

## ITEM P-304 CEMENT-TREATED AGGREGATE BASE COURSE (CTB)

### DESCRIPTION

**304-1.1** This item shall consist of a cement-treated base (CTB) course composed of mineral aggregate and cement, uniformly blended and mixed with water. The mixed material shall be spread and shaped with a mechanical spreader, and compacted with rollers in accordance with these specifications and in conformance to the lines, grades, dimensions, and cross-sections shown on the plans.

### MATERIALS

**304-2.1 Aggregate.** The aggregate shall be select granular materials, comprised of crushed or uncrushed gravel and/or stone, or recycled cement concrete. The material shall be free of roots, sod, and weeds. The crushed or uncrushed aggregate shall consist of hard, durable particles meeting the requirements in the table below.

**Cement Treated Aggregate Base Material Requirements**

Material Test	Requirement	Standard
<b>Coarse Aggregate Portion (retained on the No. 4 (4.75 mm) sieve)</b>		
Resistance to Degradation	Loss: 40% maximum	ASTM C131
Soundness of Aggregates by Use of Sodium Sulfate <b>or</b> Magnesium Sulfate	Loss after 5 cycles: 10% maximum using Sodium sulfate - or - 15% maximum using magnesium sulfate	ASTM C88
Flat Particles, Elongated Particles, or Flat and Elongated Particles <sup>1</sup>	10% maximum, by weight, for fraction retained on the ½ inch (12.5mm) sieve and 10% maximum, by weight, for the fraction passing the 1/2-inch (12.5 mm) sieve	ASTM D4791
Clay lumps and friable particles	Less than or equal to 3 percent	ASTM C142
<b>Fine Aggregate Portion (Passing the No. 40 (425µm) sieve)</b>		
Liquid limit	Less than or equal to 25	ASTM D4318
Plasticity Index	Not more than 6	ASTM D4318

<sup>1</sup> A flat particle is one having a ratio of width to thickness greater than five (5); an elongated particle is one having a ratio of length to width greater than five (5).

**304-2.2 Gradation Requirements.** The aggregate shall conform to the gradation(s) shown in the table below per ASTM C136. A dense, well-graded aggregate blend that meets the requirements of the table shall be selected by the Contractor and used in the final mix design. The final aggregate blend shall be well graded from coarse to fine within the limits designated in the table and shall not vary from the low limit on one sieve to the high limit on adjacent sieves, or vice versa.

**Aggregate Gradation for CTB Material**

<b>Sieve Size</b>	<b>Design Range Percentage by Weight Passing</b>	<b>Contractor's Final Gradation</b>	<b>Job Control Grading Band Tolerances for Contractor's Final Gradation<sup>2</sup> Percent</b>
2 inch (50 mm)	100		±0
1 inch (25.0 mm)	90-100		±5
No. 4 (4.75 mm)	45-95		±8
No. 10 (2.00 mm)	37-80		±8
No. 40 (425 µm)	15-50		±5
No. 200 (75 µm)	0-15		±3

For Contractor quality control, sample the aggregate stockpile in accordance with ASTM D75 and perform gradation tests in accordance with ASTM C136 a minimum of once per week during production of CTB.

**304-2.3 Sampling and testing.**

**a. Aggregate base materials.** The Contractor shall take samples of the aggregate base stockpile in accordance with ASTM D75 to verify initial aggregate base requirements and gradation. Material shall meet the requirements in paragraphs 304-2.1 and 304-2.2. This sampling and testing will be the basis for approval of the aggregate base quality requirements. The Contractor must provide stockpile gradation sample testing as part of the mix design submittal, one week prior to CTB production, and a minimum of once per week during production of CTB.

**304-2.4 Cement.** Cement shall conform to the requirements of ASTM C150, Type I or II.

**304-2.5 Cementitious additives.** Pozzolanic and slag cement may be added to the CTB mix. If used, each material must meet the following requirements:

**a. Pozzolan.** Pozzolanic materials must meet the requirements of ASTM C618, Class F, or N with the exception of loss of ignition, where the maximum shall be less than 6%.

**b. Slag cement (ground granulated blast furnace (GGBF) slag).** Slag shall conform to ASTM C989, Grade 100, or 120.

**304-2.6 Water.** Water used in mixing or curing shall be from potable water sources. Other sources shall be tested in accordance with ASTM C1602 prior to use.

**304-2.7 Curing materials.** Curing material shall be a white-pigmented, liquid membrane-forming compound conforming to ASTM C309, Type 2, Class A or Class B (wax-based).

**304-2.8 Bond Breaker.** Choke stone shall be an ASTM C33 Number 89 stone.

**COMPOSITION OF MIXTURE**

**304-3.1 General.** The CTB material shall be composed of a mixture of aggregate, cementitious material, and water. Fly ash or slag cement may be used as a partial replacement for cement.

**304-3.2 Mix design.** The mix design shall use a cement content that, when tested in the laboratory per ASTM D1633, produces a 7-day compressive strength between 300 pounds per square inch minimum and 600 pounds per square inch maximum. Avoid higher strengths due to potential to cause shrinkage and reflective cracks.

Wet-dry and/or freeze-thaw tests shall be performed in accordance with ASTM D559 and ASTM D560 respectively. The weight loss for each type of test shall not exceed 14% after 12 cycles.

The mix design shall include a complete list of materials, including type, brand, source, and amount of cement, fine aggregate, coarse aggregate, water, and cementitious additives.

Should a change be made in aggregate sources or type of cement, or if cementitious additives are added or deleted from the mix, production of the CTB mix shall be stopped and a new mix design shall be submitted.

**304-3.3 Submittals.** At least 30 days prior to the placement of the CTB, the Contractor shall submit certified test reports to the Owner's Authorized Representative (OAR) for those materials proposed for use during construction, as well as the mix design information for the CTB material. Tests older than six (6) months shall not be used. The certification shall show the ASTM or AASHTO specifications or tests for the material, the name of the company performing the tests, the date of the tests, the test results, and a statement that the material did or did not comply with the applicable specifications. The submittal package shall include the following:

a. Source(s) of materials, including aggregate, cement, cementitious additives, curing, and bond-breaking materials.

b. Physical properties of the aggregates, cement, cementitious additives, curing, and bond-breaking materials.

c. Mix design:

- Mix identification number
- Aggregate gradation
- Cement content
- Water content
- Cementitious materials content
- Compaction and strength results
- Laboratory compaction characteristics (maximum dry density and optimum moisture content)
- Compressive strength at seven (7) days
- Wet-dry and/or freeze-thaw weight loss.

No CTB material shall be placed until the submittal is accepted in writing by the OAR.

During production, the Contractor shall submit batch tickets for each delivered load.

### **EQUIPMENT**

**304-4.1 Mixing.** The mixer shall be a batch or continuous-flow type stationary mixer that produces a well-blended, uniform mixture of aggregate, cement, water, and pozzolan. The mixer shall be equipped with calibrated metering and feeding devices that introduce the aggregate, cement, water, and cementitious additives (if used) into the mixer in the specified quantities.

The OAR shall have free access to the plant at all times for inspection of the plant's equipment and operation and for sampling the CTB mixture.

**304-4.2 Hauling.** The CTB material shall be transported from the plant to the job site in trucks or other hauling equipment having beds that are smooth, clean, and tight. Truck bed covers shall be provided and used to protect the CTB from weather. CTB material that becomes wet during transport shall be rejected.

**304-4.3 Placing.** CTB material shall be placed with a mechanical spreader capable of receiving, spreading, and shaping the mixture without segregation into a uniform layer or lift. The equipment shall be equipped with a strike-off plate and end gates capable of being adjusted to the layer thickness and width.

**304-4.4 Compaction.** The number, type, and weight of rollers and/or compactors shall be sufficient to compact the mixture to the required density.

## CONSTRUCTION METHODS

**304-5.1 Control Strip.** The first half-day of construction shall be considered the control strip. The Contractor shall demonstrate, in the presence of the OAR, that the materials, equipment, and construction processes meet the requirements of the specification. Control strips that do not meet specification requirements shall be removed and replaced at the Contractor's expense. Full operations shall not continue until the control strip has been accepted by the OAR. Upon acceptance of the control strip by the OAR, the Contractor shall use the same equipment, materials, and construction methods for the remainder of construction, unless adjustments made by the Contractor are approved in advance by the OAR.

**304-5.2 Weather limitations.** The CTB shall not be placed on frozen surfaces or when weather conditions will detrimentally affect quality of the finished course. Apply cement when the ambient temperature is a minimum of 40°F and rising and aggregate are not frozen or contain frost. If ambient temperature falls below 40°F, protect completed CTB areas against freezing.

The Contractor should stop operations prior to and during rain allowing time to cover and protect any freshly placed material. Areas damaged by rain shall be replaced at the Contractor's expense.

**304-5.3 Maintenance.** Completed portions of the cement-stabilized area may be opened to local traffic provided the curing process is not impaired and to other traffic after the curing period has elapsed, provided that the cement-stabilized course has hardened sufficiently to prevent surface marring or distortion by equipment or traffic. Protect finished portions of cement stabilized base from traffic of equipment used in constructing adjoining sections in a manner to prevent marring or damaging completed work. The CTB shall be protected from freezing until covered.

**304-5.4 Preparation of underlying course.** The underlying course shall be checked by the OAR before placing and spreading operations are started. Prior to placing the material, the final grade should be firm, moist and free of frost. Use of chemicals to eliminate frost will not be permitted. The underlying course shall be wetted in advance of placing the CTB layer.

**304-5.5 Grade control.** Grade control between the edges of the CTB shall be accomplished at intervals of 50 feet on the longitudinal grade and at 25 feet on the transverse grade.

**304-5.6 Placing.** The CTB mixture shall be deposited on the moistened subgrade or subbase and spread into a uniform layer of specified width and thickness that, when compacted and trimmed, conforms to the required line, grade, and cross-section. The longitudinal joints shall be located so there is a 2 foot minimum offset from planned joints in any overlying layer. Placement of the material shall begin along the centerline of the pavement on a crowned section or on the highest elevation contour of a pavement with variable cross slope.

The Contractor shall install the CTB layer in single compacted layer no greater than 6 inches thick.

**304-5.7 Compaction.** All compaction operations shall be completed within 2 hours from the start of mixing. The field density of the compacted mixture shall be at least 98% of the maximum density in accordance with paragraph 304-6.1a. At the start of compaction, the moisture content shall be within  $\pm 2$  percentage points of the specified optimum moisture. Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified.

**304-5.8 Finishing.** After compaction, shape the surface of the CTB layer to the specified lines, grades, and cross-section. During the finishing process, the surface shall be kept moist by means of fog-type sprayers.

Compaction and finishing shall produce a smooth, dense surface, free of ruts, cracks, ridges, and loose material.

**304-5.9 Construction limitations.** All placement, compaction, and finishing operations shall be completed within two (2) hours from the start of mixing. Material not completed within the 2-hour time limit shall be removed and replaced at the Contractor's expense.

At the end of each day's construction and/or when operations are interrupted for more than 30 minutes, a straight transverse construction joint shall be formed by a header or by cutting back into the compacted material to form a true vertical face.

Completed portions may be opened to light traffic, if approved by the OAR, and provided the curing is not impaired.

**304-5.10 Curing.** The compacted and finished CTB shall be cured with the approved curing agents as soon as possible, but in no case later than two (2) hours after completion of the finishing operations. Curing material(s) shall meet the requirements in paragraph 304-2.7. The layer shall be kept moist using a moisture-retaining cover or a light application of water until the curing material is applied.

The surface of the CTB layer shall be uniformly sprayed with a liquid membrane-forming curing compound at the rate of one gallon to not more than 100 square feet to obtain a uniform cover over the surface. Hand spraying of odd widths or shapes and CTB surfaces exposed by the removal of forms is permitted.

The curing seal shall be maintained and protected until the pavement is placed. If the surface of the finished CTB and/or the curing seal becomes damaged, additional curing material shall be applied at the time it is damaged or when the damage is first observed.

**304-5.11 Surface tolerance.** The Contractor shall perform smoothness and grade checks in the presence of the OAR. Any area not meeting smoothness and grade shall be corrected by the Contractor at the Contractor's expense.

**a. Smoothness.** The finished surface shall not vary more than  $\pm 3/8$ -inch when tested with a 12-foot straightedge applied parallel with and at right angles to the centerline, and, moved continuously forward at half the length of the 12-foot straightedge for the full length of each line on a 50-foot grid.

**b. Grade.** The grade shall be measured on a 50-foot grid and shall be within  $\pm 0.05$  feet of the specified grade.

**304-5.12 Bond-breaker.** Choke stone per paragraph 304-2.8 shall be placed on the surface of the lean concrete to prevent bonding. The choke stone shall be placed in a layer approximately  $1/4$ -inch (6mm) thick.

## MATERIAL ACCEPTANCE

**304-6.1 Acceptance sampling and testing.** Cement Treated Aggregate base course shall be accepted for density and thickness on an area basis. Two tests shall be made for density and thickness for each 1,200 square yards but not less than four (4) tests per day of production. Sampling locations will be determined on a random basis per ASTM D3665.

**a. Density testing.** CTB samples representing the material placed shall be taken to establish density and moisture requirements in accordance with ASTM D558. Additional CTB samples will be taken daily to verify density and moisture requirements. The OAR shall perform all density tests.

Each area shall be accepted for density when the field density is at least **98%** of the maximum density of laboratory specimens. The in-place field density shall be determined in accordance with **ASTM D6938**, Procedure A, direct transmission method. The in-place moisture content shall be determined in accordance with ASTM D2216. Perform in-place density test immediately after completion of compaction to determine degree of compaction. If the material fails to meet the density requirements, compaction shall continue or the material shall be removed and replaced at the Contractor's expense. Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified.

**b. Thickness.** The thickness of the CTB shall be determined by survey on a 25-foot by 25-foot survey grid.

When the thickness measurement is deficient by more than 1/2 inch, the area represented by the tests shall be removed and replaced at the Contractor's expense.

### REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

#### ASTM International (ASTM)

ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C150	Standard Specification for Portland Cement
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregate
ASTM C174	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D558	Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures
ASTM D559	Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures
ASTM D560	Standard Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures
ASTM D977	Standard Specification for Emulsified Asphalt
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1633	Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders
ASTM D2397	Standard Specification for Cationic Emulsified Asphalt

ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D3666	Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

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