PART IV – RIGID BASE COURSES
ITEM P-301 SOIL-CEMENT BASE COURSE

DESCRIPTION

301-1.1 This item shall consist of constructing a base course by uniformly mixing together soil, portland cement, and water. The mixed material shall be spread, shaped, and compacted in accordance with these specifications and in conformity to the dimensions and typical cross section shown on the plans. Tests shall be required for each approved soil that will be included in the treated layer.

Runway, taxiway, or apron pavements shall be built in a series of parallel lanes using a plan of processing that reduces longitudinal and transverse joints to a minimum.

MATERIALS

301-2.1 PORTLAND CEMENT. Portland 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 IV.

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301-2.2 WATER. Water shall be clean and free from sewage, oil, acid, strong alkalies, or vegetable matter. Water of questionable quality shall be tested in accordance with the requirements of AASHTO T 26.

301-2.3 SOIL. The soil shall consist of an approved select soil. The soil shall be free of roots, sod, weeds, and shall not contain gravel or stone retained on a 1-inch (25 mm) sieve or more than 45% retained on a No. 4 sieve, as determined by ASTM C 136.

301-2.4 BITUMINOUS MATERIAL. The types, grades, controlling specifications, and application temperatures for the bituminous materials used for curing the soil-cement are listed in Table 1. The Engineer shall designate the specific material used.

TABLE 1. BITUMINOUS MATERIALS

Type and Grade	Specification	Application Temperature	
		Deg. F	Deg. C
Cutback Asphalt			
RC-70	ASTM D 2028	120-160	50-70
RC-250	ASTM D 2028	160-200	70-95
Emulsified Asphalt			
RS-1, SS-1	ASTM D 977	75-130	25-55
CRS-1	ASTM D 2397	75-130	25-55

CEMENT QUANTITY

301-3.1 LABORATORY SOIL TESTS. Prior to base course construction, laboratory tests of soils shall be made to determine the quantity of cement required in the mix.

Test specimens containing various amounts of cement are to be compacted in accordance with ASTM D 558, and the optimum moisture for each amount of cement is to be determined. Samples at the optimum moisture shall be subjected to the wet-dry and the freeze-thaw test in accordance with ASTM D 559 and D 560, respectively.

The specified cement content for construction shall be that at which the weight loss of the specimens subjected to 12 cycles of either the wet-dry or the freeze-thaw is not more than 14% for granular soils, 10% for the more plastic granular and silty soils, and 7% for clay soils.

The compressive strength of soaked specimens should increase both with age and with increase in cement content.

CONSTRUCTION METHODS

301-4.1 WEATHER LIMITATIONS. The soil-cement base shall not be mixed or placed while the atmospheric temperature is below 35° F (2° C) or when conditions indicate that the temperature may fall below 35° F (2° C) within 24 hours, or when the weather is foggy or rainy, or when the soil or subgrade is frozen.

301-4.2 EQUIPMENT. The soil-cement may be constructed with any equipment that will meet the requirements for soil pulverization, cement application, mixing, water application, incorporation of materials, compaction, finishing, and curing specified herein.

301-4.3 PREPARATION. The area to be paved shall be graded and shaped to conform to the grades and typical cross section shown on the plans. Any soft or yielding areas in the subgrade shall be removed and replaced with acceptable soil and compacted as specified.

301-4.4 PULVERIZATION. The soil for the base course shall be so pulverized that at the completion of moist-mixing, 100% by dry weight passes a 1-inch (25 mm) sieve and a minimum of 80% passes a No. 4 sieve, exclusive of gravel or stone retained on the No. 4 sieve.

301-4.5 CEMENT APPLICATION, MIXING, AND SPREADING. Mixing of the soil, cement, and water shall be accomplished either by the mixed-in-place or the central-plant-mixed method.

The percentage of moisture in the soil, at the time of cement application, shall not exceed the quantity that will permit a uniform and intimate mixture of soil and cement during mixing operations, and it shall not exceed the specified optimum moisture content for the soil-cement mixture.

Method A – Mixed-in-place. The specified quantity of cement shall be spread uniformly on the soil.

Cement that has been displaced shall be replaced before mixing is started. After the cement has been applied, it shall be mixed with the soil. Mixing shall continue until the cement has been sufficiently blended with the soil to prevent the formation of cement balls when water is applied.

Immediately after the soil and cement have been mixed, water shall be incorporated into the mixture. Excessive concentrations of water on or near the surface shall be avoided. A water supply and pressure distributing equipment shall be provided that will assure the application within 3 hours of all mixing water on the section being processed. After all mixing water has been applied, mixing shall continue until a uniform and intimate mixture of soil, cement, and water has been obtained.

Method B – Central plant mixed. The soil, cement, and water shall be mixed in a pugmill, either of the batch or continuous-flow type. The plant shall be equipped with feeding and metering devices that will add the soil, cement, and water into the mixer in the specified quantities. Soil and cement shall be mixed sufficiently to prevent cement balls from forming when water is added. Mixing shall continue until a uniform and intimate mixture of soil, cement, and water is obtained.

The mixture shall be hauled to the project in trucks equipped with protective covers. The mixture shall be placed on the moistened subgrade in a uniform layer by an approved spreader(s). Not more than 30 minutes shall elapse between the placement of soil-cement in adjacent lanes.

The layer of soil-cement shall be uniform in thickness and surface contour and of such quantity that the completed base will conform to the required grade and cross section. Dumping of the mixture in piles or windrows upon the subgrade will not be permitted.

Not more than 60 minutes shall elapse between the start of moist mixing and the start of compaction of soil-cement.

301-4.6 COMPACTION. Immediately upon completion of the spreading operations, the mixture shall be thoroughly compacted. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density.

The field density of the compacted mixture shall be at least 98 percent of the maximum density of laboratory specimens prepared from samples of the cement-treated base material taken from the material in place. The specimens shall be compacted and tested in accordance with ASTM D 558. The in-place field density shall be determined in accordance with ASTM D 1556. Any mixture that has not been compacted shall not be left undisturbed for more than 30 minutes. The moisture content of the mixture at the start of compaction shall not be below nor more than 2 percentage points above the optimum moisture content. The optimum moisture content shall be determined in accordance with ASTM D 558 and shall be less than that amount which will cause the mixture to become unstable during compaction and finishing.

301-4.7 FINISHING. Finishing operations shall be completed during daylight hours, and the completed base course shall conform to the required lines, grades, and cross section. If necessary, the surface shall be lightly scarified to eliminate any imprints made by the compacting or shaping equipment. The surface shall then be recompacted to the required density.

301-4.8 CONSTRUCTION JOINTS. At the end of each day's run, a transverse construction joint shall be formed by a header or by cutting back into the compacted material to form a true vertical face free of loose material.

The protection provided for construction joints shall permit the placing, spreading, and compacting of base material without injury to the work previously laid. Where it is necessary to operate or turn any equipment on the completed base course, sufficient protection and cover shall be provided to prevent damage to the finished surface. A supply of mats or wooden planks shall be maintained and used as approved and directed by the Engineer.

Care shall be exercised to ensure thorough compaction of the base material immediately adjacent to all construction joints. When spreading or compacting base material adjacent to a previously constructed lane, care shall be taken to prevent injury to the work already constructed.

301-4.10 PROTECTION AND CURING. After the base course has been finished to grade and compacted as specified herein, it shall be protected against drying for a period of 7 days by the application of bituminous material or other acceptable methods. The curing method shall begin as soon as possible, but no later than 24 hours after the completion of finishing operations. The finished base course shall be kept moist continuously until the curing material is placed.

The bituminous material specified shall be uniformly applied to the surface of the completed base course at the rate of approximately 0.2 gallon per square yard (0.92 liter/square meter) with approved heating and distributing equipment. The exact rate and temperature of application to give complete coverage without excessive runoff shall be as specified.

At the time the bituminous material is applied, the surface shall be dense, free of all loose and extraneous material, and shall contain sufficient moisture to prevent penetration of the bituminous material. Water shall be applied in sufficient quantity to fill the surface voids immediately before the bituminous curing material is applied.

The curing material shall be maintained and applied as needed by the Contractor during the 7-day protection period so that all of the soil-cement will be covered effectively during this period.

Finished portions of soil-cement that are used by equipment in constructing an adjoining section shall be protected to prevent equipment from marring or damaging the completed work.

When the air temperature may be expected to reach the freezing point, sufficient protection from freezing shall be given the soil-cement for 7 days after its construction and until it has hardened.

Other curing materials such as moist straw or hay may be used if approved.

301-4.11 CONSTRUCTION LIMITATIONS. When any of the operations after the application of cement are interrupted for more than 30 minutes or when the uncompacted soil-cement mixture is wetted by rain so that the moisture content is exceeded by a small amount, the decision to reconstruct the portion affected shall rest with the Engineer. In the event the uncompacted, rain-wetted mixture exceeds the specified moisture content tolerance, the Contractor shall reconstruct at his/her expense the portion affected. All material along the longitudinal or transverse construction joints not properly compacted shall be removed and replaced, at the Contractor's expense, with properly moistened and mixed soil-cement compacted to specified density.

301-4.12 SURFACE TESTS. The finished surface shall not vary more than 3/8 inch (9 mm) when tested with a 16-foot (4.8 m) straightedge applied parallel with, or at right angles to, the longitudinal axis of the pavement. Any variations in excess of this tolerance shall be corrected by the Contractor, at his/her own expense, and in a manner satisfactory to the Engineer.

301-4.13 THICKNESS. The thickness of the soil-cement base course shall be determined from measurements of cores drilled from the finished base or from thickness measurements at holes drilled in the base at intervals so that each test shall represent no more than 300 square yards (250 square meters). The average thickness of the base constructed during one day shall be within 1/2 inch (12 mm) of the thickness shown on the plans, except that the thickness of any one point may be within 3/4 inch (13 mm) of that shown on the plans. Where the average thickness shown by the measurements made in one day's construction is not within the tolerance given, the Engineer shall evaluate the area and determine if, in his/her opinion, it shall be reconstructed at the Contractor's expense or the deficiency deducted from the total material in place.

301-4.14 MAINTENANCE. The Contractor shall be required to maintain, at his/her own expense, the entire base course within the limits of his/her contract in a condition satisfactory to the Engineer from the time he starts work until all the work has been completed. Maintenance shall include immediate repairs of any defects that may occur either before or after the cement is applied. The work shall be done by the Contractor at his/her own expense and repeated as often as necessary to keep the area intact at all times. Repairs shall be made in a manner that will insure restoration of a uniform surface and the durability of the part repaired. Faulty work must be replaced for the full depth of treatment. Any low areas shall be remedied by replacing the material for the full depth of treatment rather than by adding a thin layer of soil-cement to the completed work.

METHOD OF MEASUREMENT

301-5.1 The quantity of soil-cement base course to be paid for shall be the number of square yards (square meters) of completed and accepted base course.

301-5.2 Portland cement shall be measured by the hundredweight.

BASIS OF PAYMENT

301-6.1 Payment shall be made at the contract unit price per square yard (square meter) for soil-cement base course. This price shall be full compensation for furnishing all materials, except portland cement, and for all preparation, delivering, placing, and mixing of these materials; and for all labor, equipment, tools and incidentals necessary to complete the item.

301-6.2 Payment shall be made at the contract unit price per hundredweight for cement. This price shall be full compensation for furnishing this material and for all delivery, placing, and incorporation of this material, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-301-6.1 Soil-Cement Base Course—per square yard (square meter)

Item P-301-6.2 Portland Cement—per hundredweight

TEST REQUIREMENTS

ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM D 558	Moisture-Density Relations of Soil-Cement Mixtures
ASTM D 559	Wetting-and-Drying Tests of Compacted Soil-Cement Mixtures
ASTM D 560	Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures
ASTM D 1556	Test for Density of Soil In-Place by the Sand Cone Method
AASHTO T 26	Quality of Water to be Used in Concrete

MATERIAL REQUIREMENTS

ASTM C 150	Portland Cement
ASTM D 977	Emulsified Asphalt
ASTM D 202	Cutback Asphalt
ASTM D 239	Cationic Emulsified Asphalt

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ITEM P-304 CEMENT-TREATED BASE COUSE

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.

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.

304-2.2 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.

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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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.

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

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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 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 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 selected by the Contractor shall be used. The entire surface of the CTB shall be coated with a de-bonding compound applied in a quality sufficient to prevent bonding of the PCC pavement to the base course. If an impervious membrane or asphalt emulsion is used as a curing material, additional applications of curing materials may be required. The Contractor shall be responsible for selecting the de-bonding compound and determining the necessary application rate. The de-bonding compound shall be approved by the Engineer prior to being incorporated into the work.

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) density test, 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 compacted and tested for density and moisture content in accordance with ASTM D 558. Using the density results for each sublot comprising a lot, an average 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 lot density. 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. 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, 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 density determined for the lot. 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 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, including 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 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

End P-304

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, 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.

* *

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

* *

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

306-2.2 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. Ground Granulated Blast Furnace Slag (Slag Cement). 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) or Asphalt emulsion conforming to the requirements of ASTM D 977, Type SS-1h..

*** ***

The Engineer may add additional curing materials Modify the Bond Breaker paragraph accordingly.

*** ***

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. 3-day and 7-day strengths 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 3-day strength is greater than 500 psi (3,447 kPa), the Contractor shall construct 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, plus or minus 1/2 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.

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

* *

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.

* *

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 acceptable consolidation without segregation 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 segregation. 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 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.

306-5.9 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.

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 required by paragraph306-3.1.1or if shown on the plans, transverse contraction joints shall 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.

* *

The Engineer should include a note or detail on the plans when joints are required due to excessive strength or otherwise.

* *

306-5.10.3 Concrete Saws. When sawing of joints are specified, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at the required rate. The Contractor shall provide at least one standby saw in good working order. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job both before and at all times during econocrete placement.

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.

* *

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

* *

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 side-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. The entire surface of the econoncrete shall be coated with a de-bonding compound applied in a quality sufficient to prevent bonding of the PCC pavement to the econocrete. If an impervious membrane or asphalt emulsion is used as a curing material, additional applications of curing materials may be required. The Contractor shall be responsible for selecting the de-bonding compound and determining the necessary application rate. The de-bonding compound shall be approved by the Engineer prior to being incorporated into the work. 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.

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.

* *

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

* *

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.

If the maximum 7-day compressive strength values exceed the maximum strength requirements when evaluated in accordance with paragraph 306-6-2.1, the Contractor shall propose a jointing plan for approval by the Engineer.

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 constructed, a bond-breaker shall be used.

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 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

END P-306

PART V – FLEXIBLE SURFACE COURSES
ITEM P-401 PLANT MIX BITUMINOUS PAVEMENTS

DESCRIPTION

401-1.1 This item shall consist of pavement courses composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

* *

This specification is intended to be used for the surface course for airfield flexible pavements subject to aircraft loadings of gross weights greater than 12,500 pounds (5670 kg) and is to apply within the limits of the pavement designed for full load bearing capacity.

The dimensions and depth of the "surface course" for which this specification applies shall be that as is defined by the Engineer's pavement design as performed in accordance with FAA Advisory Circular 150/5320-6, current edition.

For courses other than the surface course, such as stabilized base courses, binder courses and/or truing and leveling courses; for pavements designed to accommodate aircraft gross weights of 12,500 pounds (5670 kg) or less; and for pavements intended to be used for roads, shoulder pavements, blast pads, and other pavements not subject to full aircraft loading, specification Item P-403 may be used.

State highway department specifications may be used for shoulders, access roads, perimeter roads, stabilized base courses under Item P-501, and other pavements not subject to aircraft loading. When state highway specification are approved, include all applicable/approved state specifications in the contract documents.

* *

MATERIALS

401-2.1 AGGREGATE. Aggregates shall consist of crushed stone, crushed gravel, or crushed slag with or without natural sand or other inert finely divided mineral aggregate. The portion of combined materials retained on the No. 4 (4.75 mm) sieve is coarse aggregate. The portion of combined materials passing the No. 4 (4.75 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No. 200 (0.075 mm) sieve is mineral filler.

a. Coarse Aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of matter that would prevent thorough coating and bonding with the bituminous material and be free from organic matter and other deleterious substances. The percentage of wear 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.

* *

Aggregates with a higher percentage loss of wear or soundness may be specified in lieu of those above, provided a satisfactory service record under similar conditions of service and exposure has been demonstrated.

* *

Aggregate shall contain at least **[ ]** percent by weight of individual pieces having two or more fractured faces and **[ ]** percent by weight having at least one fractured face. The area of each face shall be equal to at least 75 percent of the smallest midsectional 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. Fractured faces shall be obtained by crushing.

* *

For pavements designed for aircraft gross weights of 60,000 pounds (27 200 kg) or more, the Engineer shall specify 70 percent for two fractured faces and 85 percent for one fractured face. For pavements designed for aircraft gross weights less than 60,000 pounds (27 200 kg), the Engineer shall specify 50 percent for two fractured faces and 65 percent for one fractured face.

In areas where slag is not available or desired, the references to it should be deleted from all aggregate paragraphs.

* *

The aggregate shall not contain more than a total of 8 percent, by weight, of flat particles, elongated particles, and flat and elongated particles, when tested in accordance with ASTM D 4791 with a value of 5:1.

* *

The Engineer may specify ASTM D 4791 with a ratio of 3:1. If so, replace the above paragraph as follows: "The aggregate shall not contain more than a total of 20 percent by weight of flat particles, elongated particles, and flat and elongated particles when tested in accordance with ASTM D4791 with a value of 3:1."

* *

Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 mg/cubic meter) when tested in accordance with ASTM C 29.

b. Fine Aggregate. Fine aggregate shall consist of clean, sound, durable, angular shaped particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter and shall contain no clay balls. The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318.

Natural (nonmanufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. **[The fine aggregate shall not contain more than 15 percent natural sand by weight of total aggregates.]** If used, the natural sand shall meet the requirements of ASTM D 1073 and shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318.

The aggregate shall have sand equivalent values of **[ ]** or greater when tested in accordance with ASTM D 2419.

* *

Typically the sand equivalent value should be 45, unless local conditions require lower value.

The addition of natural sand to a mix containing all crushed coarse and fine aggregates will normally increase its workability and compactability. However, the addition of excessive amounts of natural sand tends to decrease the stability of the mixture. The requirement for a sand equivalent value of 45 usually limits the use of natural sand; however, the maximum of 15 percent natural sand may be included for locations where low stabilities are a chronic problem.

* *

c. Sampling. ASTM D 75 shall be used in sampling coarse and fine aggregate, and ASTM C 183 shall be used in sampling mineral filler.

401-2.2 MINERAL FILLER. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242.

401-2.3 BITUMINOUS MATERIAL. Bituminous material shall conform to the following requirements: **[ ]**.

* *

Asphalt cement binder shall conform to [AASHTO M320 Performance Grade (PG) [_____]] [ASTM D 3381 Table 1, 2, or 3 Viscosity Grade][ASTM D 946 Penetration Grade [_____]]. Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Copies of these certifications shall be submitted to the Engineer. The Engineer shall specify the grade of bituminous material, based on geographical location and climatic conditions. Asphalt Institute Superpave Series No. 1 (SP-1) provides guidance on the selection of performance graded binders. Table VI-1, Selecting Asphalt Grade, contained in the Asphalt Institute's Manual Series-1 (MS-1) provides guidance on the selection of asphalt type. For cold climates, Table 2 of ASTM D 3381 may be specified to minimize the susceptibility for thermal cracking. The Engineer should be aware that PG asphalt binders may contain modifiers that require elevated mixing and compaction temperatures that exceed the temperatures specified in Item P-401.

Grades of some materials are listed below:

NOTE: Performance Graded (PG) asphalt binders should be specified wherever available. The same grade PG binder used by the state highway department in the area should be considered as the base grade for the project (e.g. the grade typically specified in that specific location for dense graded mixes on highways with design Equivalent Standard Axle Loads (ESALS) less than 10 million). The exception would be that grades with a low temperature higher than PG XX-22 should not be used (e.g. PG XX-16 or PG XX-10), unless the Engineer has had successful experience with them. Typically, rutting is not a problem on airport runways. However, at airports with a history of stacking on end of runways and taxiway areas, rutting has accrued due to the slow speed of loading on the pavement. If there has been rutting on the project or it is anticipated that stacking may accrue during the design life of the project, then the following grade "bumping" should be applied for the top 125 mm (5 inches) of paving in the end of runway and taxiway areas: for aircraft tire pressure between 100 and 200 psi, increase the high temperature one grade; for aircraft tire pressure greater than 200 psi, increase the high temperature two grades. Each grade adjustment is 6 degrees C. Polymer Modified Asphalt, PMA, has shown to perform very well in these areas. The low temperature grade should remain the same.

Additional grade bumping and grade selection information is given in Table A.

Table A. Binder Grade Selection and Grade Bumping Based on Gross Aircraft Weight.

Aircraft Gross Weight (pounds)	High Temperature Adjustment to Base Binder Grade	
	Pavement Type	
	Runway	Taxiway/Apron
Less than 12,500	--	--
Less than 60,000	--	1
Less than 100,000	--	1
Greater than 100,000	1	2

NOTES:
1. PG grades above a –22 on the low end (e.g. 64–16) are not recommended. Limited experience has shown this to be a poor performer.
2. PG grades below a 64 on the high end (e.g. 58-22) are not recommended. These binders often provide tender tendencies.
3. PG grades above a 76 on the high end (e.g. 82-22) are very stiff and may be difficult to work and compact.

Grade Specification			
Penetration Grade ASTM D 946	Viscosity Grade ASTM D 3381		Performance Graded Asphalt Institute Superpave Series No. 1(SP-1)
40-50 60-70 85-100 100-120 120-150	AC-5 AC-10 AC-15 AC-20 AC-30 AC-40	AR-1000 AR-2000 AR-4000 AR-8000	In general, the Engineer should choose a PG-asphalt binder that has been approved for use in the vicinity by the State DOT, and is locally available. In general, a high reliability (98 percent) on both the high and low temperature categories is sufficiently conservative.

*** ***

The Contractor shall furnish vendor's certified test reports for each lot of bituminous material shipped to the project. The vendor's certified test report for the bituminous material can be used for acceptance or tested independently by the Engineer.

401-2.4 PRELIMINARY MATERIAL ACCEPTANCE. Prior to delivery of materials to the job site, the Contractor shall submit certified test reports to the Engineer for the following materials:

a. Coarse Aggregate.

(1) Percent of wear.
(2) Soundness.
(3) Unit weight of slag.
(4) Percent fractured faces.

b. Fine Aggregate.

(1) Liquid limit.
(2) Plasticity index.
(3) Sand equivalent.

c. Mineral Filler.

d. Bituminous Material. Test results for bituminous material shall include temperature/viscosity charts for mixing and compaction temperatures.

The certification(s) shall show the appropriate ASTM test(s) for each material, the test results, and a statement that the material meets the specification requirement.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

401-2.5 ANTI-STRIPPING AGENT. Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the Department of Transportation of the State in which the project is located.

COMPOSITION

401-3.1 COMPOSITION OF MIXTURE. The bituminous plant mix shall be composed of a mixture of well-graded aggregate, filler and anti-strip agent if required, and bituminous material. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF).

401-3.2 JOB MIX FORMULA. No bituminous mixture for payment shall be produced until a job mix formula has been approved in writing by the Engineer. The bituminous mixture shall be designed using procedures contained in Chapter 5, MARSHALL METHOD OF MIX DESIGN, of the Asphalt Institute's Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete, sixth edition.

The design criteria in Table 1 are target values necessary to meet the acceptance requirements contained in paragraph 401-5.2b. The criteria is based on a production process which has a material variability with the following standard deviations:

Stability (lbs.) = 270
Flow (0.01 inch) = 1.5
Air Voids (%) = 0.65

If material variability exceeds the standard deviations indicated, the job mix formula and subsequent production targets shall be based on a stability greater than shown in Table 1, and the flow and air voids shall be targeted close to the mid-range of the criteria in order to meet the acceptance requirements.

Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D 4867, shall not be less than 75. Anti-stripping agent shall be added to the asphalt, as necessary**,** to produce a TSR of not less than 75. If an antistrip agent is required, it will be provided by the Contractor at no additional cost to the Owner.

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Engineer may specify a TSR of not less than 80 in areas that are prone to stripping at a TSR of 75. Engineer may specify one or more freeze-thaw conditioning cycles in areas that are prone to stripping at a TSR of 75.

*** ***

The job mix formula shall be submitted in writing by the Contractor to the Engineer at least **[ ]** days prior to the start of paving operations and shall include as a minimum:

a. 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 job mix formula.

b. Percent of asphalt cement.

c. Asphalt performance, viscosity or penetration grade, and type of modifier if used.

d. Number of blows of hammer compaction per side of molded specimen.

e. Mixing temperature.

f. Compaction temperature.

g. Temperature of mix when discharged from the mixer.

h. Temperature-viscosity relationship of the asphalt cement.

i. Plot of the combined gradation on the Federal Highway Administration (FHWA) 45 power gradation curve.

j. Graphical plots of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content.

k. Percent natural sand.

l. Percent fractured faces.

m. Percent by weight of flat particles**,** elongated particles, and flat and elongated particles (and criteria).

n. Tensile Strength Ratio (TSR).

p. Antistrip agent (if required).

q. Date the job mix formula was developed.

The Contractor shall submit to the Engineer the results of verification testing of three (3) asphalt samples prepared at the optimum asphalt content. The average of the results of this testing shall indicate conformance with the job mix formula requirements specified in Tables 1, 2 and 3.

When the project requires asphalt mixtures of differing aggregate gradations, a separate job mix formula and the results of job mix formula verification testing must be submitted for each mix.

The job mix formula for each mixture shall be in effect until a modification is approved in writing by the Engineer. Should a change in sources of materials be made, a new job mix formula must be submitted within [ ] days and approved by the Engineer in writing before the new material is used. After the initial production job mix formula(s) has/have been approved by the Engineer and a new or modified job mix formula is required for whatever reason, the subsequent cost of the Engineer's approval of the new or modified job mix formula will be borne by the Contractor. There will be no time extension given or considerations for extra costs associated with the stoppage of production paving or restart of production paving due to the time needed for the Engineer to approve the initial, new or modified job mix formula.

* *

The Engineer shall specify the number of days. A minimum of 10 days is recommended.

Job mix formula not developed within the previous 90 days are not recommended.

The Marshall Design Criteria applicable to the project shall be specified by the Engineer from the information shown below and inserted into Table 1. Asterisks denote insert points.

Test Property	Pavements Designed for Aircraft Gross Weights of 60,000 Lbs. or More or Tire Pressures of 100 Psi or More	Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lbs. or Tire Pressures Less Than 100 Psi
Number of Blows	**75**	**50**
Stability, pounds (newtons)	**2150 (9564)**	**1350 (6005)**
Flow, 0.01 in. (0.25 mm)	**10-14**	**10-18**
Air Voids (percent)	**2.8-4.2**	**2.8-4.2**
Percent Voids in Mineral Aggregate (minimum)	**See Table 2**	**See Table 2**

* *

TABLE 1. MARSHALL DESIGN CRITERIA

TEST PROPERTY	*
Number of blows	*
Stability, pounds (newtons) minimum	*
(newtons) minimum	
Flow, 0.01 in. (0.25 mm)	*
Air voids (percent)	*
Percent voids in mineral aggregate, minimum	See Table 2

TABLE 2. MINIMUM PERCENT VOIDS IN MINERAL AGGREGATE

Maximum Particle Size		Minimum Voids in Mineral Aggregate, percent
in.	**mm**	**Percent**
½	12.5	16
¾	19.0	15
1	25.0	14
1-½	37.5	13

* *

Modifications to the minimum Voids in Mineral Aggregate (VMA) as found in Table 2 may be made depending on the definition of maximum particle size and/or local conditions. Modifications to the flow criteria may be required for modified asphalt cement binders.

* *

The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation or gradations specified in Table 3 when tested in accordance with ASTM C 136 and C 117.

The gradations in Table 3 represent the limits that shall determine the suitability of aggregate for use from the sources of supply. The aggregate, as selected (and used in the JMF), shall have a gradation within the limits designated in Table 3 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be well graded from coarse to fine.

Deviations from the final approved mix design for bitumen content and gradation of aggregates shall be within the action limits for individual measurements as specified in paragraph 401-6.5a. The limits still will apply if they fall outside the master grading band in Table 3.

The maximum size aggregate used shall not be more than one-half of the thickness of the course being constructed except where otherwise shown on the plans or ordered by the Engineer.

TABLE 3. AGGREGATE - BITUMINOUS PAVEMENTS

Sieve Size	Percentage by Weight Passing Sieve
1-½ in. (37.50 mm)	*
1 in. (25.0 mm)	*
¾ in. (19.0 mm)	*
½ in. (12.5 mm)	*
⅜ in. (9.5 mm)	*
No. 4 (4.75 mm)	*
No. 8 (2.36 mm)	*
No. 16 (1.18 mm)	*
No. 30 (0.60 mm)	*
No. 50 (0.30 mm)	*
No. 100 (0.15 mm)	*
No. 200 (0.075 mm)	*
Asphalt percent	
Stone or gravel	*
Slag	*

The aggregate gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when aggregates of varying specific gravities are used, as indicated in the Asphalt Institute Manual Series No. 2 (MS-2), Chapter 3.

*** ***

The aggregate gradation shall be specified by the Engineer from the gradations shown in this note. The gradation shall be inserted into Table 3. Asterisks denote insert points.

Where locally-available aggregates cannot be economically blended to meet the grading requirements of the gradations shown, the gradations may be modified to fit the characteristics of such local aggregates with approval of the FAA. The modified gradation must produce a paving mixture that satisfies the mix design requirements.

AGGREGATE - BITUMINOUS PAVEMENTS				
Sieve Size	**Percentage by Weight Passing Sieves**			
	1-½" max	**1" max**	**¾ " max**	**½" max**
1-½ in. (37.5 mm)	100	--	--	--
1 in. (24.0 mm)	86-98	100	--	--
¾ in. (19.0 mm)	68-93	76-98	100	--

AGGREGATE - BITUMINOUS PAVEMENTS				
Sieve Size	**Percentage by Weight Passing Sieves**			
	1-½" max	**1" max**	**¾ " max**	**½" max**
½ in. (12.5 mm)	57-81	66-86	79-99	100
⅜ in. (9.5 mm)	49-69	57-77	68-88	79-99
No. 4 (4.75 mm)	34-54	40-60	48-68	58-78
No. 8 (2.36 mm)	22-42	26-46	33-53	39-59
No. 16 (1.18 mm)	13-33	17-37	20-40	26-46
No. 30 (0.600 mm)	8-24	11-27	14-30	19-35
No. 50 (0.300 mm)	6-18	7-19	9-21	12-24
No. 100 (0.150 mm)	4-12	6-16	6-16	7-17
No. 200 (0.075 mm)	3-6	3-6	3-6	3-6
Asphalt percent:				
Stone or gravel	4.5-7.0	4.5-7.0	5.0-7.5	5.5-8.0
Slag	5.0-7.5	5.0-7.5	6.5-9.5	7.0-10.5

* *

401-3.3 RECYCLED ASPHALT CONCRETE. Recycled HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement. The RAP shall be of a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed 2 inches. The recycled HMA mix shall be designed using procedures contained in AI MS-02. The recycled asphalt concrete mix shall be designed using procedures contained in the Asphalt Institute's Manual Series Number 2 (MS-2). The percentage of asphalt in the RAP shall be established for the mixture design according to ASTM D 2172 using the appropriate dust correction procedure. The job mix shall meet the requirements of paragraph 401-3.2 RAP should only be used for shoulder surface course mixes and for any intermediate courses. The amount of RAP shall be limited to **[ ]** percent.

* *

> **Reclaimed Asphalt Pavement (RAP) should not be used for surface mixes, except on shoulders. It can be used very effectively in lower layers or for shoulders. Engineer to specify the maximum percentage of reclaimed asphalt allowed in the mix. The amount of RAP shall be limited to 30 percent, as long as the resulting recycled mix meets all requirements that are specified for virgin mixtures. The Contractor may obtain the RAP from the job site or an existing source.**

* *

In addition to the requirements of paragraph 401-3.2, the job mix formula shall indicate the percent of reclaimed asphalt pavement and the percent and viscosity grade of new asphalt. The Contractor shall submit documentation to the Engineer, indicating that the mixing equipment proposed for use is adequate to mix the percent of RAP shown in the job mix formula and meet all local and national environmental regulations.

* *

> **The appropriate test should be selected to conform to the grade of new asphalt specified. If a penetration grade is specified, use penetration test. If a viscosity grade is specified, use a viscosity test. If a PG asphalt binder is specified, use the dynamic shear rheometer and bending beam tests.**

* *

The blend of new asphalt cement and the RAP asphalt binder shall meet the requirements in paragraph 401-2.3. The virgin asphalt cement shall not be more than two standard asphalt material grades different than that specified in paragraph 401-2.3

* *

Delete paragraph 401-3.3 in its entirety if recycled asphalt pavement is not to be allowed and include a sentence that RAP will not be permitted to be used. RAP containing coal tars may require additional precautions during production and may be excluded.

* *

401-3.4 TEST SECTION. Prior to full production, the Contractor shall prepare and place a quantity of bituminous mixture according to the job mix formula. The amount of mixture shall be sufficient to construct a test section **[ ]** long and **[ ]** wide**,** placed in two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the construction of the course which it represents. A cold joint is an exposed construction joint at least 4 hours old or whose mat has cooled to less than 160° F. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment 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.

THE TEST SECTION SHALL BE EVALUATED FOR ACCEPTANCE AS A SINGLE LOT IN ACCORDANCE WITH THE ACCEPTANCE CRITERIA IN PARAGRAPH 401-5.1 AND 401-6.3. THE TEST SECTION SHALL BE DIVIDED INTO EQUAL SUBLOTS. AS A MINIMUM THE TEST SECTION SHALL CONSIST OF 3 SUBLOTS.

The test section shall be considered acceptable if; 1) stability, flow, mat density, air voids, and joint density are 90 percent or more within limits, 2) gradation and asphalt content are within the action limits specified in paragraphs 401-6.5a and 5b, and 3) the voids in the mineral aggregate are within the limits of Table 2.

If the initial test section should prove to be unacceptable, the necessary adjustments to the job mix formula, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the Contractor's expense. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Any additional sections that are not acceptable shall be removed at the Contractor's expense. Full production shall not begin until an acceptable section has been constructed and accepted in writing by the Engineer. Once an acceptable test section has been placed, payment for the initial test section and the section that meets specification requirements shall be made in accordance with paragraph 401-8.1.

Job mix control testing shall be performed by the Contractor at the start of plant production and in conjunction with the calibration of the plant for the job mix formula. If aggregates produced by the plant do not satisfy the gradation requirements or produce a mix that meets the JMF. It will be necessary to reevaluate and redesign the mix using plant-produced aggregates. Specimens shall be prepared and the optimum bitumen content determined in the same manner as for the original design tests.

* *

The test section should be a minimum of 300 feet (90 m) long and 20 to 30 feet (6 to 9 m) wide. The test section affords the Contractor and the Engineer an opportunity to determine the quality of the mixture in place, as well as performance of the plant and laydown equipment.

* *

Contractor will not be allowed to place the test section until the Contractor Quality Control Program, showing conformance with the requirements of Paragraph 401-6.1, has been approved, in writing, by the Engineer.

401-3.5 TESTING LABORATORY. The Contractor's laboratory used to develop the job mix formula shall meet the requirements of ASTM D 3666 including the requirement to be accredited by a national authority such as the National Voluntary Laboratory Accreditation Program (NVLAP), the American Association for Laboratory Accreditation (AALA), or AASHTO Accreditation Program (AAP). Laboratory personnel shall meet the requirements of Section 100 of the General Provisions. A certification signed by the manager of the laboratory stating that it meets these requirements shall be submitted to the Engineer prior to the start of construction. The certification shall contain as a minimum:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

e. ASTM D 3666 certification of accreditation by a nationally recognized accreditation program.

CONSTRUCTION METHODS

401-4.1 WEATHER LIMITATIONS. The bituminous mixture shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 4. The temperature requirements may be waived by the Engineer, if requested; however, all other requirements including compaction shall be met.

TABLE 4. BASE TEMPERATURE LIMITATIONS

Mat Thickness	Base Temperature (Minimum)	
	Deg. F	Deg. C
3 in. (7.5 cm) or greater	40	4
Greater than 1 in. (2.5 cm) but less than 3 in. (7.5 cm)	45	7
1 in. (2.5 cm) or less	50	10

401-4.2 BITUMINOUS MIXING PLANT. Plants used for the preparation of bituminous mixtures shall conform to the requirements of ASTM D 995 with the following changes:

a. Requirements for All Plants.

(1) Truck Scales. The bituminous mixture shall be weighed on approved scales furnished by the Contractor, or on certified public scales at the Contractor's expense. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of the General Provisions, Section 90-01.

In lieu of scales, and as approved by the Engineer, asphalt mixture weights may be determined by the use of an electronic weighing system equipped with an automatic printer that weighs the total paving mixture. Contractor must furnish calibration certification of the weighing system prior to mix production and as often thereafter as requested by the Engineer.

(2) Testing Facilities. The Contractor shall provide laboratory facilities at the plant for the use of the Engineer's acceptance testing and the Contractor's quality control testing. The Engineer will always have priority in the use of the laboratory. The lab shall have sufficient space and equipment so that both testing representatives (Engineer's and Contractor's) can operate efficiently. The lab shall also meet the requirements of ASTM D 3666.

The plant testing laboratory shall have a floor space area of not less than 150 square feet, with a ceiling height of not less than 7-½ feet. The laboratory shall be weather tight, sufficiently heated in cold weather, air-conditioned in hot weather to maintain temperatures for testing purposes of 70 degrees F +/- 5 degrees F. The plant testing laboratory shall be located on the plant site to provide an unobstructed view, from one of its windows, of the trucks being loaded with the plant mix materials.

Laboratory facilities shall be kept clean, and all equipment shall be maintained in proper working condition. The Engineer shall be permitted unrestricted access to inspect the Contractor's laboratory facility and witness quality control activities. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

As a minimum, the plant testing laboratory shall have:

(a) Adequate artificial lighting
(b) Electrical outlets sufficient in number and capacity for operating the required testing equipment and drying samples.
(c) Fire extinguishers (2), Underwriter's Laboratories approved
(d) Work benches for testing, minimum 2-½ feet by 10 feet.
(e) Desk with 2 chairs
(f) Sanitary facilities convenient to testing laboratory
(g) Exhaust fan to outside air, minimum 12 inch blade diameter
(h) A direct telephone line and telephone including a FAX machine operating 24 hours per day, seven days per week
(i) File cabinet with lock for Engineer
(j) Sink with running water, attached drain board and drain capable of handling separate material
(k) Metal stand for holding washing sieves
(l) Two element hot plate or other comparable heating device, with dial type thermostatic controls for drying aggregates
(m) Mechanical shaker and appropriate sieves (listed in JMF, Table 3) meeting the requirements of ASTM E-11 for determining the gradation of coarse and fine aggregates in accordance with ASTM C 136
(n) Marshall testing equipment meeting ASTM D 6926, ASTM D 6927, automatic compaction equipment capable of compacting three specimens at once and other apparatus as specified in ASTM C 127, D 2172, D 2726, and D 2041
(o) Oven, thermostatically controlled, inside minimum 1 cubic foot
(p) Two volumetric specific gravity flasks, 500 cc
(q) Other necessary hand tools required for sampling and testing
(r) Library containing contract specifications, latest ASTM volumes 4.01, 4.02, 4.03 and 4.09, AASHTO standard specification parts I and II, and Asphalt Institute Publication MS-2.
(s) Equipment for Theoretical Specific Gravity testing including a 4,000 cc pycnometer, vacuum pump capable of maintaining 30 ml mercury pressure and a balance, 16-20 kilograms with accuracy of 0.5 grams
(t) Extraction equipment, centrifuge and reflux types and ROTOflex equipment
(u) A masonry saw with diamond blade for trimming pavement cores and samples
(v) Telephone

Approval of the plant and testing laboratory by the Engineer requires all facilities and equipment to be in good working order during production, sampling and testing. Failure to provide the specified facilities shall be sufficient cause for disapproving bituminous plant operations.

The Owner shall have access to the lab and the plant whenever Contractor is in production.

(3) Inspection of Plant. The Engineer, or Engineer's authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant: verifying weights, proportions, and material properties; and checking the temperatures maintained in the preparation of the mixtures.

(4) Storage Bins and Surge Bins. Use of surge and storage bins for temporary storage of hot bituminous mixtures will be permitted as follows:

(a) The bituminous mixture may be stored in surge bins for ***a*** period of time not to exceed 3 hours.

(b) The bituminous mixture may be stored in insulated storage bins for a period of time not to exceed 24 hours**.**

The bins shall be such that mix drawn from them meets the same requirements as mix loaded directly into trucks.

If the Engineer determines that there is an excessive amount of heat loss, segregation**,** or oxidation of the mixture due to temporary storage, no temporary storage will be allowed.

401-4.3 HAULING EQUIPMENT. Trucks used for hauling bituminous mixtures shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum products shall not be used for coating truck beds. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

401-4.4 BITUMINOUS PAVERS. Bituminous pavers shall be self-propelled with an activated heated screed, capable of spreading and finishing courses of bituminous plant mix material that will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

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.

The paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices that 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 feet (9.14 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 in use leaves tracks or indented areas, or produces other blemishes in the pavement that are not satisfactorily corrected by the scheduled operations, the use of such equipment shall be discontinued and satisfactory equipment shall be provided by the Contractor.

401-4.5 ROLLERS. Rollers of the vibratory, steel wheel, and pneumatic-tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition.

All rollers shall be specifically designed and suitable for compacting hot mix bituminous concrete and shall be properly used. Rollers that impair the stability of any layer of a pavement structure or underlying soils shall not be used. Depressions in pavement surfaces caused by rollers shall be repaired by the Contractor at its own expense.

The use of equipment that causes crushing of the aggregate will not be permitted.

a. Nuclear Densometer. The Contractor shall have on site a nuclear densometer during all paving operations in order to assist in the determination of the optimum rolling pattern, type of roller and frequencies, as well as to monitor the effect of the rolling operations during production paving. The Contractor shall also supply a qualified technician during all paving operations to calibrate the nuclear densometer and obtain accurate density readings for all new bituminous concrete. These densities shall be supplied to the Engineer upon request at any time during construction. No separate payment will be made for supplying the density gauge and technician.

401-4.6 PREPARATION OF BITUMINOUS MATERIAL. The bituminous material shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of the bituminous material delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 325 degrees F (160 degrees C), unless otherwise required by the manufacturer.

401-4.7 PREPARATION OF MINERAL AGGREGATE. The aggregate for the mixture shall be heated and dried prior to introduction into the mixer. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. The temperature of the aggregate and mineral filler shall not exceed 350 degrees F (175 degrees C) when the asphalt is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

401-4.8 PREPARATION OF BITUMINOUS MIXTURE. The aggregates and the bituminous material shall be weighed or metered and introduced into the mixer in the amount specified by the job mix formula.

The combined materials shall be mixed until the aggregate obtains a uniform coating of bitumen and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the Contractor, based on the procedure for determining the percentage of coated particles described in ASTM D 2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to achieve 95 percent of coated particles. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer. The moisture content of all bituminous mixtures upon discharge shall not exceed 0.5 percent.

* *

For batch plants, wet mixing time begins with the introduction of bituminous material into the mixer and ends with the opening of the mixer discharge gate. Distribution of aggregate and bituminous material as they enter the pugmill, speed of mixer shafts, and arrangement and pitch of paddles are factors governing efficiency of mixing. Prolonged exposure to air and heat in the pugmill harden the asphalt film on the aggregate. Mixing time, therefore, should be the shortest time required to obtain uniform distribution of aggregate sizes and thorough coating of aggregate particles with bituminous material.

* *

401-4.9 PREPARATION OF THE UNDERLYING SURFACE. Immediately before placing the bituminous mixture, the underlying course shall be cleaned of all dust and debris. A prime coat or tack coat shall be applied in accordance with Item P-602 or P-603, if shown on the plans.

* *

Engineer should evaluate the presence of paint and/or rubber deposits on the existing pavement and, if needed, may specify milling, grinding or other suitable means to remove same prior to placement of new bituminous material.

* *

401-4.10 LAYDOWN PLAN, TRANSPORTING, PLACING, AND FINISHING. Prior to the placement of the bituminous mixture, the Contractor shall prepare a laydown plan for approval by the Engineer. This is to minimize the number of cold joints in the pavement. The laydown plan shall include the sequence of paving laydown by stations, width of lanes, temporary ramp location(s), and laydown temperature. The laydown plan shall also include estimated time of completion for each portion of the work (i.e. milling, paving, rolling, cooling, etc.). Modifications to the laydown plan shall be approved by the Engineer.

The bituminous mixture shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 401-4.3. Deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

* *

Engineer may, at his option, add the following language:

"For all runway, taxiway and apron pavements, Contractor shall use a stringline to place each lane of each lift of bituminous surface course. However, at the Contractor's option, Contractor shall use stringline for first lift of bituminous surface course and then survey the grade of that lift. Provided grades of that lift of bituminous surface course meet the tolerances of paragraphs 401-5.2b(6), then Contractor may place successive lifts of bituminous surface course using a long ski, or laser control per paragraph 401-4.4. However, Contractor shall survey each lift of bituminous surface course and certify to Engineer that every lot of each lift meets the grade tolerances of paragraph 401-5.2b(6) before the next lift can be placed without a stringline. If the grades of a single lot do not meet the tolerances of 401-5.2b(6), then the Contractor shall use a stringline for each entire lift. Corrective action in paragraph 401-5.2b(6) applies to the final lift of surface course; however, for multiple lift construction, the Contractor shall correct to ensure the final lift of surface course is a minimum of [ ] inches and a maximum of [ ] inches." (Engineer to specify minimum and maximum tolerances for final lift of surface course)

* *

[The Contractor may elect to use a material transfer vehicle to deliver mix to the paver.**]**

* *

Use of a material transfer vehicle allows the paver to be operated almost continuously without stopping between truckloads of mix, if a continuous supply of mix is available from the asphalt plant. The use of a transfer vehicle is recommended on long paving lanes.

* *

Paving during nighttime construction shall require the following:

a. All paving machines, rollers, distribution trucks and other vehicles required by the Contractor for his operations shall be equipped with artificial illumination sufficient to safely complete the work.

b. Minimum illumination level shall be twenty (20) horizontal foot candles and maintained in the following areas:

(1) An area of 30 feet wide by 30 feet long immediately behind the paving machines during the operations of the machines.

(2) An area 15 feet wide by 30 feet long immediately in front and back of all rolling equipment, during operation of the equipment.

(3) An area 15 feet wide by 15 feet long at any point where an area is being tack coated prior to the placement of pavement.

c. As partial fulfillment of the above requirements, the Contractor shall furnish and use, complete artificial lighting units with a minimum capacity of 3,000 watt electric beam lights, affixed to all equipment in such a way to direct illumination on the area under construction.

d. In addition, the Contractor shall furnish [ ] portable floodlight units similar or equal to [ ].

* *

Engineer to specify the minimum number of floodlighting units and may elect to specify a particular manufacturer's lighting unit "or equal".

If nighttime paving requires the critical re-opening of airfield facilities, the following additional language should be added:

"If the Contractor places any out of specification mix in the project work area, the Contractor is required to remove it at its own expense, to the satisfaction of the Engineer. If the Contractor has to continue placing non-payment bituminous concrete, as directed by the Engineer, to make the surfaces safe for aircraft operations, the Contractor shall do so to the satisfaction of the Engineer. It is the Contractor's responsibility to leave the facilities to be paved in a safe condition ready for aircraft operations. No consideration for extended closure time of the area being paved will be given. As a first order of work for the next paving shift, the Contractor shall remove all out of specification material and replace with approved material to the satisfaction of the Engineer. When the above situations occur, there will be no consideration given for additional construction time or payment for extra costs."

* *

The initial placement and compaction of the mixture shall occur at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 250 degrees F (121 degrees C).

Edges of existing bituminous pavement abutting the new work shall be saw cut and carefully removed as shown on the drawings and painted with bituminous tack coat before new material is placed against it.

Upon arrival, the mixture shall be placed to the full width by a bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of **[ ]** except where edge lanes require less width to complete the area. Additional screed sections shall not be attached to widen paver to meet the minimum lane width requirements specified above unless additional auger sections are added to match. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 foot (30 cm); however, the joint in the surface top course shall be at the centerline of crowned pavements. Transverse joints in one course shall be offset by at least 10 feet (3 m) from transverse joints in the previous course.

Transverse joints in adjacent lanes shall be offset a minimum of 10 feet (3 m).

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools. Areas of segregation in the surface course, as determined by the Engineer, shall be removed and replaced at the Contractor's expense. The area shall be removed by saw cutting and milling a minimum of 2 inches deep. The area to be removed and replaced shall be a minimum width of the paver and a minimum of 10 feet long.

*** ***

The Engineer should add more detail as appropriate to areas that require removal and replacements. The Engineer should specify the widest paving lane practicable in an effort to hold the number of longitudinal joints to a minimum.

*** ***

401-4.11 COMPACTION OF MIXTURE. After placing, the mixture shall be thoroughly and uniformly compacted by power rollers. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained.

To prevent adhesion of the mixture to the roller, the wheels shall be equipped with a scraper and kept properly moistened but excessive water will not be permitted.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with approved power driven tampers. Tampers shall weigh not less than 275 pounds, have a tamping plate width not less than 15 inches, be rated at not less than 4,200 vibrations per minute, and be suitably equipped with a standard tamping plate wetting device.

Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching shall not be allowed.

401-4.12 JOINTS. The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

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 course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. In both methods, all contact surfaces shall be given a tack coat of bituminous material before placing any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, uncompacted, or otherwise defective **[**or which have been left exposed for more than 4 hours, or whose surface temperature has cooled to less than 160° F**]** shall be cut back [specify cutback] to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be cleaned and dry prior and given a tack coat of bituminous material prior to placing any fresh mixture against the joint. The cost of this work and tack coat shall be considered incidental to the cost of the bituminous course.

* *

Engineer may retain the bracketed language regarding the treatment of "cold joints" when considered necessary. The cutback should be no more than 6 inches.

* *

401-4.13 SKID RESISTANT SURFACES/SAW-CUT GROOVING. If shown on the plans, skid resistant surfaces for asphalt pavements shall be provided by construction of saw-cut grooves. Pavement shall be sufficiently cooled prior to grooving.

Transverse grooves shall be saw-cut in the pavement forming a ¼ inch wide by ¼ inch deep by 1-½ inches center to center configuration. The grooves shall be continuous for the entire length of the pavement. They shall be saw-cut transversely in the pavement to within 10 feet of the pavement edge to allow adequate space for equipment operation. The tolerances for saw-cut grooves shall meet the following:

a. Alignment tolerance – Plus or minus 1-½ inches in alignment for 75 feet.

b. Groove tolerance – Minimum depth 3/16 inch, except that not more than 60 percent of the grooves shall be less than ¼ inch. Maximum depth 5/16 inch. Minimum width ¼ inch. Maximum width 5/16 inch.

c. Center-to-center spacing – Minimum spacing 1-⅜ inches. Maximum spacing 1-½ inches.

Grooves shall not be less than 6 inches and not more than 18 inches from in-pavement light fixtures. Cleanup of waste material shall be continuous during the grooving operation. All waste material shall be removed from the pavement surface and disposed of off-site in accordance with governing laws and regulations. All arrangements for disposal of waste material shall be made prior to the start of grooving. Waste material shall not be allowed to enter the airport storm or sanitary sewer system.

MATERIAL ACCEPTANCE

401-5.1 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 except that coring **[**and profilograph testing**]** as required in this section shall be completed and paid for by the Contractor. Testing organizations performing these tests **[**except profilograph**]** shall meet the requirements of ASTM D 3666. All equipment in Contractor furnished laboratories shall be calibrated by an independent testing organization prior to the start of operations at the Contractor's expense.

* *

See note to Engineer in section 401-5.2b(5) regarding the use of profilograph testing. If this testing is specified, it is performed and paid for by the Contractor.

* *

a. Plant-Produced Material. Plant-produced material shall be tested for stability, flow, and air voids on a lot basis. Sampling shall be from material deposited into trucks at the plant or from trucks at the job site. Samples shall be taken in accordance with ASTM D 979. A lot will consist of:

- one day or shift's production not to exceed 2,000 tons (1 814 000 kg), or
- a half day or shift's production where a day's production is expected to consist of between 2,000 and 4,000 tons (1 814 000 and 3 628 000 kg), or
- similar subdivisions for tonnages over 4,000 tons (3 628 000 kg).

Where more than one plant is simultaneously producing material for the job, the lot sizes shall apply separately for each plant.

(1) Sampling. Each lot will consist of four equal sublots. Sufficient material for preparation of test specimens for all testing will be sampled by the Engineer on a random basis, in accordance with the procedures contained in ASTM D 3665. One set of laboratory compacted specimens will be prepared for each sublot in accordance with ASTM D 6926, at the number of blows required by paragraph 401-3.2, Table 1. Each set of laboratory compacted specimens will consist of three test portions prepared from the same sample increment.

The sample of bituminous mixture may be put in a covered metal tin and placed in an oven for not less than 30 minutes nor more than 60 minutes to stabilize to compaction temperature. The compaction temperature of the specimens shall be as specified in the job mix formula.

* *

Engineer should increase hold times to not less than 60 minutes and not more than 90 minutes when absorptive aggregates are used,

* *

(2) Testing. Sample specimens shall be tested for stability and flow in accordance with ASTM D 6927. Air voids will be determined by the Engineer in accordance with ASTM D 3203.

Prior to testing, the bulk specific gravity of each test specimen shall be measured by the Engineer in accordance with ASTM D 2726 using the procedure for laboratory-prepared thoroughly dry specimens, or ASTM D 1188, whichever is applicable, for use in computing air voids and pavement density.

For air voids determination, the theoretical maximum specific gravity of the mixture shall be measured one time for each sublot in accordance with ASTM D 2041, Type C, D or E container. The value used in the air voids computation for each sublot shall be based on theoretical maximum specific gravity measurement for the sublot.

The stability and flow for each sublot shall be computed by averaging the results of all test specimens representing that sublot.

(3) Acceptance. Acceptance of plant produced material for stability, flow, and air voids shall be determined by the Engineer in accordance with the requirements of paragraph 401-5.2b.

b. Field Placed Material. Material placed in the field shall be tested for mat and joint density on a lot basis.

(1) Mat Density. The lot size shall be the same as that indicated in paragraph 401-5.1a and shall be divided into four equal sublots. One core of finished, compacted materials shall be taken by the Contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Cores shall not be taken closer than one foot from a transverse or longitudinal joint.

(2) Joint Density. The lot size shall be the total length of longitudinal joints constructed by a lot of material as defined in paragraph 401-5.1a. The lot shall be divided into four equal sublots. One core of finished, compacted materials shall be taken by the Contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. ALL CORING SHALL BE CENTERED ON THE JOINT. THE MINIMUM CORE DIAMETER FOR JOINT DENSITY DETERMINATION SHALL BE 5 INCHES.

(3) Sampling. Samples shall be neatly cut with a core drill. The cutting edge of the core drill bit shall be of hardened steel or other suitable material with diamond chips embedded in the metal cutting edge. The minimum diameter of the sample shall be five inches. Samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. The Contractor shall furnish all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Cored pavement shall be cleaned and core holes shall be filled in a manner acceptable to the Engineer and within one day after sampling.

(4) Testing. The bulk specific gravity of each cored sample will be measured by the Engineer in accordance with ASTM D 2726 or ASTM D 1188, whichever is applicable. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each sublot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined in paragraph 401-5.1a(2). The bulk specific gravity used to determine the joint density at joints formed between different lots shall be the lowest of the bulk specific gravity values from the two different lots.

(5) Acceptance. Acceptance of field placed material for mat density will be determined by the Engineer in accordance with the requirements of paragraph 401-5.2b(1). Acceptance for joint density will be determined in accordance with the requirements of paragraph 401-5.2b(3).

c. Partial Lots — Plant-Produced Material. When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and Engineer agree in writing to allow overages or other minor tonnage placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

The last batch produced where production is halted will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. In addition, an agreed to minor placement will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. Where three sublots are produced, they shall constitute a lot. Where one or two 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, i.e., n = 5 or n = 6, for example. Partial lots at the end of asphalt production on the project shall be included with the previous lot.

d. Partial Lots — Field Placed Material. The lot size for field placed material shall correspond to that of the plant material, except that, in no cases, shall less than three (3) cored samples be obtained, i.e., n = 3.

401-5.2 ACCEPTANCE CRITERIA.

a. General. Acceptance will be based on the following characteristics of the bituminous mixture and completed pavement as well as the implementation of the Contractor Quality Control Program and test results:

(1) Stability
(2) Flow
(3) Air voids
(4) Mat density
(5) Joint density
(6) Thickness
(7) Smoothness
(8) Grade

Mat density and air voids will be evaluated for acceptance in accordance with paragraph 401-5.2b(1). Stability and flow will be evaluated for acceptance in accordance with paragraph 401-5.2b(2). Joint density will be evaluated for acceptance in accordance with paragraph 401-5.2b(3).

Thickness will be evaluated by the Engineer for compliance in accordance with paragraph 401-5.2b(4). Acceptance for smoothness will be based on the criteria contained in paragraph 401-5.2b(5). Acceptance for grade will be based on the criteria contained in paragraph 401-5.2b(6).

The Engineer may at any time, notwithstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of bituminous mixture which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

b. Acceptance Criteria.

(1) Mat Density and Air Voids. Acceptance of each lot of plant produced material for mat density and air voids shall be based on the percentage of material within specification limits (PWL). If the PWL of the lot equals or exceeds 90 percent, the lot shall be acceptable. Acceptance and payment shall be determined in accordance with paragraph 401-8.1.

(2) Stability and Flow. Acceptance of each lot of plant produced material for stability and flow shall be based on the percentage of material within specification limits (PWL). If the PWL of the lot equals or exceeds 90 percent, the lot shall be acceptable. If the PWL is less than 90 percent, the Contractor shall determine the reason and take corrective action. If the PWL is below 80 percent, the Contractor must stop production until the reason for poor stability and/or flow has been determined and adjustments to the mix are made

(3) Joint Density. Acceptance of each lot of plant produced material for joint density shall be based on the percentage of material within specification limits (PWL). If the PWL of the lot is equal to or exceeds 90 percent, the lot shall be considered acceptable. If the PWL is less than 90 percent, the Contractor shall evaluate the reason and act accordingly. If the PWL is less than 80 percent, the Contractor shall cease operations and until the reason for poor compaction has been determined. IF THE PWL IS LESS THAN 71 PERCENT, THE PAY FACTOR FOR THE LOT USED TO COMPLETE THE JOINT SHALL BE REDUCED BY 5 PERCENTAGE POINTS. This lot pay factor reduction shall be incorporated and evaluated in accordance with paragraph 401-8.1.

(4) Thickness. Thickness of each lift of surface course shall be evaluated by the Engineer for compliance to the requirements shown on the plans. Measurements of thickness shall be made by the Engineer using the cores extracted for each sublot for density measurement. The maximum allowable deficiency at any point shall not be more than ¼ inch less than the thickness indicated for the lift. Average thickness of lift, or combined lifts, shall not be less than the indicated thickness. Where the thickness tolerances are not met, the lot or sublot shall be corrected by the Contractor at his expense by removing the deficient area and replacing with new pavement. The Contractor, at his expense, may take additional cores as approved by the Engineer to circumscribe the deficient area.

(5) Smoothness. The final surface shall be free from roller marks. The finished surfaces of each course of the pavement, except the finished surface of the final course, shall not vary more than ⅜ inch when evaluated with a 16 foot straightedge. The finished surface of the final course of pavement shall not vary more than ¼ inch when evaluated with a 16 foot straightedge. The lot size shall be [ ] square yards (square meters). Smoothness measurements shall be made at 50 foot intervals and as determined by the Engineer. In the longitudinal direction, a smoothness reading shall be made at the center of each paving lane. In the transverse direction, smoothness readings shall be made continuously across the full width of the pavement. However, transverse smoothness readings shall not be made across designed grade changes. At warped transition areas, straightedge position shall be adjusted to measure surface smoothness and not design grade transitions. When more than 15 percent of all measurements within a lot exceed the specified tolerance, the Contractor shall remove the deficient area to the depth of the final course of pavement and replace with new material. Skin patching shall not be

permitted. Isolated high points may be ground off providing the course thickness complies with the thickness specified on the plans. High point grinding will be limited to 15 square yards. Areas in excess of 15 square yards will require removal and replacement of the pavement in accordance with the limitations noted above.

*** ***

The Engineer shall specify the lot size. A minimum of 2,000 square yards (1 650 square meters) is recommended.

Use of a profilograph can be included in the specifications for surface smoothness for runways and taxiways on a case by case basis provided it is approved by the FAA. Use of a profilograph may not be practical for all asphalt construction. Thin lift overlays and other minimum resurfacing may not allow for removal of existing pavement roughness. However, the use of the profilograph is recommended for new construction or overlays designed to correct grade and smoothness deficiencies. If the profilograph is to be included, straightedge requirements need only apply to the perpendicular direction. To include profilograph requirements, add ASTM E 1274 to the referenced testing list and add the following:

(a) Profilograph. The Contractor shall furnish a 25 foot wheel base California type profilograph and competent operator to measure pavement surface deviations. The profilograph shall be operated in accordance with the manufacturer's instructions and at a speed no greater than 3 mph. Original profilograms for the appropriate locations interpreted in accordance with ASTM E 1274 shall be furnished to the Engineer. The profilograms shall be recorded on a scale of one inch equal to 25 feet longitudinally and one inch equal to one inch (or full scale) vertically. Profilographs shall be calibrated prior to testing.

The surface of the runway and/or taxiway pavements of continuous placement of 50 feet or more shall be tested and evaluated as described herein. One pass along the centerline shall be required for each paving lane. Runs shall be continuous through a day's production. Each trace shall be completely labeled to show paving lane and stationing.

The Contractor shall furnish paving equipment and employ methods that produce a riding surface for each section of pavement having an average profile index meeting the requirements of Table 7. A typical section will be considered to be the width of the paving lane and 1/10 of a mile long. The profile index will be determined in accordance with ASTM E 1274. A blanking band of 0.2 inches shall be used. Within each 1/10 mile section, all areas represented by high points having a deviation in excess of 0.4 inches in 25 feet or less shall be removed by the Contractor using an approved method. After removing all individual deviations in excess of 0.4 inches, additional corrective work shall be performed if necessary to achieve the required ride quality. All corrective work shall be completed prior to determination of pavement thickness.

On pavement sections where corrections were necessary, second profilograph runs shall be performed to verify that the corrections have produced an average profile index of 15 inches per mile or less. If the initial average profile index was less than 15, only those areas representing greater than 0.4 inch deviation will be re-profiled for correction verification.

Individual sections shorter than 50 feet and the last 15 feet of any section where the Contractor is not responsible for the adjoining section shall be straightedged in accordance with paragraph 401-5.2b(5).

If there is a section of 250 feet or less, the profilogram for the section shall be included in the evaluation of the previous section. If there is an independently placed section of 50

to 250 feet in length, a profilogram shall be made for that section and the pay adjustment factors for short section of Table 7 shall apply.

All costs necessary to provide the profilograph and related to furnishing the appropriate profilograms as required in this provision are incidental to pavement construction and no direct compensation will be made therefore.

* *

(6) Grade. The finished surface of the pavement shall not vary from the gradeline elevations and cross sections shown on the plans by more than ½ inch (12.70 mm). The finished grade of each lot will be determined by running levels at intervals of 50 feet (15.2 m) or less longitudinally and all breaks in grade transversely (not to exceed 50 feet) to determine the elevation of the completed pavement. The Contractor shall pay the cost of surveying of the level runs that shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer. The lot size shall be **[ ]** square yards (square meters). When more than 15 percent of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates ¾ inch or more from planned grade, the Contractor shall remove the deficient area to the depth of the final course of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off providing the course thickness complies with the thickness specified on the plans. The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130 inches wide. The peaks and ridges shall be approximately 1/32 inch higher than the bottom of the grooves. The pavement shall be left in a clean condition. The removal of all of the slurry resulting form the grinding operation shall be continuous The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement. High point grinding will be limited to 15 square yards. Areas in excess of 15 square yards will require removal and replacement of the pavement in accordance with the limitations noted above.

* *

A minimum of 2,000 square yards (1 650 square meters) is recommended.

* *

c. Percentage of Material Within Specification Limits (PWL). The percentage of material within specification limits (PWL) shall be determined in accordance with procedures specified in Section 110 of the General Provisions. The specification tolerance limits (L) for lower and (U) for upper are contained in Table 5.

d. Outliers. All individual tests for mat density and air voids shall be checked for outliers (test criterion) in accordance with ASTM E 178, at a significance level of 5 percent. Outliers shall be discarded, and the PWL shall be determined using the remaining test values.

* *

The specification tolerance limits applicable to the project, based on design criteria specified in Table 1, shall be specified by the Engineer from the information shown below and inserted into Table 5. Asterisks denote insert points.

* *

TABLE 5. MARSHALL ACCEPTANCE LIMITS FOR STABILITY, FLOW, AIR VOIDS, DENSITY

TEST PROPERTY	Pavements Designed for Aircraft Gross Weights of 60,000 Lbs. or More or Tire Pressures of 100 Psi or More		Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lbs. or Tire Pressures Less Than 100 Psi	
Number of Blows	**75**		**50**	
	Specification Tolerance Limits		**Specification Tolerance Limits**	
	L	**U**	**L**	**U**
Stability, minimum, pounds	1800	--	1000	--
Flow, 0.01-inch	8	16	8	20
Air Voids Total Mix, percent	2	5	2	5
Surface Course Mat Density, percent	96.3	[101.3]	96.3	[101.3]
Base Course Mat Density, percent	95.5	101.3]--	95.5	[101.3]
Joint density, percent	93.3	--	93.3	--

NOTE TO ENGINEER. The Engineer may specify both upper and lower PWL acceptance criteria (two-sided) for density. Use 101.3 as the Upper tolerance limits when two-sided density acceptance criteria is specified AND insert edit paragraph 401-8.1. See Notes to Engineer following paragraph 401-8.1.

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TABLE 5. MARSHALL ACCEPTANCE LIMITS FOR STABILITY, FLOW, AIR VOIDS, DENSITY

TEST PROPERTY	*	
Number of Blows	*	
	Specification Tolerance	
	L	U
Stability, minimum, pounds	*	*
Flow, 0.01-inch	*	*
Air Voids Total Mix, percent	*	*
Mat Density, percent	*	*
Joint density, percent	*	*

The criteria in Table 5 is based on production processes which have a variability with the following standard deviations:

Surface Course Mat Density (%), 1.30
Base Course Mat Density (%), 1.55
Joint Density (%), 2.1

The Contractor should note that (1) 90 PWL is achieved when consistently producing a surface course with an average mat density of at least 98 percent with 1.30% or less variability, (2) 90 PWL is achieved when consistently producing a base course with an average mat density of at least 97.5 percent with 1.55% or less variability, and (3) 90 PWL is achieved when consistently producing joints with an average joint density of at least 96 percent with 2.1% or less variability.

* *

A lot is the quantity of material to be controlled and may represent a specified tonnage or a specified number of truckloads. The lot size, to be determined by the Engineer, should, for the most part, depend on the operational capacity of the plant, but shall in no case exceed 2,000 tons (1 814 000 kg) in accordance with paragraph 401-5.1a.

* *

401-5.3 RESAMPLING PAVEMENT FOR MAT DENSITY.

a. General. Resampling of a lot of pavement will only be allowed for mat density**,** and then, only if the Contractor requests same, in writing, within 48 hours after receiving the written test results from the Engineer. A retest will consist of all the sampling and testing procedures contained in paragraphs 401-5.1b and 401-5.2b(1). Only one resampling per lot will be permitted.

(1) A redefined PWL shall be calculated for the resampled lot. The number of tests used to calculate the redefined PWL shall include the initial tests made for that lot plus the retests.

(2) The cost for resampling and retesting shall be borne by the Contractor.

b. Payment for Resampled Lots. The redefined PWL for a resampled lot shall be used to calculate the payment for that lot in accordance with Table 6.

c. Outliers. Check for outliers in accordance with ASTM E 178, at a significance level of 5 percent.

[401-5.4 LEVELING COURSE. Any course used for truing and leveling shall meet the requirements of paragraph 401-3.2, 401-5.2b(1) for air voids and 401-5.2b(2), but shall not be subject to the density requirements of paragraph 401-5.2b(1) for mat density and 401-5.2b(3). The leveling course shall be compacted with the same effort used to achieve density of the test section. The truing and leveling course shall not exceed a nominal thickness of 1-½ inches (37.5 mm). The leveling course is the first variable thickness lift of an overlay placed prior to subsequent courses.**]**

* *

Use this paragraph only when there is a need to restore proper cross-section prior to overlaying. Areas of the pavement requiring a leveling course shall be shown on the plans.

* *

CONTRACTOR QUALITY CONTROL

401-6.1 GENERAL. The Contractor shall develop a Quality Control Program in accordance with Section 100 of the General Provisions. The program shall address all elements that affect the quality of the pavement including, but not limited to:

a. Mix Design
b. Aggregate Grading
c. Quality of Materials
d. Stockpile Management
e. Proportioning
f. Mixing and Transportation
g. Placing and Finishing
h. Joints
i. Compaction

j. Surface Smoothness
k. Personnel
l. Laydown Plan

The Contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by paragraph 401-6.3 and Section 100 of the General Provisions. As a part of the process for approving the Contractor's plan, the Engineer may require the Contractor's technician to perform testing of samples to demonstrate an acceptable level of performance.

No partial payment will be made for materials that are subject to specific quality control requirements without an approved plan.

401-6.2 TESTING LABORATORY. The Contractor shall provide a fully equipped asphalt laboratory meeting the requirements of paragraph 401-3.5 and 401-4.2a(2) located at the plant or job site. The Contractor shall provide the Engineer with certification stating that all of the testing equipment to be used is properly calibrated and will meet the specifications applicable for the specified test procedures.

401-6.3 QUALITY CONTROL TESTING. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in the approved Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness. A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

a. Asphalt Content. A minimum of two tests shall be performed per lot in accordance with ASTM D 6307 or ASTM D 2172 for determination of asphalt content. The weight of ash portion of the test, as described in ASTM D 2172, shall be determined as part of the first test performed at the beginning of plant production; and as part of every tenth test performed thereafter, for the duration of plan production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture. The asphalt content for the lot will be determined by averaging the test results.

The use of the nuclear method for determining asphalt content in accordance with ASTM D 4125 is permitted, provided that it is calibrated for the specific mix being used.

b. Gradation. Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D 5444 and ASTM C 136 (Dry Sieve). When asphalt content is determined by the nuclear method, aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix or continuous mix plants, and tested in accordance with ASTM C 136 (dry sieve) using actual batch weights to determine the combined aggregate gradation of the mixture.

c. Moisture Content of Aggregate. The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C 566.

d. Moisture Content of Mixture. The moisture content of the mixture shall be determined once per lot in accordance with ASTM D 1461 **[**or AASHTO T110**]**.

*** ***

ASTM D 1461 may be replaced with AASHTO T110 moisture content testing procedure using a conventional oven or microwave.

*** ***

e. Temperatures. Temperatures shall be checked, at least four times per lot, at necessary locations to determine the temperatures of the dryer, the bitumen in the storage tank, the mixture at the plant, and the mixture at the job site.

f. In-Place Density Monitoring. The Contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D 2950.

g. Additional Testing. Any additional testing that the Contractor deems necessary to control the process may be performed at the Contractor's option.

h. Monitoring. The Engineer reserves the right to monitor any or all of the above testing.

401-6.4 SAMPLING. When directed by the Engineer, the Contractor shall sample and test any material that appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

401-6.5 CONTROL CHARTS. The Contractor shall maintain linear control charts both for individual measurements and range (i.e., difference between highest and lowest measurements) for aggregate gradation and asphalt content.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a problem and the Contractor is not taking satisfactory corrective action, the Engineer may suspend production or acceptance of the material.

a. Individual Measurements. Control charts for individual measurements shall be established to maintain process control within tolerance for aggregate gradation and asphalt content. The control charts shall use the job mix formula target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:

CONTROL CHART LIMITS FOR INDIVIDUAL MEASUREMENTS		
Sieve	Action Limit	Suspension Limit
¾ inch (19.0 mm)	0%	0%
½ inch (12.5 mm)	+/-6%	+/-9%
⅜ inch (9.5 mm)	+/-6%	+/-9%
No. 4 (4.75 mm)	+/-6%	+/-9%
No. 16 (1.18 mm)	+/-5%	+/-7.5%
No. 50 (0.30 mm)	+/-3%	+/-4.5%
No. 200 (0.075 mm)	+/-2%	+/-3%
Asphalt Content	+/-0.45%	+/-0.70%

b. Range. Control charts for range shall be established to control process variability for the test parameters and Suspension Limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of n = 2. Should the Contractor elect to perform more than two tests per lot, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for n = 3 and by 1.27 for n = 4.

CONTROL CHART LIMITS BASED ON RANGE (Based on n = 2)	
Sieve	Suspension Limit
½ inch (12.5 mm)	11 percent
⅜ inch (9.5 mm)	11 percent

No. 4 (4.75 mm)	11 percent
No. 16 (1.18 mm)	9 percent
No. 50 (0.30 mm)	6 percent
No. 200 (0.075 mm)	3.5 percent
Asphalt Content	0.8 percent

c. Corrective Action. The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and detail what action will be taken to bring the process into control. As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

(1) One point falls outside the Suspension Limit line for individual measurements or range; or

(2) Two points in a row fall outside the Action Limit line for individual measurements.

* *

The aggregate control chart parameters and Suspension and Action Limits contained in the above paragraphs are based on ¾ inch (19.0 mm) maximum size aggregate gradation. When 1-inch (25.0 mm) or 1-½ inch (37.5 mm) maximum size aggregate is specified, the Individual Measurements Chart requirements should be amended as follows:

Sieve	Action Limit	Suspension Limit
1 inch or 1-½ inch	**0%**	**0%**
¾ inch	**6%**	**11%**

When ½-inch (12.5 mm) maximum size aggregate is specified, the ¾-inch (19.0 mm) and 1-inch (25.0 mm) sieves should be deleted from the Individual Measurements Chart and the ½-inch (12.5 mm) sieve Action and Suspension Limits should be changed to 0%. For the ½-inch (12.5 mm) gradation, the ½-inch sieve should be deleted from the Range Chart.

* *

401-6.6 QUALITY CONTROL REPORTS. The Contractor shall maintain records and shall submit reports of quality control activities daily, in accordance with the Contractor Quality Control Program described in General Provisions, Section 100.

METHOD OF MEASUREMENT

401-7.1 MEASUREMENT. Plant mix bituminous concrete pavement shall be measured by the number of tons (kg) of bituminous mixture used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage.

Saw-cut grooving of bituminous pavement shall be measured by the number of square yards of saw-cut grooving as specified in-place, completed and accepted.

BASIS OF PAYMENT

401-8.1 PAYMENT. Payment for an accepted lot of bituminous concrete pavement shall be made at the contract unit price per ton (kg) for bituminous mixture adjusted according to paragraph 401-8.1a, subject to the limitation that:

The total project payment for plant mix bituminous concrete pavement shall not exceed **[ ]** percent of the product of the contract unit price and the total number of tons (kg) of bituminous mixture used in the accepted work (See Note 2 under Table 6).

Payment for accepted saw-cut grooving shall be made at the contract unit price per square yard.

The price shall be compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

* *

The Engineer shall specify a value ranging from 100 to the maximum lot pay factor amount. (106 percent for single-sided density or 103 percent when double-sided density is specified.) When the total project payment for Item P-401 pavement exceeds the contract unit price, any AIP or PFC funds used to pay the excess may require an amendment to the AIP grant or PFC application for the project.

* *

a. Basis of Adjusted Payment. The pay factor for each individual lot shall be calculated in accordance with Table 6. A pay factor shall be calculated for both mat density and air voids. The lot pay factor shall be the higher of the two values when calculations for both mat density and air voids are 100 percent or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either mat density or air voids is 100 percent or higher. The lot pay factor shall be the lower of the two values when calculations for both mat density and air voids are less than 100 percent.

TABLE 6. PRICE ADJUSTMENT SCHEDULE [1]

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96 – 100	106
90 – 95	PWL + 10
75 – 89	0.5 PWL + 55
55 – 74	1.4PWL – 12
Below 55	Reject [2]

[1] ALTHOUGH IT IS THEORETICALLY POSSIBLE TO ACHIEVE A PAY FACTOR OF 106 PERCENT FOR EACH LOT, ACTUAL PAYMENT ABOVE 100 PERCENT SHALL BE SUBJECT TO THE TOTAL PROJECT PAYMENT LIMITATION SPECIFIED IN PARAGRAPH 401-8.1.

[2] The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50 percent of the contract unit price and the total project payment shall be reduced by the amount withheld for the rejected lot.

For each lot accepted, the adjusted contract unit price shall be the product of the lot pay factor for the lot and the contract unit price. Payment shall be subject to the total project payment limitation specified in paragraph 401-8.1. Payment in excess of 100 percent for accepted lots of bituminous concrete pavement shall be used to offset payment for accepted lots of bituminous concrete pavement that achieve a lot pay factor less than 100 percent.

* *

NOTE TO ENGINEER. The Engineer may specify both upper and lower PWL acceptance criteria (two-sided) for density. Use the following pay adjustment schedule when two-sided acceptance criteria for density is specified edit Table 5 to include the Upper tolerance limits and edit paragraph 401-8.1.

TABLE 6. PRICE ADJUSTMENT SCHEDULE [1]

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
93 – 100	103
90 – 93	PWL + 10
70 – 89	0.125PWL + 88.75
40 – 69	0.75PWL +45
Below 40	Reject [2]

[1] ALTHOUGH IT IS THEORETICALLY POSSIBLE TO ACHIEVE A PAY FACTOR OF 103 PERCENT FOR EACH LOT, ACTUAL PAYMENT ABOVE 100 PERCENT SHALL BE SUBJECT TO THE TOTAL PROJECT PAYMENT LIMITATION SPECIFIED IN PARAGRAPH 401-8.1.

[2] The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50 percent of the contract unit price AND THE TOTAL PROJECT PAYMENT LIMITATION SHALL BE REDUCED BY THE AMOUNT WITHHELD FOR THE REJECTED LOT.

* *

* *

If a profilograph is used, add the following paragraphs and change existing paragraph 401-8.1b to 401-8.1d (The pay adjustment in Table 7 is optional to the Owner and Engineer when using the profilograph):

b. Profilograph Smoothness. When the final average profile index (subsequent to any required corrective action) does not exceed 7 inches per mile, payment will be made for that section at the contract unit price for the completed pavement. If the final average profile index (subsequent to any required corrective action) exceeds 7 inches per mile, but does not exceed 15 inches per mile, the Contractor may elect to accept a contract unit price adjustment in lieu of reducing the profile index.

c. Basis of Adjusted Payment for Smoothness. Price adjustment for pavement smoothness will be made in accordance with Table 7. The adjustment will apply to the total tonnage of asphalt concrete within a lot of pavement and shall be applied with the following equation:

(Tons of asphalt concrete in lot) x (lot pay factor) x (unit price per ton) x (smoothness pay factor) = payment for lot

TABLE 7. AVERAGE PROFILE INDEX SMOOTHNESS PAY FACTOR

(Inches per mile per 1/10 mile)	Short Sections	Pay Factor
00.0 - 7	00.0 - 15.0	100%
7.1 - 9	15.1 - 16	98%
9.1 - 11	16.1 - 17	96%
11.1 - 13	17.1 - 18	94%
13.1 - 14	18.1 - 20	92%
14.1 - 15	20.1 - 22	90%
15.1 & up	22.1& up	corrective work required[1]

1The Contractor shall correct pavement areas not meeting these tolerances by removing and replacing the defective work. If the Contractor elects to construct an overlay to correct deficiencies, the minimum thickness of the overlay shall not be less than twice the size of the maximum size aggregate. The corrective overlay shall not violate grade criteria and butt joints shall be constructed by sawing and removing the original pavement in compliance with the thickness/maximum aggregate size ratio. Skin patching shall not be permitted.

Unit bid price adjustment will apply to total bituminous mixture and asphalt cement quantities within the 1/10 mile segment of pavement. Deductions will be applied to recorded project quantities. Any pavement section less than 1/10 mile will be accepted on a pro-rated basis.

Material used in building the pavement above the specified grade shall not be included in the quantities for payment.

****

b. Payment. Payment will be made under:

Item P-401-8.1a	Bituminous **[Surface] [Base] [Binder] [Leveling]** Course—per ton (kg)
Item P-401-8.1b	Saw-Cut Grooving—per square yard

TESTING REQUIREMENTS

ASTM C 29	Bulk Density (“Unit Weight”) and Voids in Aggregate
ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Materials Finer than 75µm (No.200) Sieve in Mineral Aggregates by Washing
ASTM C 127	Specific Gravity and Absorption of Coarse 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 Analysis of Fine and Coarse Aggregates

ASTM C 183	Sampling and the Amount of Testing of Hydraulic Cement
ASTM C 566	Total Evaporable Moisture Content of Aggregate by Drying
ASTM D 75	Sampling Aggregates
ASTM D 979	Sampling Bituminous Paving Mixtures
ASTM D 995	Mixing Plants for Hot-Mixed Hot-Laid Bituminous Paving Mixtures
ASTM D 1073	Fine Aggregate for Bituminous Paving Mixtures
ASTM D 1188	Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1461	Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D 2041	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2419	Sand Equivalent Value of Soils and Fine Aggregate
ASTM D 2489	Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D 2726	Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D 2950	Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D 3203	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
ASTM D 3665	Random Sampling of Construction Materials
ASTM D 3666	Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D 4125	Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 4867	Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D 5444	Mechanical Size Analysis of Extracted Aggregate
ASTM D 6926	Preparation of Bituminous Specimens Using MARSHALL Apparatus
ASTM D 6927	MARSHALL Stability and Flow of Bituminous Mixtures
ASTM E 11	Wire-Cloth Sieves for Testing Purposes

ASTM E 178	Dealing with Outlying Observations
ASTM E 1274	Measuring Pavement Roughness Using a Profilograph
AASHTO T 30	Mechanical Analysis of Extracted Aggregate
[AASHTO T 110	Moisture or Volatile Distillates in Bituminous Paving Mixtures**]**
The Asphalt Institute's Manual No. 2 (MS-2)	Mix Design Methods for Asphalt Concrete

MATERIAL REQUIREMENTS

ASTM D 242	Mineral Filler for Bituminous Paving Mixtures
ASTM D 946	Penetration Graded Asphalt Cement for Use in Pavement Construction
ASTM D 3381	Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 4552	Classifying Hot-Mix Recycling Agents
AASHTO M320	Performance Graded Asphalt Binder

END OF ITEM P-401

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ITEM P-402 POROUS FRICTION COURSE

(Central Plant Hot Mix)

DESCRIPTION

402-1.1 This item shall consist of a plant mixed, open-graded porous friction course, composed of mineral aggregate and bituminous material, mixed in a central mixing plant, and placed on a prepared surface in accordance with these specifications and shall conform to the dimensions and typical cross section as shown on the plans.

* *

The porous friction course (PFC) shall be designed as a free draining wearing surface of uniform thickness. The PFC must be placed on a prepared surface, which drains freely and does not allow ponding. The PFC should not be applied over an existing PFC. Any existing PFC should be removed and the entire surface leveled prior to placement of a new PFC.

* *

MATERIALS

402-2.1 AGGREGATE. The aggregate shall consist of crushed stone, crushed gravel, or crushed slag with or without other inert finely divided mineral aggregate. The aggregate shall be composed of clean, sound, tough, durable particles, free from clay balls, organic matter, and other deleterious substances. The portion of the material retained on the No. 4 sieve shall be known as coarse aggregate, the portion passing the No. 4 sieve and retained on the No. 200 sieve as fine aggregate, and the portion passing the No. 200 sieve as mineral filler.

a. Coarse Aggregate. Coarse aggregate shall contain at least 75 percent by weight crushed pieces having two or more fractured faces and 100 percent by weight particles with one or more 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 fractures are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be obtained by crushing. The coarse aggregate shall not contain more than 8 percent, by weight of flat or elongated pieces as defined in ASTM D 693. The percentage of wear shall not be greater than 30 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 12 percent after five cycles, when tested in accordance with ASTM C 88.

b. Fine Aggregate. Fine aggregate shall have a plasticity index of not more than 6.0 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318. The percentage of wear shall not be greater than 30 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 12 percent after five cycles, when tested in accordance with ASTM C 88.

If necessary, natural sand may be used to obtain the gradation of aggregate blend or workability. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification.

402-2.2 FILLER. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242. When mineral filler is required to be batched separately, hydrated lime in the amount of 1.5 percent maximum by weight of the total aggregate shall be batched as part of the added mineral filler. No additional compensation will be allowed the Contractor for furnishing and using hydrated lime or other approved mineral filler that may be required by this specification.

402-2.3 BITUMINOUS MATERIAL. The bituminous material shall be viscosity graded asphalt cement meeting Table 1 of this section and ASTM D-3381, Table 2. A synthetic rubber additive shall be added to the bitumen in an amount not less than 2 percent by weight (% by weight of synthetic rubber solids). The bitumen and additive shall be uniformly mixed to provide a mixture meeting the following requirements:

* *

FOR FAA CENTRAL REGION PROJECTS:

TABLE 1			
Property	**ASTM**	**Min.**	**Max.**
Viscosity @ 140°F., Poises	**D-2171**	**1600**	**2400**
Viscosity @ 275°F., cSt.	**D-2170**	**325**	
Flash Point, °F.,	**D-92**	**450**	
Ductility @ 77°F (5 cm/min) cm.	**D-113**	**100**	
Ductility @ 39.2°F (5 cm/min) cm.	**D-113**	**50**	
Toughness, inch-pounds	**D-5801**	**110**	
Tenacity, inch-pounds	**D-5801**	**75**	
Thin Film Oven Test:			
Tests on Residue			
Viscosity @ 140°F., Poises	**D-2170**	**--**	**8000**
Ductility @ 77°F., (5 cm/min) cm	**D-113**	**100**	
Ductility @ 39.2°F., (5 cm/min) cm	**D-113**	**25**	

* *

Certified test results plus a sample of the bitumen-synthetic rubber mixture shall be provided for each tank load shipped to the project or for each mixed batch, whichever is smaller. Samples being tested shall contain the anti-stripping additive. No material shall be used before the test results are delivered to the Engineer. The Engineer will conduct independent acceptance tests on random samples. Material placed which does not meet specification requirements shall be removed and replaced at no additional cost to the owner. A temperature-viscosity curve for the material shall be provided to the Engineer.

* *

Samples shall be taken, however a minimum of one sample shall be tested by the Engineer to verify the submitted certification. Additional samples shall be tested if results are borderline or for any other reason. The initial test is recommended to be done early in the project.

* *

402-2.4 ANTI-STRIPPING AGENT. Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the Department of Transportation of the State in which the project is located.

COMPOSITION

402-3.1 COMPOSITION OF MIXTURE. The porous friction course shall be composed of aggregate, filler, bituminous material-synthetic rubber mixture, and anti-stripping agent.

402-3.2 JOB MIX FORMULA. No bituminous mixture shall be produced for payment until the Engineer has given written approval of the job mix formula. The job mix shall be prepared by a certified laboratory at the Contractor's expense and shall remain in effect for the duration of the project. The job mix formula shall establish a single percentage of aggregate passing each required sieve size, a single percentage of bituminous material to be added to the aggregate, the amount of anti strip agent to be added (minimum of one half of one percent by weight), and a single temperature for the mixture as it is discharged into the hauling units. Silicone may be added to the

mixture at a maximum rate of 1 ounce per 5,000 gallons of asphalt to facilitate laydown and rolling. Proper asphalt content shall be determined by mixing trial batches in the laboratory.

The job mix formula shall be submitted to the Engineer at least [30] days prior to the start of paving and shall include:

a. Percent passing each sieve size and gradation requirements.
b. Percent of asphalt cement.
c. Asphalt viscosity.
d. Mixing temperature range.
e. Temperature of mix when discharged from the mixer.
f. Temperature viscosity relationship of the asphalt cement.
g. Percent of wear (LA abrasion).
h. Plasticity Index and Liquid Limit of fine aggregate.
i. Percent fractured faces.
j. Percent elongated particles.
k. Anti-strip agent.

The Contractor shall submit samples to the Engineer, upon request, for job mix formula verification testing.

The combined aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation shown in Table 2 when tested in accordance with ASTM C 136.

The gradations in Table 2 represent the limits, which determine the suitability of the aggregate for use from the source of supply. The aggregate, as finally selected, shall have a gradation within the limits designated in Table 2 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be uniformly graded from coarse to fine.

TABLE 2. AGGREGATE-POROUS FRICTION COURSE
PERCENTAGE BY WEIGHT PASSING SIEVES

Sieve	3/4" maximum	1/2" maximum	Job-Mix (Production)
			Tolerances **
3/4"	100	---	---
1/2"	70-90	100	+/- 5%
3/8"	40-65	85-95	+/- 5%
#4	15-25	30-45	+/- 5%
#8	8-15	20-30	+/- 2%
#30	5-9	9-17	+/- 2%
#200	1-5	2-7	+/- 2%
Bitumen			+/- 0.2%
Temperature of Mix			+/- 20 degrees F.

** The gradation job mix tolerance limits will apply if they fall outside the master grading band in Table 2 except for the top two sieve sizes starting at the 100% passing band. These two sieve size bands shall also be additional limits for production.

The gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves will be subject to appropriate adjustments by the Engineer when aggregates of varying specific gravities are used. The adjustments to the job mix gradation curve should result in a curve of the same general shape as the median curve of the gradation band in Table 2 and fall within the gradation band.

The Asphalt Institutes Manual Series No. 2 (MS-2) contains a convenient procedure for "adjusting" the job mix gradation when aggregates of non uniform specific gravity are proposed for use.

The bituminous content of porous friction courses shall be expressed as a percentage of the total mix by weight and shall be approved by the Engineer on the basis of laboratory tests. The materials used in the mix design shall be the same as those used on the project.

The bituminous content shall be within plus or minus 1 percent of the value obtained from the formula:

$2K_c + 4.0$

where K_c is the surface area constant for that part of the total dry aggregate that will pass a 3/4" (19.0 mm) sieve and be retained on the No. 4 (4.75 mm) sieve. Procedures for determining K_c are contained in the Asphalt Institute's Manual Series No. 2 (MS-2). The bituminous content so estimated is the percentage by weight of the total dry aggregates and must be converted to the percent by weight of the total mix in the approved job-mix formula.

The laboratory used to develop the job mix formula shall meet the requirements of ASTM D 3666. A certification signed by the lab manager of the laboratory stating that it meets these requirements shall be submitted to the Engineer prior to the start of construction. The certification shall contain as a minimum:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.
b. A listing of equipment to be used in developing the job mix.
c. A copy of the laboratory's quality control system.
d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

402-3.3 TEST SECTION. At least one full day prior to full production, the Contractor shall prepare a quantity of bituminous mixture according to the approved job mix formula. The amount of mixture should be sufficient to construct a test section at least 50 feet long and 20 feet wide, placed in two sections and of the same depth specified on the plans. The test area will be designated by the Engineer. The underlying pavement on which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. 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. No bituminous mixture shall be produced for payment prior to successful placement of and acceptance of a test strip by the Engineer.

If the test section should prove to be unsatisfactory, the necessary adjustments to plant operation, and/or placement procedures shall be made. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. When the test section does not conform to specification requirements the test section shall be removed and replaced at the Contractors expense. Full production shall not begin without approval of the Engineer. Test sections, which conform to specification requirements, shall be measured and paid in accordance with Paragraphs 402-5.1 and 402-6.1. The asphalt content may be adjusted by the Engineer during the test section and will be used as the target asphalt content.

* *

Note: The AC content should be adjusted during the placement of test section. One method to establish the optimum AC content is with the use of a glass dish. Various AC content mixes are made in increments of 0.5% (5.5%, 6.0%, 6.5%, etc.). The mix that will completely cover the bottom of the dish should be used to start the test strip. The AC content should then be increased in the test strip until it starts to bleed. The content then is decreased by 0.5%.

* *

CONSTRUCTION METHODS

402-4.1 WEATHER AND SEASONAL LIMITATIONS. The porous friction course shall be constructed only on a dry surface when the atmospheric temperature is 50 F (10 C) and rising (at calm wind conditions) and when the weather is not foggy or rainy.

402-4.2 BITUMINOUS MIXING PLANT. Plants used for the preparation of bituminous mixtures shall conform to the requirements of ASTM D 995 with the following changes:

a. Requirements for all Plants.

(1) Truck Scales. The bituminous mixture 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.

(2) Testing Laboratory. The Contractor or producer shall provide laboratory facilities for control and acceptance testing functions during periods of mix production, sampling, and testing and whenever materials subject to the provisions of these specifications are being supplied or tested. The laboratory shall provide adequate equipment, space, and utilities as required for the performance of the specified tests.

(3) Inspection of Plant. The Engineer, or Engineer's authorized representative, shall have access, at all times, to all parts of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and materials properties; and checking the temperatures maintained in the preparation of the mixtures.

(4) Storage Bins and Surge Bins. Paragraph 3.9 of ASTM D 995 is deleted.

402-4.3 HAULING EQUIPMENT. Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds. Petroleum products shall not be used for coating truck beds. To prevent the mixture from adhering to them, the beds shall be lightly coated with an approved asphalt release agent. 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. If conditions warrant, truck beds shall be insulated and covers shall be securely fastened so that the mixture will be delivered to the site at the specified temperature.

402-4.4 BITUMINOUS PAVERS. Bituminous pavers shall be self-contained, power-propelled units with an activated screed or strike-off assembly, heated if necessary, and shall be capable of spreading and finishing courses of bituminous plant-mix material which will meet the specified thickness, smoothness, and grade.

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. The screed or strike-off assembly shall effectively produce a finished surface of the required smoothness and texture without tearing, shoving, or gouging the mixture.

The paver shall be capable of operating at forward speeds consistent with satisfactory laying of the mixture.

Pavers shall be equipped with an automatic grade control system capable of maintaining the screed elevation as specified herein. The control system shall be automatically activated from either a reference line or surface through a system of mechanical sensors or sensor-directed mechanisms or devices that will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface.

The controls shall be capable of working in conjunction with any of the following attachments:

a. Ski-Type device of not less than 30 feet in length or as directed by the Engineer.
b. Taut stringline (wire) set to grade.
c. Short ski or shoe.
d. Laser controls.

The controls shall be so arranged that independent longitudinal grade controls can be operated simultaneously on both sides of the machine or independently on either side. The electronic controls shall be arranged so that the machine can be controlled automatically, semi-automatically, or manually.

The automatic equipment shall be capable of controlling the grade to within plus or minus one-eighth inch and the transverse slope to within plus or minus one tenth of one percent from the controlling grade.

The machine shall be equipped with a spirit level or other type of slope indicator that will continuously indicate the average transverse slope of the screen. Curvature of spirit level tubes shall be as required to produce a bubble movement of not less than one-eighth inch for each one-tenth of one percent change in the transverse slope.

The paving machine shall be capable of being equipped with an infrared joint heater if directed by the Engineer. The output of infrared energy shall be in the one to six micron range. Converters shall be arranged end to end directly over the joint to be heated in sufficient numbers to continuously produce, when in operation, a minimum of 240,000 BTU per hour. The joint heater shall be positioned not more than one inch above the pavement to be heated and in front of the paver screed and shall be fully adjustable. Heaters will be required to be in operation at all times.

402-4.5 ROLLERS. Rollers shall be steel wheel. Split drum rollers are not acceptable. They shall be in good condition, capable of reversing without backlash, and operating at slow speeds to avoid displacement of the bituminous mixture. The wheels shall be equipped with adjustable scrapers and sprinkling apparatuses using a water soluble asphalt release agent, approved by the engineer, to prevent the bituminous mixture from sticking to the wheels. The number, type, and weight of rollers shall be sufficient to compact the mixture without detrimentally affecting the material.

402-4.6 PREPARATION OF MINERAL AGGREGATE. The aggregate for the mixture shall be dried and heated at the central mixing plant before entering the mixer. When introduced into the mixer, the combined aggregate moisture content (weighted according to the composition of the blend) shall be 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 absorption for the aggregate blend shall be the weighted average of the absorption values for the coarse aggregate retained on the No. 4 sieve (4.75 mm) and the fine aggregate passing the No. 4 sieve (4.75 mm). The water content test will be conducted in accordance with ASTM C 566. In no case shall the moisture content be such that foaming of the mixture occurs prior to placement. At the time of mixing, the temperature of the aggregate shall be within the range specified in the job mix formula. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. Particular care shall be taken so that aggregates high in calcium or magnesium content are not damaged by overheating. The aggregate shall be screened to specified sizes and conveyed in separate bins ready for mixing with bituminous material.

402-4.7 PREPARATION OF BITUMINOUS MIXTURE. The bituminous mixture shall be prepared in a central mixing plant. The mixture shall be prepared at the temperature designated by the mix design.

The dry aggregate shall be combined in the plant using the proportionate amounts of each aggregate size required to meet the specified gradation. The quantity of aggregate for each batch shall be determined, measured, and conveyed into the mixer.

The quantity of bituminous material for each batch or the calibrated amount for continuous mixers shall be determined by the certified laboratory that prepared the mix design. It shall be measured by weight and introduced into the mixer within the temperature range specified in the job mix formula. For batch mixers, all aggregates shall be in the mixer before the bitumen material is added. In no case shall the temperature of the aggregate be more than 25°F above the temperature of the bituminous material. Mixing shall continue until all particles are coated uniformly. In no case shall the bituminous mixture be stored in storage silos or surge bins.

402-4.8 TRANSPORTATION AND DELIVERY OF THE MIXTURE. The mixture shall be placed at a temperature between 250°F and 300°F. Loads shall be sent from the plant so that all spreading and compacting of the mixture may be accomplished during daylight hours. Excessive waiting or delay of haul trucks at the job site shall not be allowed and mix supplied at temperatures outside the specified range will not be accepted. Bleeding and rich spots resulting from segregation during transportation shall not be accepted.

402-4.9 SPREADING AND LAYING. Immediately before placing the porous friction course, the underlying course shall be cleared of all loose or deleterious material with power blowers, power brooms, or hand brooms as

directed. A tack coat conforming to Item P-603 Bituminous Tack Coat shall be placed on all existing surfaces for bonding the PFC to the existing surface. Placement of the PFC must be delayed until the tack coat has properly cured.

The mixture shall be deposited from haul units directly into the laydown machine hopper and placed in a continuous operation.

Hauling over material already placed shall not be permitted until the material has been thoroughly compacted and allowed to cure for a period of at least 12 hours.

402-4.10 COMPACTION OF MIXTURE. After spreading, rolling shall be done immediately. Two or four passes, at the discretion of the Engineer, with a steel wheel roller weighing no more than 10 tons, shall be made for compaction. Care should be taken to avoid over rolling or rolling when material is too cool. To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened using a water soluble asphalt release agent approved by the engineer. Rolling operations shall be conducted in such a manner that shoving or distortion will not develop. The amount of rolling shall be limited to only that necessary for compacting the porous friction course and bonding it to the underlying surface course. Any mixture, which becomes loose, broken, mixed with dirt, or in any way defective, shall be removed and replaced with fresh mixture and immediately compacted to conform to the surrounding area. Such rework shall be done at the Contractor's expense. Spreading of the mixture shall be done carefully with particular attention given to making the operation as continuous as possible. Hand working shall be kept to an absolute minimum.

Contractor quality control shall utilize a nuclear gauge to monitor compaction efforts.

402-4.11 JOINTS. The formation of all joints shall be made in such a manner as to ensure a continuous bond between old and new sections of the course. All joints shall present the same texture, density, and smoothness as other sections of the course.

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 course, 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 bituminous 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 bituminous material prior to placing any fresh mixture against the joint. The longitudinal joint shall offset that in the existing course by at least 1 foot (30 cm).

402-4.12 SHAPING EDGES. While the surface is being compacted and finished, the Contractor shall carefully shape the longitudinal outside edges of the PFC to a vertical face at the established edge. When transitioning from PFC to existing pavement, transverse edges shall be constructed with a finer graded bituminous mixture.

*** ***

Edge lips shall not exceed 3-inches; however, they are preferred to be less than 1.5-inches. This may be a problem on projects that have excessive surface irregularities.

*** ***

402-4.13 SURFACE TESTS. The Contractor is responsible for supplying an acceptable metal 12-foot straight edge. After completion of final rolling, the finished surface shall be tested with the 12-foot straightedge and shall not vary more than 1/4 inch. The 12-foot straight edge shall be applied parallel with and at right angles to the runway centerline in a pattern that includes longitudinal and transverse joints. The 12-foot straightedge shall be advanced approximately 1/2 its length in the line of measurement. Areas of the porous friction course exceeding the specified tolerances shall be removed, as directed by the Engineer, and replaced with new material at the

Contractor's expense. The Engineer shall immediately notify the Contractor of such unsatisfactory visual defects such as non-uniform texture, roller marks, bleeding of bituminous material, cracking and shoving of the mixture during rolling operations. Areas of the porous friction course, which possess such defects, shall be removed, as directed by the Engineer, and replaced with new material at the Contractors expense. Skin patching or hand working shall not be permitted.

402-4.14 ACCEPTANCE SAMPLING AND TESTING OF BITUMINOUS MATERIAL AND AGGREGATE. The Engineer, at no cost to the Contractor, shall perform all acceptance sampling and testing. The testing laboratory performing the testing shall meet the requirements of ASTM D 3666.

Samples of the PFC mixture shall be taken at the point of discharge in hauling units and tested to control uniformity in bituminous content and gradation. Samples shall be taken in accordance with ASTM D 979 and prepared in accordance with ASTM D 2172 or ASTM D 6307. One sample shall be taken from each lot on a random basis in accordance with procedures contained in ASTM D 3665. A lot shall consist of 1,000 tons or 1/2 day's production, whichever is less. Should the average bituminous content for any two consecutive lots not fall within job mix tolerances under 402-3.1, the Contractor shall cease production until such out-of-tolerance conditions have been remedied. Any material, placed after the contractor has been informed of two consecutive failing tests, shall be rejected and removed at the Contractor's expense.

Aggregate from each hot bin or aggregate feed shall be sampled on a random basis and tested for gradation analysis in accordance with ASTM C 136. One sample shall be taken on a random basis in accordance with ASTM D 3665 for each lot. A lot shall consist of 500 tons or 1/4 day's production, whichever is less. If any two consecutive samples fail to meet the tolerances of the job mix formula gradation, the Contractor shall cease plant production until such out-of tolerance conditions have been remedied. Any material, placed after the contractor has been informed of two consecutive failing tests, shall be rejected and removed at the Contractor's expense.

The Engineer will notify the Contractor of unsatisfactory visual defects in the completed bituminous friction course such as non-uniform texture, roller marks, bleeding of bituminous material, cracking and shoving of the mixture during the roller operations, or nonconformance to the surface smoothness criteria specified. Unsatisfactory bituminous friction course shall be removed and replaced at the Contractor's expense as directed by the Engineer.

402-4.15 BITUMINOUS AND AGGREGATE MATERIAL (CONTRACTOR'S RESPONSIBILITY). Samples of the bituminous and aggregate materials that the Contractor proposes to use, together with a statement of their source and character, shall be submitted for approval prior to use. The Contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish material subject to this and all other pertinent requirements of the contract. Only those materials that have been tested and approved for the intended use shall be acceptable.

The Contractor shall furnish the vendor's certified test reports for each carload or equivalent of bituminous material shipped to the project. The report shall be delivered to the Engineer before permission is granted to use the material. The vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All test reports shall be subject to verification by testing sample materials received for use on the project.

402-4.16 PROTECTION OF PAVEMENT. After final rolling, no vehicular traffic of any kind shall be permitted on the pavement until it has cured at least 12 hours or unless otherwise authorized by the Engineer. Newly constructed pavement areas shall not be opened to aircraft traffic until 24 hours after completion or unless otherwise authorized by the Engineer.

METHOD OF MEASUREMENT

402-5.1 Porous friction course shall be measured by the number of **[square yards (square meters)][tons (kg)]** of mixture used in the accepted work.

Only the areas of the porous friction course meeting the following thickness requirements shall be measured for payment:

To determine the thickness of the finished PFC, the Engineer shall take one core sample, not less than 2 inches (5 cm) in diameter, at random from each unit of the completed PFC area. A unit of the completed area shall be one paving lane wide by 1,000 feet (304 m) long. The last unit in any one paving lane shall include any remaining length in addition to the 1,000 feet (304 m).

When the measurement of any core is more than the maximum or less than the minimum allowable thickness, as shown in Table 3, additional cores shall be taken at 20-foot intervals (6 m) (parallel to and at right angles to the runway centerline) until the completed PFC is within such maximum or minimum thickness for the subunit being tested. Out-of-tolerance areas shall be deducted from the total **[square yards (square meters)][tons (kg)]** PFC for payment. If, in the Engineer's judgment, such out of tolerance areas warrant removal, the PFC shall be removed and the underlying course shall be cleaned (ready for reconstruction), all at the Contractor's expense.

TABLE 3. ALLOWABLE FINISHED PFC THICKNESS

	Nominal		Maximum		Minimum	
	in.	mm	in.	mm	in.	mm
3/4 in. aggregate	1.0	25	1.50	37	0.75	19
1/2 in. aggregate	0.75	19	1.25	32	0.50	12

BASIS OF PAYMENT

402-6.1 Payment shall be made at the respective contract prices per **[square yard (square meter)][ton (kg)]** for porous friction course and per **[gallon (liter)][ton (kg)]** for bituminous material. The prices shall be full compensation for furnishing all materials; for all preparation and storage of materials; for cleaning the existing surface; for mixing, hauling, placing, and compacting the mixture (including initial test section); and for all tools, equipment, and incidentals necessary to complete each item. No separate payment is included in the contract for furnishing and batching mineral filler, or anti-stripping agents, should such items be required.

Rehabilitation of the existing pavement surface and the tack coat shall be measured and paid for at their respective contract prices.

Payment will be made under:

Item P-402-6.1	Porous Friction Course—**[per square yard (square meter)][ton (kg)]**
Item P-402-6.2	Bituminous material—**[per gallon (liter)][ton (kg)]**

TESTING REQUIREMENTS

ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 127	Density, Specific Gravity, and Absorption of Coarse Aggregates
ASTM C 128	Density, Specific Gravity, and Absorption of Fine Aggregate
ASTM C 131	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C 566	Total Evaporable Moisture Content of Aggregate by Drying
ASTM D 693	Crushed Aggregate for Macadam Pavements

ASTM D 979	Sampling Bituminous Paving Mixtures
ASTM D 995	Mixing Plants for Hot-Mixed Hot-Laid Bituminous Paving Mixtures
ASTM D 2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2741	Susceptibility of Polyethylene Bottles to Soot Accumulation
ASTM D 3665	Random Sampling of Paving Materials
ASTM D 3666	Minimum Requirements for Agencies Testing and Inspecting Bituminous Paving Materials
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 6307	Standard Test Method for Asphalt Content of Hot Mix Asphalt by Ignition Method

MATERIAL REQUIREMENTS

ASTM D 242	Mineral Filler for Bituminous Paving Mixtures
ASTM D 3381	Viscosity-Graded Asphalt Cement for Use in Pavement Construction

END OF ITEM P-402

ITEM P-403 PLANT MIX BITUMINOUS PAVEMENTS (BASE, LEVELING OR SURFACE COURSE)

DESCRIPTION

403-1.1 This item shall consist of a **[ ]** course composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

* *

Specify base and/or leveling course(s). Surface course may also be specified but only for those pavements designed to accommodate aircraft of gross weights less than or equal to 12,500 pounds (5,670 kg) or for surface course of shoulders, blast pads, service roads, etc. Item P-401 is to be specified for surface courses for pavements designed to accommodate aircraft gross weights greater than 12,500 pounds (5,670 kg).

This specification is to be used as a base or leveling course for pavements designed to accommodate aircraft of gross weights greater than 12,500 pounds (5,670 kg). State highway department specifications may be used in lieu of this specification for access roads, perimeter roads, stabilized base courses under Item P-501, and other pavements not subject to aircraft loading, or for pavements designed for aircraft gross weights of 12,500 pounds (5,670 kg) or less.

Where a state highway department specification is to be used in lieu of this specification, the state specification must have a demonstrated satisfactory performance record under equivalent loadings and exposure. When a density requirement is not specified by a state specification, it is to be modified to incorporate the language found in paragraphs 403-5.1, 403-5.2 and 403-5.3. When state highway specification are approved, include all applicable/approved state specifications in the contract documents.

* *

MATERIALS

403-2.1 AGGREGATE. Aggregates shall consist of crushed stone, crushed gravel, or crushed slag with or without natural sand or other inert finely divided mineral aggregate. The portion of combined materials retained on the No. 4 (4.75 mm) sieve is coarse aggregate. The portion of combined materials passing the No. 4 (4.75 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No. 200 (0.075 mm) sieve is mineral filler.

a. Coarse Aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of matter that would prevent thorough coating and bonding with the bituminous material and be free from organic matter and other deleterious substances. The percentage of wear shall not be greater than **[ ]** 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.

* *

Percentage of wear shall not exceed 40 for surface, binder, and leveling courses and 50 for base course. Aggregates with a higher percentage loss of wear or soundness may be specified in lieu of those indicated, provided a satisfactory service record under similar conditions of service and exposure has been demonstrated.

* *

Aggregate shall contain at least **[ ]** percent by weight of individual pieces having two or more fractured faces and **[ ]** percent by weight having at least one fractured face. The area of each face shall be equal to at least 75 percent of the smallest midsectional 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. Fractured faces shall be obtained by crushing.

* *

For pavement courses designed for aircraft gross weights of 60,000 pounds (27 200 kg) or more, the Engineer shall specify 70 percent for two fractured faces and 85 percent for one fractured face. For pavement courses designed for aircraft gross weights less than 60,000 pounds (27 200 kg), the Engineer shall specify 50 percent for two fractured faces and 65 percent for one fractured face.

In areas where slag is not available or desired, the references to it should be deleted from all aggregate paragraphs.

* *

The aggregate shall not contain more than a total of 8 percent, by weight, of flat particles, elongated particles, and flat and elongated particles, when tested in accordance with ASTM D 4791 with a value of 5:1.

* *

The Engineer may specify ASTM D 4791 with a ratio of 3:1. If so, replace the above paragraph as follows: "The aggregate shall not contain more than a total of 20 percent by weight of flat particles, elongated particles, and flat and elongated particles when tested in accordance with ASTM D4791 with a value of 3:1."

* *

Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 mg/cubic meter) when tested in accordance with ASTM C 29.

b. Fine Aggregate. Fine aggregate shall consist of clean, sound, durable, angular shaped particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter and shall contain no clay balls. The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318.

Natural (nonmanufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. **[**The fine aggregate shall not contain more than 15 percent natural sand by weight of total aggregates.**]** If used, the natural sand shall meet the requirements of ASTM D 1073 and shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318.

The aggregate shall have sand equivalent values of **[ ]** or greater when tested in accordance with ASTM D 2419.

*** ***

Typically the sand equivalent value should be 45, unless local conditions require lower value.

The addition of natural sand to a mix containing all crushed coarse and fine aggregates will normally increase its workability and compactability. However, the addition of excessive amounts of natural sand tends to decrease the stability of the mixture. The requirement for a sand equivalent value of 45 usually limits the use of natural sand; however, the maximum of 15 percent natural sand may be included for locations where low stabilities are a chronic problem.

*** ***

c. Sampling. ASTM D 75 shall be used in sampling coarse and fine aggregate, and ASTM C 183 shall be used in sampling mineral filler.

403-2.2 MINERAL FILLER. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242.

403-2.3 BITUMINOUS MATERIAL. Bituminous material shall conform to the following requirements: **[ ]**.

*** ***

Asphalt cement binder shall conform to [AASHTO MP1 Performance Grade (PG) [_____]] [ASTM D 3381 Table 1, 2, or 3 Viscosity Grade][ASTM D 946 Penetration Grade [_____]]. Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Copies of these certifications shall be submitted to the Engineer. The Engineer shall specify the grade of bituminous material, based on geographical location and climatic conditions. Asphalt Institute Superpave Series No. 1 (SP-1) provides guidance on the selection of performance graded binders. Table VI-1, Selecting Asphalt Grade, contained in the Asphalt Institute's Manual Series-1 (MS-1) provides guidance on the selection of asphalt type. For cold climates, Table 2 of ASTM D 3381 may be specified to minimize the susceptibility for thermal cracking. The Engineer should be aware that PG asphalt binders may contain modifiers that require elevated mixing and compaction temperatures that exceed the temperatures specified in Item P-403.

Grades of some materials are listed below:

NOTE: Performance Graded (PG) asphalt binders should be specified wherever available. The same grade PG binder used by the state highway department in the area should be considered as the base grade for the project (e.g. the grade typically specified in that specific location for dense graded mixes on highways with design ESALS less than 10 million). The exception would be that grades with a low temperature higher than PG XX-22 should not be used (e.g. PG XX-16 or PG XX-10), unless the Engineer has had successful experience with them. Typically, rutting is not a problem on airport runways. However, at airports with a history of stacking on end of runways and taxiway areas, rutting has accrued due to the slow speed of loading on the pavement. If there has been rutting on the project or it is anticipated that stacking may accrue during the design life of the project, then the following grade "bumping" should be applied for the top 125 mm (5 inches) of paving in the end of runway and taxiway areas: for aircraft tire pressure between 100 and 200 psi, increase the high temperature one grade; for aircraft tire pressure greater than 200 psi, increase the high temperature two grades. Each grade adjustment is 6 degrees C. Polymer Modified Asphalt, PMA, has shown to perform very well in these areas. The low temperature grade should remain the same.

Additional grade bumping and grade selection information is given in Table A.

TABLE A. BINDER GRADE SELECTION AND GRADE BUMPING BASED ON GROSS AIRCRAFT WEIGHT.

Aircraft Gross Weight (pounds)	High Temperature Adjustment to Base Binder Grade	
	Pavement Type	
	Runway	Taxiway/Apron
Less than 12,500	--	--
Less than 60,000	--	1
Less than 100,000	--	1
Greater than 100,000	1	2

NOTES:
1. PG grades above a –22 on the low end (e.g. 64–16) are not recommended. Limited experience has shown this to be a poor performer.
2. PG grades below a 64 on the high end (e.g. 58-22) are not recommended. These binders often provide tender tendencies.
3. PG grades above a 76 on the high end (e.g. 82-22) are very stiff and may be difficult to work and compact.

Grade Specification			
Penetration Grade ASTM D 946	Viscosity Grade ASTM D 3381		Performance Graded Asphalt Institute Superpave Series No. 1(SP-1)
40-50 60-70 85-100 100-120 120-150	AC-5 AC-10 AC-15 AC-20 AC-30 AC-40	AR-1000 AR-2000 AR-4000 AR-8000	In general, the Engineer should choose a PG-asphalt binder that has been approved for use in the vicinity by the State DOT, and is locally available. In general, a high reliability (98 percent) on both the high and low temperature categories is sufficiently conservative.

*** ***

The Contractor shall furnish vendor's certified test reports for each lot of bituminous material shipped to the project. The vendor's certified test report for the bituminous material can be used for acceptance or tested independently by the Engineer.

403-2.4 PRELIMINARY MATERIAL ACCEPTANCE. Prior to delivery of materials to the job site, the Contractor shall submit certified test reports to the Engineer for the following materials:

a. Coarse Aggregate.

(1) Percent of wear.
(2) Soundness.
(3) Unit weight of slag.
(4) Percent fractured faces

b. Fine Aggregate.

(1) Liquid limit.

(2) Plasticity index.
(3) Sand equivalent.

c. Mineral Filler.

d. Bituminous Material. Test results for bituminous material shall include temperature/viscosity charts for mixing and compaction temperatures.

The certification(s) shall show the appropriate ASTM test(s) for each material, the test results, and a statement that the material meets the specification requirement.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

403-2.5 ANTI-STRIPPING AGENT. Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the Department of Transportation of the State in which the project is located.

COMPOSITION

403-3.1 COMPOSITION OF MIXTURE. The bituminous plant mix shall be composed of a mixture of well-graded aggregate, filler and anti-strip agent if required, and bituminous material. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF).

403-3.2 JOB MIX FORMULA. No bituminous mixture for payment shall be produced until a job mix formula has been approved in writing by the Engineer. The bituminous mixture shall be designed using procedures contained in Chapter 5, MARSHALL METHOD OF MIX DESIGN, of the Asphalt Institute's Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete, sixth edition, and shall meet the requirements of Tables 1, 2 and 3.

* *

Engineer may specify the Eastern Region Laboratory Procedures Manual (ERLPM), Section 2 in lieu of MS-2.

* *

Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D 4867, shall not be less than 75. Anti-stripping agent shall be added to the asphalt, as necessary, to produce a TSR of not less than 75. If an antistrip agent is required, it will be provided by the Contractor at no additional cost to the Owner.

* *

Engineer may specify a TSR of not less than 80 in areas that are prone to stripping at a TSR of 75.

* *

The job mix formula shall be submitted in writing by the Contractor to the Engineer at least **[ ]** days prior to the start of paving operations and shall include as a minimum:

a. 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 job mix formula.
b. Percent of asphalt cement.

c. Asphalt performance, viscosity or penetration grade, and type of modifier if used.

d. Number of blows of hammer compaction per side of molded specimen.

e. Mixing temperature.

f. Compaction temperature.

g. Temperature of mix when discharged from the mixer.

h. Temperature-viscosity relationship of the asphalt cement.

i. Plot of the combined gradation on the Federal Highway Administration (FHWA) 45 power gradation curve.

j. Graphical plots of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content.

k. Percent natural sand.

l. Percent fractured faces.

m. Percent by weight of flat particles, elongated particles, and flat and elongated particles (and criteria).

n. Tensile Strength Ratio (TSR).

o. Antistrip agent (if required).

The Contractor shall submit to the Engineer the results of verification testing of three (3) asphalt samples prepared at the optimum asphalt content. The average of the results of this testing shall indicate conformance with the job mix formula requirements specified in Tables 1, 2 and 3.

When the project requires asphalt mixtures of differing aggregate gradations, a separate job mix formula and the results of job mix formula verification testing must be submitted for each mix.

The job mix formula for each mixture shall be in effect until a modification is approved in writing by the Engineer. Should a change in sources of materials be made, a new job mix formula must be submitted within [ ] days and approved by the Engineer in writing before the new material is used. After the initial production job mix formula(s) has/have been approved by the Engineer and a new or modified job mix formula is required for whatever reason, the subsequent cost of the Engineer's approval of the new or modified job mix formula will be borne by the Contractor. There will be no time extension given or considerations for extra costs associated with the stoppage of production paving or restart of production paving due to the time needed for the Engineer to approve the initial, new or modified job mix formula.

*** ***

The Engineer shall specify the number of days. A minimum of 10 days is recommended.

For mixes with maximum size aggregate of 1" or less, the Marshall Design Criteria applicable to the project shall be specified by the Engineer from the information shown below and inserted into Table 1. Asterisks denote insert points.

Test Property	Pavements Designed for Aircraft Gross Weights of 60,000 Lbs. or More or Tire Pressures of 100 Psi or More	Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lbs. or Tire Pressures Less Than 100 Psi

Test Property	**Pavements Designed for Aircraft Gross Weights of 60,000 Lbs. or More or Tire Pressures of 100 Psi or More**	**Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lbs. or Tire Pressures Less Than 100 Psi**
Number of Blows	**75**	**50**
Stability, pounds (newtons)	**1800 (8006)**	**1000 (4448)**
Flow, 0.01 in. (0.25 mm)	**8-16**	**8-20**
Air Voids (percent)	**2-5**	**2-5**
Percent Voids in Mineral Aggregate (minimum)	**See Table 2**	**See Table 2**

For mixes with maximum size aggregate greater than 1 inch up to a maximum of 1-½ inches, the Marshall Design Criteria shall be modified by the Engineer per the guidance found in Asphalt Institute Manual Series No. 2 (MS-2), Chapter 5 and the test method specified shall be ASTM D 5581 in lieu of ASTM D 6926. Modifications to the flow criteria may be required for modified asphalt cement binders.

****

TABLE 1. MARSHALL DESIGN CRITERIA

TEST PROPERTY	*
Number of blows	*
Stability, pounds (newtons) minimum	*
(newtons) minimum	
Flow, 0.01 in. (0.25 mm)	*
Air voids (percent)	*
Percent voids in mineral aggregate, minimum	See Table 2

TABLE 2. MINIMUM PERCENT VOIDS IN MINERAL AGGREGATE

Maximum Particle Size		Minimum Voids in Mineral Aggregate, percent
in.	mm	Percent
½	12.5	16
¾	19.0	15
1	25.0	14
1-½	37.5	13

****

Modifications to the minimum VMA as found in Table 2 may be made depending on the definition of maximum particle size and/or local conditions.

****

The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation or gradations specified in Table 3 when tested in accordance with ASTM C 136 and C 117.

The gradations in Table 3 represent the limits that shall determine the suitability of aggregate for use from the sources of supply. The aggregate, as selected (and used in the JMF), shall have a gradation within the limits designated in Table 3 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be well graded from coarse to fine.

Deviations from the final approved mix design for bitumen content and gradation of aggregates shall be within the action limits for individual measurements as specified in paragraph 403-6.5a. The limits still will apply if they fall outside the master grading band in Table 3.

The maximum size aggregate used shall not be more than one-half of the thickness of the course being constructed except where otherwise shown on the plans or ordered by the Engineer.

TABLE 3. AGGREGATE - BITUMINOUS PAVEMENTS

Sieve Size	Percentage by Weight Passing Sieve
1-½ in. (37.50 mm)	*
1 in. (25.0 mm)	*
¾ in. (19.0 mm)	*
½ in. (12.5 mm)	*
⅜ in. (9.5 mm)	*
No. 4 (4.75 mm)	*
No. 8 (2.36 mm)	*
No. 16 (1.18 mm)	*
No. 30 (0.60 mm)	*
No. 50 (0.30 mm)	*
No. 100 (0.15 mm)	*
No. 200 (0.075 mm)	*
Asphalt percent	
Stone or gravel	*
Slag	*

The aggregate gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when aggregates of varying specific gravities are used, as indicated in the Asphalt Institute Manual Series No. 2 (MS-2), Chapter 3.

*** ***

The aggregate gradation shall be specified by the Engineer from the gradations shown in this note. The gradation shall be inserted into Table 3. Asterisks denote insert points.

Where locally-available aggregates cannot be economically blended to meet the grading requirements of the gradations shown, the gradations may be modified to fit the characteristics of such local aggregates with approval of the FAA. The modified gradation must produce a paving mixture that satisfies the mix design requirements.

AGGREGATE - BITUMINOUS PAVEMENTS				
Sieve Size	**Percentage by Weight Passing Sieves**			
	1-½" max	**1" max**	**¾ " max**	**½" max**
1-½ in. (37.5 mm)	**100**	**--**	**--**	**--**
1 in. (24.0 mm)	**86-98**	**100**	**--**	**--**
¾ in. (19.0 mm)	**68-93**	**76-98**	**100**	**--**
½ in. (12.5 mm)	**57-81**	**66-86**	**79-99**	**100**
⅜ in. (9.5 mm)	**49-69**	**57-77**	**68-88**	**79-99**
No. 4 (4.75 mm)	**34-54**	**40-60**	**48-68**	**58-78**
No. 8 (2.36 mm)	**22-42**	**26-46**	**33-53**	**39-59**
No. 16 (1.18 mm)	**13-33**	**17-37**	**20-40**	**26-46**
No. 30 (0.600 mm)	**8-24**	**11-27**	**14-30**	**19-35**
No. 50 (0.300 mm)	**6-18**	**7-19**	**9-21**	**12-24**
No. 100 (0.150 mm)	**4-12**	**6-16**	**6-16**	**7-17**
No. 200 (0.075 mm)	**3-6**	**3-6**	**3-6**	**3-6**
Asphalt percent: **Stone or gravel** **Slag**	 **4.5-7.0** **5.0-7.5**	 **4.5-7.0** **5.0-7.5**	 **5.0-7.5** **6.5-9.5**	 **5.5-8.0** **7.0-10.5**

*** ***

403-3.3 RECYCLED ASPHALT CONCRETE. Recycled HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement. The RAP shall be of a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed 2 inches. The recycled HMA mix shall be designed using procedures contained in AI MS-02. The recycled asphalt concrete mix shall be designed using procedures contained in the Asphalt Institute's Manual Series Number 2 (MS-2). The percentage of asphalt in the RAP shall be established for the mixture design according to ASTM D 2172 using the appropriate dust correction procedure. The job mix shall meet the requirements of paragraph 403-3.2 RAP should only be used for shoulder surface course mixes and for any intermediate courses. The amount of RAP shall be limited to **[ ]** percent.

*** ***

Reclaimed Asphalt Pavement (RAP) should not be used for surface mixes, except on shoulders. It can be used very effectively in lower layers or for shoulders. Engineer to specify the maximum percentage of reclaimed asphalt allowed in the mix. The amount of RAP shall be limited to 30 percent, as long as the resulting recycled mix meets all requirements that are specified for virgin mixtures. The Contractor may obtain the RAP from the job site or an existing source.

*** ***

In addition to the requirements of paragraph 403-3.2, the job mix formula shall indicate the percent of reclaimed asphalt pavement and the percent and viscosity grade of new asphalt. The Contractor shall submit documentation to the Engineer, indicating that the mixing equipment proposed for use is adequate to mix the percent of RAP shown in the job mix formula and meet all local and national environmental regulations.

* *

The appropriate test should be selected to conform to the grade of new asphalt specified. If a penetration grade is specified, use penetration test. If a viscosity grade is specified, use a viscosity test. If a PG asphalt binder is specified, use the dynamic shear rheometer and bending beam tests. RAP containing coal tars may be require additional precautions during production and may be excluded.

* *

The blend of new asphalt cement and the RAP asphalt binder shall meet the requirements in paragraph 403-2.3. The virgin asphalt cement shall not be more than two standard asphalt material grades different than that specified in paragraph 403-2.3

* *

Delete paragraph 403-3.3 in its entirety if recycled asphalt pavement is not to be allowed and include a sentence that RAP will not be permitted to be used.

* *

403-3.4 TEST SECTION. Prior to full production, the Contractor shall prepare and place a quantity of bituminous mixture according to the job mix formula. The amount of mixture shall be sufficient to construct a test section **[ ]** long and **[ ]** wide**,** placed in two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the construction of the course which it represents. A cold joint is an exposed construction joint at least 4 hours old or whose mat has cooled to less than 160°F. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment 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.

THE TEST SECTION SHALL BE EVALUATED FOR ACCEPTANCE AS A SINGLE LOT IN ACCORDANCE WITH THE ACCEPTANCE CRITERIA IN PARAGRAPH 403-5.1 AND 403-6.3. THE TEST SECTION SHALL BE DIVIDED INTO EQUAL SUBLOTS. AS A MINIMUM THE TEST SECTION SHALL CONSIST OF 3 SUBLOTS.

The test section shall be considered acceptable if the average mat density of the test section cores is greater than or equal to 98 percent and the average joint density of the test section cores is greater than or equal to 95 percent. If the initial test section should prove to be unacceptable, the necessary adjustments to the job mix formula, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the Contractor's expense. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Any additional sections that are not acceptable shall be removed at the Contractor's expense. Full production shall not begin until an acceptable section has been constructed and accepted in writing by the Engineer. Once an acceptable test section has been placed, payment for the initial test section and the section that meets specification requirements shall be made in accordance with paragraph 403-8.1.

Job mix control testing shall be performed by the Contractor at the start of plant production and in conjunction with the calibration of the plant for the job mix formula. If the aggregates produced by the plant do not satisfy the gradation requirements or produce a mix that meets the JMF, it will be necessary to reevaluate and redesign the mix using plant-produced aggregates. Specimens shall be prepared and the optimum bitumen content determined in the same manner as for the original design tests.

* *

The test section should be a minimum of 300 feet (90 m) long and 20 to 30 feet (6 to 9 m) wide. The test section affords the Contractor and the Engineer an opportunity to determine

the quality of the mixture in place, as well as performance of the plant and laydown equipment.

*** ***

403-3.5 TESTING LABORATORY. The Contractor's laboratory used to develop the job mix formula shall meet the requirements of ASTM D 3666 including the requirement to be accredited by a national authority such as the National Voluntary Laboratory Accreditation Program (NVLAP), the American Association for Laboratory Accreditation (AALA), or AASHTO Accreditation Program (AAP). A certification signed by the manager of the laboratory stating that it meets these requirements shall be submitted to the Engineer prior to the start of construction. The certification shall contain as a minimum:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

e. ASTM D 3666 certification of accreditation by a nationally recognized accreditation program.

CONSTRUCTION METHODS

403-4.1 WEATHER LIMITATIONS. The bituminous mixture shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 4. The temperature requirements may be waived by the Engineer, if requested; however, all other requirements including compaction shall be met.

TABLE 4. BASE TEMPERATURE LIMITATIONS

Mat Thickness	Base Temperature (Minimum)	
	Deg. F	Deg. C
3 in. (7.5 cm) or greater	40	4
Greater than 1 in. (2.5 cm) but less than 3 in. (7.5 cm)	45	7
1 in. (2.5 cm) or less	50	10

403-4.2 BITUMINOUS MIXING PLANT. Plants used for the preparation of bituminous mixtures shall conform to the requirements of ASTM D 995 with the following changes:

a. Requirements for All Plants.

(1) Truck Scales. The bituminous mixture shall be weighed on approved scales furnished by the Contractor, or on certified public scales at the Contractor's expense. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of the General Provisions, Section 90-01.

In lieu of scales, and as approved by the Engineer, asphalt mixture weights may be determined by the use of an electronic weighing system equipped with an automatic printer that weighs the total paving mixture. Contractor must furnish calibration certification of the weighing system prior to mix production and as often thereafter as requested by the Engineer.

(2) Testing Facilities. The Contractor shall provide laboratory facilities at the plant for the use of the Engineer's acceptance testing and the Contractor's quality control testing. The Engineer will always have priority in

the use of the laboratory. The lab shall have sufficient space and equipment so that both testing representatives (Engineer's and Contractor's) can operate efficiently. The lab shall also meet the requirements of ASTM D 3666.

The plant testing laboratory shall have a floor space area of not less than 150 square feet, with a ceiling height of not less than 7-½ feet. The laboratory shall be weather tight, sufficiently heated in cold weather, air-conditioned in hot weather to maintain temperatures for testing purposes of 70 degrees F +/- 5 degrees F. The plant testing laboratory shall be located on the plant site to provide an unobstructed view, from one of its windows, of the trucks being loaded with the plant mix materials.

Laboratory facilities shall be kept clean, and all equipment shall be maintained in proper working condition. The Engineer shall be permitted unrestricted access to inspect the Contractor's laboratory facility and witness quality control activities. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

As a minimum, the plant testing laboratory shall have:

(a) Adequate artificial lighting

(b) Electrical outlets sufficient in number and capacity for operating the required testing equipment and drying samples.

(c) Fire extinguishers (2), Underwriter's Laboratories approved

(d) Work benches for testing, minimum 2-½ feet by 10 feet.

(e) Desk with 2 chairs

(f) Sanitary facilities convenient to testing laboratory

(g) Exhaust fan to outside air, minimum 12 inch blade diameter

(h) A direct telephone line and telephone including a FAX machine operating 24 hours per day, seven days per week

(i) File cabinet with lock for Engineer

(j) Sink with running water, attached drain board and drain capable of handling separate material

(k) Metal stand for holding washing sieves

(l) Two element hot plate or other comparable heating device, with dial type thermostatic controls for drying aggregates

(m) Mechanical shaker and appropriate sieves (listed in JMF, Table 3) meeting the requirements of ASTM E-11 for determining the gradation of coarse and fine aggregates in accordance with ASTM C 136

(n) Marshall testing equipment meeting ASTM D 6926, ASTM D 6927, or ASTM D 5581 as necessary, automatic compaction equipment capable of compacting three specimens at once and other apparatus as specified in ASTM C 127, D 2172, D 2726, and D 2041

(o) Oven, thermostatically controlled, inside minimum 1 cubic foot

(p) Two volumetric specific gravity flasks, 500 CC

(q) Other necessary hand tools required for sampling and testing

(r) Library containing contract specifications, latest ASTM volumes 4.01, 4.02,4.03 and 4.09, AASHTO standard specification parts I and II, and Asphalt Institute Publication MS-2.

(s) Equipment for Theoretical Specific Gravity testing including a 4,000 cc pycnometer, vacuum pump capable of maintaining 30 ml mercury pressure and a balance, 16-20 kilograms with accuracy of 0.5 grams

(t) Extraction equipment, centrifuge and reflux types and ROTOflex equipment

(u) A masonry saw with diamond blade for trimming pavement cores and samples

(v) Telephone

Approval of the plant and testing laboratory by the Engineer requires all facilities and equipment to be in good working order during production, sampling and testing. Failure to provide the specified facilities shall be sufficient cause for disapproving bituminous plant operations.

The Owner shall have access to the lab and at the plant whenever Contractor is producing asphalt for the project.

(3) Inspection of Plant. The Engineer, or Engineer's authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant: verifying weights, proportions, and material properties; and checking the temperatures maintained in the preparation of the mixtures.

(4) Storage Bins and Surge Bins. Use of surge bins or storage bins for temporary storage of hot bituminous mixtures will be permitted as follows:

(a) The bituminous mixture may be stored in surge bins for a period of time not to exceed 3 hours.

(b) The bituminous mixture may be stored in insulated storage bins for a period of time not to exceed 24 hours**.**

The bins shall be such that mix drawn from them meets the same requirements as mix loaded directly into trucks.

If the Engineer determines that there is an excessive amount of heat loss, segregation or oxidation of the mixture due to temporary storage, no temporary storage will be allowed.

403-4.3 HAULING EQUIPMENT. Trucks used for hauling bituminous mixtures shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of an approved asphalt release agent. Petroleum products shall not be used for coating truck beds. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

403-4.4 BITUMINOUS PAVERS. Bituminous pavers shall be self-propelled with an activated heated screed, capable of spreading and finishing courses of bituminous plant mix material that will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

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.

The paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices that 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 feet (9.14 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 in use leaves tracks or indented areas, or produces other blemishes in the pavement and/or base course that are not satisfactorily corrected by the scheduled operations, the use of such equipment shall be discontinued and satisfactory equipment shall be provided by the Contractor.

403-4.5 ROLLERS. Rollers of the vibratory, steel wheel, and pneumatic-tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition.

All rollers shall be specifically designed and suitable for compacting hot mix bituminous concrete and shall be properly used. Rollers that impair the stability of any layer of a pavement structure or underlying soils shall not be used. Depressions in pavement surfaces caused by rollers shall be repaired by the Contractor at its own expense.

The use of equipment that causes crushing of the aggregate will not be permitted.

a. Nuclear Densometer. The Contractor shall have on site a nuclear densometer during all paving operations in order to assist in the determination of the optimum rolling pattern, type of roller and frequencies, as well as to monitor the effect of the rolling operations during production paving. The Contractor shall also supply a qualified technician during all paving operations to calibrate the nuclear densometer and obtain accurate density readings for all new bituminous concrete. These densities shall be supplied to the Engineer upon request at any time during construction. No separate payment will be made for supplying the density gauge and technician.

403-4.6 PREPARATION OF BITUMINOUS MATERIAL. The bituminous material shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of the bituminous material delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 325 degrees F (160 degrees C), unless otherwise required by the manufacturer.

403-4.7 PREPARATION OF MINERAL AGGREGATE. The aggregate for the mixture shall be heated and dried prior to introduction into the mixer. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. The temperature of the aggregate and mineral filler shall not exceed 350 degrees F (175 degrees C) when the asphalt is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

403-4.8 PREPARATION OF BITUMINOUS MIXTURE. The aggregates and the bituminous material shall be weighed or metered and introduced into the mixer in the amount specified by the job mix formula.

The combined materials shall be mixed until the aggregate obtains a uniform coating of bitumen and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the Contractor, based on the procedure for determining the percentage of coated particles described in ASTM D 2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to achieve 95 percent of coated particles. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer. The moisture content of all bituminous mixtures upon discharge shall not exceed 0.5 percent.

* *

For batch plants, wet mixing time begins with the introduction of bituminous material into the mixer and ends with the opening of the mixer discharge gate. Distribution of aggregate and bituminous material as they enter the pugmill, speed of mixer shafts, and arrangement and pitch of paddles are factors governing efficiency of mixing. Prolonged exposure to air and heat in the pugmill hardens the asphalt film on the aggregate. Mixing time, therefore, should be the shortest time required to obtain uniform distribution of aggregate sizes and thorough coating of aggregate particles with bituminous material.

* *

403-4.9 PREPARATION OF THE UNDERLYING SURFACE. Immediately before placing the bituminous mixture, the underlying course shall be cleaned of all dust and debris. A prime coat or tack coat shall be applied in accordance with Item P-602 or P-603, if shown on the plans.

* *

Engineer should evaluate the presence of paint and rubber deposits on the existing pavement and, if needed, may specify milling, grinding or other suitable means to remove same prior to placement of new bituminous material.

* *

403-4.10 LAYDOWN PLAN, TRANSPORTING, PLACING, AND FINISHING. Prior to the placement of the bituminous mixture, the Contractor shall prepare a laydown plan for approval by the Engineer. This is to minimize the number of cold joints in the pavement. The laydown plan shall include the sequence of paving laydown by stations, width of lanes, temporary ramp location(s), and laydown temperature. The laydown plan shall also include estimated time of completion for each portion of the work (i.e. milling, paving, rolling, cooling, etc.). Modifications to the laydown plan shall be approved by the Engineer.

The bituminous mixture shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 403-4.3. Deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

[The Contractor may elect to use a material transfer vehicle to deliver mix to the paver.**]**

* *

Use of a material transfer vehicle allows the paver to be operated almost continuously without stopping between truckloads of mix, if a continuous supply of mix is available from the asphalt plant. The use of a transfer vehicle is recommended on long paving lanes.

* *

Paving during nighttime construction shall require the following:

a. All paving machines, rollers, distribution trucks and other vehicles required by the Contractor for his operations shall be equipped with artificial illumination sufficient to safely complete the work.

b. Minimum illumination level shall be twenty (20) horizontal foot candles and maintained in the following areas:

(1) An area of 30 feet wide by 30 feet long immediately behind the paving machines during the operations of the machines.

(2) An area 15 feet wide by 30 feet long immediately in front and back of all rolling equipment, during operation of the equipment.

(3) An area 15 feet wide by 15 feet long at any point where an area is being tack coated prior to the placement of pavement.

c. As partial fulfillment of the above requirements, the Contractor shall furnish and use, complete artificial lighting units with a minimum capacity of 3,000 watt electric beam lights, affixed to all equipment in such a way to direct illumination on the area under construction.

d. In addition, the Contractor shall furnish [ ] portable floodlight units similar or equal to [ ].

* *

Engineer to specify the minimum number of floodlighting units and may elect to specify a particular manufacturer's lighting unit "or equal".

If nighttime paving requires the critical re-opening of airfield facilities, the following additional language should be added:

"If the Contractor places any out of specification mix in the project work area, the Contractor is required to remove it at its own expense, to the satisfaction of the Engineer. If the Contractor has to continue placing non-payment bituminous concrete, as directed by the Engineer, to make the surfaces safe for aircraft operations, the Contractor shall do so to the satisfaction of the Engineer. It is the Contractor's responsibility to leave the facilities to be paved in a safe condition ready for aircraft operations. No consideration for extended closure time of the area being paved will be given. As a first order of work for the next paving shift, the Contractor shall remove all out of specification material and replace with approved material to the satisfaction of the Engineer. When the above situations occur, there will be no consideration given for additional construction time or payment for extra costs."

* *

The initial placement and compaction of the mixture shall occur at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 250ºF (121ºC).

Edges of existing bituminous pavement abutting the new work shall be saw cut and carefully removed as shown on the drawings and painted with bituminous tack coat before new material is placed against it.

Upon arrival, the mixture shall be placed to the full width by a bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of **[ ]** except where edge lanes require less width to complete the area. Additional screed sections shall not be attached to widen paver to meet the minimum lane width requirements specified above unless additional auger sections are added to match. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 foot (30 cm); however, the joint in the surface top course shall be at the centerline of crowned pavements. Transverse joints in one course shall be offset by at least 10 feet (3 m) from transverse joints in the previous course.

Transverse joints in adjacent lanes shall be offset a minimum of 10 feet (3 m).

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools. Areas of segregation in the course, as determined by the Engineer, shall be removed and replaced at the Contractor's expense. The area shall be removed by saw cutting and milling a minimum of 2 inches deep. The area to be removed and replaced shall be a minimum width of the paver and a minimum of 10 feet long.

* *

The Engineer should specify the widest paving lane practicable in an effort to hold the number of longitudinal joints to a minimum.

* *

403-4.11 COMPACTION OF MIXTURE. After placing, the mixture shall be thoroughly and uniformly compacted by power rollers. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained.

To prevent adhesion of the mixture to the roller, the wheels shall be equipped with a scraper and kept properly moistened using a water soluble asphalt release agent approved by the engineer.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with approved power driven tampers. Tampers shall weigh not less than 275 pounds, have a tamping plate width not less than 15 inches, be rated at not less than 4,200 vibrations per minute, and be suitably equipped with a standard tamping plate wetting device.

Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching shall not be allowed.

403-4.12 JOINTS. The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

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 course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. In both methods, all contact surfaces shall be given a tack coat of bituminous material before placing any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, uncompacted, or otherwise defective **[**or which have been left exposed for more than 4 hours, or whose surface temperature has cooled to less than 160^0 F**]** shall be cut back [specify cutback] to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be cleaned and dry and given a tack coat of bituminous material prior to placing any fresh mixture against the joint. The cost of this work and tack coat shall be considered incidental to the cost of the bituminous course.

* *

Engineer may retain the bracketed language regarding the treatment of "cold joints" when considered necessary. The cutback should be no more than 6 inches.

* *

MATERIAL ACCEPTANCE

403-5.1 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.

a. Field Placed Material. Material placed in the field shall be tested for mat and joint density on a lot basis. A lot will consist of:

- one day or shift’s production not to exceed 2,000 tons (1 814 000 kg), or
- a half day or shift’s production where a day's production is expected to consist of between 2,000 and 4,000 tons (1 814 000 and 3 628 000 kg), or
- similar subdivisions for tonnages over 4,000 tons (3 628 000 kg).

Where more than one plant is simultaneously producing material for the job, the lot sizes shall apply separately for each plant.

(1) Mat Density. The lot shall be divided into four equal sublots. One core of finished, compacted materials shall be taken by the Contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Cores shall not be taken closer than one foot from a transverse or longitudinal joint.

(2) Joint Density. The lot shall be divided into four equal sublots. One core of finished, compacted materials shall be taken by the Contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Edge of cores will be taken within 6 inches of the joint of the same lot material but not directly on the joint.

(3) Sampling. Samples shall be neatly cut with a core drill. The cutting edge of the core drill bit shall be of hardened steel or other suitable material with diamond chips embedded in the metal cutting edge. The minimum diameter of the sample shall be five inches. Samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. The Contractor shall furnish all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Cored pavement shall be cleaned and core holes shall be filled in a manner acceptable to the Engineer and within one day after sampling.

(4) Testing. The bulk specific gravity of each cored sample will be measured by the Engineer in accordance with ASTM D 2726 or ASTM D 1188, whichever is applicable. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each sublot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined as follows:

(a) Sufficient material for preparation of test specimens for all testing will be sampled by the Engineer on a random basis, in accordance with the procedures contained in ASTM D 3665. One set of laboratory compacted specimens will be prepared for each sublot in accordance with ASTM D 6926, at the number of blows required by paragraph 403-3.2, Table 1. Each set of laboratory compacted specimens will consist of three test portions prepared from the same sample increment. The sample of bituminous mixture may be put in a covered metal tin and placed in an oven for not less than 30 minutes or more than 60 minutes to stabilize to compaction temperature. The compaction temperature of the specimens shall be as specified in the job mix formula.

*** ***

Engineer should increase hold times to not less than 60 minutes and not more than 90 minutes when absorptive aggregates are used,

* *

(b) The bulk specific gravity of each test specimen shall be measured by the Engineer in accordance with ASTM D 2726 using the procedure for laboratory-prepared thoroughly dry specimens, or ASTM D 1188, whichever is applicable, for use in computing pavement density.

(c) The bulk specific gravity used to determine the joint density at joints formed between different lots shall be the lowest of the bulk specific gravity values from the two different lots.

(5) Acceptance. Acceptance of field placed material for mat and joint density will be determined by the Engineer in accordance with the requirements of paragraph 403-5.2b.

d. Partial Lots — Field Placed Material. When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and Engineer agree in writing to allow overages or other minor tonnage placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

The last batch produced where production is halted will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. In addition, an agreed to minor placement will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. Where three sublots are produced, they shall constitute a lot. Where one or two 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, i.e., n = 5 or n = 6, for example. Partial lots at the end of asphalt production on the project shall be included with the previous lot.

403-5.2 ACCEPTANCE CRITERIA.

a. General. Acceptance will be based on the following characteristics of the bituminous mixture and completed pavement and test results:

(1) Mat density
(2) Joint density
(3) Thickness
(4) Smoothness
(5) Grade

Mat density will be evaluated for acceptance in accordance with paragraph 403-5.2b(1). Joint density will be evaluated for acceptance in accordance with paragraph 403-5.2b(2).

Thickness will be evaluated by the Engineer for compliance in accordance with paragraph 403-5.2b(3). Acceptance for smoothness will be based on the criteria contained in paragraph 403-5.2b(4). Acceptance for grade will be based on the criteria contained in paragraph 403-5.2b(5).

The Engineer may at any time, notwithstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of bituminous mixture which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

b. Acceptance Criteria.

(1) Mat Density. Acceptance of each lot of plant produced material for mat density shall be based on the average of all of the densities taken from the sublots. If the average mat density of the lot so established equals or exceeds 96 percent, the lot shall be acceptable. If the average mat density of the lot is below 96 percent, the lot shall be removed and replaced at the Contractor's expense.

(2) Joint Density. Acceptance of each lot of plant produced material for joint density shall be based on the average of all of the joint densities taken from the sublots. If the average joint density of the lot so established equals or exceeds 94 percent, the lot shall be acceptable. If the average joint density of the lot is less than 94 percent, the Contractor shall stop production and evaluate the method of compacting joints. Production may resume once the reason for poor compaction has been determined and appropriate measures have been taken to ensure proper compaction.

(3) Thickness. Thickness of each course shall be evaluated by the Engineer for compliance to the requirements shown on the plans. Measurements of thickness shall be made by the Engineer using the cores extracted for each sublot for density measurement. The maximum allowable deficiency at any point shall not be more than ¼ inch less than the thickness indicated for the lift. Average thickness of lift, or combined lifts, shall not be less than the indicated thickness. Where thickness deficiency exceeds the specified tolerances, the lot or sublot shall be corrected by the Contractor at his expense by removing the deficient area and replacing with new pavement. The Contractor, at his expense, may take additional cores as approved by the Engineer to circumscribe the deficient area.

(4) Smoothness. The final surface shall be free from roller marks. The finished surfaces of each course of the pavement, except the finished surface of the final surface course, shall not vary more than ⅜ inch when evaluated with a 16 foot straightedge. The finished surface of the final surface course shall not vary more than ¼ inch when evaluated with a 16 foot straightedge. The lot size shall be [ ] square yards (square meters). Smoothness measurements shall be made at 50 foot intervals and as determined by the Engineer. In the longitudinal direction, a smoothness reading shall be made at the center of each paving lane. In the transverse direction, smoothness readings shall be made continuously across the full width of the pavement. However, transverse smoothness readings shall not be made across designed grade changes. At warped transition areas, straightedge position shall be adjusted to measure surface smoothness and not design grade transitions. When more than 15 percent of all measurements within a lot exceed the specified tolerance, the Contractor shall remove the deficient area to the depth of the course of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off providing the course thickness complies with the thickness specified on the plans. High point grinding will be limited to 15 square yards. Areas in excess of 15 square yards will require removal and replacement of the course in accordance with the limitations noted above.

*** ***

The Engineer shall specify the lot size. A minimum of 2,000 square yards (1 650 square meters) is recommended.

*** ***

(5) Grade. The finished surface of the pavement shall not vary from the gradeline elevations and cross sections shown on the plans by more than ½ inch (12.70 mm). The finished grade of each lot will be determined by running levels at intervals of 50 feet (15.2 m) or less longitudinally and all breaks in grade transversely (not to exceed 50 feet) to determine the elevation of the completed pavement. The Contractor shall pay the cost of surveying of the level runs that shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer. The lot size shall be [ ] square yards (square meters). When more than 15 percent of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates ¾ inch or more from planned grade, the Contractor shall remove the deficient area to the depth of the final course of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off providing the course thickness complies with the thickness specified on the plans. High point grinding will be limited to 15 square yards. The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130 inches wide. The peaks and ridges shall be approximately 1/32 inch higher than the bottom of the grooves. The pavement shall be left in a clean condition. The removal of all of the slurry resulting form the grinding operation shall be continuous. The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement. Areas in excess of 15 square yards will require removal and replacement of the pavement in accordance with the limitations noted above.

c. Density Outliers. If the tests within a lot include a very large or a very small value that appears to be outside the normal limits of variation, check for an outlier in accordance with ASTM E 178, at a significance level of 5 percent, to determine if this value should be discarded.

* *

A minimum of 2,000 square yards (1,650 square meters) is recommended.

* *

403-5.3 RESAMPLING PAVEMENT FOR MAT DENSITY.

a. General. Resampling of a lot of pavement will only be allowed for mat density and then, only if the Contractor requests same in writing, within 48 hours after receiving the written test results from the Engineer. A retest will consist of all the sampling and testing procedures contained in paragraphs 403-5.1b(1). Only one resampling per lot will be permitted.

(1) A redefined mat density shall be calculated for the resampled lot. The number of tests used to calculate the redefined mat density shall include the initial tests made for that lot plus the retests.

(2) The cost for resampling and retesting shall be borne by the Contractor.

b. Payment for Resampled Lots. The redefined mat density for a resampled lot shall be used to evaluate the acceptance of that lot in accordance with Paragraph 403-5.2.

[403-5.4 LEVELING COURSE. Any course used for truing and leveling shall meet the requirements of paragraph 403-3.2, but shall not be subject to the density requirements of paragraph 403-5.1. The leveling course shall be compacted with the same effort used to achieve density of the test section. The truing and leveling course shall not exceed a nominal thickness of 1-½ inches (37.5 mm). The leveling course is the first variable thickness lift of an overlay placed prior to subsequent courses.**]**

* *

Use this paragraph only when there is a need to restore proper cross-section prior to overlaying. Areas of the pavement requiring a leveling course shall be shown on the plans.

* *

CONTRACTOR QUALITY CONTROL

403-6.1 GENERAL. The Contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by paragraph 403-6.3, including but not limited to:

a. Mix Design
b. Aggregate Grading
c. Quality of Materials
d. Stockpile Management
e. Proportioning
f. Mixing and Transportation
g. Placing and Finishing
h. Joints
i. Compaction
j. Surface smoothness

403-6.2 TESTING LABORATORY. The Contractor shall provide a fully equipped asphalt laboratory meeting the requirements of paragraph 403-3.5 and 403-4.2a(2) located at the plant or job site. The Contractor shall provide the Engineer with certification stating that all of the testing equipment to be used is properly calibrated and will meet the specifications applicable for the specified test procedures.

403-6.3 QUALITY CONTROL TESTING. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in the approved Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness.

a. Asphalt Content. A minimum of two tests shall be performed per lot in accordance with ASTM D 2172 for determination of asphalt content. The weight of ash portion of the test, as described in ASTM D 2172, shall be determined as part of the first test performed at the beginning of plant production; and as part of every tenth test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture. The asphalt content for the lot will be determined by averaging the test results.

The use of the nuclear method for determining asphalt content in accordance with ASTM D 4125 is permitted, provided that it is calibrated for the specific mix being used.

b. Gradation. Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D 5444 and ASTM C 136 (Dry Sieve). When asphalt content is determined by the nuclear method, aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix or continuous mix plants, and tested in accordance with ASTM C 136 (dry sieve) using actual batch weights to determine the combined aggregate gradation of the mixture.

c. Moisture Content of Aggregate. The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C 566.

d. Moisture Content of Mixture. The moisture content of the mixture shall be determined once per lot in accordance with ASTM D 1461 **[**or AASHTO T110**]**.

*** ***

ASTM D 1461 may be replaced with an AASHTO moisture content testing procedure using a conventional oven or microwave. The frequency can also change in the specification depending on the probability of incurring a moisture problem.

*** ***

e. Temperatures. Temperatures shall be checked, at least four times per lot, at necessary locations to determine the temperatures of the dryer, the bitumen in the storage tank, the mixture at the plant, and the mixture at the job site.

f. In-Place Density Monitoring. The Contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D 2950.

g. Additional Testing. Any additional testing that the Contractor deems necessary to control the process may be performed at the Contractor's option.

h. Monitoring. The Engineer reserves the right to monitor any or all of the above testing.

403-6.4 SAMPLING. When directed by the Engineer, the Contractor shall sample and test any material that appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

403-6.5 CONTROL CHARTS. The Contractor shall maintain linear control charts both for individual measurements and range (i.e., difference between highest and lowest measurements) for aggregate gradation and asphalt content.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a problem and the Contractor is not taking satisfactory corrective action, the Engineer may suspend production or acceptance of the material.

a. Individual Measurements. Control charts for individual measurements shall be established to maintain process control within tolerance for aggregate gradation and asphalt content. The control charts shall use the job mix formula target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:

CONTROL CHART LIMITS FOR INDIVIDUAL MEASUREMENTS		
Sieve	Action Limit	Suspension Limit
¾ inch (19.0 mm)	0%	0%
½ inch (12.5 mm)	+/-6%	+/-9%
⅜ inch (9.5 mm)	+/-6%	+/-9%
No. 4 (4.75 mm)	+/-6%	+/-9%
No. 16 (1.18 mm)	+/-5%	+/-7.5%
No. 50 (0.30 mm)	+/-3%	+/-4.5%
No. 200 (0.075 mm)	+/-2%	+/-3%
Asphalt Content	+/-0.45%	+/-0.70%

b. Range. Control charts for range shall be established to control process variability for the test parameters and Suspension Limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of n = 2. Should the Contractor elect to perform more than two tests per lot, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for n = 3 and by 1.27 for n = 4.

CONTROL CHART LIMITS BASED ON RANGE (Based on n = 2)	
Sieve	Suspension Limit
½ inch (12.5 mm)	11 percent
⅜ inch (9.5 mm)	11 percent
No. 4 (4.75 mm)	11 percent
No. 16 (1.18 mm)	9 percent
No. 50 (0.30 mm)	6 percent
No. 200 (0.075 mm)	3.5 percent
Asphalt Content	0.8 percent

c. Corrective Action. The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and detail what action will be taken to bring the process into control. As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

(1) One point falls outside the Suspension Limit line for individual measurements or range; or

(2) Two points in a row fall outside the Action Limit line for individual measurements.

*** ***

The aggregate control chart parameters and Suspension and Action Limits contained in the above paragraphs are based on ¾ inch (19.0 mm) maximum size aggregate gradation. When 1-inch (25.0 mm) or 1-¼ inch (31.2 mm) maximum size aggregate greater than ¾" is specified, the Individual Measurements Chart requirements should be amended as follows:

Sieve	**Action Limit**	**Suspension Limit**
1 inch or greater or 1-½ inch	**0%**	**0%**
¾ inch	**26%**	**11%**

When ½-inch (12.5 mm) maximum size aggregate is specified, the ¾-inch (19.0 mm) and 1-inch (25.0 mm) sieves should be deleted from the Individual Measurements Chart and the ½-inch (12.5 mm) sieve Action and Suspension Limits should be changed to 0%. For the ½-inch (12.5 mm) gradation, the ½-inch sieve should be deleted from the Range Chart.

*** ***

403-6.6 QUALITY CONTROL REPORTS. The Contractor shall maintain records and shall submit reports of quality control activities daily.

METHOD OF MEASUREMENT

403-7.1 MEASUREMENT. Plant mix bituminous concrete pavement shall be measured by the number of tons (kg) of bituminous mixture used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage.

BASIS OF PAYMENT

403-8.1 PAYMENT. Payment for an accepted lot of bituminous concrete pavement shall be made at the contract unit price per ton (kg) for bituminous mixture**.** The price shall be compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-403-8.1a	Bituminous **[ ] [**Surface**] [**Base**] [**Binder**] [**Leveling**]** Course —per ton (kg)

TESTING REQUIREMENTS

ASTM C 29	Bulk Density (“Unit Weight”) and Voids in Aggregate
ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Materials Finer than 75µm (No.200) Sieve in Mineral Aggregates by Washing
ASTM C 127	Specific Gravity and Absorption of Coarse 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 Analysis of Fine and Coarse Aggregates
ASTM C 183	Sampling and the Amount of Testing of Hydraulic Cement
ASTM C 566	Total Evaporable Moisture Content of Aggregate by Drying
ASTM D 75	Sampling Aggregates
ASTM D 979	Sampling Bituminous Paving Mixtures
ASTM D 995	Mixing Plants for Hot-Mixed Hot-Laid Bituminous Paving Mixtures
ASTM D 1073	Fine Aggregate for Bituminous Paving Mixtures
ASTM D 1074	Compressive Strength of Bituminous Mixtures
ASTM D 1188	Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1461	Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D 2041	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2419	Sand Equivalent Value of Soils and Fine Aggregate
ASTM D 2489	Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D 2726	Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D 2950	Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D 3203	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
ASTM D 3665	Random Sampling of Construction Materials
ASTM D 3666	Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D 4125	Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 4867	Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D 5444	Mechanical Size Analysis of Extracted Aggregate
ASTM D 5581	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6" Diameter Specimen)

ASTM D 6926	Preparation of Bituminous Specimens Using MARSHALL Apparatus
ASTM D 6927	MARSHALL Stability and Flow of Bituminous Mixtures
ASTM E 11	Wire-Cloth Sieves for Testing Purposes
ASTM E 178	Dealing with Outlying Observations
AASHTO T 30	Mechanical Analysis of Extracted Aggregate
[AASHTO T 110	Moisture or Volatile Distillates in Bituminous Paving Mixtures**]**
The Asphalt Institute's Manual No. 2 (MS-2)	Mix Design Methods for Asphalt Concrete

MATERIAL REQUIREMENTS

ASTM D 242	Mineral Filler for Bituminous Paving Mixtures
ASTM D 946	Penetration Graded Asphalt Cement for Use in Pavement Construction
ASTM D 3381	Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 4552	Classifying Hot-Mix Recycling Agents
AASHTO MP1	Performance Graded Binder Designation

END OF ITEM P-403

PART VI – RIGID PAVEMENT
ITEM P-501 PORTLAND CEMENT CONCRETE PAVEMENT

DESCRIPTION

501-1.1 This work shall consist of pavement composed of Portland cement concrete, **[with reinforcement] [without reinforcement]** constructed on a prepared underlying surface in accordance with these specifications and shall conform to the lines, grades, thickness, and typical cross sections shown on the plans.

* *

The Engineer shall specify with or without reinforcement.

* *

MATERIALS

501-2.1 AGGREGATES.

a. Reactivity. Aggregates shall be tested for deleterious reactivity with alkalis in the cement, which may cause excessive expansion of the concrete. Tests of coarse and fine aggregate shall be made in accordance with ASTM C 1260. If the expansion of the coarse or fine aggregate test specimens, tested in accordance with ASTM C 1260, does not exceed 0.10 % at 16 days from casting, the coarse or fine aggregates shall be accepted.

If the expansion at 16 days is greater than 0.10%, tests of combined materials shall be made in accordance with ASTM C 1260 or ASTM C 1567 using the aggregates, cementitious materials, and/or specific reactivity reducing chemicals in the proportions proposed for the mixture design. If the expansion of the proposed combined materials test specimens, tested in accordance with ASTM C 1260 or ASTM C 1567, does not exceed 0.10 % at [30] days from casting, the proposed combined materials will be accepted. If the expansion of the proposed combined materials test specimens is greater than 0.10% at 30 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10 % at 30 days, or new aggregates shall be evaluated and tested.

* *

The Engineer shall specify, require, and at a minimum, insert Appendix 1 contained in FAA Engineering Brief No. 70 when runway deicing chemicals will be used on the pavement. The Engineer must provide Contractors and bidders with a notification that the test protocols and decision tree contained FAA Engineering Brief No. 70 will be part of the contract.

* *

b. Fine Aggregate. Fine aggregate shall conform to the requirements of ASTM C 33. Gradation shall meet the requirements of Table 1 when tested in accordance with ASTM C 136, except as may otherwise be qualified under Section 6 of ASTM C 33.

TABLE 1. GRADATION FOR FINE AGGREGATE (ASTM C 33)

Sieve Designation (Square Openings)	Percentage by Weight Passing Sieves
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	95-100
No. 8 (2.36 mm)	80-100
No. 16 (1.18 mm)	50-85
No. 30 (600 micro-m)	25-60
No. 50 (300 micro-m)	10-30
No. 100 (150 micro-m)	2-10

c. Coarse Aggregate. Coarse aggregate shall conform to the requirements of ASTM C 33. Gradation, within the separated size groups, shall meet the requirements of Table 2 when tested in accordance with ASTM C 136. When the nominal maximum size of the aggregate is greater than 1 inch, the aggregates shall be furnished in two size groups.

Aggregates delivered to the mixer shall consist of crushed stone, crushed or uncrushed gravel, air-cooled blast furnace slag, crushed recycled concrete pavement, or a combination thereof. The aggregate shall be composed of clean, hard, uncoated particles and shall meet the requirements for deleterious substances contained in ASTM C 33, Class **[ ]**. Dust and other coating shall be removed from the aggregates by washing. The aggregate in any size group shall not contain more than 8 percent by weight of flat or elongated pieces when tested in accordance with ASTM D 4791. A flat or elongated particle is one having a ratio between the maximum and the minimum dimensions of a circumscribing rectangular prism exceeding 5 to 1.

* *

The Engineer shall specify the Class in accordance with Table 3 of ASTM C 33 or based on historical data. In areas affected by Disintegration Cracking (D-cracking), the Engineer should add ASTM C 666, Resistance of Concrete to Rapid Freezing and Thawing, to the list of testing requirements.

* *

The percentage of wear shall be no more than **[ ]** when tested in accordance with ASTM C 131 or ASTM C 535.

* *

The Engineer shall specify the percentage of wear. It should not exceed 40 percent. In certain cases where aggregate of this quality cannot be obtained economically, aggregate with a higher percentage of wear may be used if a satisfactory service record of at least 5 years' duration under similar conditions of service and exposure has been demonstrated.

* *

* *

The Engineer shall specify the aggregate to be furnished from the table shown in this note. The appropriate gradation shall be inserted into Table 2. Insert points are denoted by asterisks. Where locally available aggregates cannot be economically blended to meet the grading requirements, the gradations may be modified by the Engineer to fit the characteristics of such locally available aggregates.

GRADATION FOR COARSE AGGREGATE

Sieve Designations (square openings)		Percentage by Weight Passing Sieves				
		From 2" to No. 4 (50.8 mm - 4.75 mm)		From 1-1/2" to No. 4 (38.1 mm - 4.75 mm)		From 1" to No. 4 (25.0 mm-4.75 mm)
in.	mm	#3 2"-1"	#57 1"-No.4	#4 1-1/2"-3/4"	#67 3/4"-No.4	#57 1"-No.4
2-1/2	63	100	---	---	---	---
2	50.8	90-100	---	100	---	---
1-1/2	38.1	35-70	100	90-100	---	100
1	25.0	0-15	95-100	20-55	100	95-100
3/4	19.0	---	---	0-15	90-100	---
1/2	12.5	0-5	25-60	---	---	25-60
3/8	9.5	---	---	0-5	20-55	---
No. 4	4.75	---	0-10	---	0-10	0-10
No. 8	2.36	---	0-5	---	0-5	0-5

TABLE 2. GRADATION FOR COARSE AGGREGATE
ASTM C 33

Sieve Designations (square openings)		Percentage by Weight Passing Sieves	
in.	mm	*	*
2-1/2	63	*	*
2	50.8	*	*
1-1/2	38.1	*	*
1	25.0	*	*
3/4	19.0	*	*
1/2½	12.5	*	*
3/8	9.5	*	*
No. 4	4.75	*	*
No. 8	2.36	*	*

Aggregate gradations that produce concrete mixtures with well-graded or optimized aggregate combinations may be substituted for the requirements of Tables 1 and Table 2 with prior approval of the Engineer and the FAA. The contractor shall submit complete mixture information necessary to calculate the volumetric components of the mixture.

****

Aggregate susceptibility to Disintegration (D) Cracking. Aggregates that have a history of D-cracking shall not be used. Prior to approval of mixture design and production of Portland cement concrete the Contractor shall submit written certification that the aggregate does not have a history of D-Cracking and that the aggregate meets the specified State requirements.

(1) Other sources of crushed stone aggregate shall be approved if the durability factor as determined by ASTM C 666 is greater than or equal to 95 and all other quality test requirements within these specifications are fulfilled. The FAA will consider and reserves final approval of other State classification procedures.

(2) Crushed gravel and sand-gravel aggregates shall not be required to meet freeze-thaw durability ratings. These aggregates shall be approved for use in concrete by the state highway agency in the state from which the aggregate originates and the state in which they are to be used and shall meet all other criteria within these specifications.

501-2.2 CEMENT. Cement shall conform to the requirements of ASTM **[ ]** Type **[ ]**.

*** ***

The Engineer shall specify one of the following: ASTM C 150 - Type I, II, III, or V.

ASTM C 595 - Type IP, IS.

ASTM C 1157 – Types GU, HE, HS, MH, LH

ASTM C 150 covers portland cements. ASTM C 595 covers blended hydraulic cements as follows: IP - Portland-Pozzolan Cement, IS - Portland Blast-Furnace Slag Cements ASTM C 1157 covers the following hydraulic cements: General Use (GE), High-Early Strength (HE), Moderate Sulfate Resistance (MS), High Sulfate Resistance (HS), Moderate Heat of Hydration (MH), and Low Heat of Hydration (LH). The chemical requirements for all cement types specified should meet suitable criteria for deleterious activity in accordance with ASTM C 33 or based on historical data. Low alkali cements (less than 0.6% total equivalent alkalinity, the low reactivity option in ASTM C 595, or Option R in ASTM C 1157) should be specified when any doubt exists.

Total Alkalis (Na2O & K2O) of the cement secured for the production of concrete shall be independently verified in accordance with ASTM C 114.

*** ***

If for any reason, cement becomes partially set or contains lumps of caked cement, it shall be rejected. Cement salvaged from discarded or used bags shall not be used.

Only cements containing less than 0.6% equivalent alkali or cements that can demonstrate a positive reduction in the expansion created by alkali-silica reactions shall be used.

501-2.3 CEMENTITIOUS MATERIALS.

a. Fly Ash or Natural Pozzolan. Fly ash shall 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 Table 3 contained in ASTM C 618 shall apply.]** Fly ash such as is produced in furnace operations utilizing liming materials or soda ash (sodium carbonate) as an additive shall not be acceptable. The Contractor shall furnish vendor's certified test reports for each shipment of Fly Ash used in the project. The vendor's certified test report can be used for acceptance or the material may be tested independently by the Engineer.

*** ***

Delete class C Pozzolan for areas of potential alkali silica reactive aggregates.

*** ***

b. Blast Furnace Slag (Slag Cement). Ground Granulated Blast Furnace (GGBF) slag shall conform to ASTM C 989, Grade 100 or 120. GGBF shall be used only at a rate between 25 and 55 percent of the total cementitious material by mass.

* *

GGBFS (Slag Cement), must be permitted at the contractor's option, unless its use can be determined to be inappropriate for technical reasons documented by the owner or the design engineer.

* *

501-2.4 PREMOLDED JOINT FILLER. Premolded joint filler for expansion joints shall conform to the requirements of **[ASTM D 1751] [ASTM D 1752, Type II or III]** and shall be punched to admit the dowels where called for on the plans. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise specified by the Engineer. When the use of more than one piece is required for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to the Engineer.

* *

The Engineer shall designate either ASTM D 1751 or ASTM D 1752. Joint filler must be compatible with joint sealants.

* *

501-2.5 JOINT SEALER. The joint sealer for the joints in the concrete pavement shall meet the requirements of Item P-605 and shall be of the type(s) specified in the plans.

501-2.6 STEEL REINFORCEMENT. Reinforcing shall consist of **[ ]** conforming to the requirements of ASTM **[ ].**

* *

The Engineer shall designate one of the following:

Welded steel wire fabric ASTM A 185

Welded deformed steel fabric ASTM A 497

Bar mats ASTM A 184 or A 704

Welded wire fabric shall be furnished in flat sheets only.

Delete this paragraph when not applicable to the project.

* *

501-2.7 DOWEL AND TIE BARS. Tie bars shall be deformed steel bars and conform to the requirements of ASTM A 615 or ASTM A 996, except that rail steel bars, Grade 50 or 60, shall not be used for tie bars that are to be bent or restraightened during construction. Tie bars designated as Grade 40 in ASTM A 615 can be used for construction requiring bent bars.

Dowel bars shall be plain steel bars conforming to ASTM A 615 or ASTM A 966 and shall be free from burring or other deformation restricting slippage in the concrete. High strength dowel bars shall conform to ASTM A 714, Class 2, Type S, Grade I, II or III, Bare Finish. Before delivery to the construction site each dowel bar shall be painted with one coat of paint conforming to MIL-DTL-24441/20A.SSPC Paint 5 or SSPC Paint 25.Metal or plastic collars shall be full circular device supporting the dowel until the epoxy hardens.

The sleeves for dowel bars used in expansion joints shall be metal or other type of an approved design to cover 2 to 3 inches (50 mm to 75 mm) of the dowel, with a closed end and with a suitable stop to hold the end of the bar at least 1 inch (25 mm) from the closed end of the sleeve. Sleeves shall be of such design that they will not collapse during construction.

501-2.8 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. 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.

501-2.9 COVER MATERIAL FOR CURING. Curing materials shall conform to one of the following specifications:

a. Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C 309, Type 2, Class B, or Class A if wax base only.

b. White polyethylene film for curing concrete shall conform to the requirements of ASTM C 171.

c. White burlap-polyethylene sheeting for curing concrete shall conform to the requirements of ASTM C 171.

d. Waterproof paper for curing concrete shall conform to the requirements of ASTM C 171.

501-2.10 ADMIXTURES. The use of any material added to the concrete mix shall be approved by the Engineer. The Contractor shall submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, the Engineer may require the Contractor to submit complete test data from an approved laboratory showing that the material to be furnished meets all of the requirements of the cited specifications. Subsequent tests may be made of samples taken by the Engineer from the supply of the material being furnished or proposed for use on the work to determine whether the admixture is uniform in quality with that approved.

a. Air-Entraining Admixtures. Air-entraining admixtures shall meet the requirements of ASTM C 260 and shall consistently entrain the air content in the specified ranges under field conditions. The air-entrainment agent and any water reducer admixture shall be compatible.

b. Chemical Admixtures. Water-reducing, set retarding, and set-accelerating admixtures shall meet the requirements of ASTM C 494, including the flexural strength test.

501-2.11 EPOXY-RESIN. Epoxy-resin used to anchor dowels and tie bars in pavements shall conform to the requirements of ASTM C 881, Type I, Grade 3, Class C. Class A or B shall be used when the surface temperature of the hardened concrete is below 60 degrees F (16 degrees C).

501-2.12 MATERIAL ACCEPTANCE. Prior to use of materials, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction. The certification shall show the appropriate ASTM test(s) for each material, the test results, and a statement that the material passed or failed.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

MIX DESIGN

501-3.1 PROPORTIONS. Concrete shall be designed to achieve a 28-day flexural strength that meets or exceeds the acceptance criteria contained in paragraph 501-5.2 for a flexural strength of **[ ]** psi. The mix shall be designed using the procedures contained in Chapter 9 of the Portland Cement Association's manual, "Design and Control of Concrete Mixtures".

* *

The Engineer shall designate the design strength. Refer to AC 150/5320-6 for guidance when specifying flexural strength. The minimum flexural strength allowable for airport pavements is 600 psi (4 136 kPa).

Higher flexural strength can be specified when local materials make this economically feasible. However, it must be recognized that due to variations in materials, operations, and testing, the average strength of concrete furnished by a supplier must be higher than the specified strength to insure a good statistical chance of meeting the acceptance criteria throughout the duration of the job.

For pavements designed to accommodate aircraft gross weights of 30,000 pounds (13 500 kg) or less, this section may be modified to indicate that concrete shall be designed to achieve a 28-day compressive strength such that meets or exceeds the acceptance criteria for a compressive strength of 4,400 psi (30 700 kPa).

If the specified strength is required earlier than 28 days, the Engineer shall designate the time period.

* *

The Contractor shall note that to ensure that the concrete actually produced will meet or exceed the acceptance criteria for the specified strength, the mix design average strength must be higher than the specified strength. The amount of overdesign necessary to meet specification requirements depends on the producer's standard deviation of flexural test results and the accuracy that that value can be estimated from historic data for the same or similar materials.

The minimum cementitious material (cement plus fly ash, or GGBFS) shall be **[ ]** pounds per cubic yard (**[ ]** kg per cubic meter). The ratio of water to cementitious material, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates shall not be more than **[ ]** by weight.

* *

A minimum cementitious material content of 564 pounds (227 kg) should be specified. A higher minimum may be necessary to meet the specified strength when other cementitious materials are substituted or to meet durability requirements for severe freeze/thaw, deicer, or sulfate exposure.

A maximum water/cementitious ratio of 0.45 should be specified. A lower water/cementitious ratio may be necessary for severe freeze/thaw, deicer, or sulfate exposure.

* *

Prior to the start of paving operations and after approval of all material to be used in the concrete, the Contractor shall submit a mix design showing the proportions and flexural strength obtained from the concrete at 7 and 28 days. The mix design shall include copies of test reports, including test dates, and a complete list of materials

including type, brand, source, and amount of cement, fly ash, ground slag, coarse aggregate, fine aggregate, water, and admixtures. The fineness modulus of the fine aggregate and the air content shall also be shown. The mix design shall be submitted to the Engineer at least **[ ]** days prior to the start of operations. The submitted mix design shall not be more than 90 days old. Production shall not begin until the mix design is approved in writing by the Engineer.

Should a change in sources be made, or admixtures added or deleted from the mix, a new mix design must be submitted to the Engineer for approval.

* *

A minimum of 10 days is recommended.

* *

Flexural strength test specimens shall be prepared in accordance with ASTM C 192 and tested in accordance with ASTM C 78. The mix determined shall be workable concrete having a slump for side-form concrete between 1 and 2 inches (25 mm and 50 mm) as determined by ASTM C 143. For vibrated slip-form concrete, the slump shall be between 1/2 inch (13 mm) and 1 1/2 inches (38 mm).

* *

When the design strength in paragraph 501-3.1 is based on compressive strength, the specimens should be tested in accordance with ASTM C 39. Substitute compressive strength for flexural strength.

* *

501-3.2 CEMENTITIOUS MATERIALS.

a. Fly Ash. Fly ash may be used in the mix design. When fly ash is used as a partial replacement for cement, the minimum cement content may be met by considering Portland cement plus fly ash as the total cementitious material. The replacement rate shall be determined from laboratory trial mixes, but shall be between 20 and 30 percent by weight of the total cementitious material. If fly ash is used in conjunction with ground granular blast furnace slag the maximum replacement rate shall not exceed 10 percent by weight of total cementitious material.

b. Ground Slag. Ground blast-furnace slag may be used in a mix design containing Type I or Type II cement. The slag, or slag plus fly ash if both are used, may constitute between 25 to 55 percent of the total cementitious material by weight. If the concrete is to be used for slipforming operations and the air temperature is expected to be lower than 55 degrees F (13 degrees C) the percent slag shall not exceed 30 percent by weight.

* *

Due to variations in fly ash, cement, strength requirements, etc. the replacement rate specified should be based on local materials, but should be between 10-20 percent.

Concrete containing fly ash will ultimately develop a flexural strength greater than concrete without fly ash. However, the rate of development and the ultimate strength of the concrete depend on the characteristics of the fly ash, the cement used, the proportions of fly ash and cement, and the curing environment.

EPA guidelines published in 40 CFR Part 249, which implement provisions of the Resource Conservation and Recovery Act of 1976, require that contract specifications allow for the use of fly ash, unless its use can be determined to be inappropriate for technical reasons documented by the owner or the design engineer.

* *

501-3.3 ADMIXTURES.

a. Air-Entraining. Air-entraining admixture shall be added in such a manner that will insure uniform distribution of the agent throughout the batch. The air content of freshly mix air-entrained concrete shall be based upon trial mixes with the materials to be used in the work adjusted to produce concrete of the required plasticity and workability. The percentage of air in the mix shall be **[ ]**. 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.

b. Chemical. Water-reducing, set-controlling, and other approved admixtures shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted on trial mixes, with the materials to be used in the work, in accordance with ASTM C 494.

* *

The Engineer shall specify the appropriate air content as determined from the table in this note. For warm climate areas where freezing and thawing are not a factor, non-air-entrained concrete may be used.

RECOMMENDED AIR CONTENT (PERCENT)

	Maximum Size Aggregate inches (mm)				
Exposure Level	**2(51)**	**1.5(38)**	**1(25)**	**3/4(19)**	**1/2(13)**
Mild	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**
Moderate	**4.0**	**4.5**	**4.5**	**5.0**	**5.5**
Severe	**5.0**	**5.5**	**6.0**	**6.0**	**7.0**

Mild exposure - When desired for other than durability, such as to improve workability. Used where pavement will not be exposed to freezing or to deicing agents.

Moderate exposure - Service in a climate where freezing is expected but where the concrete will not be continually exposed to moisture or free water for long periods prior to freezing and will not be exposed to deicing agents or other aggressive chemicals.

Severe exposure - Concrete which is exposed to deicing chemicals or other aggressive agents or where the concrete may become highly saturated by continual contact with moisture or free water prior to freezing.

* *

501-3.4 TESTING LABORATORY. The laboratory used to develop the mix design shall meet the requirements of ASTM C 1077. The laboratory accreditation will include ASTM C 78. A certification that it meets these requirements shall be submitted to the Engineer prior to the start of mix design. The certification shall include evidence that the laboratory is inspected/accredited for the test methods required herein by a nationally recognized laboratory inspection accreditation organization.

CONSTRUCTION METHODS

501-4.1 EQUIPMENT. Equipment necessary for handling materials and performing all parts of the work shall be approved by the engineer as to design, capacity, and mechanical conditions. The equipment shall be at the jobsite sufficiently ahead of the start of paving operations to be examined thoroughly and approved.

a. Batch Plant and Equipment. The batch plant and equipment shall conform to the requirements of ASTM C 94.

b. Mixers and Transportation Equipment.

(1) General. Concrete may be mixed at a central plant, or wholly or in part in truck mixers. 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.

* *

The Engineer may specify the use of a central plant mixer if deemed necessary for a particular project.

* *

(2) Central plant mixer. Central plant mixers shall conform to the requirements of ASTM C 94.

The mixer shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades. The pickup and throwover blades shall be replaced when they have worn down 3/4 inch (19 mm) or more. The Contractor shall have a copy of the manufacturer's design on hand showing dimensions and arrangement of blades in reference to original height and depth.

(3) Truck mixers and truck agitators. Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central-mixed concrete shall conform to the requirements of ASTM C 94.

(4) Nonagitator trucks. Nonagitating hauling equipment shall conform to the requirements of ASTM C 94.

c. Finishing Equipment. The standard method of constructing concrete pavements on FAA projects shall be with an approved slip-form paving equipment designed to spread, consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the machine so a dense and homogeneous pavement is achieved with a minimum of hand finishing. The paver-finisher shall be a heavy duty, self-propelled machine designed specifically for paving and finishing high quality concrete pavements. It shall weigh at least 2200 lbs. per foot of paving lane width and powered by an engine having at least 6.0 horsepower per foot of lane width.

On projects requiring less than 500 square yards of cement concrete pavement or requiring individual placement areas of less than 500 square yards, or irregular areas at locations inaccessible to slip-form paving equipment, cement concrete pavement may be placed with approved placement and finishing equipment utilizing stationary side forms. Hand screeding and float finishing may only be utilized on small irregular areas as allowed by the Engineer.

d. Vibrators. Vibrator shall be the internal type. Operating frequency for internal vibrators shall be between 8,000 and 12,000 vibrations per minute. Average amplitude for internal vibrators shall be 0.025-0.05 inches (0.06-0.13 cm).

The number, spacing, and frequency shall be as necessary to provide a dense and homogeneous pavement and meet the recommendations of ACI 309, Guide for Consolidation of Concrete. Adequate power to operate all vibrators shall be available on the paver. The vibrators shall be automatically controlled so that they shall be stopped as

forward motion ceases. The contractor shall provide an electronic or mechanical means to monitor vibrator status. The checks on vibrator status shall occur a minimum of two times per day or when requested by the Engineer.

Hand held vibrators may be used in irregular areas only, but shall meet the recommendations of ACI 309, Guide for Consolidation of Concrete.

e. Concrete Saws. The Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions. 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.

f. Side Forms. Straight side forms shall be made of steel and shall be furnished in sections not less than 10 feet (3 m) in length. Forms shall have a depth equal to the pavement thickness at the edge, and a base width equal to or greater than the depth. Flexible or curved forms of proper radius shall be used for curves of 100-foot (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 1/8 inch (3 mm) in 10 feet (3 m), and the upstanding leg shall not vary more than 1/4 inch (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 approved by the Engineer.

g. Pavers. The paver shall be fully energized, self-propelled, and designed for the specific purpose of placing, consolidating, and finishing the concrete pavement, true to grade, tolerances, and cross section. It shall be of sufficient weight and power to construct the maximum specified concrete paving lane width as shown in the plans, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. The paver shall be equipped with electronic or hydraulic horizontal and vertical control devices.

501-4.2 FORM SETTING. Forms shall be set sufficiently in advance of the concrete placement to insure continuous paving operation. After the forms have been set to correct grade, the underlying surface 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 sufficiently to maintain the form in position for the method of placement.

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 1/8 inch (3 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 concrete.

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete.

501-4.3 CONDITIONING OF UNDERLYING SURFACE. The compacted underlying surface on which the pavement will be placed shall be widened approximately 3 feet (1 m) to extend beyond the paving machine track to support the paver without any noticeable displacement. After the underlying surface has been placed and compacted to the required density, the areas that will support the paving machine and the area to be paved shall be trimmed or graded to the plan grade elevation and profile by means of a properly designed machine. The grade of the underlying surface shall be controlled by a positive grade control system using lasers, stringlines, or guide wires. If the density of the underlying surface is disturbed by the trimming operations, it shall be corrected by additional compaction and retested at the option of the Engineer before the concrete is placed except when stabilized subbases are being constructed. If damage occurs on a stabilized subbase, it shall be corrected full depth by the Contractor. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placement of concrete. The prepared grade shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete. The underlying surface shall be protected so that it will be entirely free of frost when concrete is placed.

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Stabilized subbase is required to accommodate aircraft with gross weights in excess of 100,000 pounds (45 300 kg) per Advisory Circular 150/5320-6.

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501-4.4 CONDITIONING OF UNDERLYING SURFACE, SIDE-FORM AND FILL-IN LANE CONSTRUCTION. The prepared underlying surface shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete. Damage caused by hauling or usage of other equipment shall be corrected and retested at the option of the Engineers. If damage occurs to a stabilized subbase, it shall be corrected full depth by the Contractor. A template shall be provided and operated on the forms immediately in advance of the placing of all concrete. The template shall be propelled only by hand and not attached to a tractor or other power unit. Templates shall be adjustable so that they may be set and maintained at the correct contour of the underlying surface. The adjustment and operation of the templates shall be such as will provide an accurate retest of the grade before placing the concrete thereon. All excess material shall be removed and wasted. Low areas shall be filled and compacted to a condition similar to that of the surrounding grade. The underlying surface shall be protected so that it will be entirely free from frost when the concrete is placed. The use of chemicals to eliminate frost in the underlying surface shall not be permitted.

The template shall be maintained in accurate adjustment, at all times by the Contractor, and shall be checked daily.

501-4.5 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 such 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 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 devices 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 approved 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.

501-4.6 MIXING CONCRETE. The concrete may be mixed at the work site, in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are emptied into the drum. All concrete shall be mixed and delivered to the site in accordance with the requirements of ASTM C 94.

Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators, or nonagitating trucks. The elapsed time from the addition of cementitious material to the mix until the concrete is deposited in place at the work site shall not exceed 30 minutes when the concrete is hauled in nonagitating trucks, nor 90 minutes when the concrete is hauled in truck mixers or truck agitators. Retempering concrete by adding water or by other means will not be permitted. With transit mixers additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements provided the addition of water is performed within 45 minutes after the initial mixing operations and provided the water/cementitious ratio specified in the approved mix design is not exceeded, and approved by the Engineer.

501-4.7 LIMITATIONS ON MIXING AND PLACING. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

a. Cold Weather. Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 40 degrees F (4

degrees C) and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 35 degrees F (2 degrees C).

The aggregate shall be free of ice, snow, and frozen lumps before entering the mixer. The temperature of the mixed concrete shall not be less than 50 degrees F (10 degrees C) at the time of placement. Concrete shall not be placed on frozen material nor shall frozen aggregates be used in the concrete.

When concreting is authorized during cold weather, water and/or the aggregates may be heated to not more than 150 degrees F (66 degrees C). 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.

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Information regarding cold weather concreting practices may be found in ACI 306R, Cold Weather Concreting.

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b. Hot Weather. During periods of hot weather when the maximum daily air temperature exceeds 85 degrees F (30 degrees C), the following precautions shall be taken.

The forms and/or the underlying surface shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 90 degrees F (35 degrees C). The aggregates and/or mixing water shall be cooled as necessary to maintain the concrete temperature at or not more than the specified maximum.

The finished surfaces of the newly laid pavement shall be kept damp by applying a water-fog or mist with approved spraying equipment until the pavement is covered by the curing medium. If necessary, wind screens shall be provided to protect the concrete from an evaporation rate in excess of 0.2 psf per hour as determined in accordance with Figure 2.1.5 in ACI 305R, Hot Weather Concreting, which takes into consideration relative humidity, wind velocity, and air temperature.

When conditions are such that problems with plastic cracking can be expected, and particularly if any plastic cracking begins to occur, the Contractor shall immediately take such additional measures as necessary to protect the concrete surface. Such measures shall consist of wind screens, more effective fog sprays, and similar measures commencing immediately behind the paver. If these measures are not effective in preventing plastic cracking, paving operations shall be immediately stopped.

c. Temperature Management Program. Prior to the start of paving operation for each day of paving, the contractor shall provide the engineer with a Temperature Management Program for the concrete to be placed to assure that uncontrolled cracking is avoided. As a minimum the program shall address the following items:

(1) Anticipated tensile strains in the fresh concrete as related to heating and cooling of the concrete material.

(2) Anticipated weather conditions such as ambient temperatures, wind velocity, and relative humidity.

(3) Anticipated timing of initial sawing of joint.

501-4.8 PLACING CONCRETE. The Contractor has the option of placing the concrete with either side (fixed) forms or slip-forms. At any point in concrete conveyance, the free vertical drop of the concrete from one point to another or to the underlying surface shall not exceed 3 feet (1 m). Backhoes and Grading equipment shall not be used to distribute the concrete in front of the paver. Front end loaders will not be used unless the contractor

demonstrates that they can be used without contaminating the concrete and base course and it is approved by the Engineer.

Hauling equipment or other mechanical equipment can be permitted on adjoining previously constructed pavement when the concrete strength reaches **[a flexural strength of 550 psi (3 792 kPa)] [a compressive strength of 3,500 psi]**, based on the average of four field cured specimens per 2,000 cubic yards (1 530 cubic meters) of concrete placed. Also, subgrade and subbase planers, concrete pavers, and concrete finishing equipment may be permitted to ride upon the edges of previously constructed pavement when the concrete has attained a minimum flexural strength of 400 psi.

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The Engineer shall choose based on mix design requirement. The Engineer may specify either side form or slip-form method of paving or allow the Contractor the option as indicated.

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a. Slip-Form Construction. The concrete shall be distributed uniformly into final position by a self propelled slip-form paver without delay. The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose. The paver shall vibrate the concrete for the full width and depth of the strip of pavement being placed and the vibration shall be adequate to provide a consistency of concrete that will stand normal to the surface with sharp well defined edges. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms.

The plastic concrete shall be effectively consolidated by internal vibration with transverse vibrating units for the full width of the pavement and/or a series of equally placed longitudinal vibrating units. The space from the outer edge of the pavement to longitudinal unit shall not exceed 9 inches. The spacing of internal units shall be uniform and shall not exceed 18 inches.

The term internal vibration means vibrating units located within the specified thickness of pavement section.

The rate of vibration of each vibrating unit shall be within 8000 to 12000 cycles per minute and the amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete along the entire length of the vibrating unit an for a distance of at least one foot. The frequency of vibration or amplitude shall vary proportionately with the rate of travel to result in a uniform density and air content. The paving machine shall be equipped with a tachometer or other suitable device for measuring and indicating the actual frequency of vibrations.

The concrete shall be held at a uniform consistency. The slip-form paver shall be operated with as nearly a continuous forward movement as possible. And all operations of mixing, delivering, and spreading concrete shall be coordinated to provide uniform progress with stopping and starting of the paver held to a minimum. If for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

When concrete is being placed adjacent to an existing pavement, that part of the equipment which is supported on the existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels on which the bearing surface is offset to run a sufficient distance from the edge of the pavement to avoid breaking the pavement edge.

b. Side-Form Construction. Side form sections shall be straight, free from warps, bends, indentations, or other defects. Defective forms shall be removed from the work. Metal side forms shall be used except at end closures and transverse construction joints where straight forms of other suitable material may be used.

Side forms may be built up by rigidly attaching a section to either top or bottom of forms. If such build-up is attached to the top of metal forms, the build-up shall also be metal.

Width of the base of all forms shall be equal to at least 80 percent of the specified pavement thickness.

Side forms shall be of sufficient rigidity, both in the form and in the interlocking connection with adjoining forms, that springing will not occur under the weight of subgrading and paving equipment or from the pressure of the concrete. The Contractor shall provide sufficient forms so that there will be no delay in placing concrete due to lack of forms.

Before placing side forms, the underlying material shall be at the proper grade. Side forms shall have full bearing upon the foundation throughout their length and width of base and shall be placed to the required grade and alignment of the finished pavement. They shall be firmly supported during the entire operation of placing, compacting, and finishing the pavement.

Forms shall be drilled in advance of being placed to line and grade to accommodate tie bars where these are specified.

Immediately in advance of placing concrete and after all subbase operations are completed, side forms shall be trued and maintained to the required line and grade for a distance sufficient to prevent delay in placing.

Side forms shall remain in place at least 12 hours after the concrete has been placed, and in all cases until the edge of the pavement no longer requires the protection of the forms. Curing compound shall be applied to the concrete immediately after the forms have been removed.

Side forms shall be thoroughly cleaned and oiled each time they are used and before concrete is placed against them.

Concrete shall be spread, screeded, shaped and consolidated by one or more self-propelled machines. These machines shall uniformly distribute and consolidate concrete without segregation so that the completed pavement will conform to the required cross section with a minimum of handwork.

The number and capacity of machines furnished shall be adequate to perform the work required at a rate equal to that of concrete delivery.

Concrete for the full paving width shall be effectively consolidated by internal vibrators without causing segregation. Internal type vibrators' rate of vibration shall be not less than 7,000 cycles per minute. Amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete more than one foot from the vibrating element. The Contractor shall furnish a tachometer or other suitable device for measuring and indicating frequency of vibration.

Power to vibrators shall be connected so that vibration ceases when forward or backward motion of the machine is stopped.

The provisions relating to the frequency and amplitude of internal vibration shall be considered the minimum requirements and are intended to ensure adequate density in the hardened concrete.

c. Consolidation Testing. The provisions relating to the frequency and amplitude of internal vibration shall be considered the minimum requirements and are intended to ensure adequate density in the hardened concrete. If a lack of consolidation of the concrete is suspected by the Engineer, additional referee testing may be required. Referee testing of hardened concrete will be performed by cutting cores from the finished pavement after a minimum of 24 hours curing. Density determinations will be made based on the water content of the core as taken. ASTM C 642 shall be used for the determination of core density in the saturated-surface dry condition. Referee cores will be taken at the minimum rate of one for each 500 cubic yards of pavement, or fraction thereof.

The average density of the cores shall be at least 97 percent of the original mix design density, with no cores having a density of less than 96 percent of the original mix design density.

Failure to meet the above requirements will be considered as evidence that the minimum requirements for vibration are inadequate for the job conditions, and additional vibrating units or other means of increasing the effect of vibration shall be employed so that the density of the hardened concrete as indicated by further referee testing shall conform to the above listed requirements.

501-4.9 STRIKE-OFF OF CONCRETE AND PLACEMENT OF REINFORCEMENT. Following the placing of the concrete, it shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement shall be at the elevation shown on the plans. When reinforced concrete pavement is placed in two layers, the bottom layer shall be struck off to such length and depth that the sheet of reinforcing steel fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off, and screeded. If any portion of the bottom layer of concrete has been placed more than 30 minutes without being covered with the top layer or if initial set has taken place, it shall be removed and replaced with freshly mixed concrete at the Contractor's expense. When reinforced concrete is placed in one layer, the reinforcement may be positioned in advance of concrete placement or it may be placed in plastic concrete by mechanical or vibratory means after spreading.

Reinforcing steel, at the time concrete is placed, shall be free of mud, oil, or other organic matter that may adversely affect or reduce bond. Reinforcing steel with rust, mill scale or a combination of both will be considered satisfactory, provided the minimum dimensions, weight, and tensile properties of a hand wire-brushed test specimen are not less than the applicable ASTM specification requirements.

501-4.10 JOINTS. Joints shall be constructed as shown on the plans and in accordance with these requirements. All joints shall be constructed with their faces perpendicular to the surface of the pavement and finished or edged as shown on the plans. Joints shall not vary more than 1/2 inch (13 mm) from their designated position and shall be true to line with not more than 1/4-inch (6 mm) variation in 10 feet (3 m). The surface across the joints shall be tested with a 10-foot (3 m) straightedge as the joints are finished and any irregularities in excess of 1/4 inch (6 mm) shall be corrected before the concrete has hardened. All joints shall be so prepared, finished, or cut to provide a groove of uniform width and depth as shown on the plans.

a. Construction. Longitudinal construction joints shall be slip-formed or formed against side forms with or without keyways, as shown in the plans.

Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for more than 30 minutes or it appears that the concrete will obtain its initial set before fresh concrete arrives. The installation of the joint shall be located at a planned contraction or expansion joint. If placing of the concrete is stopped, the Contractor shall remove the excess concrete back to the previous planned joint.

b. Contraction. Contraction joints shall be installed at the locations and spacing as shown on the plans. Contraction joints shall be installed to the dimensions required by forming a groove or cleft in the top of the slab while the concrete is still plastic or by sawing a groove into the concrete surface after the concrete has hardened. When the groove is formed in plastic concrete the sides of the grooves shall be finished even and smooth with an edging tool. If an insert material is used, the installation and edge finish shall be according to the manufacturer's instructions. The groove shall be finished or cut clean so that spalling will be avoided at intersections with other joints. Grooving or sawing shall produce a slot at least 1/8 inch (3 mm) wide and to the depth shown on the plans.

c. Expansion. Expansion joints shall be installed as shown on the plans. The premolded filler of the thickness as shown on the plans, shall extend for the full depth and width of the slab at the joint, except for space for sealant at the top of the slab. The filler shall be securely staked or fastened into position perpendicular to the proposed finished surface. A cap shall be provided to protect the top edge of the filler and to permit the concrete to be placed and finished. After the concrete has been placed and struck off, the cap shall be carefully withdrawn leaving the space over the premolded filler. The edges of the joint shall be finished and tooled while the concrete is still plastic. Any concrete bridging the joint space shall be removed for the full width and depth of the joint.

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An expansion joint is primarily used as an isolation joint to separate structures with different foundations and pavements with different joint patterns. It does not provide for expansion by the material compressing, but rather allowing the joint to slip. There should rarely be an occasion to dowel an expansion joint since it defeats the purpose of the joint and does not permit isolation and slippage. A thickened-edge is the preferred load transfer method for expansion joints.

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d. Keyways. Keyways (only female keys permitted) shall be formed in the plastic concrete by means of side forms or the use of keyway liners that are inserted during the slip-form operations. The keyway shall be formed to a tolerance of 1/4 inch (6 m) in any dimension and shall be of sufficient stiffness to support the upper keyway flange without distortion or slumping of the top of the flange. The dimensions of the keyway forms shall not vary more than plus or minus 1/4 inch (6 mm) from the mid-depth of the pavement. Liners that remain in place permanently and become part of the keyed joint shall be made of galvanized, copper clad, or of similar rust-resistant material compatible with plastic and hardened concrete and shall not interfere with joint reservoir sawing and sealing.

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The Engineer should refer to Advisory Circular 150/5320-6 for guidance on the use of keyways.

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e. Tie bars. Tie bars shall consist of deformed bars installed in joints as shown on the plans. Tie bars shall be placed at right angles to the centerline of the concrete slab and shall be spaced at intervals shown on the plans. They shall be held in position parallel to the pavement surface and in the middle of the slab depth. When tie bars extend into an unpaved lane, they may be bent against the form at longitudinal construction joints, unless threaded bolt or other assembled tie bars are specified. These bars shall not be painted, greased, or enclosed in sleeves. When slip-form operations call for tie bars, two-piece hook bolts can be installed in the female side of the keyed joint provided the installation is made without distorting the keyed dimensions or causing edge slump. If a bent tie bar installation is used, the tie bars shall be inserted through the keyway liner only on the female side of the joint. In no case shall a bent tie bar installation for male keyways be permitted.

f. Dowel bars. Dowel bars or other load-transfer units of an approved type shall be placed across joints in the manner as shown on the plans. They shall be of the dimensions and spacings as shown and held rigidly in the middle of the slab depth in the proper horizontal and vertical alignment by an approved assembly device to be left permanently in place. The dowel or load-transfer and joint devices shall be rigid enough to permit complete assembly as a unit ready to be lifted and placed into position. A metal, or other type, dowel expansion cap or sleeve shall be furnished for each dowel bar used with expansion joints. These caps shall be substantial enough to prevent collapse and shall be placed on the ends of the dowels as shown on the plans. The caps or sleeves shall fit the dowel bar tightly and the closed end shall be watertight. The portion of each dowel painted with rust preventative paint, as required under paragraph 501-2.7 and shown on the plans to receive a debonding lubricant, shall be thoroughly coated with asphalt MC-70, or an approved lubricant, to prevent the concrete from bonding to that portion of the dowel. If free-sliding plastic-coated or epoxy-coated steel dowels are used, a lubrication bond breaker shall be used except when approved pullout tests indicate it is not necessary. Where butt-type joints with dowels are designated, the exposed end of the dowel shall be oiled.

Dowel bars at contraction joints may be placed in the full thickness of pavement by a mechanical device approved by the Engineer. The device shall be capable of installing dowel bars within the maximum permissible alignment tolerances. Dowels bars at longitudinal construction joints shall be bonded in drilled holes.

g. Installation. All devices used for the installation of expansion joints shall be approved by the Engineer.

The top of an assembled joint device shall be set at the proper distance below the pavement surface and the elevation shall be checked. Such devices shall be set to the required position and line and shall be securely held in place by stakes or other means to the maximum permissible tolerances during the pouring and finishing of the concrete. The premolded joint material shall be placed and held in a vertical position; if constructed in sections, there shall be no offsets between adjacent units.

Dowel bars and assemblies shall be checked for position and alignment. The maximum permissible tolerances on dowel bar alignment shall be in accordance with paragraph 501-5.2e(6). During the concrete placement operation, it is advisable to place plastic concrete directly on dowel assemblies immediately prior to passage of the paver to help maintain dowel position and alignment within maximum permissible tolerances.

When concrete is placed using slip-form pavers, dowels and tie bars shall be placed in longitudinal construction joints by bonding the dowels or tie bars into holes drilled into the hardened concrete. Holes approximately 1/8-inch to 1/4-inch (3 to 6 mm) greater in diameter than the dowel or tie bar shall be drilled with rotary-type core drills that must be held securely in place to drill perpendicularly into the vertical face of the pavement slab. Rotary-type percussion drills may be used provided that spalling of concrete does not occur. Any damage of the concrete shall be repaired by the Contractor in a method approved by the Engineer. Dowels or tie bars shall be bonded in the drilled holes using an epoxy resin material. Installation procedures shall be adequate to insure that the area around dowels is completely filled with epoxy grout. Epoxy shall be injected into the back of the hole and displaced by the insertion of the dowel bar. Bars shall be completely inserted into the hole and shall not be withdrawn and reinserted creating air pockets in the epoxy around the bar. The Contractor shall furnish a template for checking the position and alignment of the dowels. Dowel bars shall not be less than 10 inches (25 cm) from a transverse joint and shall not interfere with dowels in the transverse direction.

h. Sawing of Joints. Joints shall be cut as shown on the plans. Equipment shall be as described in paragraph 501-4.1. The circular cutter shall be capable of cutting a groove in a straight line and shall produce a slot at least 1/8 inch (3 mm) wide and to the depth shown on the plans. The top portion of the slot shall be widened by sawing to provide adequate space for joint sealers as shown on the plans. Sawing shall commence as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing and before uncontrolled shrinkage cracking of the pavement occurs. Sawing shall be carried on both during the day and night as required. The joints shall be sawed at the required spacing, consecutively in sequence of the concrete placement. Curing compound, if being used as the cure type, shall be reapplied in the initial sawcut and maintained for the remaining cure period. Curing compound shall not be applied, and used as the cure method, to any final concrete face that is to receive a sealant. All slurry and debris produced in the sawing of joints shall be removed by vacuuming and washing.

501-4.11 FINAL STRIKE-OFF, CONSOLIDATION, AND FINISHING.

a. Sequence. The sequence of operations shall be the strike-off, floating and removal of laitance, straightedging, and final surface finish. The addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted.

b. Finishing at Joints. The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material; it shall be firmly placed without voids or segregation under and around all load-transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in paragraph 501-4.8.a. After the concrete has been placed and vibrated adjacent to the joints, the finishing machine shall be operated in a manner to avoid damage or misalignment of joints. If uninterrupted operations of the finishing machine, to, over, and beyond the joints, cause segregation of concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the screed is approximately 8 inches (20 cm) from the joint. Segregated concrete shall be removed from the front of and off the joint; and the forward motion of the finishing machine shall be resumed. Thereafter, the finishing machine may be run over the joint without lifting the screed, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

c. Machine Finishing. The concrete shall be spread as soon as it is placed, and it shall be struck off and screeded by a finishing machine. The machine shall go over each area as many times and at such intervals as necessary to give to proper consolidation and to leave a surface of uniform texture. Excessive operation over a

given area shall be avoided. When side forms are used, the tops of the forms shall be kept clean by an effective device attached to the machine, and the travel of the machine on the forms shall be maintained true without lift, wobbling, or other variation tending to affect the precision finish. During the first pass of the finishing machine, a uniform ridge of concrete shall be maintained ahead of the front screed for its entire length. When in operation, the screed shall be moved forward with a combined longitudinal and transverse shearing motion, always moving in the direction in which the work is progressing, and so manipulated that neither end is raised from the side forms during the striking-off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

d. Hand Finishing. Hand finishing methods will not be permitted, except under the following conditions: in the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade; in areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical. Concrete, as soon as placed, shall be struck off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete when reinforcement is used.

The screed for the surface shall be a least 2 feet (0.6 m) longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and shall be constructed either of metal or of other suitable material covered with metal. Consolidation shall be attained by the use of suitable vibrators.

e. Floating. After the concrete has been struck off and consolidated, it shall be further smoothed and trued by means of a longitudinal float using one of the following methods:

(1) Hand Method. Long-handled floats shall not be less than 12 feet (3.6 m) in length and 6 inches (15 cm) in width, stiffened to prevent flexibility and warping. The float shall be operated from foot bridges spanning but not touching the concrete or from the edge of the pavement. Floating shall pass gradually from one side of the pavement to the other. Forward movement along the centerline of the pavement shall be in successive advances of not more than one-half the length of the float. Any excess water or laitance in excess of 1/8-inch (3 mm) thick shall be removed and wasted.

(2) Mechanical method. The Contractor may use a machine composed of a cutting and smoothing float(s), suspended from and guided by a rigid frame and constantly in contact with, the side forms or underlying surface. If necessary, long-handled floats having blades not less than 5 feet (1.5 m) in length and 6 inches (15 cm) in width may be used to smooth and fill in open-textured areas in the pavement. When the crown of the pavement will not permit the use of the mechanical float, the surface shall be floated transversely by means of a long-handled float. Care shall be taken not to work the crown out of the pavement during the operation. After floating, any excess water and laitance in excess of 1/8-inch (3 mm) thick shall be removed and wasted. Successive drags shall be lapped one-half the length of the blade.

f. Straight-edge Testing and Surface Correction. After the pavement has been struck off and while the concrete is still plastic, it shall be tested for trueness with a Contractor furnished 16-foot (5 m) straightedge swung from handles 3 feet (1 m) longer than one-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the centerline and the whole area gone over from one side of the slab to the other, as necessary. Advancing shall be in successive stages of not more than one-half the length of the straightedge. Any excess water and laitance in excess of 1/8-inch (3 mm) thick shall be removed from the surface of the pavement and wasted. Any depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the smoothness requirements of paragraph 501-5.2e(3). Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and until the slab conforms to the required grade and cross section. The use of long-handled wood floats shall be confined to a minimum; they may be used only in emergencies and in areas not accessible to finishing equipment.

501-4.12 SURFACE TEXTURE. The surface of the pavement shall be finished with either a brush or broom, burlap drag, or artificial turf finish for all newly constructed concrete pavements. It is important that the texturing

equipment not tear or unduly roughen the pavement surface during the operation. Any imperfections resulting from the texturing operation shall be corrected to the satisfaction of the Engineer.

a. Brush or Broom Finish. If the pavement surface texture is to be a type of brush or broom finish, it shall be applied when the water sheen has practically disappeared. The equipment shall operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 1/16 of an inch (2 mm) in depth.

b. Burlap Drag Finish. If a burlap drag is used to texture the pavement surface, it shall be at least 15 ounces per square yard (555 grams per square meter). To obtain a textured surface, the transverse threads of the burlap shall be removed approximately 1 foot (0.3 m) from the trailing edge. A heavy buildup of grout on the burlap threads produces the desired wide sweeping longitudinal striations on the pavement surface. The corrugations shall be uniform in appearance and approximately 1/16 of an inch (2 mm) in depth.

c. Artificial Turf Finish. If artificial turf is used to texture the surface, it shall be applied by dragging the surface of the pavement in the direction of concrete placement with an approved full-width drag made with artificial turf. The leading transverse edge of the artificial turf drag will be securely fastened to a lightweight pole on a traveling bridge. At least 2 feet of the artificial turf shall be in contact with the concrete surface during dragging operations. A variety of different types of artificial turf are available and approval of any one type will be done only after it has been demonstrated by the Contractor to provide a satisfactory texture. One type that has provided satisfactory texture consists of 7,200 approximately 0.85-inches-long polyethylene turf blades per square foot. The corrugations shall be uniform in appearance and approximately 1/16 of an inch (2 mm) in depth.

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The Engineer may specify a particular type of finish or allow the Contractor the option.

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501-4.13 SKID-RESISTANT SURFACES. A skid-resistant surface shall be provided by construction of **[ ]**.

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When a skid-resistant surface is required in the design, the Engineer shall specify either saw-cut grooves, plastic grooves, or wire combing for runway pavements served by commercial turbo-jet aircraft and include one of the following paragraphs in the specifications. In all cases, a surface texture shall be provided in the plastic concrete prior to construction of the skid-resistant surface. Wirecombing provides skid-resistance but does not prevent hydroplaning.

When saw-cut grooves are specified proper collection and disposal of the grooving waste should be specified. If disposal of the waste material is allowed on the infield grassy areas, build-up of the waste in a single location should be avoided. Wording should be provided in this paragraph to assure that the waste material is properly disposed or distributed.

SAW-CUT GROOVES. For new concrete pavements that have hardened, transverse grooves shall be saw-cut in the pavement forming a 1/4 inch (6 mm) wide by 1/4 inch (6 mm) deep by 1-1/2 inches (37 mm) center to center configuration. The grooves shall be continuous for the entire runway length. They shall be saw-cut transversely in the runway pavement to within 10 feet (3 m) of the runway pavement edge to allow adequate space for equipment operation. The maximum transverse saw-cut grooves shall not exceed 130 feet (40 m). The tolerances for the saw-cut grooves shall meet the following:

Alignment tolerance.

Plus or minus 1-1/2 inches (38 mm) in alignment for 75 feet (23 m).

Groove tolerance.

Minimum depth 3/16 inch (5 mm), except that not more than 40 percent of the grooves shall be less than 1/4 inch (6 mm).

Maximum depth 5/16 inch (8 mm).

Minimum width 1/4 inch (6 mm).

Maximum width 5/16 inch (8 mm).

Center-to-center spacing

Minimum spacing 1-3/8 inches (35 mm)

Maximum spacing 1-1/2 inches (38 mm).

Saw-cut grooves shall not be closer than 3 inches (76 mm) or more than 9 inches (229 mm) to transverse paving joints. Grooves shall not be closer than 6 inches (152 mm) and no more than 18 inches (457 mm) from in-pavement light fixtures. Grooves may be continued through longitudinal joints. Where neoprene compression seals have been installed grooves, shall not be closer than 3 inches (76 mm) or more than 5 inches (127 mm) from the longitudinal joints. Cleanup of waste material shall be continuous during the grooving operation. Waste material shall be disposed of in an approved manner. Waste material shall not be allowed to enter the airport storm or sanitary sewer system.

PLASTIC GROOVES. The grooves formed in the plastic concrete shall be 1/4 inch (6 mm) by 1/4 inch (6 mm) by 1-1/2 inches (38 mm). The grooves shall be continuous for the entire runway length and width. The tolerances for the grooves formed in plastic concrete shall meet the following:

Alignment tolerance.

Plus or minus 3 inches (76 mm) in alignment for 75 feet (23 m).

Groove tolerance.

Minimum depth 1/8 inch (3 mm)

Maximum depth 3/8 inch (10 mm).

Minimum width 1/8 inch (3 mm).

Maximum width 3/8 inch (10 mm).

Center-to-center spacing.

Minimum spacing 1-1/4 inches (32 mm).

Maximum spacing 2 inches (51 mm).

WIRE COMBING. The wire combing technique shall use steel combs or tines of various dimensions to form groove-like texture in the plastic concrete pavement and shall provide

grooves that are approximately 1/8 inch (3 mm) by 1/8 inch (3 mm) spaced 1/2 inch (13 mm) center-to center. The wire combing shall be constructed over the full pavement width. The equipment shall operate transversely across the pavement surface, perpendicular to the pavement centerline.

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501-4.14 CURING. Immediately after finishing operations are completed and marring of the concrete will not occur, the entire surface of the newly placed concrete shall be cured for a 7-day cure period in accordance with one of the methods below. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 1/2 hour during the curing period.

When a two-sawcut method is used to construct the contraction joint, the curing compound shall be applied to the sawcut immediately after the initial cut has been made. The sealant reservoir shall not be sawed until after the curing period has been completed. When the one cut method is used to construct the contraction joint, the joint shall be cured with wet rope, wet rags, or wet blankets. The rags, ropes, or blankets shall be kept moist for the duration of the curing period.

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The Engineer shall delete cure types that may not be feasible around aircraft jet blast in operating areas.

The use of supplementary cementitious materials (e.g. flyash, slag cement) or set-retarding admixtures may delay the occurrence of bleed water. Curing should be applied after bleed water is gone from the surface.

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a. Impervious Membrane Method. The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place. The curing compound shall not be applied during rainfall. Curing compound shall be applied by mechanical sprayers under pressure at the rate of 1 gallon (4 liters) to not more than 150 square feet (14 square meters). The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application the compound shall be stirred continuously by mechanical means. Hand spraying of odd widths or shapes and concrete surfaces exposed by the removal of forms will be permitted. When hand spraying is approved by the Engineer, a double application rate shall be used to insure coverage. The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film become damaged from any cause, including sawing operations, within the required curing period, the damaged portions shall be repaired immediately with additional compound or other approved means. Upon removal of side forms, the sides of the exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface.

b. Polyethylene Films. The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting. The units shall be lapped at least 18 inches (457 mm). The sheeting shall be placed and weighted to cause it to remain in contact with the surface and sides. The sheeting shall have dimensions that will extend at least twice the thickness of the pavement beyond the edges of the pavement. Unless otherwise specified, the sheeting shall be maintained in place for 7 days after the concrete has been placed.

c. Waterproof Paper. The top surface and sides of the pavement shall be entirely covered with waterproofed paper. The units shall be lapped at least 18 inches (457 mm). The paper shall be placed and weighted to cause it to remain in contact with the surface covered. The paper shall have dimensions that will extend at least twice the thickness of the pavement beyond the edges of the slab. The surface of the pavement shall be thoroughly saturated

prior to placing of the paper. Unless otherwise specified, the paper shall be maintained in place for 7 days after the concrete has been placed.

d. White Burlap-Polyethylene Sheets. The surface of the pavement shall be entirely covered with the sheeting. The sheeting used shall be such length (or width) that it will extend at least twice the thickness of the pavement beyond the edges of the slab. The sheeting shall be placed so that the entire surface and both edges of the slab are completely covered. The sheeting shall be placed and weighted to remain in contact with the surface covered, and the covering shall be maintained fully saturated and in position for 7 days after the concrete has been placed.

(1) Curing in Cold Weather. The concrete shall be maintained at a temperature of at least 50 degrees F (10 degrees 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 concrete placed during cold weather, and any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

e. Water Method. The entire area shall be covered with burlap or other water absorbing material. The material shall be of sufficient thickness to retain water for adequate curing without excessive runoff. The material shall be kept wet at all times and maintained for 7 days. When the forms are stripped, the vertical walls shall also be kept moist. It shall be the responsibility of the Contractor to prevent ponding of the curing water on the subbase."

501-4.15 REMOVING FORMS. Unless otherwise specified, forms shall not be removed from freshly placed concrete until it has hardened sufficiently to permit removal without chipping, spalling, or tearing. After the forms have been removed, the sides of the slab shall be cured as outlined in one of the methods indicated in paragraph 501-4.14. Major honeycombed areas shall be considered as defective work and shall be removed and replaced in accordance with paragraph 501-5.2(f).

501-4.16 SEALING JOINTS. The joints in the pavement shall be sealed in accordance with Item [P-605].

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The Engineer should only include the applicable specifications.

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501-4.17 PROTECTION OF PAVEMENT. The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents. This shall include watchmen to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, crossovers, and protection of unsealed joints from intrusion of foreign material, etc. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor's expense. The Contractor shall have available at all times, materials for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of rolled polyethylene sheeting at least 4 mils (0.1 mm) thick of sufficient length and width to cover the plastic concrete slab and any edges. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the plastic concrete surface. When rain appears imminent, all paving operations shall stop and all available personnel shall begin covering the surface of the unhardened concrete with the protective covering.

501-4.18 OPENING TO TRAFFIC. The pavement shall not be opened to traffic until test specimens molded and cured in accordance with ASTM C 31 have attained a flexural strength of 550 pounds per square inch (3,792 kPa) when tested in accordance with ASTM C 78. If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Prior to opening the pavement to construction traffic, all joints shall either be sealed or protected from damage to the joint edge and intrusion of foreign materials into the joint. As a minimum, backer rod or tape may be used to protect the joints from foreign matter intrusion. The pavement shall be cleaned before opening for normal operations.

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When the design strength in paragraph 501-3.1 is based on compressive strength, a strength of 3500 psi (24 130 kPa) shall be specified. Testing shall be in accordance with ASTM C 39.

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501-4.19 REPAIR, REMOVAL, REPLACEMENT OF SLABS.

a. General. New pavement slabs that are broken or contain cracks shall be removed and replaced or repaired, as specified hereinafter at no cost to the owner. Spalls along joints shall be repaired as specified. Removal of partial slabs is not permitted. Removal and replacement shall be full depth, shall be full width of the slab, and the limit of removal shall be normal to the paving lane and to each original transverse joint. The engineer will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be 4-inch (100 mm) diameter, shall be drilled by the Contractor and shall be filled by the Contractor with a well consolidated concrete mixture bonded to the walls of the hole with epoxy resin, using approved procedures. Drilling of cores and refilling holes shall be at no expense to the owner. All epoxy resin used in this work shall conform to ASTM C 881, Type V.

b. Shrinkage Cracks. Shrinkage cracks, which do not exceed 4 inches in depth, shall be cleaned and then pressure injected with epoxy resin, Type IV, Grade 1, using procedures as approved. Care shall be taken to assure that the crack is not widened during epoxy resin injection. All epoxy resin injection shall take place in the presence of the Engineer. Shrinkage cracks, which exceed 4 inches in depth, shall be treated as full depth cracks in accordance with paragraphs 4.19b and 4.19c.

c. Slabs With Cracks through Interior Areas. Interior area is defined as that area more than 6 inches (600 mm) from either adjacent original transverse joint. The full slab shall be removed and replaced at no cost to the owner, when there are any full depth cracks, or cracks greater than 4” in depth, that extend into the interior area.

d. Cracks Close To and Parallel To Joints. All cracks essentially parallel to original joints, extending full depth of the slab, and lying wholly within 6 inches either side of the joint shall be treated as specified hereinafter. Any crack extending more than 6 inches (600 mm) from the joint shall be treated as specified above in subparagraph "Slabs With Cracks Through Interior Area."

(1) Full Depth Cracks Present, Original Joint Not Opened. When the original uncracked joint has not opened, the crack shall be sawed and sealed, and the original joint filled with epoxy resin as specified below. The crack shall be sawed with equipment specially designed to follow random cracks. The reservoir for joint sealant in the crack shall be formed by sawing to a depth of 3/4 inch (19 mm), plus or minus 1/16 inch (1.6 mm), and to a width of 5/8 inch (16 mm), plus or minus 1/8 inch (3.2 mm). Any equipment or procedure which causes raveling or spalling along the crack shall be modified or replaced to prevent such raveling or spalling. The joint sealant shall be a liquid sealant as specified. Installation of joint seal shall be as specified for sealing joints or as directed. If the joint sealant reservoir has been sawed out, the reservoir and as much of the lower saw cut as possible shall be filled with epoxy resin, Type IV, Grade 2, thoroughly tooled into the void using approved procedures. If only the original narrow saw cut has been made, it shall be cleaned and pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. If filler type material has been used to form a weakened plane in the transverse joint, it shall be completely sawed out and the saw cut pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. Where a parallel crack goes part way across paving lane and then intersects and follows the original joint which is cracked only for the remained of the width, it shall be treated as specified above for a parallel crack, and the cracked original joint shall be prepared and sealed as originally designed.

(2) Full Depth Cracks Present, Original Joint Also Cracked. At a joint, if there is any place in the lane width where a parallel crack and a cracked portion of the original joint overlap, the entire slab containing the crack shall be removed and replaced for the full lane width and length.

e. Removal and Replacement of Full Slabs. Where it is necessary to remove full slabs, unless there are keys or dowels present, all edges of the slab shall be cut full depth with a concrete saw. All saw cuts shall be

perpendicular to the slab surface. If keys, dowels, or tie bars are present along any edges, these edges shall be sawed full depth 24 inches (150 mm) from the edge if only keys are present, or just beyond the end of the dowels or tie bars if they are present. These joints shall then be carefully sawed on the joint line to within 1 inch (25 mm) of the depth of the dowel or key.

The main slab shall be further divided by sawing full depth, at appropriate locations, and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and approved safe lifting devices used for attachment to the slabs. The narrow strips along keyed or doweled edges shall be carefully broken up and removed using light, hand-held jackhammers, 30 LB (14 kg) or less, or other approved similar equipment.

Care shall be taken to prevent damage to the dowels, tie bars, or keys or to concrete to remain in place. The joint face below keys or dowels shall be suitably trimmed so that there is not abrupt offset in any direction greater than 1/2 inch (12 mm) and no gradual offset greater than 1 inch (25 mm) when tested in a horizontal direction with a 12-foot (3.6 m) straightedge.

No mechanical impact breakers, other than the above hand-held equipment shall be used for any removal of slabs. If underbreak between 1-1/2 and 4 inches (37 and 100 mm) deep occurs at any point along any edge, the area shall be repaired as directed before replacing the removed slab. Procedures directed will be similar to those specified for surface spalls, modified as necessary.

If underbreak over 4 inches (100 mm) deep occurs, the entire slab containing the underbreak shall be removed and replaced. Where there are no dowels, tie bars, or keys on an edge, or where they have been damaged, dowels of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All 4 edges of the new slab shall thus contain dowels or original keys or original tie bars.

Placement of concrete shall be as specified for original construction. Prior to placement of new concrete, the underlying material (unless it is stabilized) shall be re-compacted and shaped as specified in the appropriate SECTION of these specifications. The surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

f. Repairing Spalls Along Joints. Where directed, spalls along joints of new slabs, and along parallel cracks used as replacement joints, shall be repaired by first making a vertical saw cut at least 1 inch (25 mm) outside the spalled area and to a depth of at least 2 inches (50 mm). Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and at least 1/2 inch (12 mm) of visually sound concrete. The cavity thus formed shall be thoroughly cleaned with high-pressure water jets supplemented with compressed air to remove all loose material. Immediately before filling the cavity, a prime coat of epoxy resin, Type III, Grade I, shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Pooling of epoxy resin shall be avoided. The cavity shall be filled with low slump Portland cement concrete or mortar or with epoxy resin concrete or mortar. Concrete shall be used for larger spalls, generally those more than 1/2 cu. ft. (0.014 m3) in size, and mortar SHALL BE USED FOR THE SMALLER ONES. ANY SPALL LESS THAN 0.1 CU. FT. (O.OO3 m3) shall be repaired only with epoxy resin mortar or a Grade III epoxy resin. Portland cement concrete and mortar mixtures shall be proportioned as directed and shall be mixed, placed, consolidated, and cured as directed. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the Engineer. The epoxy resin materials shall be placed in the cavity in layers not over 2 inches (50 mm) thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 140oF (60oC) at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints, or as required to be routed for cracks. The reservoir shall be thoroughly

cleaned and sealed with the sealer specified for the joints. If any spall penetrates half the depth of the slab or more, the entire slab shall be removed and replaced as previously specified.

501-4.20 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR.

* *

NOTE: It is imperative that sufficient exploration be made (not just reference to as-built drawings) so that the designer knows exactly what the existing (in place) pavement is at the jointing area—dowels, keys, tie bars, etc. and its condition. Normally the joint between the new pavement and existing pavement should be made at an existing joint in the old pavement.

* *

All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface.

a. Removal of Existing Pavement Slab.

* *

NOTE: Edit bracketed items concerning dowels and keys to conform to the design used. The best results will usually be with a design requiring that keys and dowels be sawed off and new dowels installed in drilled holes. The saw cut at a distance from the joint is always more effective if sawed with a wheel saw—which produces a 1-inch (25 mm) kerf and better prevents stress from propagating across the saw cut.

* *

When it is necessary to remove existing concrete pavement and leave adjacent concrete in place, [unless there are dowels or keys present,] the joint between the removal area and adjoining pavement to stay in place, [including dowels, tie bars or keys,] shall first be cut full depth with a standard diamond-type concrete saw. [If keys or dowels are present at this joint, the saw cut shall be made full depth 6 inches (150 mm) from the joint if only keys are present, or just beyond the end of dowels if dowels are present. The edge shall then be carefully sawed on the joint line to within 1 inch (25 mm) of the top of the dowel or key.] Next, a full depth saw cut shall be made parallel to the joint at least 24 inches (600 mm) from the joint and at least 12 inches (300 mm) from the end of any dowels. All pavement between this last saw cut and the joint line shall be carefully broken up and removed using hand-held jackhammers, 30 lb. (14 kg) or less, or the approved light-duty equipment which will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. [Where dowels or keys are present, care shall be taken to produce an even, vertical joint face below the dowels or keys. If the Contractor is unable to produce such a joint face, or if underbreak or other distress occurs, the Contractor shall saw the dowels or keys flush with the joint. The Contractor shall then install new dowels, of the size and spacing used for other similar joints, by epoxy resin bonding them in holes drilled in the joint face as specified in paragraph "Placing dowels and Tie-bars. All this shall be at no additional cost to the Owner.] [Dowels of the size and spacing indicated shall be installed as shown on the drawings by epoxy resin bonding them in holes drilled in the joint face as specified in paragraph "Placing Dowels and Tie Bars".] The joint face shall be sawed or otherwise trimmed so that there is no abrupt offset in any direction greater than 1/2-inch (12 mm) and no gradual offset greater than 1 inch (25 mm) when tested in a horizontal direction with a 12 ft. (3.6 m) straightedge.

b. Edge Repair.

* *

NOTE: Edit bracketed items on payment as appropriate.

* *

The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Areas that are damaged during construction shall be repaired at not cost to the Owner; repair of previously existing damage areas **[will be paid for as listed in the bid schedule] [will be considered a subsidiary part of concrete pavement construction]**.

(1) Spall Repair. Spalls shall be repaired where indicated and where directed. Repair materials and procedures shall be as previously specified in subparagraph "Repairing Spalls Along Joints."

(2) Underbreak Repair. All underbreak shall be repaired. First, all delaminated and loose material shall be carefully removed. Next, the underlying material shall be recompacted, without addition of any new material. Finally, the void shall be completely filled with paving concrete, thoroughly consolidated. Care shall be taken to produce an even joint face from top to bottom. Prior to placing concrete, the underlying material shall be thoroughly moistened. After placement, the exposed surface shall be heavily coated with curing compound.

(3) Underlying Material. The underlying material adjacent to the edge of an under the existing pavement which is to remain in place shall be protected from damage or disturbance during removal operations and until placement of new concrete, and shall be shaped as shown on the drawings or as directed. Sufficient material shall be kept in place outside the joint line to prevent disturbance (or sloughing) of material under the pavement that is to remain in place. Any material under the portion of the concrete pavement to remain in place, which is disturbed or loses its compaction shall be carefully removed and replaced with concrete as specified in paragraph "Underbreak Repair." The underlying material outside the joint line shall be thoroughly compacted and moist when new concrete is placed.

MATERIAL ACCEPTANCE

501-5.1 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. Concrete shall be accepted for strength and thickness on a lot basis.

* *

The Sponsor (Engineer) shall do the acceptance testing per the standard specifications.

* *

A lot shall consist of:

[ ] cubic yards ([ ] cubic meters).]
[ ] square yards ([ ] square meters).]
[a day's production not to exceed 2,000 cubic yards (1 530 cubic meters).]
[a day's production not to exceed [ ] square yards ([ ] square meters).]

Testing organizations performing these tests shall meet the requirements of ASTM C 1077, including accreditation. The accreditation will include ASTM C 78. The Contractor shall bear the cost of providing curing facilities for the strength specimens, per paragraph 501-5.1a(3), and coring and filling operations, per paragraph 501-5.1b(1).

* *

The Engineer shall specify the lot size for a project based on the total quantity and the expected production rate. The lot size should not exceed 2,000 cubic yards (1 530 cubic meters). For projects where basis of payment is square yards (square meters), the Engineer shall convert the lot size to an equivalent area that contains 2,000 cubic yards (1 530 cubic meters) or less.

Note: It is recommended that all projects have a testing meeting between the contractor, testing laboratory, and owner's representative to discuss the sampling and testing of the strength specimens. The meeting should include procedures for sampling fabrication, handling and initial and final curing, and testing of the strength specimens.

* *

a. Flexural Strength.

(1) Sampling. Each lot shall be divided into four equal sublots. One sample shall be taken for each sublot from the plastic concrete delivered to the job site. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D 3665. The concrete shall be sampled in accordance with ASTM C 172.

(2) Testing. Two (2) specimens shall be made from each sample. Specimens shall be made in accordance with ASTM C 31 and the flexural strength of each specimen shall be determined in accordance with ASTM C 78. The flexural strength for each sublot shall be computed by averaging the results of the two test specimens representing that sublot.

Immediately prior to testing for flexural strength, the beam shall be weighed and measured for determination of a sample unit weight. Measurements shall be made for each dimension; height, depth, and length, at the mid-point of the specimen and reported to the nearest tenth of an inch. The weight of the specimen shall be reported to the nearest 0.1 pound. The sample unit weight shall be calculated by dividing the sample weight by the calculated volume of the sample. This information shall be reported as companion information to the measured flexural strength for each specimen.

The samples will be transported while in the molds. The curing, except for the initial cure period, will be accomplished using the immersion in saturated lime water method.

Slump, air content, and temperature tests will also be conducted by the quality assurance laboratory for each set of strength test samples, per ASTM C 31.

(3) Curing. The Contractor shall provide adequate facilities for the initial curing of beams. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60 to 80 degrees F (16 to 27 degrees 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 using other suitable methods, provided the temperature and moisture loss requirements are met.

(4) Acceptance. Acceptance of pavement for flexural strength will be determined by the Engineer in accordance with paragraph 501-5.2b.

* *

Preventing loss of moisture is extremely important since relatively small amounts of surface drying of flexural specimens can induce tensile stresses in the extreme fibers that will markedly reduce the indicated flexural strength.

When the design strength in paragraph 501-3.1 is based on compressive strength, this paragraph should be revised as follows:

a. Compressive Strength.

(1) Sampling. Each lot shall be divided into four equal sublots. One sample shall be taken for each sublot from the plastic concrete delivered to the job site. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D 3665. The concrete shall be sampled in accordance with ASTM C 172.

(2) Testing. Two (2) specimens shall be made from each sample. Specimens shall be made in accordance with ASTM C 31 and the compressive strength of each specimen shall be determined in accordance with ASTM C 39. The compressive strength for each sublot shall be computed by averaging the results of the two test specimens representing that sublot.

(3) Curing. 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 degrees F (16 to 27 degrees 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.

* *

b. Pavement Thickness.

(1) Sampling. Each lot shall be divided into four equal sublots and one core shall be taken by the Contractor for each sublot. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D 3665. Areas, such as thickened edges, with planned variable thickness, shall be excluded from sample locations.

Cores shall be neatly cut with a core drill. The Contractor shall furnish all tools, labor, and materials for cutting samples and filling the cored hole. Core holes shall be filled by the Contractor with a non-shrink grout approved by the Engineer within one day after sampling.

(2) Testing. The thickness of the cores shall be determined by the Engineer by the average caliper measurement in accordance with ASTM C 174.

(3) Acceptance. Acceptance of pavement for thickness shall be determined by the Engineer in accordance with paragraph 501-5.2c.

c. Partial Lots. When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and Engineer agree in writing to allow overages or minor placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

Where three sublots have been produced, they shall constitute a lot. Where one or two sublots have been produced, they shall be incorporated into the next lot or the previous lot and the total number of sublots shall be used in the acceptance criteria calculation, i.e., n=5 or n=6.

d. Outliers. All individual flexural strength tests within a lot shall be checked for an outlier (test criterion) in accordance with ASTM E 178, at a significance level of 5 percent. Outliers shall be discarded, and the PWL shall be determined using the remaining test values.

501-5.2 ACCEPTANCE CRITERIA.

a. General. Acceptance will be based on the following characteristics of the completed pavement:

(1) Flexural strength

(2) Thickness

(3) Smoothness

(4) Grade

(5) Edge slump

(6) Dowel bar alignment

Flexural strength and thickness shall be evaluated for acceptance on a lot basis using the method of estimating percentage of material within specification limits (PWL). Acceptance using PWL considers the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results to calculate the percentage of material that is above the lower specification tolerance limit (L).

Acceptance for flexural strength will be based on the criteria contained in accordance with paragraph 501-5.2e(1). Acceptance for thickness will be based on the criteria contained in paragraph 501-5.2e(2). Acceptance for smoothness will be based on the criteria contained in paragraph 501-5.2e(3). Acceptance for grade will be based on the criteria contained in paragraph 501-5.2e(4).

The Engineer may at any time, not withstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to contamination, segregation, or improper slump. Such rejection may be based on only visual inspection. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

b. Flexural Strength. Acceptance of each lot of in-place pavement for flexural strength shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.

* *

When the design strength in paragraph 501-3.1 is based on compressive strength, substitute compressive strength for flexural strength.

* *

c. Pavement Thickness. **A**cceptance of each lot of in-place pavement shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.

d. Percentage of Material Within Limits (PWL). The percentage of material within limits (PWL) shall be determined in accordance with procedures specified in Section 110 of the General Provisions.

The lower specification tolerance limit (L) for flexural strength and thickness shall be:

Lower Specification Tolerance Limit (L)

Flexural Strength	0.93 × strength specified in paragraph 501-3.1
Thickness	Lot Plan Thickness in inches − 0.50 inches

* *

The lower specification tolerance limits above are based on applying statistical analysis to FAA design assumptions, and there is no need to compensate for the above factor in the design process. When the design strength in paragraph 501-3.1 is based on compressive

strength, substitute compressive strength for flexural strength and insert 4,140 psi as L for strength.

* *

e. Acceptance Criteria.

(1) Flexural Strength. If the PWL of the lot equals or exceeds 90 percent, the lot shall be acceptable. Acceptance and payment for the lot shall be determined in accordance with paragraph 501-8.1.

(2) Thickness. If the PWL of the lot equals or exceeds 90 percent, the lot shall be acceptable. Acceptance and payment for the lot shall be determined in accordance with paragraph 501-8.1.

(3) Smoothness. As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a 16-foot (5 m) straightedge or other specified device. Surface smoothness deviations shall not exceed 1/4 inch (6 mm) from a 16-foot (5 m) straightedge placed in any direction, including placement along and spanning any pavement joint edge.

Areas in a slab showing high spots of more than 1/4 inch (6 mm) but not exceeding 1/2 inch (13 mm) in 16 feet (5 m) shall be marked and immediately ground down with an approved grinding machine to an elevation that will fall within the tolerance of 1/4 inch (6 mm) or less. Where the departure from correct cross section exceeds 1/2 inch (13 mm), the pavement shall be removed and replaced at the expense of the Contractor when so directed by the Engineer.

* *

Use of the profilograph to measure pavement smoothness is optional and will be approved on a case-by-case basis. Use of a profilometer may not be practical for all construction. However, the profilograph is useful for new construction or overlays designed to correct grade and smoothness deficiencies. If the profilograph is to be included, straightedge requirements need only apply in the transverse direction. To include profilograph requirements delete paragraph (5.2e3) and replace with the following:

(3) SMOOTHNESS. As soon as the concrete has hardened sufficiently, the pavement surface shall be tested in the transverse direction with a 16-foot straightedge or other specified device. Surface smoothness deviations shall not exceed 1/4 inch from a 16-foot straightedge at any location, including placement along and spanning any pavement joint or edge.

Areas in the slab showing high spots of more than 1/4 inch but not exceeding 1/2 inch in 16 feet shall be marked and immediately ground down with an approved grinding machine to an elevation that falls within the tolerance of 1/4 inch or less. Where the departure from the correct cross section exceeds 1/2 inch, the pavement shall be removed and replaced at the expense of the Contractor when so directed by the Engineer.

In addition to the 16-foot straight edge, the Contractor shall furnish a 25' wheel base California type profilograph and competent operator to be used to measure longitudinal pavement surface deviations. The profilograph shall be operated under the supervision of the Engineer and in accordance with the manufacturer's instructions. The profilograph shall be operated at a speed no greater than a normal walk. Original profilograms for the appropriate locations interpreted in accordance with ASTM E 1274 shall be furnished to the Engineer. The profilograms shall be recorded on a scale of one inch equal to 25 feet longitudinally and one inch equal to one inch or full scale vertically. Records shall be maintained showing all smoothness measurements.

(a) The surface of Runway and Taxiway pavements of continuous placement of 50 feet or more shall be tested and evaluated as described herein. Two passes shall be made in each paving lane greater than 20 feet in width; each pass shall be six feet from and parallel with the centerline

of the paving lane. The average of the two passes shall be considered as the profilograph result for the paving lane. For paving lanes less than 20 feet in width, one pass along the centerline shall be required. Tests shall be run the next working day following concrete placement. Each trace shall be completely labeled to show paving lane, wheel pass, and stationing.

(b) The Contractor shall furnish paving equipment and employ methods that produce a riding surface for each section of pavement having an average profile index meeting the requirements of paragraph 8.1c. A typical subsection will be considered to be the width of the paving lane and 1/10 mile long. The profile index will be determined in accordance with ASTM E 1274 using a 0.2-inch blanking band. Within each 1/10th mile subsection, all areas represented by high points having a deviation in excess of 0.4 inch in 25 feet or less shall be removed by the contractor using an approved grinding device or a device consisting of multiple diamond blades. The use of a bush hammer or other impact devices will not be permitted. After removing all individual deviations in excess of 0.4 inch, additional corrective work shall be performed if necessary to achieve the required ride quality. All corrective work shall be completed prior to determination of pavement thickness.

(c) On those pavement subsections where corrections were necessary, second profilograph runs will be performed to verify that the corrections have produced an average profile index of 15 inches per mile or less. If the initial average profile index was less than 15, only those areas representing greater than 0.4-inch deviation will be re-profiled for correction verification.

(d) When the average profile index does not exceed ______ inches per mile, payment will be made for that section at the contract unit price for the completed pavement. When the average profile index exceeds ______ inches per mile, but does not exceed fifteen inches per mile, the Contractor may elect to accept a contract unit price adjustment in lieu of reducing the profile index.

*** ***

Specify the maximum inches per mile allowed for 100% payment corresponding to the pavement loading conditions as indicate in Paragraph 8.1d.

*** ***

(e) Individual sections shorter than 50 feet and the last 15 feet of any section where the contractor is not responsible for the adjoining section, shall be straightedged in accordance with Section 501.5.2e(3).

(f) If there is a section of 250 feet or less, the profilogram for that section shall be included in the evaluation of the previous section. If there is an independently placed section of 50 to 250 feet in length, a profilogram shall be made for that section and the pay adjustment factors for short sections of paragraph 8.1c shall apply.

(g) Any corrective work required shall be performed prior to joint sealing and grooving operations.

(h) All cost necessary to provide the profilograph and related to furnishing the appropriate profilograms as required in this provision are incidental to concrete pavement construction and no direct compensation will be made therefore.

*** ***

(4) Grade. An evaluation of the surface grade shall be made by the Engineer for compliance to the tolerances contained below. Records shall be maintained showing all grade measurements.

Lateral Deviation. Lateral deviation from established alignment of the pavement edge shall not exceed plus or minus 0.10 foot (30 mm) in any lane.

Vertical Deviation. Vertical deviation from established grade shall not exceed plus or minus 0.04 foot (12 mm) at any point.

(5) Edge Slump. When slip-form paving is used, not more than 15 percent of the total free edge of each 500 foot (150 m) segment of pavement, or fraction thereof, shall have an edge slump exceeding 1/4-inch (6 mm), and none of the free edge of the pavement shall have an edge slump exceeding 3/8-inch (10 mm). (The total free edge of 500 feet (150 m) of pavement will be considered the cumulative total linear measurement of pavement edge originally constructed as nonadjacent to any existing pavement; i.e., 500 feet (150 m) of paving lane originally constructed as a separate lane will have 1,000 feet (300 m) of free edge, 500 feet (150 m) of fill-in lane will have no free edge, etc.). The area affected by the downward movement of the concrete along the pavement edge shall be limited to not more than 18 inches (457 mm) from the edge. When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump shall be removed and replaced at the expense of the Contractor when so directed by the Engineer.

(6) Dowel Bar Alignment. Dowel bars and assemblies shall be checked for position and alignment. The maximum permissible tolerance on dowel bar alignment in each plane, horizontal and vertical, shall not exceed 2 percent or 1/4 inch per foot (20 mm per meter) of a dowel bar. Vertical alignment of dowels shall be measured parallel to the designed top surface of the pavement, except for those across the crown or other grade change joints. Dowels across crowns and other joints at grade changes, shall be measured to a level surface. Horizontal alignment shall be checked perpendicular to the joint edge.

f. Removal and Replacement of Concrete. Any area or section of concrete that is removed and replaced shall be removed and replaced back to planned joints. The Contractor shall replace damaged dowels and the requirements for doweled longitudinal construction joints in paragraph 501-4.10 shall apply to all contraction joints exposed by concrete removal. Removal and replacement shall be in accordance with paragraph 501-4.19 of this specification.

CONTRACTOR QUALITY CONTROL

501-6.1 QUALITY CONTROL PROGRAM. The Contractor shall develop a Quality Control Program in accordance with Section 100 of the General Provisions. The program shall address all elements that effect the quality of the pavement including but not limited to:

a. Mix Design	**e.** Proportioning	**i.** Dowel Placement and Alignment
b. Aggregate Gradation	**f.** Mixing and Transportation	**j.** Flexural or Compressive Strength
c. Quality of Materials	**g.** Placing and Consolidation	**k.** Finishing and Curing
d. Stockpile Management	**h.** Joints	**l.** Surface Smoothness

* *

When the design requires paving an area less than 600 square yards (500 square meters), the Engineer may request modification to this requirement.

* *

501-6.2 QUALITY CONTROL TESTING. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to this specification and as set forth in the Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for aggregate gradation, aggregate moisture content, slump, and air content.

A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

a. Fine Aggregate.

(1) Gradation. A sieve analysis shall be made at least twice daily in accordance with ASTM C 136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture Content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C 70 or ASTM C 566.

b. Coarse Aggregate.

(1) Gradation. A sieve analysis shall be made at least twice daily for each size of aggregate. Tests shall be made in accordance with ASTM C 136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture Content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C 566.

c. Slump. Four slump tests shall be performed for each lot of material produced in accordance with the lot size defined in Section 501-5.1. One test shall be made for each sublot. Slump tests shall be performed in accordance with ASTM C 143 from material randomly sampled from material discharged from trucks at the paving site. Material samples shall be taken in accordance with ASTM C 172.

d. Air Content. Four air content tests, shall be performed for each lot of material produced in accordance with the lot size defined in Section 501-5.1. One test shall be made for each sublot. Air content tests shall be performed in accordance with ASTM C 231 for gravel and stone coarse aggregate and ASTM C 173 for slag or other porous coarse aggregate, from material randomly sampled from trucks at the paving site. Material samples shall be taken in accordance with ASTM C 172.

e. Four unit weight and yield tests shall be made in accordance with ASTM C 138. The samples shall be taken in accordance with ASTM C 172 and at the same time as the air content tests.

501-6.3 CONTROL CHARTS. The Contractor shall maintain linear control charts for fine and coarse aggregate gradation, slump, and air content.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept up to date at all times. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and suspension Limits, or Specification limits, applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a potential problem and the Contractor is not taking satisfactory corrective action, the Engineer may halt production or acceptance of the material.

a. Fine and Coarse Aggregate Gradation. The Contractor shall record the running average of the last five gradation tests for each control sieve on linear control charts. Specification limits contained in Tables 1 and 2 shall be superimposed on the Control Chart for job control.

b. Slump and Air Content. The Contractor shall maintain linear control charts both for individual measurements and range (i.e. difference between highest and lowest measurements) for slump and air content in accordance with the following Action and Suspension Limits.

CONTROL CHART LIMITS			
Control Parameter	Individual Measurements		Range Suspension Limit
	Action Limit	Suspension Limit	
Slip Form:			
Slump	+0 to -1 inch (0-25mm)	+0.5 to -1.5 inch (13-38mm)	+/- 1.5 inch (38 mm)
Air Content	+/- 1.2%	+/- 1.8%	+/- 2.5%
Fixed Form			
Slump	+ 0.5 to -1 inch (13-25mm)	+1 to -1.5 inch (25-38mm)	+/- 1.5 inch (38mm)
Air Content	+/- 1.2%	+/- 1.8%	+/- 2.5%

The individual measurement control charts shall use the mix design target values as indicators of central tendency.

501-6.4 CORRECTIVE ACTION. The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of control. The Contractor Quality Control Program shall detail what action will be taken to bring the process into control and shall contain sets of rules to gauge when a process is out of control. As a minimum, a process shall be deemed out of control and corrective action taken if any one of the following conditions exists.

a. Fine and Coarse Aggregate Gradation. When two consecutive averages of five tests are outside of the Tables 1 or 2 specification limits, immediate steps, including a halt to production, shall be taken to correct the grading.

b. Fine and Coarse Aggregate Moisture Content. Whenever the moisture content of the fine or coarse aggregate changes by more than 0.5 percent, the scale settings for the aggregate batcher(s) and water batcher shall be adjusted.

c. Slump. The Contractor shall halt production and make appropriate adjustments whenever:

(1) one point falls outside the Suspension Limit line for individual measurements or range; or
(2) two points in a row fall outside the Action Limit line for individual measurements.

d. Air Content. The Contractor shall halt production and adjust the amount of air-entraining admixture whenever:

(1) one point falls outside the Suspension Limit line for individual measurements or range; or
(2) two points in a row fall outside the Action Limit line for individual measurements.

Whenever a point falls outside the Action Limits line, the air-entraining admixture dispenser shall be calibrated to ensure that it is operating correctly and with good reproducibility.

METHOD OF MEASUREMENT

501-7.1 Portland cement concrete pavement shall be measured by the number of **[cubic yards (cubic meters)] [square yards (square meters)]** of either plain or reinforced pavement as specified in-place, completed and accepted. Saw-cut grooving shall be measured by the number of square yards (square meters) of saw-cut grooving as specified in-place, completed and accepted.

BASIS OF PAYMENT

501-8.1 PAYMENT. Payment for accepted concrete pavement shall be made at the contract unit price **[per cubic yard (cubic meter)] [per square yard (square meter)]** adjusted in accordance with paragraph 501-8.1a, subject to the limitation that:

The total project payment for concrete pavement shall not exceed **[ ]** percent of the product of the contract unit price and the total number of **[cubic yards (cubic meters)] [square yards (square meters**)] of concrete pavement used in the accepted work (See Note 2 under Table 3).

Payment shall be full compensation for all labor, materials, tools, equipment, and incidentals required to complete the work as specified herein and on the drawings, except for saw-cut grooving.

*** ***

The Engineer shall specify a value ranging from 100 percent to 106 percent. When the total project payment for Item P-501 pavement exceeds the contract unit price, any AIP or PFC funds used to pay the excess may require an amendment to the AIP grant or PFC application for the project.

*** ***

a. Basis of Adjusted Payment. The pay factor for each individual lot shall be calculated in accordance with Table 3. A pay factor shall be calculated for both flexural strength and thickness. The lot pay factor shall be the higher of the two values when calculations for both flexural strength and thickness are 100 percent or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either flexural strength or thickness is 100 percent or higher. The lot pay factor shall be the lower of the two values when calculations for both flexural strength and thickness are less than 100 percent .

TABLE 3. PRICE ADJUSTMENT SCHEDULE [1]

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96 – 100	106
90 – 95	PWL + 10
75 – 90	0.5PWL + 55
55 – 74	1.4PWL – 12
Below 55	Reject [2]

[1] ALTHOUGH IT IS THEORETICALLY POSSIBLE TO ACHIEVE A PAY FACTOR OF 106 PERCENT FOR EACH LOT, ACTUAL PAYMENT IN EXCESS OF 100 PERCENT SHALL BE SUBJECT TO THE TOTAL PROJECT PAYMENT LIMITATION SPECIFIED IN PARAGRAPH 501-8.1.

[2] The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50 percent of the contract unit price AND THE TOTAL PROJECT PAYMENT LIMITATION SHALL BE REDUCED BY THE AMOUNT WITHHELD FOR THE REJECTED LOT.

For each lot accepted, the adjusted contract unit price shall be the product of the lot pay factor for the lot and the contract unit price. Payment shall be subject to the total project payment limitation specified in paragraph 501-8.1. Payment in excess of 100 percent for accepted lots of concrete pavement shall be used to offset payment for accepted lots of concrete pavement that achieve a lot pay factor less than 100 percent.

b. Payment. Payment shall be made under:

Item P-501-8.1a Portland Cement Concrete Pavement—**[per cubic yard (cubic meter)] [per square yard (square meter)]**

c. Basis of adjusted payment for Smoothness. Price adjustment for pavement smoothness will apply to the total area of concrete within a section of pavement and shall be applied in accordance the following equation and schedule:

(Sq yds in section) x (original unit price per sq yds) x PFm =
= reduction in payment for area within section

Average Profile Index (Inches per mile) pavement strength rating			Contract Unit Price Adjustment
over 30,000 lb	30,000 lb or less	Short Sections	PFm
0 - 7	0 - 10	0 - 15	0.00
7.1 - 9	10.1 - 11	15.1 - 16	0.02
9.1 - 11	11.1 - 12	16.1 - 17	0.04
11.1 - 13	12.1 - 13	17.1 - 18	0.06
13.1 - 14	13.1 - 14	18.1 - 20	0.08
14.1 - 15	14.1 - 15	20.1 - 22	0.10
15.1 & up	15.1 & up	22.1 & up	corrective work required

501-8.2 PAYMENT FOR SAW-CUT GROOVING. Payment for saw-cut grooving shall be made at the contract unit price per square yard (square meter) for saw-cut grooving.

* *

Delete paragraph 501-8.2 if saw-cut grooving is not included in the project.

* *

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 70	Surface Moisture in Fine Aggregate
ASTM C 78	Test for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C 88	Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 131	Test for Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C 138	Test for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C 143	Test for Slump of Hydraulic Cement Concrete
ASTM C 172	Sampling Freshly Mixed Concrete
ASTM C 173	Test for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 174	Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C 227	Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)

ASTM C 231	Test for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 289	Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
ASTM C 295	Petrographic Examination of Aggregates for Concrete
ASTM C 114	Chemical Analysis of Hydraulic Cement
ASTM C 535	Test for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 566	Total Evaporable Moisture Content of Aggregates by Drying
ASTM C 642	Test for Density, Absorption, and Voids in Hardened Concrete
ASTM C 666	Resistance of Concrete to Rapid Freezing and Thawing
ASTM C 1077	Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction And Criteria for Laboratory Evaluation
ASTM C 1260	Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM D 3665	Random Sampling of Paving Materials
ASTM D 4791	Test Method for Flat or Elongated Particles in Coarse Aggregate
ASTM E 178	Dealing With Outlying Observations
ASTM E 1274	Test for Measuring Pavement Roughness Using a Profilograph
AASHTO T 26	Quality of Water to be Used in Concrete

MATERIAL REQUIREMENTS

ASTM A 184	Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A 185	Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
ASTM A 497	Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
ASTM A 615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 704	Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
ASTM A 714	Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe
ASTM A 996	Specification for Rail-Steel and Axle Steel Deformed Bars for Concrete Reinforcement
ASTM C 33	Specification for Concrete Aggregates
ASTM C 94	Specification for Ready-Mixed Concrete
ASTM C 150	Specification for Portland Cement
ASTM C 171	Specification for Sheet Materials for Curing Concrete

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	Specification for Blended Hydraulic Cements
ASTM C 618	Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 881	Specification for Epoxy-Resin Base Bonding System for Concrete
ASTM C 989	Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM D 1751	Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving And Structural Construction
ACI 305R	Hot Weather Concreting
ACI 306R	Cold Weather Concreting
ACI 309	Guide for Consolidation of Concrete

MIL-DTL-24441/20a (1999)_Paint, Epoxy-Polyamide, Green Primer, Formula 150, Type III
Department of Defense

END ITEM P-501

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