

DIVISION C500 – RIGID PAVEMENT

SECTION C500 – PORTLAND CEMENT AND RIGID PAVEMENT

C500.01 Summary. Portland cement is used in the production of Portland cement concrete (PCC) to construct many infrastructure components including rigid pavements. This section will focus primarily on sampling and testing Portland cement and Portland cement concrete for rigid pavements. For other concrete components, see Division C600.

C500.02 Production and Operations. All sources of materials used for production of concrete must be approved prior to use. A record of this approval must be kept in the plant files and Materials & Research Central Laboratory files. This approval may be the “blanket-type” (from the Portland cement concrete supplier) for a construction season or may be on a project-by-project basis. The approval documentation consists of a letter from the Materials Laboratory identifying the source of materials that has been tested, and whether the material has been approved for use in the production of Portland cement concrete.

The materials source documentation provides the Department with a record of materials used on the project. Even though a previously tested source of material may be furnishing a material to the plant, further tests are required as a means of quality assurance. It is the responsibility of the Materials & Research technician to take the required quality assurance tests, as described in section C500.04, C500.05, and C500.06.

Delivery of concrete to a project site is not permitted until two conditions are satisfied. First, the plant must obtain approval of the sources of materials used in the concrete. Second, project field inspection personnel must verify that the placement contractor has taken all steps necessary to place the concrete according to the applicable specifications. Upon verification, project field inspection personnel will issue a release, either orally or in writing, for concrete delivery. It is the plant inspector’s duty to document the release on the truck sheet for each project. An example of a truck sheet (Form LB-1) is shown in Part E.

The following requirements for concrete production plants ensure that concrete produced and shipped to Department projects conforms to Specifications. It is the responsibility of Materials & Research Section technicians to ensure that all requirements have been met prior to production of concrete for Department projects.

- (a) *Scale Checks.* Each production facility must have its scales checked and approved prior to use. The LB-2 report (Part E) is used to document approval of the scales for use. A complete scale check should be made at least every six months, or as directed by the Engineer.

In lieu of a complete scale check, several quick checks may be made if necessary. For example, a partial batch may be weighed and the 500 lb (226 kg) test weight added to the load. The corresponding increase in load should be 500 lbs (226 kgs). Alternatively, a complete batch could be weighed and the 500 lb (226 kg) weight added to the load. This approach would check for any binding or error in the high ranges of the scales.

- (b) *Calibration of Batch Plant Operations.* If Portland cement concrete is to be made by volumetric batching and continuous mixing, additional steps must be taken to ensure functionality of the equipment. They are as follows:
- (1) *Measuring Materials.* All trucks must be calibrated and approved before use. Refer to form LB-1, which is provided in Part E. Cement, fine and coarse aggregates, water, and admixtures may be measured by weight or by volume. If volume (or weight) proportioning is employed, devices such as counters, calibrated gate openings, or flow meters must be available for controlling and determining the quantities of the ingredients discharged. In operation, the entire measuring and dispensing mechanism must produce the specified proportions of each ingredient.
 - (2) *Yield Check.* The volume of concrete discharged from the mixer is checked using a $\frac{1}{4}$ yd³ (36" x 36" x 9") (0.18m³ (900 x 900 x 225mm)) rigid box to prove the quantity of concrete produced at a given cement meter register count. For example, if a cement meter count of 550 is required to produce 1 yd³ (1 m³) of concrete, a cement meter register count of 137.5 will fill the $\frac{1}{4}$ yd³ (0.18m³) box. The accuracy of the output indicated shall be within ± 2 percent of the measured volume.

C500.03 Portland Cement. Portland cement may be accepted based on the Manufacturer's Certification. A description of this process is given below. If the manufacturer fails to fully comply with all aspects of this self-certification program, the certification may be cancelled.

Manufacturer's Certification of Portland Cement. The quality control tests and procedures of the cement manufacturer are considered adequate when the following certification program is implemented by the manufacturer and accepted by the Department. The details of the acceptance through the certification program are as follows:

- (a) The Cement and Concrete Reference Laboratory (CCRL) of the National Institute of Standards and Technology (NIST) must inspect and approve the manufacturer's control laboratory. Inspections by the CCRL must be made on each regularly scheduled visit.
- (b) The manufacturer must demonstrate that an adequate quality control program regulates the production of cement. A complete and detailed description of control methods, sampling procedures, and testing rates must be provided. A description of control charts or statistical methods used for quality control is essential and must also be provided. The manufacturer must agree to produce any data related to quality control at any time requested by the Engineer.
- (c) Before granting approval to furnish certified cement, the Department may request that the manufacturer make all production, sampling, and testing facilities available to the Department for inspection. Thereafter, the Department's

technician or representative shall be permitted, at any time, to make additional inspections as deemed necessary by the Engineer.

- (d) The manufacturer is to submit a 10 lb (5 kg) sample of each type of cement requiring approval. If the company has several cement mills, then each mill must be individually approved.
- (e) The phone and fax number for a designated technical contact must be supplied.
- (f) A monthly mill report for each type of cement or source is required to maintain certification.
- (g) If the cement has not been used for two years in a State contract, it will require re-testing, following step (d) above, to maintain certification.
- (h) Qualification for participation shall in no way be binding. If the manufacturer fails in any way to meet any qualification requirements, or does not satisfactorily follow the procedures established herein, it may be immediately withdrawn from approved certification status. In such cases, pre-testing, reserved bins, and other similar requirements will be required.

Each shipment of certified Portland cement must be accompanied by certification that the contents comply with applicable specifications. Each certification document must be signed by an authorized representative of the manufacturer. The documents must show the manufacturer's name, production location, carrier number, date loaded, amount of cement in carrier, silo or mill test reports, consignee, destination, type of cement, and contract number. However, the contract number is not required when the shipment is from a plant that is approved to produce cement for multiple projects.

When small quantities of cement are required for mortar, grouting, and similar uses, the contractor may be authorized to use bagged cement obtained from supply houses. The cement must be identified as conforming to the type required by the Special Provision item being used.

C500.04 Obtaining Samples.

- (a) *Portland Cement.* For non-certified Portland cement production facilities, Materials & Research technicians take samples from mill bins as the bins are being filled. For certified Portland cement production facilities, Department personnel obtain samples at the point of delivery. Samples are to be taken directly from the carrier unless there are extenuating circumstances. The sampling rate for both certified and non-certified facilities is shown in Table B-1. These are often referred to as "Check Samples".
- (b) *Portland Cement Concrete for Rigid Pavements.* Materials used in the production of Portland cement concrete are sampled according to methods described in Table C-17. Components of Portland cement concrete materials are sampled and tested separately to ensure that the materials used conform to applicable specification

requirements. Upon sampling of the materials, samples are labeled according to the methods described in Table C-18.

- (1) *Portland Cement.* One 10-pound (4.5 kg) sample per 550 tons (500 metric tons) of cement delivered to the plant. If less than 550 tons (500 metric tons) is delivered to the plant, at least one weekly sample shall be obtained. An example of the identification tag (LB-67) attached to the sample is shown in Part E.
- (2) *Coarse Aggregate.* One coarse aggregate sample must be taken for each 500 yd³ (375 m³) of concrete produced. A minimum of one sample per week must be taken if production at the plant is less than 500 yd³ (375 m³). Coarse aggregate samples are to be selected at a time and in a manner so as to be as representative as possible of the material being used. An example of the identification card is shown in Part E (LB-67). The number of aggregate samples required daily is determined on the basis of total plant production for Department projects. For example, if 730 yd³ (560 m³) of concrete were produced in a day, two coarse aggregate samples would be required; for 1230 yd³ (940 m³) three samples, etc.
- (3) *Fine Aggregate.* One sample of fine aggregate, obtained and tested at the production facility, is required for each 500 yd³ (375 m³) of concrete produced. A minimum of one sample per week must be taken if production at the plant is less than 500 yd³ (375 m³). Fine aggregates should be sampled in advance of use in production because they are tested at the Central Laboratory. An example of a sample identification card is shown in Part E (LB-67).
- (4) *Admixtures.* Admixtures are certified according to standards listed in Table B-1. Samples of admixtures are required only when specifically requested. The sampling rate is typically one quart (1 liter) per material.
- (5) *Latex.* One quart (1 liter) of material is taken directly from the tanker.
- (6) *Silica Fume.* One 25 lb (11.3 kg) bag is taken per source.
- (7) *Water.* If the source of water for the plant is a well or a municipal water supply system (potable), one sample per month is required. If non-potable water is used, one sample every two weeks is required. Sampling frequency may be increased as required for specific test procedures. A sample identification card is shown in Part E (LB-67).

Table C-14 shows the sampling rate for various materials at Portland cement concrete plants producing concrete for rigid pavements.

Table C-14: Minimum Sampling Quantities at Portland Cement Concrete Plants

Item	Samples Per Unit
Portland Cement	1 / 500 Tons (1 / 450 Metric Tons)
Coarse Aggregate	1 / 500 Tons (1 / 450 Metric Tons)
Fine Aggregate	1 / 500 Tons (1 / 450 Metric Tons)
Slag Cement	1 / 500 Tons (1 / 450 Metric Tons)
Water	1 Sample per Calendar Month
Latex	1 Quart / yd ³ (1 Liter / 1.39 m ³)
Silica Fume	1 / 100 Tons (1 / 90 Metric Tons)
Pozzolans (Fly Ash)	1 / 500 Tons (1 / 450 Metric Tons)

- (e) *Portland Cement Concrete for Project Assurance.* Materials are sampled at a rate to allow for tests to be performed at the frequencies listed in Table C-15.

C500.05 Handling, Packaging, and Shipping.

- (a) *Portland Cement Concrete for Rigid Pavements.* Concrete cylinders produced in the field are labeled according to the procedures shown in table C-18.
- (b) *Portland Cement.* Portland cement samples are shipped in sealed airtight bags to prevent contamination.
- (c) *Coarse Aggregate.* Coarse aggregate samples are shipped in sealed containers to prevent contamination.
- (d) *Fine Aggregate.* Fine aggregate samples are shipped in sealed containers to prevent contamination from moisture and foreign materials.
- (e) *Admixtures.* Admixtures are shipped in airtight, lidded containers.
- (f) *Water.* Water samples are shipped in sealed containers to prevent contamination.
- (g) *Latex.* Latex samples are shipped in a sealed glass or plastic quart jar.
- (h) *Silica Fume.* Silica fume samples are shipped in airtight plastic bags, jars, or small buckets.
- (i) *Pozzolans.* Pozzolan samples are shipped in airtight plastic bags, jars, or small buckets.

C500.06 Tests Performed. Tests performed on Portland cement and Portland cement concrete for rigid pavements are listed in Table B-1 for quick reference. The names of the test procedures are listed in Table C-19. Rigid pavement materials are tested in the field, at the plant, and in the laboratory. The quantity of testing for each item and the location of the testing, are referenced below.

- (a) *Portland Cement.* Materials obtained from the reserved bins at non-certified mills are tested according to AASHTO testing specifications. The materials may be incorporated into Portland cement concrete when they have passed the applicable tests.

Materials obtained from certified manufacturers are tested and the results are compared with the manufacturer's certification data. If the test results do not agree with the manufacturer's test results, an investigation will be conducted to determine the cause of the discrepancy.

- (b) *Testing Portland Cement Concrete for Rigid Pavements.*

- (1) *Plant Testing.* Portland cement concrete components are tested at the same rate as at the plant location.

- a. *Portland Cement.* Portland cement samples are tested in accordance with the methods described in the Portland cement section above. An example of a test report (Form LB-18) is shown in Part E.
- b. *Coarse Aggregates.* Coarse aggregates are tested at the plant for gradation purposes. The results of the gradation tests are recorded on Form LB-59 (Part E). If a problem arises, other tests such as Los Angeles Abrasion, specific gravity, and other material properties will be performed at the Central Laboratory. Coarse aggregate gradations are tested at the same rate as the samples that were obtained.
- c. *Fine Aggregates.* Fine aggregates are tested at the laboratory. An example of the results (Form LB-50) is provided in Part E.
- d. *Admixtures.* Admixtures are predominantly certified prior to use, but are tested according to relevant AASHTO specifications (depending on the type of admixture in question) if problems arise.
- e. *Water.* Tests performed on water used in Portland cement concrete are listed in Table B-1.
- f. *Latex.* Generally, latex is tested only when a problem occurs with the material or a test is requested. In those cases, the latex is tested for solids and pH level.
- g. *Silica Fume.* Silica fume is certified to meet required chemical and physical properties outlined on Form LB-80.

h. *Pozzolans*. Typical pozzolans used at the Department consist of fly ash or slag (LB-79 and LB-80, respectively), which are tested according to required procedures outlined in these forms.

(2) *Field Testing*. Portland cement concrete is tested in the field to verify material conformance to the specifications. The test methods are listed in Table C-11. The frequency at which the concrete is tested is based on the rate of placement in the field and is shown in the table below.

Table C-15: Test Properties/Minimum Testing Frequency of PCC in the Field

Test Property	Frequency
Air content	1 test per 500 yd ³ (400 m ³) concrete placed
Slump	1 test per 500 yd ³ (400 m ³) concrete placed
Compressive strength (cylinders)	4 cylinders* per 500 yd ³ (400 m ³) concrete placed
Temperature	1 test per 500 yd ³ (400 m ³) concrete placed

* 2 for 7-day compressive strength and 2 for 28-day compressive strength

C500.06 Test Report Evaluations and Distributions. Test results and reports are distributed as shown in Table C-16.

Table C-16: Distribution of Test Results and Reports

Test Results/Reports		Distribution for Each Test Result/Report
LB-1	Truck Sheet	Manufacturer – 1 copy Plant file – 1 copy Producer – 1 copy Lab file – original
LB-76	Portland Cement Test Results	
LB-78	Slag Cement Test Results	
LB-79	Fly Ash (or Pozzolans) Test Results	
LB-80	Silica Fume Test Results	
LB-50	Fine Aggregate Test Results	
LB-59	Coarse Aggregate Test Results	
LB-82	Latex Test Results	
LB-81	Water Test Results	
LB-62	Air Content, Slump, and Temperature Test Results	Plant file – 1 copy Producer – 1 copy Lab file – original
LB-11	Compressive Strength Test Results	
Manufacturer's Certification Information: Inspection Report of Manufacturer Control Laboratory Bin Tests and Plant Tests Cement Shipped		Chief Materials & Research Engineer Department of Transportation Materials & Research Section P.O. Box 778 Dover, DE 19903

Table C-17: Division 500 - Sampling Methods	
Method ID	Method Name
DOH 5	Sampling Stone, Slag, Gravel, Sand and Sand Block for Use as Highway Materials
DOH 8	Sampling of Portland Cement, 10 Lb. Sample
DOH 10	Sampling Fresh Portland Cement Concrete
ASTM 172-90	Practice for Sampling Freshly Mixed Concrete

Table C-18: Division 500 - Sample Identification Numbering
Concrete Cylinders are numbered consecutively from the beginning of testing at this laboratory, the Sample Identification is E#####, where the # sign represents the number of the test
Coarse aggregate samples start with Test # 1 on January 1 and are numbered consecutively until December 31. Example: D-1-02 D = Delaware , 1 = test number, 02 = Year 2002
Fine aggregate samples are numbered consecutively from the start of the fiscal year, July 1, until June 30 the following year
Fine and coarse aggregate specific gravity tests numbers are numbered consecutively from initiation of the computer program storing data to now.
Portland cement samples obtained are numbered consecutively in the order the sample was received. C###, Yr, where ### represent the number of the sample and Yr represents the year that the sample was received

Table C-19: Division 500 - Test Methods	
Test ID	Test Name
DOH 11	Making and Curing Concrete Compression and Flexural Test Specimens in the Field
DOH 12	Obtaining and Testing Drilled Portland Cement Concrete Cores
DOH 14	Air Content of Freshly Mixed Portland Cement Concrete (Acme Air Meter Type B)
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
AASHTO T21	Organic Impurities in Fine Aggregates for Concrete
AASHTO T22	Compressive Strength of Cylindrical Concrete Specimens
AASHTO T23	Making and Curing Concrete Test Specimens in the Field
AASHTO T24	Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
AASHTO T27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T105	Chemical Analysis of Hydraulic Cement
AASHTO T106	Compressive Strength of Hydraulic Cement Mortar (Using 50-mm or 2-in Cube Specimens)
AASHTO T107	Autoclave Expansion of Portland Cement
AASHTO T119	Slump of Hydraulic Cement Concrete
AASHTO T129	Normal Consistency of Hydraulic Cement
AASHTO T131	Time of Setting of Hydraulic Cement by Vicat Needle
AASHTO T133	Density of Hydraulic Cement
AASHTO T137	Air Content of Hydraulic Cement Mortar
AASHTO T152	Air Content of Freshly Mixed Concrete by the Pressure Method
AASHTO T153	Fineness of Hydraulic Cement by Air Permeability Apparatus
AASHTO T154	Time of Setting of Hydraulic Cement by Gillmore Needles
AASHTO T162	Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
AASHTO T186	Early Stiffening of Hydraulic Cement (Paste Method)
AASHTO T196	Air content of Freshly Mixed Concrete by the Volumetric Method
AASHTO T199	Air Content of Freshly Mixed Concrete by the Chace Indicator
AASHTO T277	Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
AASHTO T299	Rapid Identification of Alkali-silica Reaction Products in Concrete
AASHTO T303	Accelerated Detection of Potentially Deleterious Expansion of Mortar Bars Due to Alkali-Silica Reaction
AASHTO T309	Temperature of Freshly Mixed Portland Cement Concrete

Table C-20: Division 500 - Certification Test Procedures / Material Standards	
Test ID	Test Name
AASHTO M31	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
AASHTO M152	Flow Table for Use in Tests of Hydraulic Cement
AASHTO M154	Air-Entraining Admixtures for Concrete
AASHTO M201	Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
AASHTO M220	Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
AASHTO M240	Blended Hydraulic Cement
AASHTO M282	Joint Sealants, Hot-Poured, Elastomeric-Type, for Portland Cement Concrete Pavements
AASHTO M295	Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
AASHTO M301	Joint sealants, Hot-Poured, for Concrete and Asphalt Pavements
AASHTO M302	Ground Iron Blast-Furnace Slag for Use in Concrete and Mortars
AASHTO M307	Microsilica for Use in Concrete and Mortar