April 26, 2012

REVISION OF SECTIONS 105, 106, 412, AND 601

CONFORMITY TO THE CONTRACT OF

PORTLAND CEMENT CONCRETE PAVEMENT AND DOWEL BARS FOR TRANSVERSE WEAKENED PLANE JOINTS

**NOTICE**

This is a standard special provision that revises or modifies CDOT’s *Standard Specifications for Road and Bridge Construction.* It has gone through a formal review and approval process and has been issued by CDOT’s Project Development Branch with formal instructions for its use on CDOT construction projects. It is to be used as written without change. Do not use modified versions of this special provision on CDOT construction projects, and do not use this special provision on CDOT projects in a manner other than that specified in the instructions unless such use is first approved by CDOT’s Standards and Specifications Unit. The instructions for use on CDOT construction projects appear below.

Other agencies which use the *Standard Specifications for Road and Bridge Construction* to administer construction projects may use this special provision as appropriate and at their own risk.

**Instructions for use on CDOT construction projects:**

Use on all projects with Portland cement concrete pavement

The designer will place a note in the General Notes indicating whether the project will be accepted by flexural strength or compressive strength.

The Region Materials Engineer shall be consulted for assigning the acceptance criteria.

For rural projects the following criteria will be used for assigning acceptance criteria:

* Projects with greater than 5,000 sq. yds of PCCP will be accepted by flexural strength criteria.
* Projects with 5,000 or less sq. yds of PCCP will be accepted by compressive strength criteria
* If a rural project with greater than 5,000 sq. yds of PCCP consists of scattered repairs, or only intersection replacements, compressive strength criteria will be used for acceptance.

For metro area projects:

* Projects with more than 50,000 sq.yds. will be flexural strength.
* Project with less than 5,000 sq.yds. will be compressive strength
* Projects with 5,000 to 50,000 sq.yds could be either compressive or flexural. Consult the RME to determine acceptance method

Sections 105, 106 and 601 of the Standard Specifications are hereby revised for this project as follows:

Delete subsection 105.06 and replace with the following:

**105.06 Conformity to the Contract of Portland Cement Concrete Pavement.** Conformity to the Contract of all Portland Cement Concrete Pavement, Item 412, will be determined in accordance with the following:

When the Engineer finds that the materials furnished, the work performed, or the finished product does not conform with the Contract, or the Pay Factor (PF) for an element's process is less than 0.75 but that reasonably acceptable work has been produced, the Engineer will determine the extent of the work that will be accepted and remain in place. The Engineer will use a Contract Modification Order to document the justification for allowing the work to remain in place and the price adjustment that will be applied.

When the Engineer finds the materials furnished, work performed, or the finished product is not in conformity with the Contract, or the PF for an element's process is less than 0.75 and has resulted in an inferior or unsatisfactory product, the work or material shall be removed and replaced or otherwise corrected by and at the expense of the Contractor. When the PF for any process is 0.75 or greater, the finished quantity of work represented by the process will be accepted at the calculated pay factor.

Materials will be sampled and tested by the Contractor and the Department in accordance with subsection 106.06 and with procedures contained in the Department's Field Materials Manual. The approximate quantity represented by each sample will be as set forth in subsection 106.06, Tables 106-2 and 106-3. Additional samples may be selected and tested at the Engineer's discretion.

1. Incentive and Disincentive Payments (I/DP) will be made based on a statistical analysis that yields Pay Factors (PF) and Quality Levels (QL). The PF and QL will be made based on test results for the elements of compressive strength and pavement thickness (compressive strength criteria) or the elements of flexural strength and pavement thickness (flexural strength criteria). The Department will indicate in the plans whether compressive strength or flexural strength criteria will be used.

Incentive or Disincentive payment will not be made for thickness of concrete pavement furnished by the Contractor and placed by others.

When compressive strength criteria is indicated, then the QL will be calculated for the elements of compressive strength and pavement thickness on a process basis. When flexural strength criteria is indicated, then the QL will be calculated for the elements of flexural strength and pavement thickness on a process basis. A separate process will be established for an element when a change in the process affects that element. A process will consist of the test results from a series of random samples. Test results determined to have sampling or testing errors will not be used. All materials produced will be assigned to a process. A change in process is defined as a change that affects the element involved. Changes in mix design, material source, design pavement thickness, or the method being utilized to place the pavement are considered changes in process. The following is provided to clarify changes in processes for each element:

1. Construction of mainline pavement, including the shoulders if placed with the mainline, is a single process, providing there are no changes in process as described above.

2. Construction of ramps, acceleration and deceleration lanes, shoulders placed separately, and areas requiring hand work are considered separate processes.

3. A change in the mix design is a process change for the compressive strength element or the flexural strength element, but is not a process change for the pavement thickness element.

(b) When it is necessary to represent material by one or two tests, each individual test shall have a PF computed in accordance with the following:

If the value of the test is at or above the lower tolerance limit, then PF = 1.000. If the value of the test is below the lower tolerance limit, then:

PF = 1.00 – [0.25(TL -T0)/V]

where: PF = pay factor.

V = V factor from Tables 105-4 or 105-5.

T0 = the individual test value.

TL= lower tolerance limit.

(c) The following procedures will be used to compute Incentive and Disincentive Payments (I/DP), quality levels (QL), and pay factors (PF) for processes represented by three or more tests:

1. Quality Level (QL) will be calculated according to CP-71.

2. Compute the PF for the process. When the process has been completed, the number of tests (Pn) it includes shall determine the formula to be used to compute the final pay factor in accordance with the following:

A. For compressive strength and pavement thickness:

When 3 ≤ Pn ≤ 5

If QL ≥ 85, then PF = 1.00 + (QL ‑ 85)0.001333

If QL < 85, then PF = 1.00 + (QL ‑ 85)0.005208

When 6 ≤ Pn ≤ 9

If QL ≥ 90, then PF = 1.00 + (QL ‑ 90)0.002000

If QL < 90, then PF = 1.00 + (QL ‑ 90)0.005682

When 10 ≤ Pn ≤ 25

If QL ≥ 93, then PF = 1.00 + (QL ‑ 93)0.002857

If QL < 93, then PF = 1.00 + (QL ‑ 93)0.006098

When Pn ≥ 26

If QL ≥ 95, then PF = 1.00 + (QL ‑ 95)0.004000

If QL < 95, then PF = 1.00 + (QL ‑ 95)0.006757

B. For flexural strength:

When 3 ≤ Pn ≤ 5

If QL ≥ 85, then PF = 1.00 + (QL ‑ 85)0.002000

If QL < 85, then PF = 1.00 + (QL ‑ 85)0.005208

When 6 ≤ Pn ≤ 9

If QL ≥ 90, then PF = 1.00 + (QL ‑ 90)0.003000

If QL < 90, then PF = 1.00 + (QL ‑ 90)0.005682

When 10 ≤ Pn ≤ 25

If QL ≥ 93, then PF = 1.00 + (QL ‑ 93)0.004286

If QL < 93, then PF = 1.00 + (QL ‑ 93)0.006098

When Pn ≥ 26

If QL ≥ 95, then PF = 1.00 + (QL ‑ 95)0.006000

If QL < 95, then PF = 1.00 + (QL ‑ 95)0.006757

3. Compute the I/DP for the process:

I/DP = (PF‑1)(QR)(UP)

where: QR = Quantity Represented by the process.

UP = Unit Price bid for the Item.

The total I/DP for an element shall be computed by accumulating the individual I/DP for each process of that element.

(d) As acceptance test results become available, they will be used to calculate accumulated QL and Incentive and Disincentive Payments (I/DP) for each element and for the item. The Contractor's test results and the accumulated calculations shall be made available to the Engineer upon request. The Engineer's test results and the calculations will be made available to the Contractor as early as reasonably practical. Numbers from the calculations shall be carried to significant figures and rounded according to AASHTO Standard Recommended Practice R-11, Rounding Method.

I/DP will be made to the Contractor in accordance with subsection 412.24(a). During production, interim I/DP will be computed for information only. The Pn will change as production continues and test results accumulate. The Pn at the time an I/DP is computed shall determine the formula to be used.

(e) The Contractor will not have the option of accepting a price reduction or disincentive in lieu of producing specification material. Continued production of non‑specification material will not be permitted. Material which is obviously defective may be isolated and rejected without regard to sampling sequence or location within a process.

**Table 105‑4**

**"V" FACTORS AND INCENTIVE PAYMENTS**

**COMPRESSIVE STRENGTH CRITERIA**

|  |  |  |  |
| --- | --- | --- | --- |
| **Element** | **V factor** | **Maximum Incentive Payment** | **Lower Tolerance Limit, TL** |
| Compressive Strength | 400 psi | 2.00 percent | 4,500 psi |
| Pavement Thickness | 0.4 inch | 2.00 percent | Plan Thickness  -0.4 inch |
|  |  |  |  |

**Table 105‑5**

# "V" FACTORS AND INCENTIVE PAYMENTS

**FLEXURAL STRENGTH CRITERIA**

|  |  |  |  |
| --- | --- | --- | --- |
| **Element** | **V factor** | **Maximum Incentive Payment** | **Lower Tolerance Limit, TL** |
| Flexural Strength | 50 psi | 3.00% | 570 psi |
| Pavement Thickness | 0.4 inch | 2.00% | Plan Thickness  -0.4" |

*Sand Equivalence*. If compressive strength criteria is indicated then the sand equivalence (SE) as determined by CP 37 will be considered acceptable when the running average of three consecutive tests is greater than 80 percent and no individual test result is less than 75 percent. When the running average of three consecutive SE tests falls below 80 percent or an individual SE test result falls below 75 percent, paving operations shall be suspended. The Contractor shall submit a written plan to correct the low SE test results to the Engineer for approval. The Contractor shall not continue paving operations until the Engineer approves the plan in writing and three SE test results from random samples in the stockpile are above 80 percent.

Delete subsection 106.06 and replace with the following:

**106.06 Sampling and Testing of Portland Cement Concrete Paving.** All Portland Cement Concrete Pavement, Item 412, shall be tested in accordance with the following quality control and acceptance testing procedures:

* + 1. *Quality Control Testing*. The Contractor shall be responsible for quality control testing of all elements listed in Table 106‑2 or 106-3. Quality control testing shall be performed at the expense of the Contractor. The Contractor shall develop a quality control plan (QCP) in accordance with the following:

Quality Control Plan. For each element listed in Tables 106-2 or 106-3, the QCP must provide adequate details to ensure that the Contractor will perform quality control. The Contractor shall submit the QCP to the Engineer at the preconstruction conference. The Contractor shall not start any work on the project until the Engineer has approved the QCP in writing.

* 1. Frequency of Tests or Measurements. The QCP shall indicate a random sampling frequency, which shall be equal to or more frequent than that shown in Table 106-2 or 106-3. The quality control tests shall be independent of acceptance tests.
  2. Test Result Chart. Each quality control test result, the appropriate area, volume, and the tolerance limits shall be plotted. The chart shall be posted daily at a location convenient for viewing by the Engineer.
  3. Quality Level Chart. The QL for each element in Table 106-2 or 106-3 shall be plotted. The QL shall be calculated in accordance with the procedure in CP 71 for Determining Quality Level. The QL shall be calculated on tests 1 through 3, then tests 1 through 4, then tests 1 through 5, then thereafter the last five consecutive test results. The area of material represented by the last test result shall correspond to the QL.
  4. F-test and t-test Charts. If flexural strength criteria is indicated, then the results of F-test and t-test analysis between the Department's verification tests of flexural strength and the Contractor's quality control tests of flexural strength shall be shown on charts. The F-test and t-test shall be calculated in accordance with standard statistical procedures using all verification tests and quality control tests completed to date. When a verification test is completed, the F-test and t-test calculations shall be redone. The area of material represented by the last test result shall correspond to the F-test and t-test. A warning value of 5 percent and an alert value of 1 percent shall be shown on each chart. The chart shall be posted daily at a location convenient for viewing by the Engineer.

Point of Sampling. The material for quality control testing shall be sampled by the Contractor using CP 61. The location where material samples will be taken shall be indicated in the QCP.

* + - 1. Testing Standards. The QCP shall indicate which testing standards will be followed. Acceptable standards are Colorado Procedures, AASHTO and ASTM. The order of precedence is Colorado Procedures, AASHTO procedures and then ASTM procedures.

The compressive strength test for quality control will be the average strength of two test cylinders cast in plastic molds from a single sample of concrete, cured under standard laboratory conditions, and tested three to seven days after molding.

* + - 1. Testing Supervisor Qualifications. The person in charge of and responsible for the quality control testing shall be identified in the QCP. This person shall be present on the project and possess one or more of the following qualifications:
      2. Registration as a Professional Engineer in the State of Colorado.
      3. Registration as an Engineer in Training in the State of Colorado with two years of paving experience.
      4. A Bachelor of Science in Civil Engineering or Civil Engineering Technology with three years of paving experience.
      5. National Institute for Certification in Engineering (NICET) certification at level III or higher in the subfields of Transportation Engineering Technology, Highway Materials, or Construction Materials Testing Engineering Technology, Concrete and four years of paving experience.
      6. Technician Qualifications. Technicians performing tests shall meet the requirements of Colorado Procedure 10.
      7. Testing Equipment. All of the testing equipment used to conduct quality control testing shall conform to the standards specified in the test procedures and be in good working order. If flexural strength criteria is indicated, then the Contractor shall provide the following equipment and supplies which will not be paid for separately but shall be included in the work:
  1. A separate, temperature controlled facility of at least 300 square feet usable space. This facility shall be used exclusively for the molding, storage and testing of concrete test specimens as required. This facility shall be provided in addition to other facilities required in Section 620. The storage facility shall have sufficient water storage capacity for curing all required test specimens. The storage facility shall provide separate storage tanks for each type of required testing. Each storage tank shall have a continuously recording thermometer and sufficient blank charts for the project. Temperatures of each storage tank shall be recorded for the duration of the project.
  2. A machine for testing flexural strength of concrete specimens. The machine shall be used only for flexural strength tests. The machine shall be model number FX-250 manufactured by Forney with a DR2001 digital monitor or an approved equal. Both the Contractor and the Engineer will use this machine for testing concrete specimens. The machine shall meet the requirements of AASHTO T 97 and T 22 and the following: The machine and the flexural strength assembly shall be of a rigid construction. The applied vertical load shall be uniformly distributed to the third points and uniformly across the width of the beam (transverse distribution). Uniform distribution of the load is defined as less than a 3 percent variation in the load between each of the nine strain gages placed in the middle third section of the tension face for loads from 1,000 to 10,000 pounds. One firm that can evaluate and assess the ability of the machine to distribute the load evenly is KPFF Consulting Engineers, Chicago Illinois 847-859-7790 (Paul Okamoto). Other firms may be capable of evaluating and assessing the load distribution of the machine. The Engineer must approve the firm prior to assessing the machine. The machine shall be ready for use and certified two days before paving begins. After the machine has been certified and accepted by the Engineer it shall not be moved until all portland cement concrete paving and flexural strength acceptance tests have been completed.
  3. Beam molds for molding all test specimens required. This shall include all testing described in subsection 106.06.

1. Reporting and Record Keeping. The Contractor shall report the results of the tests to the Engineer in writing at least once per day.

The Contractor shall assemble a Quality Control (QC) notebook and update it daily. This notebook shall contain all worksheets, test results forms, test results charts and quality level charts for each of the elements listed in Table 106-2 or 106-3. The Contractor shall submit examples of worksheets, test result forms and test results charts in accordance with CP 12B as part of the Contractor's Quality Control Plan (QCP). The Contractor shall submit the QC notebook to the Engineer for review once a month on the date agreed to at the Pre-Construction Conference.

The QC notebook will be returned to the Contractor with a list of recognized deficiencies within two working days after submittal. Deficiencies may include, but are not limited to, the failure to submit the notebook on time or an absence of the required reports. For any month in which deficiencies are identified, the QC notebook will be submitted for review two weeks after the QC notebook is returned. Upon the second recognized deficiency the Engineer will notify the Contractor, and the pay estimate shall be withheld until the Contractor submits, in writing, a report detailing the cause for the recognized deficiency. The report shall include how the Contractor plans to resolve the deficiencies. Additional recognized deficiencies will result in a delay of the pay estimate until the Contractor has identified and resolved the deficiency along with revising and resubmitting his QCP to address these issues. Once the Engineer has reviewed and approved the revised QCP the estimate may be paid. Upon submittal of the QC notebook for the semi-final estimate, the QC notebook shall become the property of the Department. The Contractor shall make provisions such that the Engineer can inspect quality control work in progress, including QC notebook, sampling, testing, plants, and the Contractor's testing facilities at any time.

* + 1. *Acceptance Testing.* Acceptance testing frequencies shall be in accordance with the Schedule (Quality Assurance) in the Department’s Field Materials Manual. Except for flexural strength, acceptance tests will be conducted by and at the expense of the Department. Acceptance sampling and testing procedures will be in accordance with the Department's Field Materials Manual with the following exceptions and inclusions:

A split sample from an acceptance test shall not be used for a quality control test. The Engineer will designate the location where samples are to be taken. Samples shall be taken by the Contractor in accordance with CP 61. The Engineer will be present during the sampling and take possession of all acceptance samples. Samples transported in different containers will be combined and mixed before molding specimens. All materials are subject to inspection and testing at all times.

Pavement thickness acceptance will be determined by cores.

The compressive strength test for acceptance will be the average compressive strength of three test cylinders cast in plastic molds from a single sample of concrete and cured under standard laboratory conditions prior to testing. If the compressive strength of any one specimen differs from the average by more than 10 percent, that specimen will be deleted and the average strength will be determined using the remaining two specimens. If the compressive strength of more than one specimen differs from the average by more than 10 percent the average strength will be determined using all three specimens. Each set of three cylinders will be tested at 28 days after molding.

Acceptance tests for flexural strength shall be the Contractor's quality control tests. The flexural strength tests shall be the average flexural strength of four test beams. The test beams shall be prepared according to AASHTO T 23 with the following additional requirements: Specimens shall be consolidated by internal vibration without the vibrator being inserted in the center six inches of the specimen's long dimension. The flexural strength of each specimen shall be measured according to AASHTO T 97 with the following additional requirements: If the flexural strength of only one specimen differs from the average by more than 10 percent, that specimen shall be deleted and the average strength shall be determined using the remaining three specimens. If the flexural strength of more than one specimen differs from the average by more than 10 percent, the test value shall be the average of all four specimens. Each set of four beams shall be tested at 28 days after molding. Leather shims shall be used in each test.

* + 1. *Verification Testing.* Verification testing will be used only when flexural strength criteria is indicated and is the responsibility of the Department. The Department will determine the locations where samples or measurements are to be taken. The location of sampling shall be based on a stratified random procedure.

Verification sampling and testing procedures will be in accordance with Sections 105, 106, 412, the Schedule for Minimum Materials Sampling, Testing and Inspection in the Department's Field Materials Manual, and CP 13. Samples for verification and acceptance testing shall be taken by the Contractor in accordance with CP 61 in the presence of the Engineer.

An analysis of test results will be performed after all test results are known using the t-test and F-test statistical methods with an alpha value set at 0.05. If either the above t-test and F-test analysis shows a significant difference, then the following items shall be checked: comparison of beam fracture locations and types, computations and flexural testing machine outputs, curing tank temperature charts, slump and air contents, plant batch tickets for major changes, review of sampling, molding, testing procedures, along with IAT check tests and any other investigations that may clarify the significant differences. If after a review of the data no reasons can be determined for the significant difference, the Department's test data shall be used for determining Quality Levels and Incentive or Disincentive according to the methods in this Section.

* + 1. *Check Testing.* The Contractor and the Engineer shall conduct a check testing program (CTP) prior to the placement of any concrete pavement. The check testing program will include a conference directed by the Region Materials Engineer of the Contractor's testers and the Department's testers concerning methods, procedures and equipment for compressive or flexural strength testing. Check testing shall be completed before any portland cement concrete pavement is placed. A set of three cylinders or four beams will be molded by both the Contractor and the Department's project testers from a split sample. The specimens will be sampled, molded and cured for seven days and tested for compressive or flexural strength according to the procedures of Section 106. The Department's Independent Assurance Tester will also mold, cure and test a set of three cylinders or four beams, but the Independent Assurance Test results will not be entered in the check testing analysis. If the results of the check tests do not meet the following criteria, then the check testing will be repeated until the following criteria are met:

1. The average of the Contractor's test results and the average of the Department's test results shall be within 10 percent of the average of all test results.
2. Each specimen test result shall be within 15 percent of the average of all test results.

When compressive strength criteria is indicated, a check test must also be conducted on the sand equivalent test. A set of 5 sand equivalents will be run by both the Contractor's and the Department's project tester, from a split sample. The average of the absolute differences between tests taken by the quality control personnel and the acceptance testing personnel will be compared to the acceptable limits shown in Table 13-1 of CP 13. The CTP will be continued until the acceptance and quality control test results are within the permissible ranges shown in Table 13-1 of CP 13.

During production, split samples of randomly selected acceptance tests will be compared to the permissible ranges shown in Table 13-1 of CP 13. The minimum frequency will be as shown in Table 106-3.

If production has been suspended and then resumed, the Engineer may order a CTP between tests taken by quality control and acceptance testing persons to assure the test results are within the permissible ranges shown in Table 13-1 of CP 13. Check test results shall not be included in quality control testing. The Region Materials Engineer shall be called upon to resolve differences if a CTP shows unresolved differences beyond the ranges shown in Table 13-1 of CP 13.

* + 1. *Independent Assurance Testing*. Independent Assurance Tests (IAT) for flexural strength will be performed at a frequency of 1 per 50,000 sq. yds. The sample for the IAT will be a split sample of the Contractor's quality control test. The Department's representative performing verification tests shall also use a split sample of the Contractor's quality control test and participate in the IAT. The IAT for flexural strength will be the average flexural strength of four test beams prepared according to the requirements of Section 106 and cured for seven days.
    2. *Testing Schedule.* All samples used to determine Incentive or Disincentive payment by quality level formulas in accordance with Section 105, will be selected by a stratified random process.

**Table 106‑2  
TESTING SCHEDULE ‑ ITEM 412  
PORTLAND CEMENT CONCRETE  
PAVEMENT, FLEXURAL STRENGTH CRITERIA**

| **Element** | **Minimum Testing Frequency**  **Contractor's Quality Control** |
| --- | --- |
| Aggregate Gradation and Sand Equivalent | For the first five days, minimum of 1/day, then 1/10,000 sq. yds. After 5 days, 1/40,000 sq. yds. |
| Slump | First three loads each day, then as needed for control. |
| Water Cement Ratio | First three loads each day, then 1/500 cu. yds. |
| Air Content and Yield | Minimum of 1/day, then 1/2,500 sq. yds. |
| Flexural Strength | Minimum of 1/day, then 1/2,500 sq. yds. |
| Compressive Strength | 1/10,000 sq. yds. |
| Pavement Thickness | In accordance with subsection 412.21. |
| Pull Test Joints | Minimum of six transverse and six longitudinal joint locations for the 1st 2500 linear feet, then three transverse and three longitudinal joints thereafter |
| Load Transfer Dowel Bar Placement | In accordance with subsection 412.13 (b) 2 |
| Tining Depth | 1 per 528 linear feet in each lane and shoulder wider than 8 feet. |

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**Table 106‑3**

**TESTING SCHEDULE ‑ ITEM 412**

**PORTLAND CEMENT CONCRETE**

**PAVEMENT, COMPRESSIVE STRENGTH CRITERIA**

|  |  |
| --- | --- |
| **Element** | **Minimum Testing Frequency**  **Contractor's Quality Control** |
| Aggregate Gradation | Minimum of 1/day, then 1/10,000 sq. yds. |
| Slump | First three loads each day, then as needed for control. |
| Compressive Strength, Air Content, Yield, and Sand Equivalent | Minimum of 1/day, then 1/2,500 sq. yds. |
| Pavement Thickness | In accordance with subsection 412.21. |
| Pull Test Joints | Minimum of six transverse and six longitudinal joint locations for the 1st 2500 linear feet, then three transverse and three longitudinal joints thereafter |
| Load Transfer Dowel Bar Placement | In accordance with subsection 412.13 (b) 2 |
| Tining Depth | 1 per 528 linear feet in each lane and shoulder wider than 8 feet. |
| Water Cement Ratio | First three loads each day, then 1/500 cu. yds. |

Subsection 412.10 shall include the following:

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

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

Delete Subsection 412.13 (b) 2 and add replace with the following:

*2. Transverse Weakened Plane Joints.* When dowel bars are specified in the Contract, they shall be installed within the tolerances and of the size, grade, and spacing specified. Horizontal support wires or shipping braces shall be non-deformed bars or wires with a diameter less than or equal to 0.307 inches (gauge 0 wire). The number of horizontal support wires or shipping braces shall be limited to five per assembly. The horizontal support wires or shipping braces shall not be cut prior to concrete placement. The center of the dowel assembly or the insertion location shall be marked on both sides of the pavement slab for reference in sawing the joint. Dowel bars shall be furnished in a rigid welded assembly or placed by a dowel bar insertion (DBI) machine.

When a DBI is used, the Contractor shall submit details and specifications of the proposed slip-form paver and DBI to the Engineer a minimum of 14 calendar days prior to the Concrete Pavement Pre-Paving Conference. The Contractor shall detail his methodology for ensuring correct marking of dowel bar insertion points and correct sawing of the joints. The Contractor shall ensure that the slip-form paver is compatible with the DBI.

The rigid assembly shall be fabricated from number 1/0 wire or heavier with vertical support wires every 1 foot. Assembly shall be securely fastened to the subbase and constructed to firmly hold all the dowel bars at T/2 depth, parallel to each other and to the pavement grade and alignment. See standard plan M-412-1 for schematic describing the measurement of each tolerance. Dowel placement tolerances shall be as follows:

Target Tolerances:

Horizontal & Vertical Translation ≤ 1.0 inch,

Longitudinal (Side) Shift ≤ 2.1 inches,

Horizontal & Vertical Rotational Alignment ≤ 0.5 inch

Rejection Tolerance:

Horizontal & Vertical Translation > 1.5 inch,

Longitudinal (Side) Shift > 3.0 inches,

Horizontal & Vertical Rotational Alignment > 1.5 inch,

A weighted-score system will be used to conduct a joint-by-joint evaluation of rotational misalignments of the dowel bars. The Joint Score, as defined in this evaluation, is a measure of the combined effects of rotational misaligned dowel bars at a joint. A Joint Score is determined by summing the product of the weights (given in Table 412-1) and the number of bars in each misalignment category and adding 1. For example, if a joint has four misaligned bars in the 0.6 to 0.8 inch range, the joint score is 9; if a joint has one misaligned bar in the range 0.6 to 0.8 inch and one bar in the 1 to 1.5 inch range, the score is 8. A Joint Score of 10 is the critical level, above which the risk of joint locking is considered high.

**Table 412-1  
WEIGHTING FACTORS USED TO DETERMINE JOINT SCORE**

|  |  |
| --- | --- |
| Range of Rotational Misalignment | Weight |
| 0.4 in < d < 0.6 in. | 0 |
| 0.6 in < d < 0.8 in. | 2 |
| 0.8 in < d < 1 in. | 4 |
| 1 in < d < 1.5 in. | 5 |

Rejection Criteria:

Horizontal and Vertical Rotational Alignment—

Evaluate on joint-by-joint basis, using the Joint Score.

Isolated locked joints (as indicated by a Joint Score greater than 10) will be allowed, provided the adjacent joints have Joint Scores 10 or less.

Reject any bars with misalignment greater than 1.5 in.

Longitudinal (side) shift—

Reject any joints with fewer than three bars with a minimum embedment length of 6 in. under each wheel path.

Depth—

Reject any bar with the concrete cover above the bar less than 3 in. or the saw-cut depth.

Reject any joints with fewer than three bars with a minimum concrete cover below the bar of 3 in. in each wheel path

Corrective Measures:

The following corrective measures will be considered for the bars or joints that fail to meet the minimum standard as described by the Rejection Criteria. The Contractor shall submit his method of repair to the Engineer for approval. All materials shall be preapproved.

Horizontal or Vertical misalignment.

Saw-cut the misaligned bars.

Retrofit dowel bars to ensure that at least three dowel bars are provided in each wheel path that satisfy the Target Tolerances*.*

Longitudinal (side) Shift and missing bars.

Retrofit dowel bars to ensure that at least three dowel bars are provided in each wheel path that satisfy the Target Tolerances*.*

Depth.

Inadequate cover over the bar—If the problem bar can be removed, remove the entire bar and retrofit replacement bars to ensure that at least three dowel bars are provided in each wheel path that satisfy the Target Tolerances*.* If the problem bar cannot be removed, perform full-depth repair.

Inadequate cover below the bar—Retrofit dowel bars to ensure that at least three dowel bars are provided in each wheel path that satisfy the Target Tolerances*.*

In addition to the above written procedures, the Contractor may propose full depth removal and replacement of the joint.

Regardless of the dowel bar placement method used, the Contractor shall demonstrate his ability to place dowel bars in conformance with the specifications by placement of a test section.

The test section shall be a minimum of 300 feet in length. Following placement of the test section, the Contractor shall shut down paving operations. During the shutdown period, the Contractor shall evaluate all joints in the test section using the MIT-Scan-2, analyze the results and submit the results to the Engineer. Paving operations shall not be restarted until the Engineer approves the test section results. The test section will be found acceptable if 85% of the dowel bars placed are found to be within the rejection criteria. All dowel bars exceeding the Rejection Criteria must be addressed using the above suggested corrective measures.

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

Upon completion of the test section(s) and for each week of production, the Contractor shall prepare a report from the measurements obtained. All data shall be submitted in the manufacturer’s native file format, along with the calibration files. The Contractor shall submit a standard report generated using MagnoProof software (electronic Excel report) to the Engineer at the start of each working week during production for the previous weeks work.

The electronic report shall include the following:

1. Contract number, date, highway number and direction of traffic.
2. Joint number, lane number and station.
3. Bar number and x-location of dowel bar.
4. Horizontal and vertical misalignment in inches.
5. Side shift in inches.
6. Depth to center of dowel bars in inches.
7. Joint Score
8. All out-of-tolerance readings shall be highlighted in red.

Due to potential magnetic interference from tie bars, dowel bars located within 15 inches of a tied joint shall not be included in the evaluation.

When the test section is found to be unacceptable, the Contractor shall perform corrective actions and place a second test section. The Contractor shall develop a written plan outlining the steps to be taken in order to pave a successful test section, this plan shall be submitted to the Engineer for review and approval. If the second test section is found to be unacceptable, the Contractor shall pave no more than 500 feet per day until an acceptable test section has been achieved.

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

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

When any joint score is above 10 or any one bar in a single joint exceeds the rejection criteria, joints shall be tested in each direction from the affected location, until two consecutive joints are found to be within specification. Standard testing frequency shall apply thereafter.

All delays or costs associated with proposed equipment being rejected for use, by the Engineer will not be paid for by the Department, and will be considered an Non-excusable Delay in accordance with subsection 108.08 (c) 2.

When concrete shoulders or widenings are constructed subsequent to the driving lanes, transverse weakened plane joints shall immediately be formed in the plastic concrete of these widenings to create an extension of the existing transverse joint. This tooled joint shall be formed in such a manner that it controls the cracking and shall be sawed and sealed in accordance with the above requirements.

In subsection 412.21, delete the first sentence in the sixth paragraph.

In subsection 601.02, delete Class E and P Concrete from Table 601-1 and replace with the following:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Concrete Class** | **Required Field Compressive Strength (psi)** | **Cementitious Material Content: Minimum or Range (lbs/yd3)** | **Air Content: % Range (Total)** | **Water/Cementitious** **Material Ratio: Maximum or Range** |
| **E** | 4500 at 28 days | 520 | 4 – 8 | 0.44 |
| **P** | 4500 at 28 days | 520 | 4 – 8 | 0.44 |

In subsection 601.02, delete the sixth and ninth paragraphs and replace with the following:

**Class E** concrete may be used for fast track pavements needing early strength in order to open a pavement to service soon after placement. Class E concrete shall meet the requirements of Class P concrete. ASTM C150 Type III or ASTM C1157 Type HE cement may be used.

**Class P** concrete is used in pavements. Additional requirements are: The concrete mix shall consist of a minimum 55 percent AASHTO M 43 size No. 357 or No. 467 coarse aggregate by weight of total aggregate. If all transverse joints are doweled, the concrete mix shall consist of a minimum 55 percent AASHTO M 43 sizes No. 57, No. 6, No. 67, No. 357, or No. 467 coarse aggregate by weight of total aggregate. The laboratory trial mix shall produce a minimum average 28 day flexural strength of 650 psi when flexural strength criteria is indicated and 700 psi when compressive strength criteria is indicated.