted on a wet surface, when the ambient temperature is below 40°F, or when other unsuitable conditions exist, unless approved by the Engineer.

(a) Sawing, Cleaning, and Sealing

Joints in PCCP shall be sawed, cleaned, and sealed when specified. Air compressors shall be capable of producing a minimum air pressure of 100 psi. Water blasting shall not be applied under pressure which may damage the concrete. The existing joints shall be sawed to the width and depth as shown on the plans. Slurry or saw residue remaining in the slot shall be immediately flushed with water. Traffic may be allowed on the PCCP for up to seven calendar days after the saw cutting prior to sealing.

Joints shall be sealed with joint sealing materials in accordance with the sealant manufacturer's recommendations. Transverse joints shall be sealed with hot poured joint sealant, silicone sealant, or preformed elastomeric joint sealant. Longitudinal

joints shall be sealed with hot poured joint sealant or silicone sealant.

Application of asphalt materials shall be completed without covering existing pavement markings. When traffic is to be maintained within the limits of the section, temporary traffic control measures in accordance with 801 shall be used. Treated areas shall not be opened to traffic until the asphalt material has set.

(b) Cleaning and Filling

Joints in PCCP shall be cleaned and filled when specified. Cleaning shall include removal of old sealant and backer rod. Air compressors shall be capable of producing a minimum air pressure of 100 psi. Water blasting shall not be utilized.

Joints shall be filled with hot poured joint sealant in accordance with the manufacturer's recommendations within 1/4 in. below the surface. A distributor in accordance with 409.03 shall be used with an indirect-heat double boiler kettle and mechanical agitator. The hot poured joint sealant shall be placed utilizing a "V" shaped wand tip, to allow the penetration of the materials into the joints.

507.05 PCCP Patching

(a) Full Depth and Partial Depth Patching

PCCP patching shall be in accordance with 506.

(b) Joint Repair

PCCP joint repair shall be in accordance with 509.

507.06 Profiling

Profiling consists of the diamond grinding of the pavement. The grinding shall be completed by mechanical grinding equipment in accordance with 508.08(c). Grinding shall be completed in a longitudinal direction and shall begin and end at lines normal to the pavement centerline in any ground section. The operation shall be coordinated such that the slurry or residue materials are continuously removed from the pavement. The slurry shall not encroach into adjacent pavement lanes carrying traffic, or flow into gutters or other drainage facilities and shall be immediately and directly deposited into a tanker truck and removed from the jobsite. Final disposal of the material shall be in accordance with 104.07 and 203.08. Pavement smoothness will be measured and adjusted in accordance with 501.25 and 501.28(d) after the cracks are routed, cleaned, and sealed in accordance with 507.03 and joints are sawed, cleaned, and resealed in accordance with 507.04.

507.07 Undersealing

Undersealing shall be in accordance with 612.

507.08 Retrofit Load Transfer for PCCP

Retrofit load transfer consists of diamond saw slot cutting and placing dowel bar assemblies in the PCCP, parallel to the centerline of the roadway without damaging

adjacent PCCP. The diamond-sawed slot shall be cut using two diamond saw blades per slot to cut the edges of the slot. The PCC within the slot and the burrs and bumps remaining in the base of the slots after cutting shall be removed with hand tools, or mechanical chipping hammers not to exceed a nominal 15 lb in weight and shall be operated at a maximum angle of 45° from the pavement surface.

All surfaces of the slots shall be thoroughly cleaned by sand blasting and all cracks in the slots shall be sealed with a silicone sealer. The slots shall be cleaned and blown dry with compressed air.

Dowel bar assemblies shall be as shown on the plans. Prior to placement, the assemblies shall be coated with a bond breaking material and placed on non-metallic supports in the slots. Dowel bars shall be parallel to the pavement surface.

Rapid setting patch material shall be mixed and cured in accordance with the manufacturer's recommendations. The material shall be placed in the slots and troweled to match existing adjoining PCCP. Excess material removed during placing and troweling shall not be reused.

Transverse contraction joints with retrofitted load transfers shall be sawed for the full lane width and sealed in accordance with 503.03(a) except the joint shall be cut in one operation. Transverse random cracks with retrofitted load transfer slots shall be routed and sealed for the full lane width in accordance with 503.05.

PCCP damaged outside the area of the slots due to the Contractor's operations shall be repaired in an acceptable manner or replaced.

507.09 Method of Measurement

Routing and sealing of cracks, filling of cracks, sawing and sealing of joints, and filling of joints will be measured by the linear foot, complete in place. Retrofit load transfer will be measured by each dowel bar assembly installed, complete in place.

PCCP patching will be measured in accordance with 506.13. PCCP joint repair will be measured in accordance with 509.18. Profiling, regardless of depth, will be measured by the square yard. Asphalt material and drilled holes for undersealing will be measured in accordance with 612.07.

Construction activities for the cutting, cleaning of the PCCP, dowel bars, dowel bar supports, dowel bar end caps, foam core board, patching material and all other incidentals will not be measured.

Routing of cracks or sawing of joints will not be measured. Routing and sealing of transverse random cracks at retrofitted load transfer assemblies will not be measured.

Temporary traffic control measures for routing, sealing or filling of cracks or

sawing, sealing, or filling of joints, and profiling will be measured in accordance with 801.17.

507.10 Basis of Payment

Routing and sealing of cracks, filling of cracks, sawing and sealing of joints, and filling of joints will be paid for by the linear foot, complete in place. The accepted quantities of retrofit load transfer will be paid for at the contract unit price per each assembly installed, complete in place.

PCCP patching will be paid for in accordance with 506.14. PCCP joint repair will be paid for in accordance with 509.19. Profiling will be paid for by the square yard. Undersealing and drilled holes will be paid for in accordance with 612.08.

The cost of temporary traffic control measures will be paid for in accordance with 801.18.

Payment will be made under:

Pay Item	Pay Unit Symbol
Cracks in PCCP, Filled	LFT
Cracks in PCCP, Rout and Seal	LFT
Joints in PCCP, Filled	LFT
Joints in PCCP, Saw and Seal	LFT
Profiling PCCP	SYS
Retrofit Load Transfer	EACH

The cost of cutting of slots, cleaning, dowel bars, dowel bar supports, dowel bar end caps, foam board, mortar, and curing materials shall be included in the cost of the pay item, retrofit load transfer.

The cost of cleaning, sealing materials, and all incidentals shall be included in the cost of the pay item cracks in PCCP, filled or joints in PCCP, filled.

The cost of routing, cleaning, sealing materials, and all incidentals shall be included in the cost of the pay item cracks in PCCP, rout and seal.

The cost of sawing, cleaning, sealing materials, and all incidentals shall be included in the cost of the pay item joints in PCCP, saw and seal.

The cost of all grinding, diamond cutting heads, and cleaning of the pavement, shall be included in the cost of the pay item for profiling.

SECTION 508 – EQUIPMENT

508.01 Mixing, Transportation, and Placement of PCC Mixtures

The Contractor shall provide and calibrate all equipment necessary for mixing, transportation, and placement of the PCCP.

508.02 Mixing Plant

(a) Plant Inspection

The concrete production equipment shall be capable of producing a uniform mixture. A plant inspection in accordance with 106.03 will be made by the Engineer annually, after a plant is moved, or as deemed necessary.

(b) Proportioning System

Batching plants shall be equipped to proportion aggregates and bulk cement by weight by means of automatic and interlocked proportioning devices. PCCP produced in accordance with 501 and 502 shall document each ingredient in each batch.

All scales shall be accurate to within ±0.5% throughout their range. For applied loads less than 1,000 lb on the cement scale and 4,000 lb on the aggregate scale, the scales shall be accurate to 2.0% or 1 gradation.

Meters for both admixtures and water shall be accurate to within 1.0%.

Means of control shall be provided so that as the quantity desired in the weighing hopper is approached, the materials may be added at a slower rate and shut off with precision. The following proportioning tolerances shall be used for batching:

1. admixtures.....±3%
2. aggregates.....±2%
3. cementitious materials.....±1%
4. water, volume or weight.....±1%.

The plant shall be equipped with a recording device capable of producing a ticket to permanently record the batch number, time of day, weight of all materials in the mix, volume or weight of mixing water added, and admixture quantities or equipped with a suitable non-resettable batch counter which will correctly indicate the number of batches produced. The CMD number shall be included on the ticket.

(c) Material Storage

The plant shall have separate storage bins or tanks for each material in the mixture. Each compartment shall discharge efficiently and freely into the weighing hopper or feed through a meter.

1. Aggregates

The aggregate storage area shall be well drained. All stockpiles shall be

sufficiently separated and identified by signs or other approved methods.

2. Cementitious Materials

The storage bins shall be sealed and vented to preclude dusting during operation and have a sampling port.

3. Admixtures

Separate tanks for each admixture shall be provided.

(d) Hoppers

Weighing hoppers shall be constructed to eliminate accumulation of materials and to discharge fully. The fine aggregate and coarse aggregate shall be weighed separately into a weigh hopper in the respective amounts defined in the CMD. Separate scales and hoppers shall be used for weighing the cement. SCMs may be weighed into the cement hopper in one cumulative operation provided that the portland cement is weighed in first.

(e) Mixing System

The concrete mixing system shall be either a central stationary mixer or a transit truck mixer. Each mixer shall have attached in a prominent place a manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete, the speed of rotation of the mixing drum or blades, and the manufacturer's name and address.

The mixer shall be capable of combining the ingredients of the concrete within the specified time into a thoroughly mixed and uniform mass.

1. Central or Stationary Mixers

Stationary mixers shall be equipped with a timing device which does not enable the batch to be discharged until the specified mixing time has elapsed.

2. Truck Mixers

Truck mixers shall be equipped with means by which the number of revolutions of the drum at mixing speed may be verified.

508.03 Transportation

(a) Truck Mixers and Truck Agitators

Truck mixers and agitators shall be capable of maintaining and discharging the concrete at a satisfactory rate and degree of uniformity. The haul units shall be examined daily for accumulations of hardened concrete or mortar and compared to the manufacturer's standard for wear of blades.

(b) Non-Agitator Trucks

Bodies of non-agitating hauling equipment shall be smooth, mortar-tight, metal containers. They shall be capable of discharging the concrete at a controlled rate. The

bodies shall be examined daily for accumulations of hardened concrete, mortar, or foreign matter.

508.04 Placement Equipment

(a) Slipform

The paver shall spread, consolidate, and shape the freshly placed concrete in one complete pass to provide a dense and homogeneous pavement. The paver shall be of sufficient weight and power to construct the specified PCCP, at an adequate variable forward speed, and without transverse, longitudinal, or vertical instability. The paver shall be equipped with an automated steering and elevation control system.

The paver shall consolidate by vibrating the concrete for the full width and depth of the PCCP. Vibration shall be accomplished by internal vibrators, which have a variable frequency range of 7,000 to 12,000 vibrations per minute. The amplitude of vibration shall be between 0.025 in. and 0.06 in. The vibrators shall be spaced and operated to achieve acceptable consolidation. The paver shall include a handheld tachometer or other suitable device for measuring the frequency of the vibrators. The automated vibrator control shall be capable of stopping vibration when forward movement ceases.

Mechanical tie bar inserters shall be rigidly attached to the paver and may be operated manually or automatically controlled.

A mechanical belt placer, if used, shall have a re-combining deflector plate mounted on the end of the discharge belt.

(b) Form Riding Equipment

The finishing machine shall be supported by forms and be equipped with two or more oscillating type transverse screeds and a transverse smoothing float.

Forms for riding equipment shall be of sufficient thickness to maintain the true cross-section and shall be furnished in sections no less than 10 ft in length. Forms shall have a minimum depth equal to the prescribed edge thickness of the concrete pavement without a horizontal joint, and a minimum base width equal to the depth of the forms. Flexible or curved forms shall be of an acceptable design.

Forms shall be provided with adequate devices for secure setting so that when in place they can withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Flange braces shall extend outward on the base a minimum of 2/3 of the height of the form. The top face of the form shall not vary from a true plane by more than 1/8 in. in 10 ft and the upstanding leg shall not vary by more than 1/4 in. The forms shall contain provisions for locking the ends of abutting form sections together tightly for secure setting.

The transverse screed and transverse smoothing float shall be suspended from and

guided by a rigid frame. The frame shall have a maximum effective wheel base of 14 ft. The length of the float shall be approximately 2 in. less than the normal width of the pavement and have an adjustable crown section. The forward speed of the float shall be adjustable.

The vibration equipment shall consolidate the full width and depth of the strip of PCCP being placed. Vibrators may be either the surface pan type or the internal type with either immerse tube or multiple spuds.

Vibrators may be attached to the spreader or the finishing machine or mounted on a separate carriage. The frequency of the surface pan type shall be 3,500 impulses per minute or greater. The frequency of the internal type shall have no less than 5,000 impulses per minute for tube vibrators and spud vibrators shall have a frequency of from 10,000 to 12,000 impulses per minute in air.

The paver shall include a device, such as a handheld tachometer for measuring the frequency of the vibrators. Vibrators shall have automatic controls, which stop vibration when forward motion ceases. The maximum spacing of spud vibrators shall be 2 ft. A warning device shall be connected to each vibrator circuit to indicate a failure of any individual vibrator and shall be visible from the ground.

(c) Hand Placement

1. Steel Forms

Steel forms shall be 10 ft or greater in length. Forms shall be capable of being staked in three locations or more for each 10 ft section and shall be equipped to interlock. Forms shall support finishing equipment without deflection in either the vertical or horizontal direction. The top face of the form shall not vary from a true plane by more than 1/8 in. in 10 ft.

2. Wood Forms

Wood forms shall support finish equipment without deflection in either vertical or horizontal direction.

3. Finishing Equipment

Finishing equipment shall be capable of producing a uniform surface free of voids and in accordance with the planned profiles and cross-section.

A mechanical tube finisher shall consist of a single or multiple rotating strike-off/finish tubes setting approximately transverse to the longitudinal movement of the machine. The length of finish tubes shall be a minimum of 2 ft longer than the planned PCCP width. The forward speed of the machine as well as the rate of the finish tube rotation shall be variable and it shall be reversible to allow for multiple finish passes.

A vibratory screed finisher shall consist of a truss frame with a minimum base width of 1 ft, which extends across the transverse width of the PCCP. The frame shall

extend 2 ft beyond the width of the PCCP and shall hold its shape when moved forward. The screed shall move forward with either hydraulic or manual winches capable of maintaining the screed at a right angle to the direction of travel. The screed shall be vibrated as it moves forward and the vibration shall stop when forward motion ceases. Vibration shall be accomplished with mechanical driven eccentric weights or with auxiliary driven pneumatic vibrators.

A mechanical bridge deck finishing machine shall consist of a single or multiple rotating cylinders setting approximately parallel to the longitudinal movement of the machine and operating transversely. The forward motion of the machine as well as the transverse movement of the finish cylinders shall be variable.

A hand operated strike off shall be rigid and shall hold its shape when moved forward with a combined longitudinal and transverse motion.

A mechanical belt placer, if used, shall have a re-combining deflector plate mounted on the end of the discharge belt.

4. Vibrators

Hand spud vibrators shall be capable of transmitting 7,000 to 10,800 impulses per minute in air. The diameter of the head shall be 1 1/4 to 2 1/2 in.

508.05 Curing

Mechanical equipment shall be self-supported and ride on wheels or tracks located outside the paving lane. The mechanical sprayer shall be capable of applying a continuous uniform film at a minimum rate of 1 gal./150 sq ft and shall be of the fully atomizing type. The equipment shall provide adequate agitation of the compound during application.

Hand spraying equipment shall be of the fully atomizing type.

508.06 Tining Equipment

The mechanical device shall have automated elevation and steering controls to ensure the forming of straight grooves of uniform depth and alignment in the plastic PCCP, without tearing the surface. The mechanical device shall have a single row of steel tines spaced as specified.

Hand tools consisting of fluted floats, rakes with spring steel tines, or finned floats with a single row of fins shall produce grooves which conform to the same requirements as those specified for the grooves formed by the mechanical device.

508.07 Sawing Equipment

Sawing equipment shall be self-propelled single or gang-mounted units. The saw shall be capable of maintaining the specified alignment and depth of cut without damaging the PCCP.

508.08 Miscellaneous Equipment

(a) Hand Tools

Long handled floats used to smooth and fill in open texture areas in the pavement shall have blades no less than 5 ft in length and 6 in. in width. Equipment made of or coated with aluminum or aluminum alloys shall not be used.

Straightedges shall be 10 ft in length and mounted on a long handle. The handle shall be 3 ft longer than 1/2 of the width of the pavement being placed.

(b) Joint Sealing

Joint sealant material shall be installed using manufacturer's recommended equipment.

Air compressors shall be capable of producing a minimum air pressure of 80 psi.

Water blasting equipment shall be capable of operating at 1,500 psi without damaging the PCCP.

(c) Grinding

Grinding shall be completed by mechanical grinding equipment using diamond tipped saw blades mounted on a power driven, self-propelled machine containing transverse and longitudinal grade controls. The cutting head shall be no less than 36 in. wide to produce a uniform texture per the full width of the cutting head shaft.

The pavement surface after cutting shall have a uniform texture but shall not be smooth or polished. Tearing or dislodging of aggregates will not be allowed.

508.09 Testing Facility and Equipment

(a) Testing Facility

The testing facility shall be capable of maintaining a controlled curing environment in accordance with AASHTO T 23 and contain sufficient storage tanks with curing solution to cure both production control and acceptance test beams.

Water shall be conveniently available for cleaning testing equipment and for serving other tasks at the facility. Office space, having suitable heat and air conditioning, shall be provided to the Department within the testing facility. A telephone shall be provided in the testing facility. Floor space shall be provided for a Department furnished beam breaker.

A current set of AASHTO's Standard Specifications for Transportation Materials and Methods of Sampling and Testing, Part 2 Tests, and ASTM C173 shall be provided.

(b) Testing Equipment

Testing equipment shall be provided to perform production control testing and shall be maintained in suitable working order. The equipment shall be in accordance with AASHTO requirements where applicable. The Contractor shall provide a spud vibrator with power source in suitable working order.

(c) Inertial Profiler

The inertial profiler shall be in accordance with ITM 917.

SECTION 509 - PORTLAND CEMENT CONCRETE PAVEMENT, PCCP, JOINT REPAIR

509.01 Description

This work shall consist of partial depth repairs and bottom-half of slab repairs at PCCP joints in accordance with 105.03.

MATERIALS

509.02 Materials

Materials shall be in accordance with the following:

Admixtures for Use in Concrete	912.03
Chemical Anchor System	901.05
Coarse Aggregate, Class A, Size No. 12*	904.03
Curing Materials	912.01(e)2
Epoxy Coated Reinforcing Bars	910.01(b)9
Fine Aggregate, Size No. 23	904.02
Joint Filler	906.01
Hot Poured Joint Sealant	906.02(a)2
Latex Modifiers	912.04
Portland Cement	901.01(b)
Rapid Hardening Hydraulic Cement	901.01(d)
Rapid Setting Patch Materials**	901.07
Water	913.01

* Crushed stone only

** The material may be extended with a coarse aggregate that is approved by the manufacturer and the Engineer.

Organic retarders, including food grade citric acid, may be used in concrete containing rapid hardening hydraulic cement.

Prepackaged concrete patching material shall be identified as grade 3U18 or 3U58 and selected from the QPL of Concrete for PCCP Joint Repair.

509.03 Concrete Mix Design

A CMD for the partial depth joint repair and bottom-half joint repair shall be

identified as being one of the following types and shall be in accordance with 509.04:

(a) prepackaged concrete patching material, CPM
(b) ordinary portland cement-based concrete, OPCC
(c) rapid hardening cement-based concrete, RHCC
(d) latex modified concrete, very early strength, LMC-VE
(e) rapid setting patch materials, RSP.

A CMDS for OPCC, RHCC, and LMC-VE shall be submitted in accordance with 506.03, except that the trial batch shall be in accordance with 509.06. Prepackaged concrete patching materials, CPM and RSP are not required to follow the submittal format of a CMDS, however, the Department shall be notified of their intended use. The CMDS, or notification of using CPM or RSP, shall be submitted a minimum of seven calendar days prior to the trial batch.

509.04 Concrete Mix Criteria

The fine aggregate for OPCC, RHCC, or LMC-VE shall be at least 48% but not more than 52% of the total volume of the aggregate in each unit volume of concrete. Proportions shall be based on aggregates in the bulk SSD condition.

The blend of coarse and fine aggregates for OPCC, RHCC, or LMC-VE shall meet the requirements stated in the table below. Aggregate volumes within the repair concrete will be determined based on the bulk SSD properties for each aggregate:

COMBINED GRADATION OF COARSE AND FINE AGGREGATES	
Sieve Size	Percent Passing
3/8 in. (9.5 mm)	98 - 100
No. 4 (4.75 mm)	77 - 93
No. 8 (2.36 mm)	40 - 80
No. 16 (1.18 mm)	25 - 50
No. 30 (600 µm)	15 - 35
No. 50 (300 µm)	0 - 18
No. 100 (150 µm)	0 - 8
No. 200 (75 µm)	0 - 2.3

(a) CPM or OPCC

CPM or OPCC shall produce workable mixtures, with the minimum amount of water, having the following properties:

Portland cement content.....846 lb/cu yd
Maximum slump for OPCC and CPM 3U18.....1.5 in.[A]
Maximum slump for CPM 3U58.....6 in.[A]
Maximum water/cementitious ratio.....0.400[B]

Air Content .....7.0% ±1.5%
Minimum modulus of rupture .....500 psi at 7 days[C]
Minimum compressive strength .....3,200 psi at 7 days[D]
Maximum shrinkage in air .....0.060% at 28 days[D]
Relative Yield for OPCC .....1.00 ±0.02

[A] Measured five minutes after discharge from the mixer.

[B] The target water cement ratio shall be established at the time of the trial batch and shall be based on the slump requirement.

[C] Concrete beams and cylinders cast for the purpose of evaluating the mix criteria shall be cured in accordance with AASHTO T 23 Section 10.1, Standard Cure conditions.

[D] The maximum allowable shrinkage will only apply if the Contractor requests to omit tooling as part of re-establishing the longitudinal joint prior to sawing. Testing shall be in accordance with ASTM C157 and conducted on specimens cast using the same materials stated in the CMDS. A Type A certification in accordance with 916 shall be provided to the Department's Concrete Engineer.

Air-entraining admixtures may be used. No other chemical admixtures shall be used.

(b) RHCC or LMC-VE Mixes

All RHCC or LMC-VE mixes shall be proportioned to meet the following requirements and properties:

Rapid hardening cement content
for RHCC or LMC-VE ..... 658 lb/cu yd, minimum
Latex modifier for LMC-VE ..... 3.5 gal./94 lb cement
Maximum allowable water/cementitious
ratio for LMC-VE ..... 0.440[A]
Maximum allowable water/cementitious
ratio for RHCC ..... 0.450[B]
Slump ..... 3 to 7 in.[C]
Air Content for RHCC ..... 6.5% ±1.5%[D]
Air Content for LMC-VE ..... 0.0% - 6.0%
Minimum modulus of rupture ..... 500 psi[E]
Minimum compressive strength ..... 3,200 psi[E]
Maximum shrinkage in air ..... 0.060% at 28 days[F]

[A] Including the water in the latex.

[B] During production of RHCC, the water cement ratio shall be

maintained within ±0.020 of the target stated on the CMDP, not to exceed 0.450.

[C] Measured four to five minutes after discharge from the mixer.

[D] If the RHCC has a permeability of 900 coulombs or less at 56 days, the acceptable range of air content is allowed to be the same as LMC-VE. Verification of this property will be determined from testing of specimens cast at the trial batch. Testing will be done per AASHTO T 277, with the value determined by averaging the result of two specimens.

[E] Concrete beams and cylinders cast for the purpose of evaluating the mix criteria shall be cured in accordance with AASHTO T 23 Section 10.1, Standard Cure conditions. RHCC and LMC-VE shall achieve the minimum modulus of rupture in 12 hours or less. All RHCC and LMC-VE mixes shall provide opening to traffic within the requirements for maintenance of traffic and lane closure restrictions.

[F] The maximum allowable shrinkage will only apply if the Contractor requests to omit tooling the longitudinal joint prior to sawing. Testing shall be in accordance with ASTM C157 and conducted on specimens cast from concrete at the trial batch. A Type A certification in accordance with 916 shall be provided to the Department's Concrete Engineer.

(c) RSP

Prepackaged RSP material may be extended with a coarse aggregate as recommended by the manufacturer. Water shall be added in an amount not to exceed the amount recommended by the manufacturer. The material shall meet the same requirements for slump, compressive strength, and shrinkage as stated in 509.04(b).

509.05 Quality Control Plan

A QCP shall be in accordance with sections 1.1 through 4.7 of ITM 803, except that the QC Technician shall be an ACI-Certified Concrete Field Testing Technician, Grade I. The QCP shall be submitted to the Engineer a minimum of 15 days prior to commencing PCCP joint repair. Work shall not begin until written notice has been received that the QCP was accepted by the Engineer. At a minimum, the QCP shall contain the following information concerning aspects of producing, placing, finishing, and curing the joint repair concrete for joint restoration:

(a) Copies of all applicable AASHTO, ASTM, and ITM standards relevant to work being performed.

(b) Testing facility, if applicable, and a list of testing equipment meeting the requirements of Section 6.3.1 of ITM 803.

(c) Materials shall be identified as to their source, transportation, handling, and storage.

(d) Process control of aggregate when bulk aggregate is used. To include, but not limited to:

1. Gradation testing for each aggregate and calculation of blended gradation for control within allowable tolerance.

2. Absorption values for each aggregate, how they were determined, and subsequently checked.

3. Daily measurement and control of moisture content of each aggregate used in the concrete.

(e) Trial batch demonstration shall describe the procedures, location, mixing equipment, batching sequence, accuracy, and verification. The identification and intended use of each concrete mix.

(f) Batching of the concrete during repair operations shall be described to include weighing on scales, intended size of the batch, batching method, sequence, and mixing time. The methods to monitor materials used and the record of each batch shall also be included.

(g) Process control of the concrete shall address the following concrete properties as appropriate for the mix: sampling and testing for slump, relative yield, air content, water cementitious ratio, and temperature. The frequency of tests shall be the first batch of the day and not less than three times per day including the first. If volumetric batching of concrete is utilized, the yield will be checked as described in 722.05(a) at the beginning of the day and not less than two times per day including the first load from each mobile mixer. The QCP shall include details as to actions in response to test results.

(h) Joint repair operations shall be described, to include the materials and equipment used for re-establishing longitudinal and transverse joints; delivery, placement, consolidation, finishing, smoothness, texturing, curing of concrete, and procedures for monitoring each operation.

(i) Process control for weather restrictions shall be addressed, including what materials will be on-hand to protect the edges

and surface of the repair area, and what corrective actions are proposed in case the joint repair concrete is damaged by rain.

(j) Documentation and submittals.

509.06 Trial Batch

A trial batch shall be produced and tested to verify that the repair concrete is in accordance with the appropriate criteria for CPM, OPCC, RHCC, LMC-VE, or RSP concrete mixes.

The trial batch shall be conducted prior to production. The equipment used for mixing concrete at the trial batch shall be the same as what is identified in the QCP for use during field production.

The modulus of rupture from flexural strength testing and compressive strength will be determined by averaging a minimum of two tested specimens for each age. The beams and cylinders shall be cured in accordance with AASHTO T 23 Section 10.1, Standard Cure conditions. Only the specimen types intended for job control in accordance with 509.14 and determining opening to traffic strength in accordance with 509.17 are required to be included in the trial batch.

The Engineer will test the concrete for the plastic and hardened concrete properties as follows using the property values listed in 509.04.

	CPM	OPCC	RHCC, LMC-VE	RSP
Compressive strength	12, 36, 72 h	12, 36, 72 h	3, 6, 12, 24 h	3, 6, 12 h
Modulus of rupture	12, 36, 72 h	12, 36, 72 h	3, 6, 12, 24 h	3, 6, 12 h
Plastic testing	air, slump, W/C ratio*	relative yield, air, slump, W/C ratio*	relative yield, air, slump	slump
* The W/C ratio will be calculated after mix has been tested for slump.				

The Engineer will provide the Contractor the results of the tests. Relative yield will be measured in accordance with 722.05(a) for repair concrete produced in a volumetric mixer. Mobile mixers will be calibrated in accordance with 722.13.

The trial batch shall be of a sufficient quantity to allow the Engineer to perform all required tests from the same batch. Trial batch concrete shall not be used for more than one test.

CONSTRUCTION REQUIREMENTS

509.07 Pre-Work Meeting Requirements

A pre-work meeting between the Engineer and the Contractor will be held on-site

prior to beginning the work. The Contractor shall be prepared to discuss the following:

(a) work schedule,

(b) traffic control plan,

(c) equipment calibration and adjustments,

(d) inspection and evaluation of the condition and adequacy of equipment, including units for transport of materials,

(e) CMDP,

(f) the Contractor's daily rate of production per work crew, and

(g) QCP.

509.08 PCCP Removal

PCCP removal areas for partial depth repairs will be determined by sounding and will be marked. The Contractor shall remove all concrete to the limits shown on the plans or as directed by the Engineer.

A machine configured to safely and consistently mill the necessary profile as detailed on the plans shall be provided. The teeth on the milling head shall be spaced at either 1/2 in. or 5/8 in. The milling machine shall be approved by the Engineer prior to the start of milling operations. Whenever possible, the rotating axis of the milling head shall operate perpendicular to the joint being repaired. Should PCCP removal be confined to one side of a joint, the milling machine shall not cause damage to the adjacent pavement.

Unless otherwise approved by the Engineer, areas that are less than 1 sq ft shall be removed by saw cutting and chipping. The saw cutting shall be to a depth of 2 in. within the marked area. Overlapping saw cuts at the outer perimeter of the repair shall not extend more than 2 in. beyond the intersection. Removal of the concrete within the limits of the saw cuts shall be by hand chipping tools or handheld mechanically driven equipment.

Mechanical hammers may be used to remove the concrete inside the area delineated by the saw cuts but shall not be heavier than a nominal 35 lb class. Mechanically driven tools shall be operated at a maximum angle of 45° from the PCCP surface. A jack hammer with a wide chisel bit shall be used at a distance of 2 in. from the saw cut to remove the vertical edge and create a taper similar to the milling operations.

Removal areas within JRCP are not required to utilize milling to initiate partial depth repairs. Saw cutting and hand chipping may be used as described above. Any

wire mesh reinforcement exposed during the removal operations shall be removed.

PCCP removal areas shall not remain open overnight unless otherwise approved by the Engineer. Shoulders or adjacent PCCP damaged during the removal operations shall be repaired as directed.

Milling, or sawing and hand chipping, is allowed for transverse joint repairs that intersect a longitudinal joint that has already undergone partial depth joint repair. Removal areas along a longitudinal joint shall not disturb a transverse joint that has already undergone partial joint repair in accordance with this specification.

Prior to any transverse joint repair that intersects a previous longitudinal repair, the existing partial depth repair along the longitudinal joint shall have achieved at least 12 h of curing, a passing soundness inspection, and adequate strength, as defined in 509.17.

If there is no need for the transverse joint repair to completely cross the longitudinal joint, milling operations along the transverse joint shall stop short of the longitudinal joint so as not to cause damage beyond the longitudinal joint. Sawing and hand chipping shall be used to complete the removal process up to the longitudinal joint.

Longitudinal joint repairs shall be terminated 12 in. or more from a transverse joint.

The Engineer will check milled surfaces after PCCP removal to identify any unsound concrete that remains. Limits of the removal area will be identified by sounding with a rock hammer. Areas of unsound concrete will be marked and shall be removed with a chipping hammer. Removal of unsound concrete below the elevation of the tops of dowel bars or tie bars is not intended and unsound concrete shall remain in place in these areas. For transverse joints, any voids or significant surface irregularities resulting from the hand chipping operations that extend below the elevation of the top of the dowel bars shall be filled using hand placed clean sand to make a uniform, level, bedding material to support the joint filler. For longitudinal joints, void space below the elevation of the top of tie bars shall be filled with repair concrete.

Dowel bars shall not be damaged during the removal of unsound concrete. At locations where a transverse joint meets the edge of pavement, or where joints intersect, the Engineer will determine if the concrete is deteriorated for the entire depth, within the limits detailed on the plans for bottom-half joint repair. If either end of a dowel bar is exposed or misaligned in a bottom-half joint repair, the exposed portion shall be removed or cut flush with the concrete surface, as directed by the Engineer.

If the combination of removal for partial depth joint repair and bottom-half joint

repair exposes more than two adjacent dowels at a contraction joint, the Engineer shall be notified to determine if full depth patching is to be conducted in accordance with 506.08(b).

If a snowplowable RPM is to be installed in an area of partial depth joint repair, the width of the removal area, in proximity to where the RPM is to be installed, may be increased to provide the necessary clearances as specified in 509.16.

509.09 Surface Preparation and Joint Filler Installation

The milled or hand chipped cavities shall be prepared to provide a clean, irregular surface for the development of a good bond between the joint repair concrete and the existing pavement.

Broken concrete pieces shall be removed and the cavities shall be swept clean. The surface of the cavity shall be thoroughly sandblasted and cleaned with compressed air to remove all dust and chips. Cleaning with compressed air shall be performed as close to placing the concrete as possible, but not after installing any joint filler. If joint filler material has been installed, the surface may be cleaned again by using compressed air at low pressure to not damage the in-place filler or sand below the top of any exposed dowel bar just prior to placing the grout or concrete. The air lines for sandblasting and compressed air cleaning shall be equipped with oil traps to prevent contamination of the surfaces.

(a) Joint Filler - General Requirements

The installation of joint filler is required before concrete placement and shall be of a width that matches the existing transverse or longitudinal joint being repaired or a minimum width of 3/8 in., whichever is greater. The joint filler shall extend at least 3 in. beyond the length of the patch area. Joint filler shall be installed as one piece for the depth of the repair. Splicing long lengths of joint filler may be allowed. The method of splicing shall be as approved by the Engineer.

(b) Joint Filler at Transverse Joints and Bottom Half Repairs

Use of joint filler is required for establishing compression relief at all existing transverse D-1 contraction joints and along both the longitudinal and transverse joint sides of a bottom-half repair.

The joint filler shall not only re-establish the joint within the repair but shall also prevent the infiltration of the concrete into and across the crack or joint. Prior to placement of the joint filler at a transverse contraction joint, the joint shall be tooled or widened sufficiently at the bottom of the repair to create a slot so that the joint filler can be inserted a minimum of 1/4 in. below the bottom of the repair concrete. The base of the slot shall not extend below the elevation of the top of any exposed dowel bar. Joint filler shall be cut or trimmed to match the irregularities of the concrete at the bottom of the slot. Duct tape shall be placed as a bond breaker on exposed dowel bars.

Any void space that exists below the top of exposed dowels shall be filled with clean No. 23 natural sand that is sufficiently dry to flow into the gap.

(c) Longitudinal Joints

Joint repairs at longitudinal joints shall utilize either a joint filler to re-establish the joint or perform both of the following:

1. Tool the plastic repair concrete after placement to create a weak plane at the original joint location. The joint tooling equipment shall be identified in the QCP. Tooling of the joint may be eliminated if the concrete used in the patch has been verified by the Engineer as meeting the shrinkage requirements stated in 509.04.

2. Saw the joint after the repair concrete has adequately hardened. Sawing of the tooled joint shall be performed with a 1/4 in. blade. Sawing shall be done with care as soon as possible without causing excessive raveling of the repair material. The depth of the saw cut shall extend below the full depth of the repair by at least 1/4 in., but no closer than 1 in. above the tie bar. If it is determined that a crack forms at the bottom of the tooled joint before sawing can be performed without raveling, sawing to re-establish the joint shall not be performed.

Areas designated by the Engineer as requiring bottom-half joint repair shall be prepared as shown on the plans. The reinforcing bars shall be installed in accordance with 503.03(g).

509.10 Concrete Mixing and Transportation

For onsite weighing and batching of OPCC or RHCC, the appropriate number of pre-packaged bags of cement, shall be at the mixing site to accommodate the day's production. The fine and coarse aggregate shall be pre-weighed to within 2 % of their target for the batch size and placed in appropriate containers. Each aggregate component for a batch shall be identified as to material and weight, to facilitate accurate batching into the mixer in the proper sequence.

Water, air-entraining agent, and chemical admixtures, if appropriate, shall be at the mixing site. The water necessary to provide the required slump shall be measured by weight or volume and recorded for each batch. All components of cement, aggregates, water, air-entraining agent, and any organic retarder shall be charged into a paddle type mixer according to the sequence defined in the QCP and mixed for a minimum of five minutes. The location of mixing shall be on the job site in close proximity to the joint repair operations.

Prepackaged concrete, CPM 3U18, and an air-entraining admixture, may be used

instead of batching individual components. Pre-packaged concrete, CPM 3U58, shall not be modified with admixtures.

A prepackaged RSP material containing coarse aggregate may be used. Addition of water and mixing shall be in accordance with the manufacturer's instructions.

Wash water shall not be used as a portion of the mixing water for any joint repair concrete.

LMC-VE shall be mixed in a mobile type volumetric mixer meeting the requirements of 722.09(a). The Engineer may also allow batching and mixing of OPCC or RHCC in a mobile type volumetric mixer, except the mixer shall carry sufficient quantities of unmixed ingredients to produce at least 2 cu yds and is not required to be self-propelled. Calibration of the mixer shall be in accordance with 722.13.

509.11 Weather Limitations

Joint repair concrete that has been placed shall be protected from rain. Materials described in the QCP for protection of the edges and surface of the repair area shall be readily available for use. Should any damage result, the Engineer will suspend operations until corrective action as described in the QCP is taken.

Joint repair concrete shall not be placed when either the ambient temperature or existing concrete pavement temperature is less than 50°F.

Temperature restrictions for chemical anchor systems used in anchoring deformed steel reinforcement for bottom half repairs shall be in accordance with the manufacturer's recommendations.

509.12 Placing and Finishing Concrete

All CPM, OPCC, and RSP repair concrete mixes shall be placed within 15 minutes of mixing. RHCC and LMC-VE shall be placed within five minutes of mixing. All repair concrete shall be placed such that a cold joint does not occur within the limits of any type of joint repair. Placement may be isolated to one side of a joint if the joint face or joint filler is properly supported. Repair along a transverse joint that intersects a previously repaired longitudinal joint is allowed as described in 509.08.

For CPM and OPCC mixes, the cleaned surface shall be lightly sprayed with water to wet the surface without ponding and a bonding grout shall be applied to the prepared surface. The grout shall consist of two parts Type I or Type II portland cement and one part sand mixed with sufficient water to form a slurry that can be spread evenly onto the prepared concrete surface. The grout shall be mixed mechanically and applied by brushing or scrubbing, with a stiff bristle broom, onto the prepared and wetted concrete surface. The pot life of the grout shall not extend beyond 1 h. CPM or OPCC repair material shall be placed immediately after applying the bonding grout.

For RHCC and LMC-VE mixes, thoroughly soak the cleaned surface and maintain it in a wet condition for at least 2 h immediately prior to placing the repair concrete. Maintaining a wet surface shall be accomplished by covering the soaked surface with wet burlap. The burlap shall be re-wetted as necessary. A layer of white opaque polyethylene film, that is at least 4 mils thick, may be used to offset the need to rewet the burlap. Prior to placing the joint repair material, the burlap shall be removed. Any standing water in depressions, holes, or areas of concrete removal shall be blown out with compressed air or other type of blower sufficient for removal, or by using an approved vacuum system. The surface shall be damp at time of placing the repair concrete. Bonding grout shall not be used.

For RSP mixes, the cleaned surface shall be lightly sprayed with water to thoroughly wet the surface without ponding. RSP repair material shall be placed immediately after wetting the surface. Bonding grout shall not be used.

When using a bonding grout, if the material dries or whitens prior to placing the concrete joint repair material, the repair material shall not be placed. The dried grout shall be thoroughly removed by sandblasting and cleaning as specified in 509.09.

Concrete for partial depth joint repair shall be placed monolithically with concrete for bottom-half joint repair, using the same concrete mixture. Concrete shall be consolidated by internal vibration and struck off level to the adjacent PCCP. Joint filler shall remain straight for the length of the repair, within a tolerance of ±1/4 in. Concrete shall be hand finished and shall be controlled so that excess mortar and water is not worked into the surface. Final hand finishing shall have the trowels or floats work the surface from the joint toward the edge of the patch to avoid tearing the new concrete away from the existing pavement.

Edging is required for fresh concrete adjacent to all joint filler or forms. Concrete repairs at transverse joints shall not protrude into an HMA shoulder by more than 3/8 in. by forming or sawing the edges. The concrete surface of the partial depth joint repair shall be textured by brooming in the longitudinal direction of the repair. All repairs shall be broom textured regardless of subsequent surface treatments.

The final finished surface of the repair shall not vary more than 1/8 in. from the existing pavement surface as measured with a straightedge over the joint. Partial depth patches that are not smooth shall be corrected by diamond grinding. Such grinding shall be completed after the concrete has gained sufficient strength for opening to traffic.

Immediately upon completion of finishing and texturing of the partial depth joint repair for all mixture types including CPM, OPCC, RHCC, LMC-VE, and RSP, grout shall be applied with a brush to the entire perimeter of the repair. Proportioning and mixing of the grout shall be the same as previously described in this section for bonding of CPM and OPCC mixes.

509.13 Curing

A resin-based liquid membrane forming compound in accordance with 912.01(e)2 shall be applied as soon as possible after the bleed water has dissipated. The compound shall be agitated in the shipping container to obtain a homogenous mixture for transfer to the job site application equipment. Application of curing compound shall be in accordance with the following:

(a) Rate of application shall be at least 1 gal. per 200 sq ft of surface curing area.

(b) Curing compound shall be applied to provide a uniform, solid, white opaque coverage on all exposed concrete surfaces similar to a white sheet of paper.

(c) If the applied curing compound is damaged by rain or other means during the curing period, the damaged area shall be repaired as soon as possible by re-application at a rate equal to the original coat.

(d) If the Engineer determines that the initial, or corrective re-application, results in unsatisfactory curing, the Engineer may prohibit the use of curing compound and instead require the use of wet double burlap or waterproof covers in accordance with 504.04.

Whenever weather conditions exist that cause unusual or adverse placing and finishing conditions or equipment failures occur, the application of curing materials shall be expedited, or the mixing and placing operations shall be temporarily suspended as the conditions require.

When a deficiency is identified in the curing process, the joint repair shall be removed and replaced. If the repair is removed exposing an underlying bottom-half repair, the bottom-half repair shall also be removed and replaced.

509.14 Job Control

Control of concrete for slump, air content, or relative yield, as appropriate for the mix, and strength based on modulus of rupture obtained from flexural strength beams or compressive cylinders will be determined from the tests performed by the Engineer in accordance with 505.

If additional manpower for concrete sampling is deemed necessary by the Engineer, the Contractor shall furnish the additional labor. Testing for slump, air content, and relative yield, as appropriate for the mix, will be on the first batch of the day and a minimum of once per every 400 cu ft thereafter. Beams or cylinders will be made for evaluating the quality of the delivered mix at least once for every three days of production or whenever slump, relative yield, or air content are failing the upper limit. The beams or cylinders will be tested for compliance with strength requirements,

at an age consistent with the mixtures intended use as defined in 509.04. Beams or cylinders for this purpose shall be cured in accordance with Section 10.1 of AASHTO T 23 and 505.01(a).

The Engineer will notify the Contractor when measurements for slump, unit weight, air content, or modulus of rupture are outside of the specified requirements. Rounding will be in accordance with 109.01(a).

509.15 Joint Sealing

Joint openings within a repair area shall be maintained for the full depth of the joint repair concrete as described in sections 509.09 and 509.12. Longitudinal and transverse joints shall be sawed to create a reservoir for the sealant, to be followed by cleaning and sealing.

If the longitudinal joint was re-established by sawing in accordance with 509.09(c)2, additional sawing to create a reservoir for the sealant is not required.

If the longitudinal joint was not sawed due to cracking in accordance with 509.09(c)2, the reservoir for the sealant shall be sawcut to a maximum depth of 7/8 in.

The cleaning and sealing of the joint shall be in accordance with 507.04(a) and as follows. Transverse and longitudinal joints shall be sealed with hot poured joint sealant in accordance with the sealant manufacturer's recommendations. Joints shall be sealed with joint sealing materials within 1/4 in. below the surface and shall extend beyond the limits of the patch to any existing sealant that is to remain in place.

A distributor in accordance with 409.03 shall be used with an indirect-heat double boiler kettle and mechanical agitator. The hot poured joint sealant shall be placed utilizing a "V" shaped wand tip to allow the penetration of the material into the joints.

Any grinding to correct smoothness of partial depth patches shall be completed prior to joint sealing.

509.16 Snowplowable RPMs

Snowplowable RPM shall be located and installed in accordance with 808.11, except that the marker shall be installed a minimum of 2 in. from the longitudinal joint. If the marker is installed within the limits of the partial depth patch, the slot shall be at least 2 in. from the edge of the repair. The repair material shall have attained a modulus of rupture of 500 psi or greater from flexural strength testing or 4,000 psi from compressive testing, prior to creating the slot for the adhesive and RPM. The slot may be created by grinding or by saw cutting and hand chipping. Each RPM installation will be inspected for proper installation. There shall be no visual cracks at the surface of the partial depth patch and the installation will be sounded to detect any loss of bond between the partial depth patch material and the substrate PCCP. Any such defect shall require repair of the partial depth patch and reinstallation of the RPM to the satisfaction of the Engineer, which may involve removal and replacement of the

partial depth patch along the longitudinal joint between the limits of the transverse contraction joints. Any such repairs shall be made at no additional cost to the Department.

509.17 Opening to Traffic

Opening to traffic strength will be based on the modulus of rupture from one flexural strength test or the average of two cylinders. Cylinders will be either 6 in. by 12 in. or 4 in. by 8 in. Completed partial depth repairs and bottom-half repairs may be opened to traffic when flexural strength tests indicate a minimum modulus of rupture of 500 psi or when compressive strength tests indicate a minimum of 3,200 psi based on the average of the two individual cylinder breaks. Beams or cylinders for this purpose will be cast from repair concrete placed near the very end of each day's production for each different CMDP used and cured in accordance with Section 10.2 of AASHTO T 23 and 505.01(a).

Prior to opening to traffic, the Contractor and the Engineer will conduct an inspection of the partial depth patches to determine if there are any failures. Failures will include, but are not limited to, debonding of the repair concrete or random surface cracks. Repair of the failed partial depth joint repair or bottom-half joint repair shall be completed by an approved method prior to opening the pavement to non-construction traffic.

509.18 Method of Measurement

Partial depth joint repair will be measured at the surface, by the square foot, using linear dimensions measured to the nearest 0.1 ft.

Bottom-half joint repair will be measured by the square foot using linear dimensions measured to the nearest 0.1 ft at the mid-depth of the pavement, when the following conditions are met:

(a) The PCCP is removed full depth to visibly expose the subbase below.

(b) The minimum number of reinforcing bars are furnished and installed as shown on the plans.

If the above requirements for bottom-half repairs are not met, the Engineer will only take measurements for payment under partial depth joint repair regardless of depth of the repair.

Additional removal width to accommodate the Contractor's equipment will not be measured.

For repairs at intersecting joints, the same area of joint repair will not be measured twice.

Sawing and sealing of joints in areas of partial depth joint repair will not be measured.

509.19 Basis of Payment

Partial depth joint repair and bottom-half joint repair will be paid for at the contract unit price per square foot. Measured areas of partial depth joint repair that are not located at a joint or crack will be paid as partial depth joint repair.

Payment will be made under:

Pay Item	Pay Unit Symbol
Joint Repair, Partial Depth	SFT
Joint Repair, Bottom-half	SFT

The cost of the trial batch for each concrete mixture, removing and disposing of the in-place concrete pavement as marked by the Engineer, tapering the edges of the repair back at 30 to 60 degrees, cleaning, sandblasting and air blasting, treatment of dowel bars, furnishing and installing bonding grout, furnishing and installing joint filler or tooling and sawing to re-establish the joint within or along the repair, furnishing and placing the concrete within the repair, vibrating, screeding, finishing, texturing, placing cement slurry around the edges, curing and protecting the concrete, sawing and sealing to re-establishing joints, cleanup, and any other materials, labor, equipment, or incidentals necessary to complete the work as specified shall be included in the cost of the joint repair, partial depth pay item.

The cost of removal and disposal of the in-place concrete pavement as determined by the Engineer, cleaning sandblasting and air blasting, treatment of dowel bars, furnishing and installing steel reinforcement, furnishing and installing bonding grout, furnishing and installing joint filler and sawing to re-establish the joint within or along the repair, furnishing, placing, and vibrating the concrete within the repair, sawing and sealing to re-establishing joints, cleanup, and any other materials, labor, equipment, or incidentals necessary to complete the work as specified shall be included in the cost of the joint repair, bottom-half pay item.

Areas of removal for PCCP Joint Repair, which after inspection by the Engineer, are determined to need PCCP Patching, Full Depth in accordance with 506.08(b), will be paid at 40% of the contract unit price per sq ft for the work represented for both Joint Repair, Partial Depth and Joint Repair, Bottom-half. PCCP Patching, Full Depth will be paid at 100% of the contract unit price.

During periods of overnight lane closure, if the Engineer inspects an area of joint repair and determines that PCCP Patching, Full Depth in accordance with 506.08(b) is necessary, the joint repair may be completed if needed to meet the opening to traffic requirement. If completed in order to meet the opening to traffic requirement, the joint repair will be paid at 100% of the contract unit price.

Joint repair areas that do not meet the curing requirements of 509.13 shall be removed and replaced at no additional cost to the Department.

Additional removal width to accommodate the Contractor's equipment shall be at no additional cost to the Department.

Removal and replacement of partial depth patches and snowplowable raised pavement markers as described in 509.16 for debonding and other defects shall be at no additional cost to the Department.