APPENDIX A
FINAL DRAFT UPDATE OF ITEM P-304
CEMENT-TREATED BASE COURSE

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 crushed and graded portland cement concrete (PCC). The material shall be free of roots, sod, and weeds. The crushed or uncrushed aggregate shall consist of hard, durable particles of accepted quality, free from an excess of soft, flat, elongated, or disintegrated pieces, and objectionable matter. The method used in producing the aggregate shall be such that the finished product is as consistent as practicable. All stones and rocks of inferior quality shall be wasted. When recycled PCC is used as the aggregate, it must meet the requirements for virgin aggregate.

The percentage of wear of the crushed aggregate retained on the No. 4 (4.75-mm) sieve shall not be greater than 40 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 10 percent, or the magnesium sulfate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

When tested in accordance with ASTM C 136, the aggregate shall conform to the gradations shown in Table 1. An aggregate blend that meets the requirements of Table 1 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. The portion of final aggregate blend passing the No. 40 (425-µm) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 when tested in accordance with ASTM D 4318.

Table 1. Aggregate gradation for CTB material.

Sieve Size	Percentage by Weight Passing Sieves	
	Gradation A	Gradation B
2 in (51 mm)	100 [1]	100 [1]
No. 4 (4.75 mm)	45 - 100	55 - 100
No. 10 (1.80 mm)	37 - 80	45 - 100
No. 40 (450 µm)	15 - 50	25 - 80
No. 80 (210 µm)	0 - 25	10 - 35

[1] Maximum size of aggregate is 1 in (25.4 mm) when used as a base course under Item P-501, Portland Cement Concrete Pavement.

If recycled PCC does not meet the requirements of virgin aggregate, the Engineer should evaluate the test parameters for recycled aggregate.

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The Engineer shall refer to the new specification on recycled PCC aggregate for additional guidance.

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All aggregate samples required for testing shall be furnished by the Contractor at the expense of the Contractor. Sampling shall be performed by the Contractor in accordance with ASTM D 75.

304-2.1.1 Reactivity. Virgin crushed material (stone or gravel) or crushed and graded recycled PCC materials to be used in CTB shall be evaluated and tested by the Contractor for alkali-aggregate reactivity in accordance with ASTM C 1260. The test results shall have a measured expansion equal to or less than 0.10 percent in 16 days. The laboratory conducting the tests shall meet requirements of ASTM C 3666. Bank run gravel material is excluded from this requirement.

304-2.2 CEMENT. Cement shall conform to the requirements of ASTM [ ].

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The Engineer shall specify ASTM C 150 Type I, II, III, IV, or V or ASTM C 595 Type IS, IS-A, IP, IP-A, P, or PA. Type II cement shall be specified in areas with a history of sulfate reaction with the selected aggregate.

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304-2.3 CEMENTITIOUS ADDITIVIES. Pozzolanic and ground granulated blast furnace (GGBF) slag 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 C 618, Class C, F, or N with the exception of loss of ignition, where the maximum shall be less than 6 percent for Class F or N. [The supplementary optional chemical and physical properties of tables 1A and 2A contained in ASTM C 618 shall apply].

b. GGBF Slag. Slag shall conform to ASTM C 989, Grade 80, 100, or 120.

304-2.4 WATER. Water used in mixing or curing shall be clean and free of oil, salt, acid, alkali, sugar, vegetable, or other deleterious substances injurious to the finished product. Water shall be tested in accordance with the requirements of AASHTO T 26. Water known to be of potable quality may be used without testing.

304-2.5 CURING MATERIALS. Curing materials shall conform to the requirements provided below, as defined by the type of pavement surface to be placed on top of the CTB layer.

304-2.5.1 Portland Cement Concrete (PCC) Pavement. For curing CTB placed under PCC pavement, use white-pigmented, liquid membrane-forming compound conforming to ASTM C 309, Type 2, Class A or Class B (wax-based).

304-2.5.2 Hot Mix Asphalt (HMA) Pavement. For curing CTB placed under HMA pavement, use emulsified asphalt conforming to ASTM C 977 or ASTM D 2397 (Table 2).

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If emulsified asphalt is allowed as a curing agent, the Engineer shall specify the type and grade of material to be used and the corresponding application temperature from Table 2.

Table 2. Emulsified asphalt curing material.

Type and Grade	Specification	Application Temperature	
		°F	°C
Emulsified Asphalt			
RS-1, SS-1	ASTM D 977	75 - 130	25 - 55
CRS-1	ASTM D 2397	75 - 130	25 - 55

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304-2.6 SAND BLOTTER. If emulsified asphalt is used as a curing material, sand shall be applied, when required, for the prevention of pick-up of emulsion curing materials. The sand material shall be clean, dry, and non-plastic.

304-2.7 CHOKE STONE. Choke stone shall be used as a bond-breaker between the CTB and PCC surface. It shall conform to the requirements of the new FAA specification for choke stone.

COMPOSITION OF MIXTURE

304-3.1 GENERAL. The CTB material shall be composed of a mixture of aggregate, [Portland cement] [blended hydraulic cement], and water. Fly Ash or GGBF slag may be used as a partial replacement for Portland cement.

304-3.2 MIX DESIGN. The mix design shall utilize a cement content that, when tested in the laboratory according to ASTM D 1633, produces a 7-day compressive strength meeting the following requirements:

a. For CTB placed under PCC pavement: 500 psi (3,447 kPa) minimum and 1,000 psi (6,895 kPa) maximum.

b. For CTB placed under HMA pavement: 750 psi (5,170 kPa) minimum and 1,000 psi (6,895 kPa) maximum.

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In areas subject to considerable wet-dry and/or freeze-thaw cycles, insert the following statement:

"Wet-dry and/or freeze-thaw tests shall be performed in accordance with ASTM D 559 and D 560, respectively. The weight loss for each type of test shall not exceed 14 percent after 12 cycles. However, if a 7-day compressive strength of 750 psi (5,170 kPa) is achieved, the wet-dry and freeze-thaw tests are not necessary."

An estimated cement content may be determined from Table 1, Chapter 2, of the Soil-Cement Laboratory Handbook, published by the Portland Cement Association (PCA). In designing the mixture, cement contents above and below the initial estimated amount should be tested to determine the minimum quantity of cement needed to achieve the required strength (or strength and durability where freeze-thaw resistance is deemed necessary by the Engineer).

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If the minimum compressive strength value is not achieved within the specified time, the material will not be subject to removal, but further construction and other traffic shall only be allowed on the surface when the strength is 350 psi (2,413 kPa). Laboratory tests can be used to determine when the strength is obtained.

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, if used. It shall also contain the 7-day compressive strength test results and the results of the wet-dry and/or freeze-thaw tests.

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 [ ] days prior to the placement of the CTB, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction, as well as the mix design information for the CTB material. Tests older than 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. Sources 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.

d. Laboratory test results
   - compaction and strength testing procedures.
   - laboratory compaction characteristics (maximum dry density and optimum moisture content).
   - compressive strength at 7 days.
   - Wet-dry and/or freeze-thaw weight loss, if applicable.

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

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Insert the appropriate number of days for Contractor submittal of certified test reports for the proposed materials; 10 to 20 days is typical.

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EQUIPMENT

All equipment necessary to mix, transport, place, compact, and finish the CTB material shall be furnished by the Contractor. The equipment shall be inspected and approved by the Engineer at the job site prior to the start of construction operations.

304-4.1 MIXING. The mixer shall be a batch or continuous-flow type stationary mixer and 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. If necessary, a screening device shall be used to remove oversized material greater than 2 in (51 mm) from the raw aggregate feed prior to mixing.

Free access to the plant must be provided at all times for inspection of the plant's equipment and operation and for sampling the CTB mixture and its components, as deemed necessary by the Engineer.

304-4.2 HAULING. The mixed 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 rain. CTB material that becomes wet during transport shall be subject to rejection.

304-4.3 PLACING. CTB material shall be placed using a mechanical spreader or a machine 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 capable of being adjusted to the specified layer thickness. It shall also be equipped with two end gates or cut off plates, so that the CTB may be spread in widths varying up to lane width.

304-4.4 COMPACTION. Compaction of the CTB layer shall be accomplished using one or a combination of the following pieces of equipment:

- Tamping or grid roller.
- Steel-wheeled roller
- Vibratory roller.
- Pneumatic-tire roller.
- Vibrating plate compactor (for areas inaccessible to rollers).

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

304-4.5 FINISHING. Final trimming of the compacted CTB to meet surface requirements shall be accomplished using a self-propelled grader or trimming machine, with a mold board cutting edge, which is at least 12 ft (3.7 m) wide and is automatically controlled by sensors in conjunction with an independent grade control from a taut stringline. Stringline will be required on both sides of the sensor controls for the pilot lane. For all other lanes, a single stringline on the outside and grade matching with previously completed adjacent lanes is permissible.

CONSTRUCTION METHODS

304-5.1 WEATHER LIMITATIONS.

304-5.1.1 Cold Weather. The CTB material shall not be mixed or placed while the air temperature is below 40°F (4°C) or when conditions indicate that the temperature may fall below 35°F (2°C) within 24 hours. The CTB shall not be placed on frozen surfaces.

304-5.1.1 Rain. The CTB may not be placed when rainfall is occurring. If an unexpected rain event occurs during placement, the layer should be quickly compacted. CTB material that becomes wet by rain during transport or placement shall be evaluated by the Engineer, and may be subject to rejection.

304-5.2 PREPARATION OF UNDERLYING COURSE. The underlying course shall be checked by the Engineer before placing and spreading operations are started, in order to ensure that it is free of any ruts, depressions, or bumps and is finished to the correct grade. Any ruts or soft yielding places caused by improper drainage conditions, hauling, or any other cause, shall be corrected before the CTB mixture is placed thereon. The underlying course shall be wetted in advance of placing the CTB layer. The final prepared grade prior to placing the CTB should be in a firm and moist condition free of frost. Use of chemicals to eliminate frost will not be permitted.

To ensure proper drainage, placement of the base 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.

304-5.3 GRADE CONTROL. Grade control between the edges of the CTB shall be accomplished by grade stakes, steel pins, or forms placed in lanes parallel to the centerline and at intervals of 50 ft (15.2 m) or less on the longitudinal grade and at 25 ft (7.6 m) or less on the transverse grade.

304-5.4 HANDLING, MEASURING, AND BATCHING. The continuous flow central plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Aggregate stockpiles shall be constructed in a manner that prevents segregation and intermixing of deleterious materials.

Aggregates that are segregated or mixed with earth or foreign material will not be accepted.

Continuous flow plants shall be equipped with feeders to proportion aggregates and bulk cement, by weight, automatically and accurately. When bulk cement is used, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, such as a chute, boot or other device, to prevent loss of cement. The device shall be arranged to provide positive assurance that the cement content specified is present in each batch.

304-5.5 MIXING. Aggregate and cement may be proportioned either by weight or volume, and shall be mixed sufficiently to prevent the forming of cement balls when water is added. The mixing time shall be that which is required to secure an intimate, uniform mixture of aggregate, cement, water, and pozzolan (if used). The minimum mixing time will be based on the uniformity and consistency of the mixture.

304-5.6 PLACING. The CTB mixture shall be deposited on the moistened subgrade or subbase and spread into a uniform layer of such width and thickness that, following compaction and trimming, conforms to the required grade and cross-section. The Contractor may install the CTB layer in single or multiple compacted lifts; however, each compacted lift must be at least 4 in (102 mm) thick and no greater than 6 in (152 mm) thick. In multi-lift construction, the surface of the compacted lift shall be kept moist until covered with the next lift. Successive lifts shall be placed and compacted so that the required total depth of the CTB layer is completed within 12 hours.

A single spreader may be used, provided it is capable of placing a uniform, full-depth layer of material across the full width of the base in one pass. Otherwise, two or more spreaders will be required, and shall be operated so that spreading progresses along the full width of the base in a uniform manner.

304-5.7 COMPACTION. Immediately upon completion of the spreading operations, the CTB material shall be thoroughly compacted using approved compaction equipment. At the start of compaction, the moisture content shall be within 2 percentage points of the specified optimum moisture.

304-5.8 FINISHING. Upon completion of compaction, the surface of the CTB layer shall be shaped 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 be done in such a manner as to produce a smooth, dense surface, free of ruts, cracks, ridges, and loose material. All placement, compaction, and finishing operations shall be completed within 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.

CTB layer limits that extend beyond the edges of the new PCC surface course shall be rolled down or shaped in such a manner that the drainage is away from the new PCC surface course edge.

304-5.9 CONSTRUCTION JOINTS. At the end of each day's construction, a transverse construction joint shall be formed that is a true vertical face (perpendicular to the centerline) and is free of loose material.

Longitudinal construction joints (parallel to the centerline) shall be formed to a consistent, well-defined near vertical edge that is free of loose material. The longitudinal joints shall be located such that there is a 2-ft (0.6-m) minimum offset from planned joints in any overlying layer.

While forming construction joints, the Contractor shall make sure the material in the joint area is adequately compacted and that the joints are finished level and even with the remainder of the CTB layer.

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

When asphalt emulsion is used as the curing agent, the entire surface of the CTB layer shall be uniformly sprayed with the emulsion at a rate of between 0.15 and 0.30 gal/yd^2 (0.7 and 1.4 L/m^2); the exact temperature and rate of application being that required to achieve complete and uniform coverage without runoff. Should it be necessary for construction equipment or other traffic to use the asphalt-covered surface, sufficient sand blotter cover shall be applied to prevent pick-up.

When liquid membrane-forming curing compound is used as the curing agent, the entire surface of the CTB layer shall be uniformly sprayed with the compound at the rate of 1 gal (3.8 L) to not more than 200 ft^2 (18.6 m^2). The rate of application shall be determined such that a uniform surface is obtained. The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. The compound shall be thoroughly mixed with the pigment uniformly dispersed throughout the storage tank. During application, the compound shall be stirred continuously by effective mechanical means. 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. Should the surface of the finished CTB and/or the curing seal become damaged, additional curing material shall be applied at the time it is damaged or when the damage is first observed.

304-5.11 PROTECTION. The Contractor shall protect the finished CTB against traffic. Completed portions of the CTB layer can be opened immediately to low-speed traffic and to construction equipment, provided the curing material is not damaged and the CTB is sufficiently stable to resist permanent deformation. Should the CTB be damaged, it shall be replaced using full-depth patches, and sprayed with the selected curing compound as described above. The CTB shall also be protected from freezing at all times.

304-5.12 BOND-BREAKER. When the CTB is to be placed directly beneath PCC, a bond-breaker shall be used. The bond-breaker shall be comprised of choke stone material, as specified in paragraph 304-2.7, and placed according to the new FAA specification for choke stone.

MATERIAL ACCEPTANCE

304-6.1 ACCEPTANCE SAMPLING AND TESTING. All acceptance sampling and testing, with the exception of thickness determination, necessary to determine conformance with the requirements specified in this section will be performed by the Engineer. The Contractor shall provide the required CTB samples during construction for acceptance testing purposes. The samples shall be taken in the presence of the Engineer.

Testing organizations performing these tests shall meet the requirements of ASTM D 3666. All test equipment in Contractor-furnished laboratories shall be calibrated by the testing organization prior to the start of operations.

The CTB layer shall be tested for density, thickness, grade, and surface tolerance on a lot basis, with a lot consisting of one of the following:

- One day's production not to exceed [2,000 yd^2 (1,675 m^2)].
- A half day's production, where a day's production consists of [2,000 to 4,000 yd^2 (1,675 to 3,350 m^2)].

Each lot shall be divided into four (4) equal sublots. Within each sublot, one (1) set of density tests, one (1) thickness measurement, and continuous surface straightedge tests (surface tolerance testing) shall be performed, as described below. Sampling locations shall be determined by the Engineer in accordance with the random sampling procedures contained in ASTM D 3665.

In the event that only three (3) sublots are produced, the three sublots shall constitute a complete lot. If one (1) or two (2) sublots are produced for the same reason, they shall be incorporated into the next or previous lot, and the total number of sublots shall be used in the acceptance criteria calculation.

End-of-production sublots (i.e., sublots associated with the final placement of CTB for the project and are less than a complete lot) shall be handled as follows:

- Three (3) sublots shall constitute a lot.
- One (1) or two (2) sublots shall be incorporated into the previous lot.

304-6.1.1 Density Testing. CTB samples shall be taken from each sublot and used to create laboratory test specimens representing the various sublots. The specimens shall be tested for maximum density and optimum moisture, in accordance with ASTM D 558. Using the maximum density results for each sublot comprising a lot, an average maximum density for the lot shall be determined, which will serve as the basis for acceptance of the lot with regard to density.

Within each sublot in the field, one (1) in-place density test shall be performed in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922 and ASTM D 3017. The location of the test shall be randomly selected in accordance with the procedures contained in ASTM D 3665. The in-place density results for each sublot comprising the lot shall then be averaged and compared with the corresponding average maximum density determined in the lab. Acceptance criteria for CTB density are provided in paragraph 304-6.2.1.

304-6.1.2 Thickness Testing. The CTB shall be tested for thickness using the same lot and sublot designations established for density testing. After 3 days of curing, one (1) 4-in (102-mm) diameter core per sublot shall be obtained from a random location, as identified using the procedures contained in ASTM D 3665. The thickness of each sampled core shall be determined using the caliper measurement procedures provided in ASTM C 174. The average thickness for the lot shall be determined using the individual sublot core thicknesses. Acceptance criteria for CTB thickness are provided in paragraph 304-6.2.2. At all locations where cores have been drilled, the resulting core holes shall be filled by the Contractor with CTB, HMA, or non-shrink grout.

304-6.1.3 Grade Testing. The elevations of the finished CTB shall be surveyed every 25 ft (7.6 m) on both sides of the CTB lane as soon as it has hardened sufficiently but before choke stone is applied. Acceptance criteria for CTB grade are provided in paragraph 306-6.2.3.

304-6.1.4 Surface Tolerance Testing. As soon as the CTB has hardened sufficiently but before choke stone is applied, it shall be tested for surface tolerance with a 16-ft (4.9-m) straightedge or other approved measuring device.

304-6.2 ACCEPTANCE CRITERIA. Acceptance of CTB will be based on density, thickness, grade, and surface tolerance, as described in the paragraphs below.

304-6.2.1 Density Requirements. With respect to density, each lot of compacted material will be accepted without adjustment if the average in-place density of the lot is equal to or greater than 98 percent of the average maximum density determined for the lot in the laboratory. Each lot of compacted CTB shall be accepted and payment adjusted in accordance with Table 3.

Table 3. Sliding pay scale factors for density.

Average Dry Density (%)	Payment (%)
98.0 and greater	100
97.0 - 97.9	95
96.0 - 96.9	90
95.0 - 95.9	75
Less than 95.0	Reject

If the average density is below 95 percent, the lot will be rejected and shall be removed and replaced at the Contractor's expense. In multi-layer construction, density shall be tested for each lift, and all lifts within a rejected lot shall be removed and replaced. No payment shall be made for removed lifts. Replacement lifts shall be paid in accordance with this section.

304-6.2.2 Thickness Requirements. The completed thickness shall be as shown on the plans. When the average lot thickness is not deficient by more than ½ in (12.5 mm) from the plan thickness, full payment shall be made. If the average lot thickness is deficient by more than 1 in (25.4 mm), it shall be removed and replaced at the Contractor's expense. When such measurement is deficient by more than ½ in (12.5 mm) but less than 1 in (25.4 mm) from the plan thickness, one additional core shall be taken at random from each sublot within the lot. The thickness of these additional cores shall be determined as indicated in paragraph 304-6.1.2. A new average lot thickness shall be recomputed based on these additional cores and the original cores taken from each sublot. If the recomputed average lot thickness is not deficient by more than ½ in (12.5 mm) from the plan thickness, full payment shall be made. If the average lot thickness is deficient by more than ½ in (12.5 mm) from the plan thickness, the entire lot shall be removed and replaced at the Contractor's expense or shall be permitted to remain in-place at an adjusted payment of 75 percent of the contract unit price.

When the measured thickness is more than that indicated on the plans, it will be considered as conforming to the requirements, provided the surface of the completed CTB layer is within the established grade and surface tolerance requirements.

304-6.2.3 Grade Requirements. When the completed surface is higher than ½ in (12.5 mm) above the grade shown in the plans, the surface shall be trimmed, at the Contractor's expense, with an approved grinding machine to an elevation that falls within a tolerance of ¼ in (6 mm) or less.

304-6.2.4 Surface Tolerance Requirements. The finished surface, as determined before choke stone is applied, shall not vary more than ⅜ in (9.5 mm) when tested with a 16-ft (4.9-m) straightedge applied parallel with, or at right angles to, the centerline of the CTB area. Areas in the CTB showing high spots greater than ⅜ in (9.5 mm) over 16 ft (4.9 m) shall be marked and immediately trimmed with an approved grinding machine. Such trimming shall be at the Contractor's expense.

METHOD OF MEASUREMENT

304-7.1 CEMENT-TREATED BASE COURSE. The quantity of cement-treated base course to be paid for will be determined by measurement of the number of [yd^2 (m^2)] of CTB actually constructed and accepted by the Engineer as complying with the plans and specifications.

BASIS OF PAYMENT

304-8.1 CEMENT-TREATED BASE COURSE. Payment shall be made at the contract unit price per [yd^2 (m^2)] for cement-treated base course. This price shall be full compensation for furnishing all materials, except cement; for all preparation, manipulation, placing, and curing of these materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Each lot of CTB material will be accepted for density at the full contract price adjusted in accordance with Table 3 in paragraph 304-6.2.1.

Payment will be made for cement-treated base course--per [yd^2 (m^2)].

TESTING REQUIREMENTS

ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Sieve or Screen Analysis of Fine and Coarse Aggregate
ASTM C 174	Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C 1260	Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM D 75	Sampling Aggregates
ASTM D 558	Moisture-Density Relations of Soil-Cement Mixtures
ASTM D 559	Test Methods for Wetting & Drying Compacted Soil Cement Mixtures
ASTM D 560	Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures
ASTM D 1556	Density of Soil in Place by the Sand-Cone Method
ASTM D 1633	Compressive Strength of Molded Soil-Cement Cylinders

ASTM D 2167	Density of Soil in Place by the Rubber-Balloon Method
ASTM D 2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods
ASTM D 3017	Water Content of Soil and Rock in Place by Nuclear Methods
ASTM D 3665	Random Sampling of Paving Materials
ASTM D 3666	Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
AASHTO T 26	Quality of Water to be Used in Concrete

MATERIAL REQUIREMENTS

ASTM C 150	Portland Cement
ASTM C 309	Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 595	Blended Hydraulic Cements
ASTM C 618	Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 989	Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM D 977	Emulsified Asphalt
ASTM D 2397	Cationic Emulsified Asphalt

APPENDIX B
FINAL DRAFT UPDATE OF ITEM P-306
ECONOCRETE BASE COURSE

DESCRIPTION

306-1.1 This item shall consist of a subbase material, herein termed econocrete, that is composed of aggregate and cement uniformly blended together and mixed with water. The mixture may also include approved cementitious additives, in the form of fly ash or slag, and chemical admixtures. The mixed material shall be spread, shaped, and consolidated using concrete paving equipment in accordance with these specifications and in conformity to the lines, grades, dimensions, and typical cross-sections shown on the plans.

MATERIALS

306-2.1 AGGREGATE. The coarse aggregate fraction shall be crushed stone, crushed or uncrushed gravel, crushed and adequately seasoned, air-cooled, iron blast furnace slag, crushed recycled concrete pavement, or a combination thereof. The fine aggregate fraction may be part of the natural aggregate blend as obtained from the borrow source or it may be natural sand that is added at the time of mixing.

The aggregate shall consist of hard, durable particles, free from an excess of flat, elongated, soft, or disintegrated pieces, or objectionable matter (e.g., roots, sod, weeds, organic impurities, etc.). A flat particle is one having a ratio of width to thickness greater than five; an elongated particle is one having a ratio of length to width greater than five.

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The Engineer should specify limits for deleterious materials using guidance contained in ASTM C 33.

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The design aggregate blend shall conform to one of the gradations shown in Table 1, when tested in accordance with ASTM C 136.

Table 1. Aggregate gradation for econocrete.

Sieve Size (square openings)	Percentage by Weight Passing Sieves	
	1½ -in (37.5-mm) Maximum	1-in (25-mm) Maximum
2 in (51 mm)	--	--
1½ in (37.5 mm)	100	--
1 in (25 mm)	70 - 95	100
¾ in (19 mm)	55 - 85	70 - 100
No. 4 (4.75 mm)	30 - 60	35 - 65
No. 40 (425 µm)	10 - 30	15 - 30
No. 200 (75 µm)	0 - 15	0 – 15

306-2.1.1 Reactivity. Both coarse and fine aggregate shall be tested by the Contractor for alkali-aggregate reactivity in accordance with ASTM C 1260. The aggregate used for testing shall be the coarse aggregate (all size groups) and fine aggregate that will be used for the work. Should the test data indicate an expansion of greater than 0.10 percent at 16 days, the Contractor may propose mitigation.

306-2.2 CEMENT. Cement shall conform to the requirements of ASTM [ ].

* *
The Engineer shall specify ASTM C 150 Type I, II, III, IV, or V or ASTM C 595 Type IS, IS-A, IP, IP-A, P, or PA. Type II cement shall be specified in areas with a history of sulfate reaction with the selected aggregate.
* *

306-2.3 CEMENTITIOUS ADDITIVES. Pozzolanic and ground granulated blast furnace (GGBF) slag may be added to the econocrete mix. If used, each material must meet the following requirements:

a. Pozzolan. Pozzolanic materials must meet the requirements of ASTM C 618, Class F Flyash.

b. GGBF Slag. Slag shall conform to ASTM C 989, Grade 80, 100 or 120.

306-2.4 CHEMICAL ADMIXTURES. The Contractor shall submit certificates indicating that the material to be furnished meets all the requirements listed below. In addition, the Engineer may require the Contractor to submit complete test data showing that the material to be furnished meets all the requirements of the cited specification.

a. Air-Entraining Admixtures. Air-entraining admixtures shall meet the requirements of ASTM C 260.

b. Water-Reducing Admixtures. Water-reducing, set-controlling admixtures shall meet the requirements of ASTM C 494, Type A, water-reducing or Type D, water-reducing and retarding. Water-reducing admixtures shall be added at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

306-2.5 WATER. Water used in mixing or curing shall be clean and free of oil, salt, acid, alkali, sugar, vegetable, or other deleterious substances injurious to the finished product. Water will be tested in accordance with the requirements of AASHTO T 26. Water known to be of potable quality may be used without testing.

306-2.6 CURING MATERIALS. For curing econocrete, use white-pigmented, liquid membrane-forming compound conforming to ASTM C 309, Type 2, Class A or Class B (wax-based).

306-2.7 CHOKE STONE. Choke stone shall be used as a bond-breaker between the econocrete and PCC surface. It shall conform to the requirements of the new FAA specification for choke stone.

COMPOSITION OF MIXTURE

306-3.1 MIX DESIGN. The econocrete mix design shall be based on trial batch results conducted in the laboratory. The econocrete shall be designed to meet the criteria in this section.

306-3.1.1 Compressive Strength. Compressive strength shall not be less than 500 psi (3,445 kPa) nor greater than 800 psi (5,516 kPa) at 7 days. The 7-day strength shall be taken as the average of two compressive strength test results. All compressive strength specimens shall be prepared and tested in accordance with ASTM C 192 and ASTM C 39, respectively.

If the minimum strength value is not achieved within the specified time, the material is not subject to removal, but further construction and other traffic will only be allowed on the surface when the compressive strength is at least 350 psi (2,413 kPa). Laboratory tests can be used to determine when the strength is obtained.

If the 3-day strength is greater than 500 psi (3,447 kPa), the Contractor shall notch transverse joints in the econocrete layer in accordance with paragraph 306-5.10.2.

* *

In locations subject to freeze-thaw cycles, insert the following "The freeze-thaw weight loss shall not exceed 14 percent when tested in accordance with ASTM D 560."

* *

If there is a change in aggregate sources, type of cement used, or pozzolanic materials, a new mix design must be submitted.

306-3.1.2 Air Content. The percentage of air entrainment shall be 6 percent. Air content shall be determined by testing in accordance with ASTM C 231 for gravel and stone coarse aggregate and ASTM C 173 for slag and other highly porous coarse aggregate.

306-3.2 SUBMITTALS. At least [ ] days prior to the placement of the econocrete, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction, as well as the mix design information for the econocrete material. Tests older than 6 months shall not be used. The certification shall show the appropriate 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. Sources of materials, including aggregate, cement, admixtures, and curing and bond breaking materials.
b. Physical properties of the aggregates, cement, admixtures, curing and bond breaking materials.
c. Mix design.
    - mix identification number.
    - weight of saturated surface-dry aggregates (fine and coarse).

- combined aggregate gradation.
- cement factor.
- water content.
- water-cementitious material ratio (by weight).
- volume of admixtures and yield for one cubic yard (cubic meter) of econocrete.

d. Laboratory test results.
- slump.
- air content.
- compressive strength at 3, 7, and 28 days (average values).
- wet/dry and/or freeze-thaw weight loss (when applicable).

In addition, where applicable, the Contractor shall submit for approval by the Engineer a jointing plan for transverse joints in the econocrete layer.

* *

Insert the appropriate number of days for Contractor submittal of the certified test reports and the mix design; 15 to 30 days is typical.

* *

EQUIPMENT

306-4.1 All equipment necessary to mix, transport, place, compact, and finish the econocrete material shall be furnished by the Contractor. The equipment shall be subject to inspection and approval by the Engineer.

306-4.2 MIXING. Econocrete may be mixed in a stationary mixer, either at a central batch plant or at the site, or in a truck mixer. The mixer type and capacity shall be inspected and approved by the Engineer before production begins. Each mixer shall have attached in a prominent place a manufacturer's nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

306-4.2.1 Stationary Plant Mixer. The batch plant and equipment shall conform to the requirements of ASTM C 94. Unrestricted access to the plant must be provided to the Engineer at all times for inspection of the plant's equipment and operation and for sampling the econocrete mixture and its components.

The mixers shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades.

306-4.2.2 Truck Mixers. Truck mixers used for mixing econocrete shall conform to the requirements of ASTM C 94. Econocrete may be entirely mixed in a truck mixer or partially mixed in a stationary mixer with mixing completed in a truck mixer. Truck mixers shall be equipped with an accurate continuous registering electronically or mechanically activated revolution counter, by which the number of drum revolutions may be verified.

306-4.3 HAULING. Mixed econocrete shall be hauled from the stationary plant to the job site in a truck agitator, a truck mixer operating at agitating speed, or a non-agitating truck. All equipment shall conform to the requirements of ASTM C 94. When truck mixers are used to mix econocrete, they may be transported to the job site in the same truck operating at agitating speeds, truck agitators, or a non-agitating truck. The bodies of non-agitating trucks shall be smooth, metal containers and shall be capable of discharging the concrete at a satisfactory controlled rate without segregation.

306-4.4 PLACING AND FINISHING.

306-4.1 Forms. Straight side forms shall be made of steel and shall be furnished in sections not less than 10 ft (3.1 m) in length. Forms shall have a depth equal to the pavement thickness at the edge. Flexible or curved forms of proper radius shall be used for curves of 100-ft (31-m) radius or less. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the Engineer.

The top face of the form shall not vary from a true plane more than ⅛ in (3 mm) in 10 ft (3.1 m), and the upstanding leg shall not vary more than ¼ in (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when accepted by the Engineer.

306-4.4.2 Pavers. Econocrete can be placed using fixed forms or slip-form pavers. The paver shall be fully energized, self-propelled and capable of spreading, consolidating, and finishing the econocrete material, true to grade, tolerances, and cross sections. The paver shall be capable of finishing the surface so that hand finishing is not required. The paver shall be of sufficient weight and power to construct the maximum specified concrete paving lane width, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. The slip-form paver shall be equipped with electronic or hydraulic horizontal and vertical control devises utilizing guide wires or stringlines on both sides of the machine. Slope control will not be allowed.

a. Concrete Pavers. Concrete pavers are approved as paver-finishing machines for econocrete, providing they are capable of handling the amount of econocrete required for the full-lane width specified, and consolidating the econocrete full depth. A concrete paver is a power-driven machine with augers, strike-off and tamper bars ahead of a pan screed, with at least one trailing oscillating screed or belt finisher.
b. Bridge Deck Pavers. Bridge deck pavers are approved as paver-finishing machines for econocrete, providing they are capable of handling the amount of econocrete required for the full-lane width specified, and consolidating the econocrete full depth. A bridge deck paver is an automatic truss paving machine, with paving carriage that strikes off, vibrates, paves, and textures the econocrete with augers, internal vibration, paving rollers, and drag pan.

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Econocrete is a weak concrete mix. As such, it should be placed with pavers suitable for paving concrete pavements. Rotating pipe and tube floats are not suitable for this type of pavement.

* *

306-4.5 CONSOLIDATION. For side-form construction, vibrators may be either the surface pan type for pavements less than 8 in (203 mm) thick or the internal type with either immersed tube or multiple spuds for the full width of the slab. They may be attached to the spreader or the finishing machine, or they may be mounted on a separate carriage. They shall not come in contact with the joint, subgrade, or side forms.

For slip-form construction, the paver shall vibrate the econocrete for the full width and depth of the strip of pavement being placed. Vibration shall be accomplished by internal vibrators.

The number, spacing, frequency, and eccentric weights of vibrators shall be provided as necessary to achieve an acceptable consolidation and finishing quality. Adequate power to operate all vibrators at the weight and frequency required for a satisfactory finish shall be available on the paver. The internal vibrators may be supplemented by vibrating screeds operating on the surface of the econocrete. The Contractor shall constantly monitor the frequency of each of the individual vibrators using electronic means and shall provide constant monitoring of the consolidation process to avoid honeycombing or over-consolidation. Areas that are visually determined to be honeycombed or over-consolidated shall be corrected at the Contractor's expense.

The vibrators and tamping elements shall be automatically controlled so that they stop operation as forward motion ceases. Any override switch shall be of the spring-loaded, momentary-contact type.

Hand held vibrators may be used in irregular areas.

306-4.6 JOINTING. The Contractor shall provide sawing equipment adequate in number of units and power to produce contraction or construction joints of the required dimensions as shown on the plans. The Contractor shall provide at least one standby saw in good working order and a supply of saw blades at the site of the work at all times during sawing operations.

CONSTRUCTION METHODS

306-5.1 WEATHER LIMITATIONS.

306-5.1.1 Cold Weather. Unless authorized by the Engineer, the temperature of the mixed econocrete shall not be less than 50°F (10°C) at the time of placement. In addition, the econocrete shall not be placed when the ambient temperature is below 40°F (4°C) or when conditions indicate that the temperature may fall below 35°F (2°C) within 24 hours. Under no circumstances shall the econocrete be placed on frozen underlying courses or mixed when the aggregate is frozen.

When mixing and placing is authorized during cold weather, the Engineer may require the water and/or the aggregates to be heated to not less than 70°F (20°C) nor more than 150°F (66°C). The aggregates may be heated by either steam or dry heat prior to being placed in the mixer. The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might be detrimental to the materials.

306-5.1.2 Hot Weather. To prevent rapid drying of newly constructed econocrete, the econocrete temperature from initial mixing through final cure shall not exceed 90°F (32°C). The aggregates and/or mixing water shall be cooled as necessary to maintain the econocrete temperature at or not more than the specified maximum. Ice or ice water may be substituted for the mixing water for this purpose.

In addition, during periods of warm weather when the maximum daily air temperature exceeds 85°F (30°C), the forms and/or the underlying material shall be sprinkled with water immediately before placing the econocrete.

306-5.1.3 Rain. All mixing and batching operations should be halted during rain showers and any plastic econocrete placed should be covered immediately. The econocrete shall be kept covered with plastic sheeting or other waterproof material until such time that the rain does not make any surface indentation on the econocrete layer. Areas damaged by rain shall be refinished or replaced.

306-5.2 FORM SETTING. Forms shall be set sufficiently in advance of the econocrete placement to ensure continuous paving operation. After the forms have been set to correct grade, the grade shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place with not less than 3 pins for each 10-ft (3.1-m) section. A pin shall be placed at each side of every joint.

Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than ¼ in (6 mm) at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the placing of econocrete.

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the econocrete. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

306-5.3 PREPARATION OF UNDERLYING COURSE. The underlying course shall be checked by the Engineer before placing and spreading operations are started, in order to ensure that it is free of any ruts, depressions, or bumps and is finished to the correct grade. Any ruts or soft yielding places in the underlying course caused by improper drainage conditions, hauling, or any other cause, shall be corrected at the Contractor's expense before the econocrete mixture is placed thereon. The underlying course should be wetted down in advance of placing the econocrete to ensure a firm, moist condition at the time of econocrete placement. The

underlying course shall be protected from frost. Usage of chemicals to eliminate frost is not permissible.

306-5.4 GRADE CONTROL. Grade control between the edges of the pavement shall be accomplished by grade stakes, steel pins or forms placed in lanes parallel to the centerline and at intervals of 50 ft (15.3 m) or less on the longitudinal grade and at 25 ft (7.6 m) or less on the transverse grade. To protect the underlying course and ensure proper drainage, the econocrete paving shall begin along the centerline of the pavement on a crowned section or on the greatest contour elevation of a pavement with variable cross slope.

306-5.5 HANDLING, MEASURING, AND BATCHING MATERIAL. The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be constructed in a manner that prevents segregation and intermixing of deleterious materials.

Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipments requiring more than 12 hours transit will be accepted as adequate binning only if the car bodies permit free drainage.

Batching plants shall be equipped to proportion aggregates and bulk cement, by weight, automatically using interlocked proportioning devised of an approved type. When bulk cement is used, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, such as a chute, boot or other device approved by the Engineer, to prevent loss of cement. The device shall be arranged to provide positive assurance that the required cement content is present in each batch.

306-5.6 MIXING. All econocrete shall be mixed and delivered to the site in accordance with the requirements of ASTM C 94. The mixing time should be adequate to produce econocrete that is uniform in appearance, with all ingredients evenly distributed. Mixing time shall be measured from the time all materials are emptied into the drum (provided all the water is added before one-fourth the preset mixing time has elapsed) and continues until the time the discharge chute is opened to deliver the econocrete.

If mixing in a plant, the mixing time shall not be less than 50 nor greater than 90 seconds. If mixing in a truck, the mixing time shall not be less than 70 nor more than 125 truck-drum revolutions at a mixing speed of not less than 6 nor more than 18 truck-drum revolutions per minute.

Retempering econocrete by adding water or by other means will not be permitted, except when econocrete is delivered in truck mixers. With truck mixers, additional water may be added to the batch materials and additional mixing performed to allow proper placement of the material, provided (a) the addition of water is performed within 45 minutes after the initial mixing operations and (b) the water/cementitious ratio specified in the mix design is not exceeded.

306-5.7 HAULING. The elapsed time from the addition of cementitious material to the mix until the econocrete is deposited in place at the work site shall not exceed 45 minutes when the concrete is hauled in nonagitating trucks, nor 90 minutes when it is hauled in truck mixers or truck agitators.

306-5.8 PLACING, CONSOLIDATING, AND FINISHING. Prior to placement of the econocrete layer, the prepared underlying course shall be well moistened with water, without saturating, in order to prevent rapid loss of moisture from the econocrete. In cold weather, the underlying course shall be protected so that it will be entirely free of frost when econocrete is placed.

The Contractor has the option of side- (fixed-) form or slip-form paving. Under both techniques, the hauled econocrete material shall be discharged onto the prepared underlying course such that segregation of the mix is minimized and minimum handling of the mix is needed. Placement of the econocrete material shall be continuous between construction joints. Workers shall not be allowed to walk in the freshly mixed econocrete with boots or shoes coated with earth or debris.

Econocrete shall not be mixed, placed, or finished when the natural light is insufficient, unless an adequate artificial lighting system is provided.

306-5.8.1 Side-Form Construction. For side-form placement, the Contractor shall verify the elevations of the fixed forms such that the thickness and finished grade of the econocrete layer will be in accordance with the requirements of the project plans and specifications. The econocrete shall be spread uniformly between the forms, immediately after it is placed using a spreading machine. Necessary hand spreading shall be done with shovels, not rakes.

The spreading shall be followed immediately by thorough consolidation using vibrating screeds or spud vibrators. Vibrators may be external or internal type, depending on the thickness of the econocrete layer. The surface vibrators may be attached to the spreader or they may be mounted on a separate carriage. They shall not come in contact with the joint, subgrade, or side forms. When spud vibrators are used, the econocrete shall be thoroughly consolidated against and along the faces of all forms and previously placed econocrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than 20 seconds in any one location, nor shall the vibrators be used to move the econocrete.

Hand finishing will not be permitted except in areas where the mechanical finisher cannot operate.

306-5.8.2 Slip-Form Construction. For slip-form construction, the Contractor shall verify the elevations of the guide wires controlling slip-form pavers such that the thickness and finished grade of the econocrete will be in accordance with the requirements of the project plans and specifications. The slip-form paver should spread, consolidate, and shape the freshly placed econocrete in one complete pass of the machine. The machine shall vibrate and finish the econocrete for the full width and depth of the layer.

FINAL FINISHING. Final finishing shall be accomplished while the econocrete is still in the plastic state. Limited surface refinishing by hand is acceptable to meet the grade and surface tolerance established in paragraphs 306-6.2.3 and 306-6.2.4, after strike off and consolidation.

If the overlying layer is to be PCC pavement, the surface of the econocrete shall not be textured. If the overlying layer is to be HMA pavement, and if the bond between the HMA layer and the econocrete is considered important for pavement performance, tining or scarifying the surface to provide a coarse texture may be permitted.

306-5.10 JOINTS. Joints shall be constructed as shown on the plans. If joints are not shown on the plans, the Contractor may elect to propose a jointing plan for approval by the Engineer.

306-5.10.1 Construction Joints. Locate all longitudinal and transverse construction joints as shown on the plans. If longitudinal joints are not shown, locate longitudinal joints within 6 in (152 mm) from planned joints in the PCC to be placed over the econocrete.

306-5.10.2 Contraction Joints. If elected by the Contractor, transverse contraction joints can be constructed by sawing the hardened econocrete to a depth of at least one-third the thickness of the econocrete base. These joints shall match within 3 in (76 mm) the planned joints of the overlying concrete surface.

306-5.11 CURING. Immediately after the finishing operations are complete and within 2 hours of placement of the econocrete, the entire surface and edges of the newly placed econocrete shall be sprayed uniformly with white pigmented, liquid membrane forming curing compound. The layer should be kept moist using a moisture-retaining cover or a light application of water until the curing material is applied. The curing compound shall not be applied during rainfall.

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Excessive delays in applying the curing compound can result in uncontrolled shrinkage cracking, which can reflect into the overlying pavement over time.

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The curing material shall be applied using mechanical sprayers under pressure at the rate of 1 gal (3.8 L) to not more than 200 ft^2 (18.6 m^2). The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. At the time of use, the compound in the tank shall be in a thoroughly mixed condition with the pigment uniformly distributed throughout the vehicle. During application the compound shall be stirred continuously by mechanical means.

Hand spraying of odd widths or shapes and econocrete surfaces exposed by the removal of forms is permitted.

Should the film of curing material become damaged from any cause, including sawing operations, within the required 28-day curing period or until the overlying course is constructed, the damaged portions shall be repaired immediately with additional compound or other approved means as quickly as practical.

Edges of the econocrete layer shall be sprayed with curing compound immediately following placement with slip-form pavers or when fixed forms are removed.

306-5.11.1 Curing in Cold Weather. The econocrete shall be maintained at a temperature of at least 50°F (10°C) for a period of 72 hours after placing and at a temperature above freezing for the remainder of the curing time. The Contractor shall be responsible for the quality and strength of the econocrete placed during cold weather, and any econocrete injured by frost action shall be removed and replaced at the Contractor's expense.

306-5.11.2 Curing in Hot Weather. When econocrete is being placed and the air temperature may be expected to rise above 90°F (32°C) shortly after placement, the econocrete layer should be cured as quickly as possible to allow curing without the formation of excessive shrinkage cracks.

306-5.12 PROTECTION. The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents. The Engineer shall decide when the pavement shall be opened to traffic. Traffic shall not be allowed on the pavement until test specimens molded and cured in accordance with ASTM C 31 have attained a compressive strength of 350 psi (2,413 kPa) when tested by ASTM C 39. The econocrete surface shall be protected from foot and vehicular traffic and other sources of abrasion until such a time. During this time, the econocrete layer shall be protected from injurious action by sun, rain, flowing water, frost, or mechanical injury. After this period, construction traffic to place the overlying layers may be allowed.

306-5.13 BOND-BREAKER. When the econocrete is to be placed directly beneath PCC pavement, a bond-breaker shall be used. A second application of the curing compound shall be applied to the econocrete layer to serve as a bond-breaker when the 7-day compressive strength values satisfy the minimum and maximum requirements stated in paragraph 306-3.1. This application shall be made at least 8 hours and not more than 24 hours prior to beginning the placement of the PCC pavement. The rate of application shall be the same as that specified for the curing application. After application of the bond-breaker coat, traffic will be limited to that required for the placement of the overlying pavement layer.

If the maximum 7-day compressive strength values exceed the maximum strength requirements when evaluated in accordance with paragraph 306-6-2.1, choke stone shall serve as a bond-breaker. This material shall be as specified in paragraph 306-2.7 and shall be placed according to the new FAA specification for choke stone.

MATERIAL ACCEPTANCE

306-6.1 ACCEPTANCE SAMPLING AND TESTING. All acceptance sampling and testing, with the exception of coring for thickness determination, necessary to determine conformance with the requirements specified in this section will be performed by the Engineer. The Contractor shall provide the required econocrete samples during construction for acceptance testing purposes. The samples shall be taken in the presence of the Engineer.

The econocrete layer shall be tested for air content, strength, thickness, grade, and surface tolerance. Sampling and testing for air shall be as specified in paragraph 306-6.1.1. Sampling and testing for strength, thickness, grade, and surface tolerance shall be on a lot basis, with a lot consisting of one of the following:

- One day's production not to exceed 2,000 yd^2 (1,675 m^2).
- A half day's production, where a day's production is expected to consist of between 2,000 and 4,000 yd^2 (1,675 and 3,350 m^2).

Each lot will be divided into four equal sublots. In the event that only three (3) sublots are produced, the three sublots shall constitute a complete lot. If, only one (1) or two (2) sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation.

End-of-production sublots (i.e., sublots associated with the final placement of econocrete for the project and are less than a complete lot) shall be handled as:

- Three (3) sublots shall constitute a lot.
- One (1) or (2) sublots shall be incorporated into the previous lot.

306-6.1.1 Air Content Testing. Air content tests shall be performed on the first three truckloads of econocrete produced at the start of operations each day and the first three truckloads produced after any scheduled or non-scheduled shutdown. Additional tests shall be performed each time a sample is taken for a strength test and when requested by the Engineer.

Air content tests shall be made in accordance with ASTM C 231. Air content test results shall be between 4 and 8 percent.

If the first test on a truckload of econocrete is not within the specification limits, a second test on the same truckload shall be made. If the second test is within the specification limits, the econocrete will be accepted with respect to entrained air content. If the second test is not within the specification limits, the truckload shall be rejected.

306-6.1.2 Compressive Strength Testing. One sample of freshly delivered econocrete shall be taken from each sublot for compressive strength testing. The econocrete shall be sampled in accordance with ASTM C 172. Sampling locations shall be determined in accordance with the random sampling procedures contained in ASTM D 3665.

At least two (2) test cylinders shall be made from each sample in accordance with ASTM C 31. The 7-day compressive strength of each cylinder shall be determined in accordance with ASTM C 39.

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Since the strength level of econocrete at an early age is considerably lower than PCC, special care is required in handling test specimens.

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The Contractor shall provide adequate facilities for the initial curing of cylinders. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60 to 80°F (16 to 27°C), and loss of moisture from the specimens must be prevented. The specimens may be stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather or in heavyweight closed plastic bags, or use other suitable methods, provided the temperature and moisture loss requirements are met.

The compressive strength for each sublot shall be computed by averaging the 7-day compressive strengths of the two test cylinders representing that sublot. The compressive strength of the lot shall be the average compressive strength of the individual sublots comprising the lot.

Specimens that are noticeably defective shall not be considered in the determination of the strength. If the test specimens fail to conform to the requirements for strength, the Engineer shall request changes in the econocrete mixture to increase the strength to meet the requirements.

306-6.1.3 Thickness Testing. After the econocrete base has cured for 3 days, one (1) 4-in (102-mm) diameter core per sublot shall be obtained from a random location, as identified using the procedures contained in ASTM D 3665. The thickness of each sampled core shall be determined using the caliper measurement procedures provided by ASTM C 174. The average thickness for the lot shall be determined using the individual sublot core thicknesses. Acceptance criteria for econocrete thickness are provided in paragraph 306-6.2.2.

When such measurement is deficient more than ½ in (12.5 mm) and not more than 1 in (25.4 mm) from the plan thickness, two additional cores shall be taken at random and used in determining the average thickness for that lot. The thickness of the cores shall be determined by average caliper measurement of cores tested in accordance with ASTM C 174.

At all locations where cores have been drilled, the resulting holes shall be filled with econocrete or non-shrink grout material, as approved by the Engineer.

306-6.1.4 Grade Testing. The elevations of the finished econocrete shall be surveyed on both sides of the econocrete lane, every 25 ft (7.6 m).

306-6.1.5 Surface Tolerance Testing. After the econocrete has hardened sufficiently, it shall be tested for surface tolerance with a 16-ft (4.9-m) straightedge provided by the Contractor.

306-6.2 ACCEPTANCE CRITERIA. Acceptance of econocrete will be based on compressive strength, thickness, grade, and surface tolerance, as described in the paragraphs below.

306-6.2.1 Compressive Strength Requirements. The econocrete shall meet all of the following compressive strength requirements on a lot basis:

- The compressive strength of the lot, tested at 7 days, shall be greater than 500 psi (3,445 kPa). When a given lot of econocrete fails to meet the minimum compressive strength requirements, the entire lot shall be replaced at the Contractor's expense.
- Not more than 20 percent of the individual cylinders in a given lot, tested at 7 days, shall have a compressive strength greater than 800 psi (5,512 kPa). When greater than 20 percent of the individual cylinders in a given lot have 7-day compressive strengths in excess of 800 psi (5,512 kPa), and transverse joints have not been notched, a choke stone layer shall be used as a bond-breaker.

306-6.2.2 Thickness Requirements. The completed thickness shall be as shown on the plans. When the average lot thickness is not deficient by more than ½ in (12.5 mm) from the plan thickness, full payment shall be made. If the lot average thickness is deficient by more than 1 in (25.4 mm), it shall be removed and replaced at the Contractor's expense. When such measurement is deficient more than ½ in (12.5 mm) and not more than 1 in (25.4 mm) from the plan thickness, one additional core shall be taken at random from each sublot within the lot. The thickness of these additional cores shall be determined as indicated in paragraph 304-6.1.2. A new lot average thickness shall be recomputed based on these additional cores and the original cores taken from each sublot. When the recomputed average lot thickness is not deficient by more than ½ in (12.5 mm) from the plan thickness, full payment shall be made. If the average lot thickness is deficient by more than ½ in (12.5 mm) from the plan thickness, the entire lot shall be removed and replaced at the Contractor's expense or shall be permitted to remain in place at an adjusted payment of 75 percent of the contract unit price.

When the measured thickness is more than that indicated on the plans, it will be considered as conforming to the requirements, provided the surface of the completed econocrete layer is within the established grade and surface tolerance requirements.

306-6.2.3 Grade Requirements. When the completed surface is more than ½ in (12.5 mm) above the grade shown in the plans, the surface shall be trimmed at the Contractor's expense using an approved grinding machine to an elevation that falls within a tolerance of ¼ in (6 mm). The ground surface shall be sprayed with curing compound at double the rate specified prior to paving.

306-6.2.4 Surface Tolerance Requirements. Surface deviations shall not exceed ⅜ in (9.5 mm) from a 16-ft (4.9-m) straightedge laid in any location parallel with or at right angles to the longitudinal axis of the centerline (includes along all edges of the paving lane). Any high spots of more than ⅜ in (9.5 mm) in 16 ft (4.9 m) shall be marked and immediately trimmed with an approved grinding machine. If the overlying layer is PCC pavement, the ground surface shall be sprayed with a double application of the curing compound at the specified rate prior to paving.

METHOD OF MEASUREMENT

306-7.1 The quantity of econocrete to be paid for will be determined by the number of [yd^2 (m^2)] of econocrete actually constructed and accepted by the Engineer as complying with the plans and specifications.

BASIS OF PAYMENT

306-8.1 The accepted quantities of econocrete will be paid for at the contract unit price per [yd^2 (m^2)] for econocrete base. The price and payment shall be full compensation for furnishing and placing all materials, provided; however, for any pavement found deficient in thickness as specified in paragraph 306-6.2.2, the reduced unit price shall be paid.

Payment will be made for econocrete base course--per [yd^2 (m^2)].

TESTING REQUIREMENTS

ASTM C 31	Making and Curing Concrete Test Specimens in the Field
ASTM C 39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C 136	Sieve or Screen Analysis of Fine and Course Aggregates
ASTM C 172	Sampling Freshly Mixed Concrete
ASTM C 173	Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 174	Measuring Length of Drilled Concrete Cores
ASTM C 192	Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar Bar Method)
ASTM D 560	Standard Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures
ASTM D 3665	Random Sampling of Paving Materials
AASHTO T 26	Quality of Water to be Used in Concrete

MATERIAL REQUIREMENTS

ASTM C 33	Specification for Concrete Aggregates
ASTM C 94	Specification for Ready-Mixed Concrete
ASTM C 150	Specification for Portland Cement
ASTM C 260	Specification for Air-Entraining Admixtures for Concrete

ASTM C 309	Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 494	Specification for Chemical Admixtures for Concrete
ASTM C 595	Standard Specification for Blended Hydraulic Cements
ASTM C 618	Specification for Fly Ash and Raw and Calcined Natural Pozzolans for Use in Portland Cement Concrete
ASTM C 989	Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

APPENDIX C
FINAL DRAFT OF ITEM P-ATPB ASPHALT-TREATED PERMEABLE BASE COURSE

DESCRIPTION

ATPB-1.1 This item shall consist of an asphalt-treated permeable base (ATPB) course drainage layer composed of mineral aggregate and asphalt cement, mixed in a central mixing plant and placed on a prepared surface in accordance with these specifications, and conforming to the lines, grades, dimensions, and typical cross-sections shown on the plans.

MATERIALS

ATPB-2.1 AGGREGATE. The aggregate shall consist of clean, sound, hard, durable, angular particles of crushed stone. The aggregate shall be free from clay balls, organic matter, and other deleterious substances in accordance with ASTM C 33.

The crushed aggregate portion retained on the ⅜-in (9.5-mm) sieve shall contain not more than 10 percent by weight of flat or elongated pieces, as defined in ASTM D 693, and shall have at least 90 percent by weight of particles with at least two fractured faces. The area of each face shall be equal to at least 75 percent of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces.

The percentage of wear of the crushed aggregate retained on the No. 4 (4.75-mm) sieve shall not be greater than 40 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 10 percent, or the magnesium sulfate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

The aggregate gradation for the ATPB mixture shall be one of the gradations selected from Table 1. Gradation shall be determined in accordance with ASTM C 117 and C 136. The aggregate shall be continuously 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 an adjacent sieve or vice versa.

Table 1. Aggregate gradation for job mix.

Sieve Size	Percentage by Weight Passing Sieves		
	Gradation A (¾ in [19 mm] max.)	**Gradation B (1 in [25 mm] max.)**	**Gradation C (1½ in [38 mm] max.)**
1½ in (38 mm)			95 - 100
1 in (25 mm)		95 - 100	72 - 82
¾ in (19 mm)	95 – 100	77 - 87	60 - 70
½ in (13 mm)	67 – 77	53 - 63	40 - 50
⅜ in (9.5 mm)	50 – 60	41 - 51	30 - 40
No. 4 (4.75 mm)	19 – 29	15 - 25	10 - 20
No. 8 (2.36 mm)	0 – 6	0 - 6	0 - 6

ATPB-2.2 ASPHALT CEMENT. Asphalt cement binder shall conform to the following requirements: [ ].

* *

The Engineer shall specify the grade and appropriate specifications of asphalt cement, based on geographical location and climatic conditions. The same asphalt grade as is used for P-401 material for the project location or a stiffer grade is deemed adequate.

* *

The asphalt binder content shall be between 2.0 and 3.5 percent, by weight of the total mixture.

ATPB-2.3 ANTI-STRIPPING AGENT. An anti-stripping agent in the form of lime shall be used to prevent stripping of the asphalt cement, particularly if the coarse aggregate is not limestone or dolomite. Lime shall be added at the rate of 0.5 to 1.0 percent by weight.

ATPB-2.4 SEPARATION LAYER. A separation layer consisting of [dense-graded aggregate meeting the gradation in Table 2] [geotextile meeting AASHTO M 288 Survivability Class 2 (woven or non-woven fabrics)] shall be placed over the prepared subgrade prior to placing any ATPB. The separation layer shall be checked and accepted in advance of spreading the ATPB.

* *

The separation layer is situated directly below the ATPB layer. Its main function is to keep underlying layers or subgrade soils from infiltrating into the ATPB. Another important function is to not allow infiltration of the separation layer into the ATPB or vice versa. It also provides a stable platform on which to build the ATPB layer.

Both dense-graded aggregate layers and geotextile layers can be used as separation layers. Lime- or cement-treated subgrades, cement-treated bases, and asphalt chip seals are not acceptable as separation layers. The typical thickness of an aggregate separation layer is 4 in (102 mm). A geotextile fabric may be used in lieu of a dense-graded aggregate separation layer when the California bearing ratio (CBR) of the layer on which it will rest is greater than 6.

In the first sentence of paragraph ATPB-2.4, specify the layer type of choice. When an aggregate separation layer is specified, insert the following table:

Table 2. Aggregate gradation for separation layer.

Sieve Size	Percentage by Weight Passing Sieve
1½ in (38 mm)	100
1 in (25 mm)	95 – 100
¾ in (19 mm)	70 – 95
No. 4 (4.75 mm)	55 – 85
No. 8 (2.36 mm)	30 – 60
No. 30 (600 μm)	12 – 30
No. 200 (75 μm)	0 – 8

* *

ATPB-2.5 CHOKE STONE. If used, the choke stone material shall conform to the requirements of the new FAA specification on choke stone.

COMPOSITION OF MIXTURE

ATPB-3.1 GENERAL. The ATPB material shall be composed of a mixture of aggregate, asphalt cement, and anti-stripping agent.

ATPB-3.2 MIX DESIGN. The job mix formula (JMF) shall establish a single percentage of dry weight of aggregate passing each required sieve size, a single percentage of asphalt cement to be added to the aggregate based on the weight of the total mix, and a single temperature for the mixture as it is discharged into the hauling units. When tested in accordance with ASTM C 136, the combined aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation specified in Table 1. The gradation band shown in Table 1 shall be applied to the JMF and used for job control.

When the component aggregates are blended together, mixed with the specified amount of asphalt cement at a temperature of 250°F (121°C), and compacted at 150°F (65°C) with 35 blows of a standard Marshall hammer, the JMF shall have a permeability of not less than 500 ft/day (152.5 m/day) nor more than 1,500 ft/day (457.5 m/day) when tested in accordance with ASTM D 2434/AASHTO T 215 (Constant Head Permeability Test). The JMF shall have a minimum asphalt binder content of 2.0 percent by weight, which can be adjusted upward to 3.5 percent to provide stability under rollers during construction and to meet the desired permeability requirements.

* *

The typical amount of asphalt used in ATPB mixtures is between 2.0 and 3.5 percent by weight. Higher mixing temperatures may be required when modified asphalts are used.

* *

The JMF shall be in effect until modifications are reviewed by the Engineer. When unsatisfactory results for any specified characteristic of the work make it necessary, the Contractor may establish a new JMF.

ATPB-3.3 SUBMITTALS. At least [ ] days prior to the placement of the ATPB, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction, as well as the mix design information for the ATPB material. The certification shall show the appropriate 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. Sources of materials, including all aggregates, asphalt cement, anti-stripping agent (if required), and geotextile materials (if selected for the separation layer).

b. Physical properties of the aggregates, asphalt cement, anti-stripping agent (if required), and geotextile materials (if selected for the separation layer).
c. Mixing temperature.
d. Temperature of mix at time of discharge from mixer.
e. JMF.
   - mix identification number.
   - percent passing each sieve size for total combined gradation, individual gradation of all aggregate stockpiles, and percent by weight of each stockpile used in the JMF.
   - asphalt grade and content.
f. Laboratory test results.
   - permeability testing procedure.
   - permeability.

* *

Insert the appropriate number of days for Contractor submittal of the certified test reports and JMF; 15 to 30 days is typical.

* *

Tests older than 6 months shall not be used. Submittals shall comply with procedures set forth in the "Shop Drawing and Sample Submittals" section of the General Conditions. No ATPB material shall be placed until the submittal is accepted in writing by the Engineer and returned to the Contractor.

EQUIPMENT

All equipment necessary to mix, transport, place, compact, and finish the ATPB material shall be furnished by the Contractor and approved by the Engineer. The equipment shall be at the job site prior to the start of construction operations for examination by the Engineer.

ATPB-4.1 MIXING. Plants used for the preparation of the ATPB material can be either batch plant or continuous mix type and shall conform to the requirements of ASTM D 995, with the following changes:

- Truck Scales—The ATPB material shall be weighed on approved scales furnished by the Contractor, or on public scales at the Contractor's expense. Such scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of Section 90 of the General Provisions.
- Testing Laboratory—All quality control and acceptance testing shall be in accordance with Section 100 of the General Provisions.
- Inspection of Plant—The Engineer shall have access, at all times, to all parts of the plant for checking adequacy of equipment; inspection operation of the plant; verifying weights, proportions, and character of materials; and checking the temperatures maintained in the preparation of the mixtures.
- Storage Bins and Surge Bins—Use of surge bins or storage bins for temporary storage of hot asphalt mixtures will not be permitted.

ATPB-4.2 HAULING. Trucks used for hauling the ATPB mixture from the plant to the job site shall have clean and smooth beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of concentrated hydrated lime and water solution. The truck beds shall be raised to drain any excess solution before loading the mixture in the trucks. Each truck shall have a suitable cover to protect the mixture from adverse weather or long hauls.

ATPB-4.3 PLACING. The ATPB material shall be placed using an asphalt lay-down machine. The lay-down machine shall be self-contained, power-propelled, and equipped with an activated screed or strike-off assembly (heated as necessary). The laydown machine shall be capable of spreading and finishing courses of ATPB material that will meet the specified thickness, smoothness, and grade. An alternative method for placement that provides compaction of the ATPB material is with a large asphalt paving machine with dual tamping bars.

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

If an automatic grade control device is used, the paver shall be equipped with a control system capable of automatically maintaining the screed elevation as specified herein. The control system shall be automatically actuated from either a reference line or a surface through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. The controls shall be capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 30 ft (9.15 m) in length.
b. Taut stringline (wire) set to grade.
c. Short ski or shoe.
d. Laser control.

If, during construction, it is found that the spreading and finishing equipment causes unacceptable displacement of the ATPB surface, the use of such equipment shall be discontinued and satisfactory equipment shall be provided by the Contractor.

ATPB-4.4 COMPACTION. A minimum of one self-propelled steel-wheel static roller with weight between 6 and 12 tons (5.4 and 10.9 metric tons) shall be used to compact the ATPB. The roller shall be in good condition and shall be capable of reversing without backlash and of compacting the CTPB without undue displacement or excessive crushing of the aggregate. The wheels shall be equipped with adjustable scrapers, water tanks, and sprinkling apparatuses to prevent the ATPB mixture from sticking to the wheels.

CONSTRUCTION METHODS

ATPB-5.1 TEST SECTION. Prior to the start of full-scale production, the Contractor shall construct a test section to demonstrate the constructability (including mixing, transporting, placing, and compacting procedures) of the ATPB.

The Contractor shall prepare the ATPB mixture according to the JMF and place it in a test section to the depth specified on the plans. The test section shall be a minimum length representing at least 1 hour of production or 500 ft (152.5 m), whichever is more restrictive, and of the expected placement width, and shall consist of two side-by-side lanes parted by a construction joint. The equipment to be used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

ATPB-5.1.1 Compaction. The Contractor shall statically compact the material by a minimum of two passes with the selected steel-wheel roller. Compaction shall continue until the aggregate is properly seated and the mixture appears stable under construction traffic.

ATPB-5.1.2 Evaluation of Test Section. The completed ATPB layer shall be considered acceptable when:

- The aggregate particles are completely coated with asphalt.
- The rolling procedure is deemed adequate when the surface becomes firm and unyielding, and there is no evidence of crushing of aggregate, such that the ATPB layer is stable under construction traffic.
- The texture of the ATPB layer looks reasonably open and water poured from a 1-gal (3.8-L) container flows through the layer within 1 minute.
- The density of core samples taken from the test section show 100 percent of the density of laboratory-compacted specimens. If the density is not achieved, additional test sections are required to establish the necessary roller weight and rolling pattern.

If the test section should prove to be unsatisfactory to the Engineer, the necessary adjustments to the mix design, plant operation, and/or rolling procedures shall be made.

Test sections that do not conform to specification requirement shall be removed and replaced at the Contractor's expense. Additional sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until a successful test section is completed.

ATPB-5.2 WEATHER LIMITATIONS. The ATPB material shall be constructed only on a dry surface when the air temperature is 40°F (4°C) and rising and under calm wind conditions. The ATPB shall not be placed when rainfall is occurring or when rain is imminent. If a rain event begins to occur immediately after placement, the layer should be compacted as quickly as possible.

ATPB-5.3 SEPARATION LAYER. Prior to the placement of the separation layer, the underlying layer shall be checked and accepted by the Engineer. The underlying layer should be

constructed to the grades and elevations specified in the plans and should be free of any ruts, depressions, or bumps.

ATPB-5.3.1 Aggregate Separation Layer. If an aggregate-type separation layer is used, it shall be uniformly spread over the subgrade and compacted.

ATPB-5.3.2 Geotextile Separation Layer. If a geotextile-type separation layer is used, the geotextile fabric shall be placed in such a manner as to avoid wrinkles. If the geotextile layer is damaged prior to the placement of the ATPB layer, that section of the geotextile shall be patched or replaced immediately. The fabric shall not be stretched so tight that it will tear as the aggregate is being placed over it. Whenever more than one section is being used, the fabric must be overlapped based on the manufacturer's recommendations.

ATPB-5.4 MIXING. The aggregate for the ATPB mixture shall be dried and heated prior to mixing with asphalt such that the combined aggregate moisture content (weighted according to the composition of the blend) is less than 0.25 percent for aggregate blends with water absorption of 2.5 percent or less, and less than 0.50 percent for aggregate blends with water absorption greater than 2.5 percent. Water absorption of aggregates shall be determined by ASTM C 127 and C 128. The water content test will be conducted in accordance with ASTM C 566.

At the time of mixing, the temperature of the aggregate shall be within the range specified in the JMF. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates.

The dried aggregates shall be combined in the mixer to meet the gradation requirements for the mix design. The asphalt cement shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. The combined materials shall be mixed until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture.

The temperature at the discharge from the plant or surge and storage bins shall be maintained between 275 and 325°F (135 and 163°C).

ATPB-5.5 HAULING. The ATPB mixture shall be transported to the job site and delivered to the asphalt paver for placement. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature. Any truck causing excessive segregation of the ATPB mixture by its suspension or other contributing factors, or that leaks or causes delays, shall be removed from the work until such conditions are corrected.

Loads shall not be sent out so late in the day as to prevent completion of the spreading and compaction of the mixture during daylight, unless sufficient artificial light is provided.

Plant production and the number of trucks used for transportation shall be such as to ensure delivery of the mixture in sufficient quantities and at such intervals to permit continuous placement of the material with minimal stopping and starting of the paving operation. Failure to maintain such delivery shall be cause to suspend the work.

ATPB-5.6 PLACING. The ATPB shall be spread at a temperature between 200 and 250°F (93 and 121°C), as measured in the hopper of the paving machine.

The ATPB material shall be placed to the full width by the asphalt paver in a uniform layer of such depth that, when compacted, it is of the required thickness and conforms to the grade and contour indicated.

The speed of the paver shall be regulated to eliminate pulling and tearing of the ATPB mat. The Contractor may install the ATPB layer in a single or multiple compacted lifts; however, each compacted lift must be at least 4 in (102 mm) thick and no greater than 6 in (152 mm) thick. If multiple lifts are used, the longitudinal joint in one lift shall offset the longitudinal joint in the lift immediately below by at least 1 ft (0.3 m); however, the joint in the surface lift shall be at the centerline of crowned pavements. Transverse joints in one lift shall be offset by at least 2 ft (0.6 m) from transverse joints in the previous lift. Transverse joints in adjacent strips shall be offset a minimum of 10 ft (3.1 m).

In placing adjacent strips of ATPB, the screed of the paving machine shall overlap the previously placed strip 3 to 4 in (76 to 102 mm) and shall be sufficiently high so that compaction will produce a smooth, dense joint. The ATPB material placed on the edge of the previously placed strip by the paver shall be pushed back to the edge of the strip being placed. Excess material shall be removed and wasted.

In areas where machine spreading is impractical, the ATPB material shall be spread using hand tools. The material shall be spread uniformly in a loose layer to prevent segregation. The material shall conform to the required grade and thickness after compaction.

ATPB-5.7 COMPACTION. Compaction of the ATPB material should begin when the temperature of the mix has cooled to 150°F (65°C) and should be completed before the temperature falls below 100°F (38°C). The ATPB material shall be compacted using the approved compaction equipment and roller pattern/sequence as determined in the test section. Sufficient rollers shall be furnished to handle the output of the plant and each roller shall operate at a speed no greater than 1.5 mi/hr (2.4 km/hr).

If the designated rolling pattern/sequence deviates from that approved in the test section, or if crushing of the aggregate is observed, work shall be stopped until the cause(s) can be determined and corrections are made. Core samples shall then be taken to determine if adequate density is being achieved and satisfactory permeability is being obtained.

In all places not accessible to the rollers, the ATPB material shall be compacted with approved mechanical hand-operated tampers.

ATPB-5.8 JOINTS. The formation of longitudinal joints shall be made in such a manner as to ensure a continuous bond between adjacent lanes of ATPB. All joints shall exhibit the same texture, density, and smoothness as other portions of the layer.

The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the ATPB material, in which case the edge shall be cut back to its full depth and width on a straight line to expose vertical face. In both methods, all contact surfaces shall be given a tack coat of asphalt material before placing any fresh mixture against the joint. Longitudinal joints which are irregular, damaged, or otherwise defective shall be cut back to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be given a tack coat of asphalt material prior to placing any fresh ATPB mixture against the joint.

ATPB-5.9 PROTECTION. The ATPB shall be maintained and protected during their construction and until the Contractor has entirely covered the material with pavement or the next layer. The Contractor shall maintain drainage at the job site, such that fine material is not allowed to wash into and clog the ATPB. In no case shall any construction traffic be allowed on the completed ATPB until the compacted mixture has reached ambient temperature. Only equipment necessary for the construction of the next higher pavement layer shall be allowed on the completed ATPB.

MATERIAL ACCEPTANCE

ATPB-6.1 ACCEPTANCE SAMPLING AND TESTING. Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be performed by the Engineer at no cost to the Contractor. Testing organizations performing these tests shall meet the requirements of ASTM D 3666. All equipment in Contractor-furnished laboratories shall be calibrated by the testing organization prior to the start of operations.

Aggregate samples shall be furnished by the Contractor in accordance with ASTM D 75 for laboratory testing prior to the start of production. Additionally, the Contractor shall furnish aggregate samples at specified intervals during production. Sampling for gradation shall be in accordance with ASTM D 75, and testing shall be in accordance with ASTM C 136 and C 117. Samples of the ATPB mixture shall be taken at the point of discharge in hauling units and tested to control uniformity in the asphalt content and gradation. Samples shall be taken in accordance with ASTM D 979. Enough mixture shall be taken to prepare duplicate tests on each sample of mixture in accordance with ASTM D 2172. Samples shall be taken at least once for any central plant-run of more than 30 minutes and at least twice for any central plant-run of more than 5 hours. Field samples will also be extracted and gradation checked for secondary control.

Should gradation analysis or asphalt binder content fail to meet the tolerances of the JMF, the Engineer may (a) order another analysis in addition to the two analyses required each day to confirm the results of the previous tests, or (b) instruct the Contractor to cease plant production until such out-of-tolerance conditions have been corrected or the permeability and density of the compacted ATPB are checked to verify that they meet or exceed the test section values.

Completed ATPB layers shall be determined as "unacceptable" on the basis of visual inspection. The Engineer shall immediately notify the Contractor of visual defects such as non-uniform

texture, evidence of material segregation, bleeding of asphalt material, cracking and shoving of the mixture, surface irregularities, and evidence of aggregate crushing during the roller operations.

"Unacceptable" ATPB shall be removed down to the surface of the separation layer, leaving a vertical face at the adjacent ATPB. The separation layer shall be re-worked or cleaned, as necessary, and a tack coat applied prior to replacing the removed ATPB material. All work shall be at the Contractor's expense. Unacceptable ATPB shall not be measured for payment.

The ATPB layer shall be tested for thickness, grade, and surface tolerance on a lot basis, with a lot consisting of one of the following:

- One day's production not to exceed 2,000 yd^2 (1,675 m^2).
- A half day's production, where a day's production is expected to consist of between 2,000 and 4,000 yd^2 (1,675 and 3,350 m^2).

Each lot will be divided into four equal sublots. However, in the event that three (3) sublots are produced due to circumstances significantly affecting the paving operation, the three sublots shall constitute a complete lot. If one (1) or two (2) sublots are produced for the same reason, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation.

End-of-production sublots (i.e., sublots associated with the final placement of ATPB for the project) shall be structured as follows:

- Three (3) sublots shall constitute a lot.
- One (1) or (2) sublots shall be incorporated into the previous lot, and the total number of sublots for that lot shall be used in the acceptance plan calculation.

ATPB-6.1.1 Thickness Testing. Upon completion of the ATPB layer, one (1) 4-in (102-mm) diameter core per sublot shall be obtained from a random location, as identified using the procedures contained in ASTM D 3665. The resulting core holes shall be filled by the Contractor with a cold-mix asphalt or other material as approved by the Engineer.

The thickness of each core sample shall be determined using the caliper measurement procedures provided by ASTM C 174. The average thickness for the lot shall be determined using the individual sublot core thicknesses. Acceptance criteria for ATPB thickness are provided in paragraph ATPB-6.2.1.

ATPB-6.1.2 Grade Testing. The elevations of the finished ATPB layer shall be surveyed on both sides of the ATPB lane, every 25 ft (7.6 m). Acceptance criteria for ATPB grade are provided in paragraph ATPB-6.2.2.

ATPB-6.1.3 Surface Tolerance Testing. After completion of the final rolling, the finished surface shall be tested with a 16-ft (4.9-m) straightedge. The straightedge shall be applied parallel with and at right angles to the centerline of the ATPB area, and shall be advanced

approximately one-half its length in the line of measurement. Acceptance criteria for ATPB surface tolerance are provided in paragraph 306-6.2.3.

ATPB-6.2 ACCEPTANCE CRITERIA. Acceptance of ATPB will be based on thickness, grade, and surface evenness, as described in the paragraphs below.

ATPB-6.2.1 Thickness Requirements.

When the average measured thickness from a lot is not deficient by more than 1 in (25 mm) from the plan thickness, full payment shall be made. When such measurement is deficient by more than 1 in (25.4 mm) from the plan thickness, the entire lot shall be removed by excavating to the required depth and replacing with new material to obtain a compacted lift thickness, at the Contractor's expense. When the measured thickness is more than indicated, it shall be considered as conforming to the requirements, provided the surface of the ATPB drainage layer is within the established grade and surface tolerance requirements.

ATPB-6.2.2 Grade Requirements. Areas in the ATPB more than ⅝ in (16 mm) below grade shown on the plans shall be corrected at the Contractor's expense by removing the defective work and replacing it with new material; areas higher that ⅝ in (16 mm) may be cut to grade by grinding.

ATPB-6.2.3 Surface Tolerance Requirements. The finished ATPB surface shall not vary more than ½ in (12.5 mm) when tested with a 16-ft (4.9-m) straightedge applied parallel with, or at right angles to, the centerline of the ATPB area. Areas of the ATPB exceeding the specified tolerances shall be corrected at the Contractor's expense by grinding or by removing the defective work and replacing it with new material.

METHOD OF MEASUREMENT

ATPB-7.1 ASPHALT-TREATED PERMEABLE BASE COURSE. Payment for ATPB course will be based the number of [tons (metric tons)] of ATPB actually constructed and accepted by the Engineer as complying with the plans and specifications.

BASIS OF PAYMENT

ATPB-8.1 ASPHALT-TREATED PERMEABLE BASE COURSE. Payment shall be made at the contract unit price per [tons (metric tons)] for ATPB at the specified thickness. This price shall be full compensation for furnishing all materials; for all preparation and storage of materials; for mixing, hauling, placing, and compacting the mixture (including the test section); and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made for asphalt-treated permeable base course—per [ton (metric ton)].

TESTING REQUIREMENTS

ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C 128	Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C 131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Sieve or Screen Analysis of Fine and Course Aggregates
ASTM C 174	Measuring Length of Drilled Concrete Cores
ASTM C 566	Total Evaporable Moisture Content of Aggregate by Drying
ASTM D 75	Sampling Aggregates
ASTM D 693	Crushed Stone, Crushed Slag, and Crushed Gravel for Dry or Water-Bound Macadam Base Courses and Bituminous Macadam Base and Surface Courses of Pavements
ASTM D 979	Sampling Bituminous Paving Mixtures
ASTM D 2172	Quantitative Extraction of Bitumen From Bituminous Paving Mixtures
ASTM D 2434/ AASHTO T 215	Constant Head Permeability
ASTM D 3665	Random Sampling of Paving Materials
ASTM D 3666	Minimum Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

MATERIAL REQUIREMENTS

ASTM C 33	Specification for Concrete Aggregates
ASTM D 995	Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
AASHTO M 288	Geotextile Specification for Highway Applications

APPENDIX D
FINAL DRAFT OF ITEM P-CTPB
CEMENT-TREATED PERMEABLE BASE COURSE

DESCRIPTION

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

MATERIALS

CTPB-2.1 AGGREGATE. The method used in producing the aggregate shall be such that the finished product is as consistent as practicable. The aggregate shall consist of clean, sound, hard, durable, angular particles of crushed stone that meets the specification requirements. The aggregate shall be free from clay balls, organic matter, and other deleterious substances in accordance with ASTM C 33.

The aggregate shall contain not more than 15 percent, by weight, of flat or elongated pieces, as defined in ASTM D 693. The percentage of wear of the crushed aggregate retained on the No. 4 (4.75-mm) sieve shall not be greater than 50 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 10 percent, or the magnesium sulfate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

When tested in accordance with ASTM C 136, the aggregate shall conform to the gradation shown in Table 1. The aggregate shall be continuously well graded from coarse to fine within the limits designated in the table and the gradation shall not vary from the low limit on one sieve to the high limit on an adjacent sieve or vice versa.

Table 1. Aggregate gradation for CTPB material.

Sieve Size	Percentage by Weight Passing Sieves		
	Gradation A (¾ in [19 mm] max.)	**Gradation B (1 in [25 mm] max.)**	**Gradation C (1½ in [38 mm] max.)**
1½ in (38 mm)			95 - 100
1 in (25 mm)		95 - 100	72 - 82
¾ in (19 mm)	95 - 100	77 - 87	60 - 70
½ in (13 mm)	67 - 77	53 - 63	40 - 50
⅜ in (9.5 mm)	50 - 60	41 - 51	30 - 40
No. 4 (4.75 mm)	19 - 29	15 - 25	10 - 20
No. 8 (2.36 mm)	0 - 6	0 - 2	0 - 6

CTPB-2.2 CEMENT. Cement shall conform to the requirements of ASTM [ ].

* *

The Engineer shall specify ASTM C 150 Type I, II, III, IV, or V or ASTM C 595 Type IS, IS-A, IP, IP-A, P, or PA.

* *

CTPB-2.3 WATER. Water used in mixing or curing shall be clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product. In addition, water shall conform to requirements of AASHTO T 26. Water known to be of potable quality may be used without testing.

CTPB-2.4 SEPARATION LAYER. A separation layer consisting of [dense-graded aggregate meeting the gradation in Table 2] [geotextile meeting AASHTO M 288 Survivability Class 2 (woven or non-woven fabrics)] shall be placed over the prepared subgrade prior to placement of any CTPB material. The separation layer shall be checked and accepted in advance of spreading the CTPB.

* *

The separation layer is situated directly below the CTPB layer. Its main function is to keep underlying layers or subgrade soils from infiltrating into the CTPB. Another important function is to not allow infiltration of the separation layer into the CTPB or vice versa. It also provides a stable platform on which to build the CTPB layer.

Both dense-graded aggregate layers and geotextile layers can be used as separation layers. Lime- or cement-treated subgrades, cement-treated bases, and asphalt chip seals are not acceptable as separation layers. The typical thickness of an aggregate separation layer is 4 in (102 mm). A geotextile fabric may be used in lieu of a dense-graded aggregate separation layer when the California bearing ratio (CBR) of the layer on which it will rest is greater than 6.

In the first sentence of paragraph CTPB-2.4, specify the layer type of choice. When an aggregate separation layer is specified, insert the following table:

Table 2. Aggregate gradation for separation layer.

Sieve Size	Percentage by Weight Passing Sieve
1½ in (38 mm)	100
1 in (25 mm)	95 - 100
¾ in (19 mm)	70 - 95
No. 4 (4.75 mm)	55 - 85
No. 8 (2.36 mm)	30 - 60
No. 30 (600 μm)	12 - 30
No. 200 (75 μm)	0 - 8

* *

CTPB-2.5 CHOKE STONE. Choke stone is only required when a CTPB is placed directly beneath a portland cement concrete (PCC) surface layer. It shall conform to the requirements of the new FAA specification for choke stone.

COMPOSITION OF MIXTURE

CTPB-3.1 GENERAL. The CTPB material shall be composed of a mixture of aggregate, cement, and water.

CTPB-3.2 MIX DESIGN. The mix design shall establish the percentage of dry weight of aggregate passing each required sieve size and the percentage of cement based upon the weight of the total mix. The combined aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation specified in Table 1, when tested in accordance with ASTM C 136. The gradation band shown in Table 1 shall be applied to the mix design and should be used for job control.

The mix design shall contain at least 250 lbs (113 kg) of cement per cubic yard and the cement paste volume shall be adequate for uniformly coating the aggregate as determined by visual examination. The mix design shall also have a permeability of not less than 500 ft/day (152.5 m/day) nor more than 1,500 ft/day (457.5 m/day) when tested in the laboratory in accordance with ASTM D 2434/AASHTO T 215 (Constant Head Permeability Test).

Should a change in aggregate sources or type of cement used be made, a new mix design shall be submitted to the Engineer for approval.

CTPB-3.3 SUBMITTALS. At least [ ] days prior to the placement of the CTPB, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction, as well as the mix design information for the CTPB material. The certification shall show the appropriate ASTM 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. Sources of materials, including all aggregates, cement, curing materials, and geotextile or aggregate separator materials (if used).
b. Physical properties of the aggregates, cement, curing materials, and geotextile materials (if used).
c. Mix design
   - mix identification number.
   - aggregate gradation.
   - cement type and content.
   - water content.
d. Laboratory test results.
   - compaction procedure.
   - permeability testing procedure.
   - permeability.

* *

Insert the appropriate number of days for Contractor submittal of the certified test reports and mix design; 15 to 30 days is typical.

* *

Tests older than 6 months shall not be used. Submittals shall comply with procedures set forth in the "Shop Drawing and Sample Submittals" section of the General Conditions. No CTPB material shall be placed until the submittal is approved by the Engineer.

EQUIPMENT

All equipment necessary to mix, transport, place, compact, and finish the CTPB material shall be furnished by the Contractor and approved by the Engineer. The equipment will be inspected by the Engineer prior to the start of construction operations.

CTPB-4.1 MIXING. The CTPB material may be mixed in a stationary mixer, either at a central batch plant or at the site. Each mixer shall have attached in a prominent place a manufacturer's nameplate showing the capacity of the drum in terms of volume of mix and the speed of rotation of the mixing drum or blades.

The batch plant and equipment shall conform to the requirements of ASTM C 94. Free access to the plant must be provided to the Engineer at all times for inspection of the plant's equipment and operation and for sampling the CTPB mixture and its components.

The mixers shall be examined daily by the Contractor and periodically by the Engineer for changes in condition due to accumulation of hard concrete or mortar or wear of blades. The pick-up and throw-over blades shall be replaced as necessary to provide adequate mixing.

CTPB-4.2 HAULING. The mixed CTPB material shall be transported from the plant to the job site in trucks or other hauling equipment having beds that are smooth and clean. Truck bed covers shall be provided to protect the CTPB during transport from rain. CTPB material that becomes wet during transport will be rejected.

CTPB-4.3 PLACING. The CTPB material shall be placed using a mechanical spreader or an asphalt paver. The spreading equipment shall be capable of placing the material, without segregation, into a uniform layer or lift meeting the required grade and cross-section. The equipment shall be equipped with a strike-off plate capable of being adjusted to the specified layer thickness. It shall also be equipped with two end gates or cut-off plates such that the CTPB may be spread in variable widths. An alternative method for placement that provides compaction of the CTPB material is with a large asphalt paving machine with dual tamping bars.

CTPB-4.4 COMPACTION. Compaction of the CTPB layer shall be accomplished using a minimum of one self-propelled, steel-wheel static roller with weight between 6 and 12 tons (5.4 to 10.9 metric tons). The roller shall be in good condition and shall be capable of reversing without backlash and of compacting the CTPB without undue displacement or excessive crushing of the aggregate.

CONSTRUCTION METHODS

CTPB-5.1 TEST SECTION. Prior to the start of full-scale production, the Contractor shall construct a test section to demonstrate the constructability (including mixing, transporting, placing, and compacting procedures) of the CTPB.

The Contractor shall prepare the CTPB mixture according to the mix design and place it in a test section to the depth specified on the plans. The test section shall be a minimum length representing at least 1 hour of production or 500 ft (152.5 m), whichever is more restrictive and of the expected placement width, and shall consist of two side-by-side lanes parted by a construction joint. The equipment to be used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

CTPB-5.1.1 Compaction. The Contractor shall statically compact the material by a minimum of two passes of the selected steel wheel roller. Compaction shall continue until the aggregate is properly seated and the mixture appears stable under construction traffic.

CTPB-5.1.2 Evaluation of Test Section. The completed CTPB layer shall be considered acceptable when:

- The aggregate particles are completely coated with cement paste.
- The rolling procedure is deemed adequate when the surface becomes firm and unyielding, and there is no evidence of crushing of aggregate, and the compacted CTPB layer is stable under construction traffic.
- The texture of the CTPB layer looks reasonably open and water poured from a 1-gal (3.8-L) container flows readily through the layer within 1 minute.

If the test section should prove to be unsatisfactory, adjustments will be made to the mix design, plant operation, and/or rolling procedures as necessary.

Test sections that do not conform to specification requirement shall be removed and replaced at the Contractor's expense. Additional test sections shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until a successful test section is completed.

CTPB-5.2 WEATHER LIMITATIONS.

CTPB-5.2.1 Cold Weather. The CTPB material shall not be mixed or placed while the air temperature is below 40°F (4°C) or when conditions indicate that the temperature may fall below 35°F (2°C) within 24 hours. The CTPB shall not be placed on frozen underlying courses or mixed when aggregate is frozen.

CTPB-5.2.2 Rain. The CTPB may not be placed when rainfall is occurring or where rain is imminent. Any CTPB material that has become excessively wet by rain during transport and/or placement will be rejected.

CTPB-5.3 SEPARATION LAYER. Prior to the placement of the separation layer, the underlying layer shall be checked and accepted by the Engineer. The underlying layer should be constructed to the grades and elevations specified in the plans and should be free of any ruts, depressions, or bumps. Any ruts or soft yielding places caused by improper drainage conditions, hauling, or any other cause, shall be corrected before the separation layer is placed thereon.

CTPB-5.3.1 Aggregate Separation Layer. If an aggregate-type separation layer is used, it shall be uniformly spread over the subgrade and compacted.

CTPB-5.3.2 Geotextile Separation Layer. If a geotextile-type separation layer is used, the geotextile fabric shall be placed in such a manner as to avoid excessive wrinkles. If the geotextile layer gets damaged prior to the placement of the CTPB layer, that section of the geotextile should be patched or replaced immediately at the Contractor's expense. The fabric shall not be stretched so tight that it will tear as the aggregate is being placed over it. Whenever more than one section is being used, the fabric must be overlapped based on the manufacturer's recommendations.

CTPB-5.4 GRADE CONTROL. Grade control between the edges of the CTPB shall be accomplished by grade stakes, steel pins, or forms placed in lanes parallel to the centerline and at intervals of 50 ft (15.2 m) or less on the longitudinal grade and at 25 ft (7.6 m) or less on the transverse grade.

CTPB-5.5 MIXING. Aggregate and cement may be proportioned either by weight or volume, and shall be mixed sufficiently to prevent the forming of cement balls when water is added. Batching weights shall be within a tolerance of 1 percent for cement and 2 percent for aggregates. The mixing time shall be that which is required to secure an intimate, uniform mixture of aggregate, cement, and water.

CTPB-5.6 HAULING. The CTPB mixture shall be transported to the job site and delivered to the spreader for placement. The elapsed time between the start of moist mixing and the time the CTPB is deposited in-place at the work site shall not exceed (a) 30 minutes when the CTPB is hauled in non-agitating trucks, or (b) 45 minutes when the CTPB is hauled in transit mixers. Retempering the CTPB material by adding water or by other means shall not be permitted.

CTPB-5.7 PLACING. The CTPB mixture shall be spread into a uniform layer of such width and thickness that, following compaction, it conforms to the required grade and cross-section. The Contractor may install the CTPB layer in a single or multiple compacted lifts; however, each compacted lift must be at least 4 in (102 mm) thick and no greater than 6 in (152 mm) thick. Successive lifts shall be placed and compacted so that each successive layer is placed on the previous layer within 1 hour.

A single spreader may be used, provided it is capable of placing a uniform, full-depth layer of material across the full width of the base in one pass. Otherwise, two or more spreaders will be required, and shall be operated so that spreading progresses along the full width of the base in a uniform manner, and the placement by each of the spreaders is no more than 1 hour apart.

CTPB-5.8 COMPACTION. Immediately upon completion of the spreading operations, the CTPB material shall be compacted using the approved compaction equipment and roller pattern/sequence, as determined in the approved test section. Sufficient rollers shall be furnished to handle the output of the plant. If the rolling pattern/sequence results in undue displacement of the surface, or causes crushing of the aggregate, work shall be stopped until the cause(s) can be determined and corrections are made.

Alternative compaction using a large asphalt paving machine with dual tamping bars may be used in lieu of the rolling.

In all places not accessible to the rollers (or the alternative paving machine), the CTPB material shall be compacted with approved mechanical hand-operated tampers.

Not more than 30 minutes shall elapse between the start of moist mixing of the CTPB material and the start of field compaction. In addition, field compaction shall be completed within 60 minutes.

CTPB-5.9 CHOKE STONE. The choke stone shall be prepared and placed in accordance with the new FAA specification for choke stone.

CTPB-5.10 PROTECTION. Completed portions of the CTPB layer, following placement of the choke stone, can be opened immediately to low-speed traffic and to construction equipment, provided the CTPB is sufficiently stable and does not ravel or loosen under such traffic. The CTPB shall also be protected from freezing until the layer above it is placed.

MATERIAL ACCEPTANCE

CTPB-6.1 ACCEPTANCE SAMPLING AND TESTING. Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be performed by the Engineer at no cost to the Contractor. Testing organizations performing these tests shall meet the requirements of ASTM D 3666. All equipment in Contractor-furnished laboratories shall be calibrated by the testing organization prior to the start of operations.

Aggregate samples shall be furnished by the Contractor in accordance with ASTM D 75 for laboratory testing prior to the start of production. Additionally, the Contractor shall furnish aggregate samples at specified intervals during production. Sampling for gradation shall be in accordance with ASTM D 75 and testing shall be in accordance with ASTM C 136 and C 117.

Completed CTPB layers shall be determined as "unacceptable" on the basis of visual inspection. The Engineer shall immediately notify the Contractor of visual defects, such as non-uniform

texture, evidence of material segregation, cracking and shoving of the mixture, surface irregularities, and evidence of aggregate crushing during the roller operations.

"Unacceptable" CTPB shall be removed down to the surface of the separation layer, leaving a vertical face at the adjacent CTPB. The separation layer shall be re-worked or cleaned, as necessary, prior to replacing the removed CTPB material. All work shall be at the Contractor's expense. Unacceptable CTPB shall not be measured for payment.

The CTPB layer shall be tested for thickness, grade, and surface tolerance on a lot basis, with a lot consisting of one of the following:

- One day's production not to exceed 2,000 yd^2 (1,675 m^2).
- A half day's production, where a day's production is expected to consist of between 2,000 and 4,000 yd^2 (1,675 and 3,350 m^2).

Each lot will be divided into four equal sublots. However, in the event that three (3) sublots are produced due to circumstances significantly affecting the paving operation, the three sublots shall constitute a complete lot. If one (1) or two (2) sublots are produced for the same reason, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation.

End-of-production sublots (i.e., sublots associated with the final placement of CTPB for the project) shall be structured as follows:

- Three (3) sublots shall constitute a lot.
- One (1) or (2) sublots shall be incorporated into the previous lot, and the total number of sublots for that lot shall be used in the acceptance plan calculation.

Within each sublot, one (1) thickness measurement and continuous surface straightedge test (for surface tolerance testing) shall be performed, as described below.

CTPB-6.1.1 Thickness Testing. Thickness testing shall commence no earlier than 3 days after placement. CTPB thickness shall be determined by measuring the depth of core holes obtained by taking one (1) 4-in (102-mm) diameter core per sublot. The core holes shall be obtained from a random location, as identified using the procedures contained in ASTM D 3665. The core holes shall be filled by the Contractor with CTPB material or Portland cement concrete (PCC), as approved by the Engineer. Acceptance criteria for CTPB thickness is provided in paragraph CTPB-6.2.1.

CTPB-6.1.2 Grade Testing. The elevations of the finished CTPB shall be surveyed on both sides of the CTPB lane, every 25 ft (7.6 m). Acceptance criteria for CTPB grade are provided in paragraph CTPB-6.2.2.

CTPB-6.1.3 Surface Tolerance Testing. As soon as the CTPB has hardened sufficiently, it shall be tested for surface tolerance with a 16-ft (4.9-m) straightedge or other specified device provided by the Contractor. The straightedge shall be applied parallel with and at right angles to

the centerline of the CTPB area, and shall be advanced approximately one-half its length in the line of measurement. Acceptance criteria for CTPB surface tolerance are provided in paragraph CTPB-6.2.3.

CTPB-6.2 ACCEPTANCE CRITERIA. Acceptance of CTPB will be based on thickness, grade, and surface tolerance, as described in the paragraphs below.

CTPB-6.2.1 Thickness Requirements. When the average measured thickness from a lot is not deficient by more than 1 in (25 mm) from the plan thickness, full payment will be made. When such measurement is deficient by more than 1 in (25 mm) from the plan thickness, the entire lot shall be removed by excavating to the required depth and replaced with new material to obtain a compacted lift thickness, at the Contractor's expense. When the measured thickness is more than indicated, it will be considered as conforming to the requirements provided the surface of the CTPB drainage layer is within the established grade and surface tolerance requirements.

CTPB-6.2.2 Grade Requirements. Areas in the CTPB more than ⅝ in (16 mm) below the grade shown on the plans shall be corrected at the Contractor's expense by removing the defective work and replacing it with new material. Areas more than ⅝ in (16 mm) above the grade shown on the plans shall be removed and replaced at the Contractor's expense.

CTPB-6.2.3 Surface Tolerance Requirements. The finished CTPB surface shall not vary more than ½ in (12.5 mm) when tested with a 16-ft (4.9-m) straightedge applied parallel with, or at right angles to, the centerline of the CTPB area. Areas of the CTPB exceeding the specified tolerance shall be corrected at the Contractor's expense by removing the defective work and replacing it with new material.

METHOD OF MEASUREMENT

CTPB-7.1 CEMENT-TREATED PERMEABLE BASE COURSE. Payment for CTPB course will be based on the number of [yd^2 (m^2)] of CTPB actually constructed and accepted by the Engineer as complying with the plans and specifications.

BASIS OF PAYMENT

CTPB-8.1 CEMENT-TREATED PERMEABLE BASE COURSE. Payment shall be made at the contract unit price per [yd^2 (m^2)] for CTPB at the specified thickness. This price shall be full compensation for furnishing all materials; for all preparation and storage of materials; for mixing, hauling, placing, compacting, and curing the mixture (including the test section); and for all labor, equipment, tools, and incidentals necessary to complete the item.

Each lot of CTPB material will be accepted for thickness at the full contract unit price when the results of core hole depth measurements indicate that the average thickness for the lot is no more than 1 in (25.4 mm) more or less than the plan layer thickness.

Payment will be made for cement-treated permeable base course—per [yd^2 (m^2)].

TESTING REQUIREMENTS

ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Sieve or Screen Analysis of Fine and Course Aggregates
ASTM D 75	Sampling Aggregates
ASTM D 693	Crushed Stone, Crushed Slag, and Crushed Gravel for Dry or Water-Bound Macadam Base Courses and Bituminous Macadam Base and Surface Courses of Pavements
ASTM D 2434/ AASHTO T 215	Constant Head Permeability
ASTM D 3665	Random Sampling of Paving Materials
ASTM D 3666	Minimum Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
AASHTO T 26	Quality of Water to be used in Concrete

MATERIAL REQUIREMENTS

ASTM C 33	Specification for Concrete Aggregates
ASTM C 94	Specification for Ready-Mixed Concrete
ASTM C 150	Specification for Portland Cement
ASTM C 595	Blended Hydraulic Cements
AASHTO M 288	Geotextile Specification for Highway Applications

APPENDIX E
DRAFT OF ITEM P-CS
CHOKE STONE INTERLAYER

DESCRIPTION

CS-1.1 This item shall consist of a choke stone interlayer comprised of crushed mineral aggregate applied to the surface of a stabilized and/or permeable base layer placed beneath Portland cement concrete (PCC) pavement. The material shall be applied to the surface of the subject layer in accordance with these specifications and in conformity to the lines, grades, dimensions, and typical cross sections shown on the plans.

* *

A choke stone is a small-size stone layer (generally ½ to 1 in [12.5 to 25 mm] thick) used to stabilize the surface of a permeable base layer placed directly beneath PCC pavement and to guard against yield loss of the overlying PCC. Additionally, the choke stone prevents bonding of the PCC layer to the underlying stabilized and/or permeable base layer.

* *

MATERIALS

CS-2.1 AGGREGATE. The method used in producing the aggregate shall be such that the finished product is as consistent as practicable. The aggregate shall consist of clean, sound, hard, durable, angular particles of crushed stone that meets the specification requirements. The aggregate shall be free from clay balls, organic matter, and other deleterious substances in accordance with ASTM C 33.

Choke stone shall be made of hard, durable, crushed aggregate having at least 90 percent fractured faces. The aggregate shall contain not more than 15 percent, by weight, of flat or elongated pieces, as defined in ASTM D 693. The percentage of wear of the crushed aggregate retained on the No. 4 (2.36-mm) sieve shall not be greater than 50 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 10 percent, or the magnesium sulfate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

The aggregate shall conform to the gradation shown in Table 1 or the gradation requirements for ASTM No. 89 stone, when tested in accordance with ASTM C 136. The aggregate shall be continuously well graded from coarse to fine and the gradation shall not vary from the low limit on one sieve to the high limit on an adjacent sieve or vice versa.

Table 1. Aggregate gradation for CHOKE STONE material.

Sieve Size	Percentage by Weight Passing Sieves Choke Stone
½ in (13 mm)	100
⅜ in (9.5 mm)	80 - 100
No. 4 (4.75 mm)	10 - 100
No. 8 (2.36 mm)	5 - 50
No. 16 (1.18 mm)	0 - 10

When used on permeable base layers, the ratio of the D_{15} of the permeable base layer to the D_{15} of the choke stone shall be less than 5. Also, the ratio of the D_{50} of the permeable base layer to the D_{50} of the choke stone shall be greater than 2.

CS-2.2 SUBMITTALS. At least [ ] days prior to the placement of the choke stone, the Contractor shall submit certified test reports to the Engineer for the material proposed for use during construction. The certification shall show the appropriate ASTM 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.

* *
Insert the appropriate number of days for contractor submittal of the certified test reports, 15 to 30 days is typical.
* *

Tests older than 6 months shall not be used. Submittals shall comply with procedures set forth in the "Shop Drawing and Sample Submittals" section of the General Conditions. No choke stone shall be placed until the submittal is approved by the Engineer.

CONSTRUCTION METHODS

CS-3.1 WEATHER LIMITATIONS. The choke stone may not be placed when rainfall is occurring or where rain is imminent.

CS-3.2 PLACEMENT. The choke stone aggregate shall be spread into a single uniform layer of such width and thickness that, following compaction, it conforms to the required grade and cross-section. The choke stone shall be placed immediately after final compaction of the underlying stabilized and/or permeable base layer. The choke stone shall be spread in a thin layer no thicker than ½ in (13 mm) using spreading equipment approved by the Engineer.

CS-3.3 COMPACTION. Immediately upon completion of the spreading operations, the choke stone material shall be compacted using two passes of a steel-wheel roller. If the rolling pattern/sequence results in undue displacement of the surface, or causes crushing of the aggregate, work shall be stopped until the cause(s) can be determined and corrections are made. Sieve testing is not required after the compaction of the choke stone.

MATERIAL ACCEPTANCE

CS-3.4 ACCEPTANCE SAMPLING AND TESTING. Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be performed by the Engineer at no cost to the Contractor. Testing organizations performing these tests shall meet the requirements of ASTM D 3666. All equipment in Contractor-furnished laboratories shall be calibrated by the testing organization prior to the start of operations.

Aggregate samples shall be furnished by the Contractor in accordance with ASTM D 75 for laboratory testing prior to the start of production. Additionally, the Contractor shall furnish aggregate samples at specified intervals during production. Sampling for gradation shall be in accordance with ASTM D 75, and testing shall be in accordance with ASTM C 136 and C 117.

CS-3.5 ACCEPTANCE CRITERIA. Completed choke stone layers shall be determined as "acceptable" or "unacceptable" on the basis of visual inspection. The Engineer shall immediately notify the Contractor of visual defects, such as improper thickness, non-uniform texture, evidence of material segregation, surface irregularities, and evidence of aggregate crushing during the roller operations.

METHOD OF MEASUREMENT

CS-4.1 Payment for choke stone course will be based on the number of [yd^2 (m^2)] of choke stone actually constructed and accepted by the Engineer as complying with the plans and specifications.

BASIS OF PAYMENT

CS-5.1 Payment shall be made at the contract unit price per [yd^2 (m^2)] for choke stone at the specified thickness. This price shall be full compensation for furnishing all materials for all preparation and storage of materials; for blending, hauling, placing, and compacting the mixture; and for all labor, equipment, tools, and incidentals necessary to complete the item.

TESTING REQUIREMENTS

ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Sieve or Screen Analysis of Fine and Course Aggregates
ASTM D 75	Sampling Aggregates
ASTM D 693	Crushed Stone, Crushed Slag, and Crushed Gravel for Dry or Water-Bound Macadam Base Courses and Bituminous Macadam Base and Surface Courses of Pavements
ASTM D 3665	Random Sampling of Paving Materials

ASTM D 3666	Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D 5821	Determining the Percentage of Fractured Particles in Coarse Aggregate