

REVISION OF SECTION 106  
SAMPLING AND TESTING OF PORTLAND CEMENT CONCRETE PAVEMENT

Section 106 of the Standard Specifications is hereby revised for this project as follows:

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:

- (a) *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. If the Contractor chooses flexural strength criteria, then the Quality Control testing for flexural strength shall be performed at the expense of the Contractor. The Contractor shall develop a quality control plan (QCP) in accordance with the following:
1. **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.
    - A. **Frequency of Tests or Measurements.** The QCP shall indicate a random sampling frequency, which shall not be less than that shown in Table 106-2 or 106-3. The quality control tests shall be independent of acceptance tests.
    - B. **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.
    - C. **Quality Level Chart.** The QL for each element in Table 106-2 or 106-3 shall be plotted. The QL will be calculated in accordance with the procedure in CP 71 for Determining Quality Level. The QL will 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.
    - D. **F-test and t-test Charts.** If the Contractor chooses flexural strength criteria, 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 will 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 will 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.
  2. **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.
  3. **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.

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4. 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:
  - A. Registration as a Professional Engineer in the State of Colorado.
  - B. Registration as an Engineer in Training in the State of Colorado with two years of paving experience.
  - C. A Bachelor of Science in Civil Engineering or Civil Engineering Technology with three years of paving experience.
  - D. 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.
5. Technician Qualifications. Technicians performing tests shall meet the requirements of Colorado Procedure 10.
6. 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 the Contractor chooses flexural strength criteria, then the Contractor shall provide the following equipment and supplies which will not be paid for separately but shall be included in the work:
  - A. 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.
  - B. 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 Construction Technology Laboratories, Skokie Illinois (847)965-7500 (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.
  - C. Beam molds for molding all test specimens required. This shall include all testing described in subsection 106.06.
7. 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

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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.

- (b) *Acceptance Testing.* Acceptance testing frequencies shall be in accordance with Table 106-2 or Table 106-3. 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 quality control test. The Engineer shall 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. 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.

- (c) *Verification Testing.* Verification testing will be used only when the Contractor chooses flexural strength criteria and is the responsibility of the Department. The Department will determine the locations where samples or measurements are to be taken. The maximum quantity of material represented by each test result and the minimum number of test results shall be in accordance with Table 106-2. 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 and 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 using 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

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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.

(d) *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 the compressive strength criteria is chosen, 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 the quality control 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 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.

- (e) 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.
- (f) *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.

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

Element	Minimum Testing Frequency Contractor's Quality Control	Minimum Testing Frequency CDOT Acceptance Testing
Aggregate Gradation and Sand Equivalent	For the first five days, 1/10,000 sq. yds. or one/day if less than 10,000 sq. yds. are placed in a day. After 5 days, 1/40,000 sq. yds.	None
Slump	First three loads each day, then as needed for control.	Witness by the Engineer.
Water Cement Ratio	First three loads each day, then 1/500 cu. yds.	First three loads each day, then 1/2000 cu. yds.
Air Content and *Yield	1/2500 sq. yds. or one/day if less than 2500 sq. yds. are placed in a day.	Minimum of 1/day. If the project total < 50,000 sq. yds. then a minimum of ten tests. If the project total ≥ 50,000 sq. yds. Then 1/5000 sq. yds.
Flexural Strength	1/2500 sq. yds. or one/day if less than 2500 sq. yds. are placed in a day.	One verification test per four quality control tests performed by the Contractor. (Approximately 1/10,000 sq. yds.).
Compressive Strength	1/10,000 sq. yds.	None
Pavement Thickness	In accordance with subsection 412.21.	Minimum of 1/day. If the project total < 50,000 sq. yds. then a minimum of ten tests. If the project total ≥ 50,000 sq. yds. Then 1/5000 sq. yds.
Pull Test Joints	Minimum of six transverse and six longitudinal joint locations for the 1 <sup>st</sup> 2500 linear feet, then three transverse and three longitudinal joints thereafter	Witness by the Engineer.
Load Transfer Dowel Bar Placement	Minimum of six transverse joint locations in each 2500 linear feet.	Witness by the Engineer.
Tining Depth	1 per 528 linear feet in each lane and shoulder wider than 8 feet.	Witness by the Engineer.
*Yield is for information only.		

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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	Minimum Testing Frequency CDOT Acceptance Testing
Aggregate Gradation and Fractured Faces	1/10,000 sq. yds. or one/day if less than 10,000 sq. yds. are placed in a day	None
Slump	First three loads each day, then as needed for control.	Minimum of 1/day. If the project total < 50,000 sq. yds. then a minimum of ten tests. If the project total $\geq$ 50,000 sq. yds., then 1/5,000 sq. yds.
Compressive Strength, Air Content, *Yield, and Sand Equivalent	1/2500 sq. yds. or one/day if less than 2500 sq. yds. are placed in a day.	Minimum of 1/day. If the project total < 50,000 sq. yds. then a minimum of ten tests. If the project total $\geq$ 50,000 sq. yds., then 1/5,000 sq. yds.
Pavement Thickness	In accordance with subsection 412.21.	Minimum of 1/day. If the project total < 50,000 sq. yds. then a minimum of ten tests. If the project total $\geq$ 50,000 sq. yds. then 1/5000 sq. yds.
Pull Test Joints	Minimum of six transverse and six longitudinal joint locations for the 1 <sup>st</sup> 2500 linear feet, then three transverse and three longitudinal joints thereafter	Witness by the Engineer.
Load Transfer Dowel Bar Placement	Minimum of six transverse joint locations in each 2500 linear feet.	Witness by the Engineer.
Tining Depth	1 per 528 linear feet in each lane and shoulder wider than 8 feet.	Witness by the Engineer.
*Yield is for information only.		