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Preparing Activity: USACE Replacing without change
UFGS-02746 (September 2003)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated March 2008

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DIVISION 32 - EXTERIOR IMPROVEMENTS

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RESIN MODIFIED PAVEMENT SURFACING MATERIAL

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SECTION 32 12 18

RESIN MODIFIED PAVEMENT SURFACING MATERIAL 04/06

NOTE: This guide specification covers the requirements for resin modified pavement surfacing material.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

NOTE: A representative of the Airfield and Pavements Branch, Geotechnical and Structures Laboratory, U.S. Army Engineer Research and Development Center (CERDC) should be consulted in the planning and designing of an RMP.

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in

this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 320 (2005) Performance-Graded Asphalt Binder

ASTM INTERNATIONAL (ASTM)

ASTM C 127 (2007) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate

ASTM C 128 (2007a) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate

ASTM C 131 (2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

ASTM C 136 (2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM C 150 (2007) Standard Specification for Portland Cement

ASTM C 566 (1997; R 2004) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying

ASTM C 618 (2005) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

ASTM C 88 (2005) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM D 140 (2001; R 2007) Sampling Bituminous

Materials

ASTM D 1461	(1985; R 2006) Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D 2041	(2003a) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	(2005) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2216	(2005) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 3381	(2005) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 4125	(2005) Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D 4791	(2005e1) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 5444	(2005) Mechanical Size Analysis of Extracted Aggregate
ASTM D 6307	(2005) Asphalt Content of Hot Mix Asphalt by Ignition Method
ASTM D 70	(2003) Specific Gravity and Density of Semi-Solid Bituminous Materials (Pycnometer Method)
ASTM D 75	(2003) Standard Practice for Sampling Aggregates
ASTM D 995	(1995b; R 2002) Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete
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1.2 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only

delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Open Graded Asphalt Job Mix Formula Job Mix Formula for Slurry Grout

Materials required to produce the open graded asphalt mixture and slurry grout job-mix-formulas in the quantities indicated below.

Aggregates representing each stockpile to be used in the production of the open-graded asphalt mixture: 45 kg 100 pounds each

Bituminous Material	19 liters 5 gallons
Slurry Grout Sand	23 kg 50 pounds
Fly Ash	23 kg 50 pounds
Cement	23 kg 50 pounds
Cross Polymer Resin	4 liters 1 gallon

Samples shall be delivered, along with the Contractor's preliminary job mix formulas, 30 days before starting production to U.S. Army Engineer Waterways Experiment Station Research and Development Center, 3909 Halls Ferry Road, Vicksburg, Mississippi, 39180-6199, ATTN: CEWESERD-GP-Q.

SD-06 Test Reports

Coarse Aggregate[; G][; G, [____]]
Coarse and Fine Aggregates[; G][; G, [____]]

Open-Graded Mix Aggregate[; G][; G, [____]]
Bituminous Material[; G][; G, [____]], [____]
Slurry Grout Sand[; G][; G, [____]]
Filler (Fly Ash)[; G][; G, [____]]
Job Mix Formula for Slurry Grout[; G][; G, [____]]
Contractor Quality Control[; G][; G, [____]]

Aggregate and QC test results. Slurry grout viscosity tests shall be conducted immediately prior to application on the pavement surface and 30 minutes thereafter.

SD-07 Certificates

Cement[; G][; G, [____]]
Cross Polymer Resin[; G][; G, [____]]
Curing Compound[; G][; G, [____]]

Copies of certificates.

1.3 PLANT, EQUIPMENT, MACHINES, AND TOOLS

1.3.1 Asphalt Mixing Plant

The bituminous asphalt plant shall have enough capacity to produce the quantities of bituminous mixtures required for the project. Plants used for the preparation of hot-mix asphalt shall conform to the requirements of **ASTM D 995** with the following changes:

a. Testing Facilities. The Contractor shall provide laboratory facilities at the plant for the use of the Government's acceptance testing and the Contractor's quality control testing.

b. Storage Bins. Use of storage bins for temporary storage of hot-mix asphalt will be permitted as follows:

(1) The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 1 hour.

(2) The asphalt plant shall have enough capacity to produce the quantities of asphalt mixtures required for the project. Hauling equipment, paving machines, rollers, miscellaneous equipment, and tools shall be provided in sufficient numbers and capacity and in proper working condition to place the asphalt paving mixtures at a rate equal to the plant output.

1.3.2 Asphalt Paver

Asphalt pavers shall be self-propelled, with an vibrating screed, heated as necessary, and shall be capable of spreading and finishing courses of hot-mix asphalt which 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.

1.3.3 Receiving hopper

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.

1.3.4 Automatic Grade Control

If an automatic grade control device is used, 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 which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. The transverse slope controller shall not be used to control grade. The controls shall be capable of working in conjunction with any of the following attachments:

- a. Ski-type device of not less than 9.14 m 30 feet in length.
- b. Taut stringline set to grade.
- c. Short ski or shoe for joint matching.
- d. Laser control.

1.3.5 Slurry Grout

The additional requirements for production of slurry grout for the Resin Modified Pavement (RMP) are a concrete batch plant, a ready mix truck, or portable mixer for grout mixing, and small 1.8 metric ton 2 ton (maximum) tandem steel wheeled vibratory roller for compaction of RMP.

1.4 SAMPLING AND TESTING

1.4.1 Aggregates

1.4.1.1 General

ASTM D 75 shall be used in sampling coarse and fine aggregates. Points of sampling will be designated by the Contracting Officer. All tests necessary to determine compliance with the specified requirements shall be made by the Contractor, using a Corps of Engineers certified Commercial Laboratory.

1.4.1.2 Sources

Sources of aggregates shall be selected well in advance of the time when the materials are required in the work. Samples shall be submitted 30 days before starting production. If a sample of material fails to meet the specified requirements, the material represented by the sample shall be replaced, and the cost of testing the replaced sample shall be at the Contractor's expense. Approval of the source of the aggregate does not relieve the Contractor of the responsibility to deliver aggregates that meet the specified requirements.

1.4.2 Bituminous Materials

Samples of bituminous materials shall be obtained in accordance with ASTM D 140. Sources shall be selected well in advance of the time

materials will be required for the work. In addition to the initial qualification testing of bituminous materials, samples shall be obtained and tested before and during construction when shipments of bituminous materials are received, or when necessary to assure that some condition of handling or storage has not been detrimental to the bituminous material.

1.5 DELIVERY, STORAGE, AND HANDLING OF MATERIALS

1.5.1 Mineral Aggregates

Mineral aggregates shall be delivered to the site of the bituminous mixing plant and stockpiled in such a manner as to preclude segregation or contamination with objectionable material.

1.5.2 Bituminous Materials

Bituminous materials shall be maintained below a temperature of 150 degrees C 300 degrees F during storage and shall not be heated by the application of a direct flame to the walls of storage tanks or transfer lines. Storage tanks, transfer lines and weigh buckets shall be thoroughly cleaned before a different type or grade of bitumen is introduced into the system.

1.5.3 Slurry Grout Sand

Slurry grout sand shall be stored at the grout production site to prevent contamination with foreign materials and saturation with rain water. Moisture content of this sand shall be determined just prior to grout production so that corrections to the job mix formula water content can be made to compensate for any moisture in the sand.

1.5.4 Cementitious Materials

The temperature of the cementitious materials, as delivered to storage at the site, shall not exceed 65 degrees C 150 degrees F.

1.6 ACCESS TO PLANT AND EQUIPMENT

The Contracting Officer shall have access at all times to all parts of the bituminous plant for checking adequacy of any equipment in use; inspecting operation of the plant; verifying weights, proportions, and character of materials; and checking temperatures maintained in preparation of the mixtures.

PART 2 PRODUCTS

2.1 AGGREGATE

Aggregate shall consist of crushed stone, or crushed gravel without sand or other inert finely divided mineral aggregate. The portion of materials retained on the 4.75 mm No. 4 sieve shall be known as coarse aggregate, the portion passing the 4.75 mm No. 4 sieve and retained on the 0.075 mm No. 200 sieve as fine aggregate. Sieve analysis of coarse and fine aggregates shall be conducted in accordance with ASTM C 136.

2.1.1 Coarse Aggregate

Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of matter that would prevent thorough coating with the bituminous material. The percentage of wear shall not be greater than 40

percent when tested in accordance with [ASTM C 131](#). The magnesium sulfate soundness loss shall not exceed 18 percent, after five cycles, when tested in accordance with [ASTM C 88](#). Aggregate shall contain at least 75 percent by weight of crushed pieces having two or more fractured faces. The area of each fractured face shall be equal to at least 75 percent of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be obtained by artificial crushing.

2.1.2 Crushed Aggregates

Particle shape of crushed aggregates shall be essentially cubical. Quantity of flat (width to thickness ratio greater than 3) and elongated particles (width to length ratio greater than 3) in any sieve size shall not exceed 8 percent by weight, when determined in accordance with [ASTM D 4791](#).

2.1.3 Open-Graded Mix Aggregate

The gradations in Table I represent the limits which shall determine the suitability of open-graded mix aggregate for use from the sources of supply. The aggregate, as finally selected, shall have a gradation within the limits designated in Table I 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 I

OPEN-GRADED MIX AGGREGATE

Sieve Size	Percent by Weight Passing
19 mm	100
12.5 mm	54-76
9.5 mm	38-60
4.75 mm	10-20
2.36 mm	8-16
0.60 mm	4-10
0.075 mm	1-3

TABLE I

OPEN GRADED MIX AGGREGATE

Sieve Size	Percent by Weight Passing
3/4 in.	100
1/2 in.	54-76
3/8 in.	38-60
No. 4	10-20
No. 8	8-16
No. 30	4-10
No. 200	1-3

Table I is based on aggregates of uniform specific gravity; the percent passing various sieves may be changed by the Contracting Officer when

aggregates of varying specific gravities are used. Adjustments of percentages passing various sieves may be directed by the Contracting Officer when aggregates vary more than 0.2 in specific gravity.

2.1.4 Slurry Grout Sand

Slurry grout sand shall consist of clean, sound, durable, particles of processed silica sand that meet the requirements for wear and soundness specified for coarse aggregate. The sand shall contain no clay, silt, or other objectionable matter. The gradations in Table II represent the limits which shall determine the suitability of silica sand for use from the sources of supply.

TABLE II

FINE SAND FOR SLURRY GROUT

Sieve Size	Percent by Weight Passing
1.18 mm	100
0.600 mm	95-100
0.075 mm	0-2

TABLE II

FINE SAND FOR SLURRY GROUT

Sieve Size	Percent by Weight Passing
No. 16	100
No. 30	95-100
No. 200	0-2

The sand gradations shown are based on sand of uniform specific gravity, and the percentages passing the various sieves will be subject to appropriate correction by the Contracting Officer when aggregates of varying specific gravities are used.

2.1.5 Filler (Fly Ash)

Fly ash shall have at least 95 percent by weight of material passing the 0.075 mm No. 200 sieve. Fly ash shall conform to ASTM C 618 Class F requirements.

2.2 BITUMINOUS MATERIAL

Bituminous material shall conform to the requirements of [ASTM D 3381 and shall be of the viscosity grade [AC-10] [AC-20] [AC-30] [AR-4000] [AR-8000] with an original penetration of 40 to 100.] [AASHTO M 320 Performance Grade (PG) [____]].

2.3 CEMENT

The cement used in the slurry grout shall be portland cement conforming to ASTM C 150, Type [I] [II] [III] [V].

2.4 CROSS POLYMER RESIN

NOTE: The cross polymer resin to be used in the slurry grout, Prosalvia-7, is a proprietary product which has been waived for use throughout the Corps of Engineers and is available from the Alyan Corporation, P.O. Box 788, Vienna, VA 22183, (703) 573-8134.

A complete description of the Marsh flow cone and the grout viscosity test method is found in ETL 1110-1-177 "Use of Resin Modified Pavement (RMP)".

A cross polymer resin of styrene and butadiene, Prosalvia L7, shall be utilized as a plasticizing and strength producing agent. After mixing the resin into the slurry grout, the mixture shall have a viscosity which would allow it to flow from a Marsh Cone in accordance with Table III. A Marsh cone has dimensions of 155 mm 6-1/8 inches base inside diameter, tapering 315 mm 12-3/8 inches to a tip inside diameter of 10 mm 3/8 inches. The 10 mm 3/8 inch diameter neck shall have a length of 60 mm 2-3/8 inches.

TABLE III

SLURRY GROUT VISCOSITY

Time Elapsed After Addition of PL7	Marsh Flow Cone Viscosity
-----	-----
0 to 30 minutes	8 to 10 seconds
After 30 minutes	9 to 11 seconds

2.5 CURING COMPOUND

Membrane-forming curing compound shall be white pigmented compounds conforming to COE CRD-C 300.

2.6 JOB MIX FORMULA FOR OPEN-GRADED ASPHALT AND SLURRY GROUT

NOTE: It is recommended that the job mix formula for the open graded bituminous mixture and the mixture proportions for the slurry grout be approved by the appropriate ERDC representative. On a case by case basis, this approval may result from a simple review of the Contractor's mix design test reports, or it may require verification of the mix design by repeating some or all of the required mix design tests. This recommendation is to ensure that proper laboratory procedures are used to determine mix designs for this new paving process.

A complete description of the proper methods used to produce job mix formulas for the open graded bituminous mixture and slurry grout is found in ETL 1110-1-177 "Use of Resin Modified Pavement (RMP)".

2.6.1 Open Graded Asphalt Job Mix Formula

The Job Mix Formula (JMF) for the open graded bituminous mixture shall be furnished by the Contractor and approved by the Government. No payment will be made for mixtures produced prior to the approval of the JMF by the Contracting Officer.

2.6.1.1 Initial Laboratory Procedure

(1) Sample aggregates according to ASTM D 75 and asphalt cement according to ASTM D 140. An open-graded asphalt concrete mix design requires a minimum of 45 kg 100lbs of each aggregate stockpile and 15 L 4 gal of asphalt cement.

(2) Oven dry aggregate stockpile samples and conduct a sieve analysis (ASTM C 136) on each sample. Determine the combination of aggregate stockpiles that results in a gradation closest to the center of the limiting gradation band. This stockpile combination will become the blending formula for the open-graded asphalt concrete.

(3) Measure apparent specific gravity of aggregates (ASTM C 127 and ASTM C 128) from each stockpile used in the final gradation. Calculate apparent specific gravity of combined aggregates using the blending formula percentages. Measure specific gravity of asphalt cement (ASTM D 70).

(4) Estimate the optimum asphalt content using the following equation:

$$\text{Optimum asphalt content} = 8.61(0.21G + 5.4S + 7.2s + 135f)^{0.2} + SG$$

where

SG = apparent specific gravity of the combined aggregates

G = percentage of material retained on the 4.75 mm No. 4 sieve

S = percentage of material passing the 4.75 mm No. 4 and retained on the 0.6 mm No. 30 sieve

s = percentage of material passing the 0.6 mm No. 30 sieve and retained on the 0.075 mm No. 200 sieve

f = percentage of material passing 0.075 mm No. 200 sieve

(5) Round the calculated optimum asphalt content value to the nearest tenth of a percent. Use this asphalt content value along with two asphalt contents above this amount and two asphalt contents below this amount in the production of mix design samples. Use 0.5 percent above and below the optimum and 1.0 percent above and below the optimum as the four additional asphalt contents. Calculate maximum theoretical specific gravities for each of these five asphalt cement contents using ASTM D 2041.

2.6.1.2 Specimen Production

Using the five mix design asphalt contents, produce three 100 mm 4 inch diameter Marshall specimens at each asphalt content. Use approximately 800 grams 1.8 lbs of combined aggregates following the previously determined aggregate blending formula for each specimen. Just before mixing, the

temperature of the aggregates should be $145 \pm 5^{\circ}\text{C}$ $290 \pm 9^{\circ}\text{F}$ and the asphalt cement should be $135 \pm 5^{\circ}\text{C}$ $275 \pm 9^{\circ}\text{F}$. With normal mixing procedures, the temperature of the asphalt mixture during compaction is $120 \pm 5^{\circ}\text{C}$ $250 \pm 9^{\circ}\text{F}$. Compact the open-graded asphalt concrete specimens with 25 blows from a $4.5 \text{ kg } 10 \text{ lbs}$ Marshall hand hammer on one side of each specimen. Allow the specimens to air cool for a minimum of 4 hours before carefully removing from molds.

2.6.1.3 Measuring voids total mix (VTM)

(1) Measure the VTM of each open-graded specimen using the following formula:

$$\text{VTM} = (1 - \text{WTAIR} / \text{Volume} * 1/\text{SGT}) * 100 \quad \text{VTM} = [1 - \text{WTAIR} / \text{Volume} * 1/(\text{SGT} * 62.4\text{lbs}/\text{CF})] * 100$$

where

WTAIR = dry weight of specimen in **grams lbs**

Volume = $0.785 (D)^2 (H)$

D = diameter in **cm feet**

H = height in **cm feet**

SGT = maximum theoretical specific gravity

(2) Calculate the average VTM for each of the five asphalt cement contents. Select the optimum asphalt content as that which resulted in a VTM value closest to 30.0 percent. If no VTM averages are in the 30.0 percent range, then make adjustments to the aggregate gradation to achieve the proper void content. Optimum asphalt contents resulting in average VTM values in the 25 to 35 percent range are acceptable, but due to normal production and construction variations, the JMF shall be based on a mix design that provides a 28 to 32 percent VTM value is required. Typical optimum asphalt contents are between 3.5 and 4.5 percent.

2.6.1.4 Job-Mix Formula Submittal

(1) The open-graded asphalt concrete job-mix formula will consist of the following information:

- (a) Percentage of each aggregate stockpile.
- (b) Percentage passing each sieve size for the blended aggregate.
- (c) Percentage of bitumen.
- (d) Temperature of discharged asphalt mixture.
- (e) Voids total mix percentage.

(2) The target temperature of the asphalt mixture when it is discharged from the mixing plant should be $125 \pm 5^{\circ}\text{C}$ $257 \pm 9^{\circ}\text{F}$. The Contractor shall adjust the temperature depending on the ambient temperatures and the haul distance from the asphalt plant to the job site to meet the lay-down temperature.

2.6.2 Job Mix Formula for Slurry Grout

The Job-Mix Formula (JMF) for the slurry grout shall be furnished by the Contractor and approved by the Government. The slurry grout job mix formula shall be developed using the proportions given in Table V.

TABLE V

RESIN MODIFIED CEMENT SLURRY GROUT MIXTURE PROPORTIONS

Material	Percent by Weight
Silica Sand	16-20
Fly Ash	16-20
Water	22-26
Portland Cement	34-40
Cross Polymer Resin	2.5-3.5

Approximately 12 to 15 kg 22 to 28 pounds of mixed slurry grout will fill in one square meter yard (25 mm 1 inch thickness) of open graded bituminous mixture with 25 to 35 percent voids total mix.

2.6.2.1 Initial Laboratory Procedure

(1) Minimum sample size is 23 kg 51 lbs for cement, sand, and fly ash; and is 4 L 1 gal for resin additive.

(2) Using the grout material proportions specified in Table V, develop a matrix of initial job-mix formulas for laboratory viscosity testing. The goal of the grout mix design is to produce a material formulation, which results in a field Marsh Flow Cone viscosity of 8.0 to 10.0 seconds. The initial formulations shall ensure that a grout formulation can be produced with a Marsh viscosity no greater than the 10.0 seconds maximum. This is accomplished by testing grout formulations with relatively high w/c ratios and the maximum allowable amount of resin additive.

(3) The grout's w/c ratio shall be between 0.65 to 0.75, unless approved by the Contracting Officer Representative. Higher w/c ratios are sometimes necessary to produce grout with Marsh Flow viscosity less than the 10.0-second maximum value. Therefore, the focus of the initial grout viscosity tests is to determine the minimum W/C ratio that will produce a grout viscosity less than or equal to 10.0 seconds. The resin additive serves as a plasticizer which reduces grout viscosity while reducing the amount of water required.

(4) The standard laboratory grout batch size should be in the 4 to 5 kg 9 to 11 lbs range. Calculate the material batch weights based on the desired proportions. Multiple grout viscosity tests are facilitated by first blending the dry ingredients (cement, sand, fly ash) for each test sample and then adding the appropriate amount of water and resin additive during the mixing process. These dry ingredient batches should be kept in air-tight containers to prevent loss of material or contamination before mixing. Replicate two samples per blend for grout viscosity testing.

2.6.2.2 Mixing

(1) The equipment needed to effectively mix the resin grout includes a laboratory mixer equipped with a wire whip mixing attachment and approximately 10 L 2.5 gal capacity mixing bowl, a

calibrated set of weight scales, and various small containers to weigh and transfer mix water and resin additive.

(2) Place dry ingredients into mixing bowl and adjust the bowl height so that the wire whip is just off of or touching the bottom and the sides of the bowl. Begin mixing the dry ingredients at a slow speed and immediately add the appropriate amount of water. Once all of the water is added, speed up the mixer to a point where the grout is being thrown onto the sides of the mixing bowl. Mix the grout at this high speed for 5 minutes, then add the appropriate amount of resin additive. Mix the grout again at a high mixing speed for an additional 3 minutes before testing for Marsh Flow viscosity.

2.6.2.3 Viscosity Testing

(1) The equipment needed to measure grout viscosity includes a Marsh Flow Cone, a 1,000 mL 0.25 gal glass or clear plastic graduated cylinder beaker, a 1,500 mL 0.38 gal (approximately) empty beaker or bucket, and a stopwatch.

(2) Immediately after mixing the grout, transfer the grout from the mixing bowl to the empty beaker or bucket. Take note of any lumps of material or excess sand in the bottom of the mixing bowl. Excess lumps indicate inadequate mixing and render the grout useless for viscosity testing. Immediately fill the Marsh Flow Cone with about 1,100 mL 0.28 gal of grout. A consistent head of grout in the flow cone is achieved for all viscosity tests by marking an 1,100 mL 0.28 gal fill line inside the flow cone. The flow cone outlet is plugged by simply placing one's finger over the outlet opening. Immediately after the flow cone is filled to the 1,100 mL 0.28 gal fill line, position the cone over the 1,000 mL 0.25 gal graduated beaker. Release the grout opening and start the stopwatch timer simultaneously. Measure the time of flow for 1 L 0.25 gal of grout from the flow cone to the nearest tenth of a second.

(3) Record each test sample's viscosity, averaging the two replicates for each blend. Adjust the grout mix proportions as needed with the following considerations:

(a) Any grout viscosity between 8.0 and 10.0 seconds is acceptable. It should be noted; however, that when field construction temperatures are expected to be comparatively high (greater than 32°C 90°F) and/or the open-graded asphalt concrete voids are expected to be considerably low (less than 30 percent), then lower viscosity grouts will help to ensure easy grout application and full grout penetration. In most cases, these variables are unknown; therefore, it is prudent to select the grout formulation which has the lowest viscosity.

(b) Select a grout job-mix formula with water and resin additive contents below the maximum allowable limits to allow the Contracting Officer Representative to approve small additions of these ingredients in the field if necessary to meet viscosity requirements.

(c) Low w/c ratios shall be selected, within the viscosity criteria, to produce grout with higher strengths; reduce the

chances for drying shrinkage cracking; and produce grout which is more consistent and better able to keep the sand in suspension during mixing and placement.

(d) When the sand is noted to settle out of solution during or immediately after mixing, the JMF shall be adjusted by reducing the amount of sand and increasing the amount of fly ash (both within the specified tolerances).

(e) If the viscosity requirements cannot be met, the Contractor shall change the source of materials. Typical problems to investigate include the following: grout sand which is too coarse, portland cement which is highly reactive during the early stages of the hydration process, fly ash with excess cementitious nature.

2.6.2.4 Job-Mix Formula Submittal

The grout job-mix formula will consist of the following information:

- (1) Percentage (by weight) of each mixture ingredient rounded to the nearest tenth of a percent.
- (2) Type and source of portland cement.
- (3) Source of fly ash, silica sand, and resin additive.
- (4) Marsh Flow Cone viscosity of job-mix-formula grout.

PART 3 EXECUTION

3.1 WEATHER LIMITATIONS

The bituminous mixture shall not be placed upon a wet surface, in rain, or when the surface temperature of the underlying course is less than 10 degrees C 50 degrees F. Once the bituminous mixture has been placed, and if rain is imminent, protective materials consisting of rolled polyethylene sheeting at least 0.1 mm 4 mils thick of sufficient length and width to cover the mixture shall be placed. If the open graded bituminous mixture becomes saturated, the Contractor shall allow the pavement voids to thoroughly dry out prior to applying the slurry grout.

3.2 PREPARATION OF OPEN GRADED MIXTURES

Rates of feed of aggregates shall be regulated so that moisture content and temperature of aggregates will be within tolerances specified. Aggregates and bitumen shall be conveyed into the mixer in proportionate quantities required to meet the JMF. Mixing time shall be as required to obtain a uniform coating of the aggregate with the bituminous material. Temperature of bitumen at time of mixing shall not exceed 135 degrees C 275 degrees F. Temperature of aggregate in the mixer shall not exceed 150 degrees C 300 degrees F when bitumen is added. Overheated and carbonized mixtures or mixtures that foam shall not be used.

3.3 WATER CONTENT OF AGGREGATES

Drying operations shall reduce the water content of mixture to less than 0.75 percent. Water content shall be determined in accordance with ASTM D 2216; weight of sample shall be at least 500 grams. The water

content shall be reported as a percentage of the total mixture.

3.4 STORAGE OF MIXTURE

The open graded bituminous mixture shall not be stored for longer than one hour prior to hauling to the job site.

3.5 TRANSPORTATION OF MIXTURE

Transportation from the mixing plant to the job site shall be in trucks having tight, clean, smooth beds lightly coated with an approved releasing agent to prevent adhesion of mixture to truck bodies. Diesel fuel shall not be used as a releasing agent. Excessive release agent shall be drained prior to loading. Each load shall be covered with canvas or other approved material of ample size to protect mixture from the weather and to prevent loss of heat. Loads that have crusts of cold, unworkable material or have become wet will be rejected. Hauling over freshly placed material will not be permitted.

3.6 TEST SECTION

Prior to full production, and in the presence of the Contracting Officer Representative, the Contractor shall prepare and place a quantity of open graded bituminous mixture and slurry grout according to the JMF. The test section shall be a minimum of 30 meters 100 feet long and 6 meters 20 feet wide placed in one section and shall be of the same depth specified for the construction of the course which it represents. 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 meet the requirements specified in paragraph ACCEPTABILITY OF WORK. If the test section should fail to meet these requirements, the necessary adjustments to the mix design, plant operation, and/or construction procedures shall be made. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications at the Contractor's expense. A representative for the resin manufacturer shall be on site during the test section construction and during the initial placement.

3.7 SURFACE PREPARATION OF UNDERLYING COURSE

Prior to placing of open graded bituminous mixture, the underlying course shall be cleaned of all foreign or objectionable matter with power brooms and hand brooms.

3.8 TACK COATING

Immediately before placing open-graded asphalt mix, contact surfaces of previously constructed pavement shall be sprayed with a coat of bituminous material as specified in Section 32 12 10 BITUMINOUS TACK AND PRIME COATS.

3.9 PLACING OPEN GRADED BITUMINOUS MIXTURE

NOTE: The amount of rolling required to achieve the required voids total mix criteria is usually 1 to 3 passes of the 1.8 metric ton (2-ton) tandem steel wheel roller in the static mode. The appropriate temperature of the freshly placed bituminous mixture required to prevent undue shoving and cutting from

the roller is usually in the 50 to 70 degrees C (120 to 160 degrees F) range. The actual number of required passes and temperature range for rolling should be determined during construction and subsequent evaluation of the test section.

The mix shall be placed at a temperature of not less than 80 degrees C 175 degrees F. Upon arrival, the mixture shall be spread to the full width (minimum 3 meters 10 feet) by a bituminous paver. It shall be struck off in a uniform layer to a depth that, when the work is completed, will produce the required thickness indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise directed, placement of the mixture shall begin along the center line of a crowned pavement or along the highest side of a sloped cross-section. The mixture shall be placed in consecutive adjacent strips. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread, raked, and luted by hand tools. The longitudinal joint in the RMP shall be offset from the longitudinal joint in the underlying asphalt pavement by at least 300 mm 1 foot.

3.9.1 Rollers

Small (1.8 metric ton 2-ton maximum) tandem steel wheel vibratory rollers shall be used to smooth over the surface of freshly placed open graded bituminous mixture. The vibratory unit shall be turned off during smoothing of the bituminous mixture. Rollers 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 roll the mixture to the voids total mix requirement of 25 to 35 percent while it is still in a workable condition. The use of equipment which causes excessive crushing of the aggregate will not be permitted.

3.9.2 Smoothing of Open Graded Bituminous Mixture

The open graded bituminous mixture shall be smoothed with one to three passes of the prescribed roller without vibration. The temperature of the freshly placed open graded bituminous mixture shall be low enough to prevent excessive shoving or cutting of the mat under the roller.

3.9.3 Protection of UngROUTed Pavement

The Contractor shall protect the ungrouted pavement and its appurtenances from traffic and against contamination from mud, dirt, wind blown debris, waterborne material, or any other contamination which could enter the void spaces of the open graded bituminous mixture before grout application. Protection against contamination shall be accomplished by keeping the construction site clean and free of such contaminants and by covering the ungrouted pavement with protective materials when directed by the Contracting Officer. Such protective materials shall consist of rolled polyethylene sheeting as described in paragraph WEATHER LIMITATIONS. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the pavement surface.

3.10 PREPARATION OF SLURRY GROUT

NOTE: Generally, the cross polymer resin should be

added to the grout mixture at the batch plant if the haul distance is less than 20 minutes. If the haul distance is greater than 20 minutes, the cross polymer resin should be added to the grout mixture at the job site.

The slurry grout shall be mixed using a batch plant, portable mixer and/or ready-mix truck and according to mix proportions stated in the approved JMF. The cross polymer resin shall be added to the mixture after all other ingredients have been thoroughly mixed. When using ready-mix trucks for transporting slurry grout, the grout mixture shall be thoroughly mixed at the job site immediately before application for a minimum of 10 minutes. Thorough mixing shall be accomplished by rotating the mixing drum at the maximum allowable revolutions per minute.

3.11 PLACING SLURRY GROUT

Temperature of the bituminous mixture shall be less than 38 degrees C 100 degrees F before applying grout. Each batch of slurry grout shall be tested at the job site immediately before placement and shall be used in the finished product only if it meets the requirements specified in paragraph ACCEPTABILITY OF WORK. The slurry grout shall be spread over the bituminous mixture using a spreader or squeegees. The application of the slurry grout shall be sufficient to fill the internal voids of the open graded bituminous mixture. The grouting operation shall begin at the lowest side of the sloped cross-section and proceed from the low side to the high side. The practical limit for the surface slope of an RMP section is 2 percent. Pavement slopes up to 5 percent can be constructed, but excess hand work and grout overruns are to be expected at slopes greater than 2 percent. The slurry grout shall be placed in successive paving lanes with a maximum width of 6 meters 20 feet. The use of strips of wood lumber or foamed rubber to separate each of the grouting lanes and the RMP from adjacent pavements is optional. The direction of the grouting operation shall be the same as used to pave the open graded bituminous mixture. The small (1.8 metric ton 2 ton maximum) tandem steel wheel roller (vibratory mode) passing over the grout covered bituminous mixture shall be used to promote full penetration of the slurry grout into the void spaces.

3.12 JOINTS

3.12.1 Joints Between Successive Lanes of RMP

Joints between successive lanes of RMP shall be made ensuring a continuous bond between the paving lanes. All RMP joints shall have the same texture, density, and smoothness as other sections of the course.

3.12.2 Joints Between RMP and Adjacent Pavements

Joints between the RMP and any surrounding pavement surfaced with portland cement concrete shall be saw cut to the full thickness of the RMP layer and filled with a joint sealant material approved by the Contracting Officer.

3.13 CURING

The curing compound shall be applied to the finished pavement surface within 2 hours of the completed slurry grout application. The curing compound shall be applied by means of a pressurized spraying machine.

Application of the curing compound shall be made uniformly in one or two coats with a total application rate of not more than 10 square meters/L 400 square feet/gallon.

3.14 PROTECTION OF GROUTED PAVEMENT

The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents for a period of 21 days. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor's expense. In order to properly protect the pavement against the effects of rain before the pavement is sufficiently hardened, the Contractor shall have available, at all times, materials for the protection of the edges and surfaces of the unhardened RMP. The protective materials and method of application shall be the same as previously described in paragraph WEATHER LIMITATIONS. When rain appears imminent, all paving operations shall stop, and all available personnel shall begin covering the surface of the hardened RMP with protective covering.

3.15 CONTRACTOR QUALITY CONTROL

NOTE: The Contractor may be able to meet the
specified quality control requirements with in-house
capability or may have to hire a material testing
firm to provide the required quality control testing.

3.15.1 General Quality Control Requirements

The Contractor shall develop an approved Quality Control Plan. Hot-mix asphalt for payment shall not be produced until the Quality Control Plan has been approved. The plan shall address all elements which 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. Mixture Volumetrics
- h. Moisture Content of Mixtures
- i. Placing and Finishing
- j. Joints
- k. Compaction
- l. Surface Smoothness

3.15.2 Quality Control Testing

The Contractor shall perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. The testing program shall include, but shall not be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, slurry grout viscosity, grade and smoothness. A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

3.15.3 Asphalt Content

A minimum of two tests to determine asphalt content will be performed per days production of open-graded asphalt mix, by one of the following methods: the extraction method in accordance with [ASTM D 2172](#), Method A or B, the ignition method in accordance with the [ASTM D 6307](#), or the nuclear method in accordance with [ASTM D 4125](#), provided the nuclear gauge is calibrated for the specific mix being used. For the extraction method, the weight of ash, as described in [ASTM D 2172](#), shall be determined as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction 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.

3.15.4 Gradation

Aggregate gradations shall be determined a minimum of twice per day from mechanical analysis of recovered aggregate in accordance with [ASTM D 5444](#). 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 plants. For batch plants, aggregates shall be tested in accordance with [ASTM C 136](#) using actual batch weights to determine the combined aggregate gradation of the mixture.

3.15.5 Temperatures

Temperatures shall be checked at least four times per day, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.15.6 Aggregate Moisture

The moisture content of aggregate used for production shall be determined a minimum of once per day in accordance with [ASTM C 566](#).

3.15.7 Moisture Content of Mixture

The moisture content of the mixture shall be determined at least once per lot in accordance with [ASTM D 1461](#) or an approved alternate procedure.

3.15.8 Air Voids

Voids total mix shall be determined from random core samples taken from in-place open-graded asphalt mixture. Sample voids shall be calculated as outlined in the Job Mix Formula criteria. Voids shall be between 25 and 35 percent. Material not meeting the void criteria shall be removed and replaced at no additional cost to the Government.

3.15.9 Grade and Smoothness

NOTE: Retain requirements for grade for projects having large paved areas where standing water or ponding of water may occur and projects with plan and profile details. All other projects shall be evaluated for the possibility of standing water before removing the grade requirements.

The Contractor shall conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraph ACCEPTABILITY OF WORK.

3.15.9.1 Grade

The final wearing surface of the pavement will be tested for conformance with specified plan grade requirements, before grout is applied. The grade will be determined by running lines of levels at intervals of 7.6 m 25 feet, or less, longitudinally and transversely, to determine the elevation of the completed pavement surface. Within 5 working days, after the completion of a particular area, the Contracting Officer will inform the Contractor in writing, of the results of the grade-conformance tests.

3.15.9.2 Smoothness

All testing shall be performed in the presence of the Contracting Officer. Detailed notes of the results of the testing shall be kept and a copy furnished to the Government immediately after each day's testing. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), the surface shall be finished to meet the approval of the Contracting Officer Representative. After the the slurry grout has sufficiently cured, but not later than 48 hours after placement, the surface of the pavement shall be tested by the Contractor in such a manner as to reveal all surface irregularities exceeding the tolerances specified in table VI. The entire area of the pavement shall be tested in both a longitudinal and a transverse direction on parallel lines. The transverse lines shall be 8 m 25 feet or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane for lines less than 6.1 m 20 feet and at the third points for lanes 6.1 m 20 feet or greater. Other areas having obvious deviations shall also be tested. Longitudinal testing lines shall be continuous across all joints. The straightedge shall be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points.

3.15.10 Job-Mix-Formula

Routine testing for acceptability of work shall be performed by a Corps of Engineers certified commercial laboratory hired by the Contractor and approved by the Contracting Officer. Additional tests required to determine acceptability of non-conforming material shall be performed by the Contractor at its own expense. The Contractor shall use a Marsh Flow

Cone for testing the viscosity of grout.

3.16 ACCEPTABILITY OF WORK

3.16.1 General

When a section of pavement fails to meet the specification requirements, that section shall be totally removed and replaced at the Contractor's expense. The Contracting Officer reserves the right to sample and test any area which appears to deviate from the specification requirements.

3.16.2 Field Sampling of RMP Materials

3.16.2.1 Open Graded Bituminous Mixture

Samples of open graded bituminous mixture shall be taken from loaded trucks for every 1,000 square meters yards of pavement, but not less than two samples for each day of paving for determining asphalt content, aggregate gradation, and laboratory compacted voids total mix. Laboratory specimens of open graded bituminous material shall be compacted in 101.6 mm 4 inch diameter molds to a 50.8 mm 2 inch thickness using 25 blows on one side from a Marshall hand hammer. Test results from the sampled open graded bituminous mixture shall be compared to the approved job-mix-formula and approved by the Contracting Officer for acceptance. The tolerances given in Table IV for sieve analysis, bitumen content, and temperature shall be applied to quality control test results on the open graded bituminous mixture as discharged from the mixing plant.

TABLE IV

JOB-MIX-FORMULA TOLERANCES

Material	Tolerance, Plus or Minus

Aggregate passing 4.75 mm or larger sieves	4 percent
Aggregate passing 2.36 and 0.60 mm sieves	3 percent
Aggregate passing 0.075 mm sieve	1 percent
Bitumen	0.20 percent
Temperature of discharge mix	10 degrees C
Voids Total Mix	2 percent

TABLE IV

JOB-MIX-FORMULA TOLERANCES

Material	Tolerance, Plus or Minus

Aggregate passing No.4 or larger sieves	4 percent
Aggregate passing Nos. 8 and 30 sieves	3 percent
Aggregate passing No. 200 sieve	1 percent
Bitumen	0.20 percent
Temperature of discharged mix	20 degrees F
Voids Total Mix	2 percent

3.16.2.2 Slurry Grout

Each batch of slurry grout shall be tested for viscosity at the jobsite after thorough mixing and before application. Any batch of slurry grout failing to meet the specified viscosity shall be rejected and removed from the jobsite. Slurry grout with visible amounts of sand settling out of suspension during application shall be rejected and removed from the jobsite.

3.16.2.3 Core Samples

Random core samples shall be taken from the in-place open graded bituminous mixture before and after application of the slurry grout. The Contractor shall take at least two field core samples before grout application and two after grout application for every 1,000 squaremeters yards of finished RMP. Half of the core samples taken after grout application shall be taken from joints between successive grouting lanes. Field core samples shall be 102 or 152 mm 4 or 6 inch diameter and extend the full depth of the RMP surface layer. The ungrouted core samples shall be tested for thickness. The grouted core samples shall be visually inspected for acceptable grout penetration. Acceptable grout penetration shall be through the full thickness of the RMP layer with a minimum of 90 percent of the visible void spaces filled with slurry grout. After testing, the Contractor shall turn over all cores to the Contracting Officer. Core holes in ungrouted RMP shall be filled with hot open graded bituminous material and leveled to match the surrounding pavement surface. Core holes in grouted RMP shall be filled within 24 hours from the time of coring with RMP material, low-shrinkage portland cement concrete material, or other approved patching material.

3.16.3 Thickness, Grade and Surface-Smoothness Requirements

Finished surface of RMP, when tested as specified below, shall conform to the thickness and grade specified and to surface smoothness requirements specified in Table VI. In areas where the thickness, grade or smoothness exceeds the tolerance, the Contractor shall remove the surface lift to full depth; the Contractor shall then replace the lift with open graded asphalt to meet specification requirements, at no additional cost to the Government. Diamond grinding may be used, after grout has cured, to remove high spots to meet grade or smoothness requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted.

NOTE: The surface smoothness requirements specified
below should be increased to 9 to 12 mm for tank
trails and non-critical pavements.

TABLE VI

SURFACE-SMOOTHNESS TOLERANCES

Direction of Testing	Resin Modified Pavement Tolerance, mm

Longitudinal	6

TABLE VI

SURFACE-SMOOTHNESS TOLERANCES

Direction of Testing	Resin Modified Pavement Tolerance, mm
-----	-----
Transverse	6

TABLE VI

SURFACE-SMOOTHNESS TOLERANCES

Direction of Testing	Resin Modified Pavement Tolerance, inch
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Longitudinal	1/4
Transverse	1/4

3.16.3.1 Thickness

The thickness of the RMP shall meet the requirements shown on the contract drawings. The measured thickness of the RMP shall not exceed the design thickness by more than 13 mm 1/2 inch, or be deficient in thickness by more than 6 mm 1/4 inch.

3.16.3.2 Surface Smoothness

Finished surfaces shall not deviate from testing edge of a 3.7 meter 12 foot straightedge more than the tolerances shown for the respective pavement category in Table VI.

3.16.3.3 Surface Texture

The surface texture shall be uniform and free of excess cement grout. Finished surface shall have all grout removed below the top of the open-graded asphalt concrete.

3.16.3.4 Grade

The finished surface of pavement shall conform to the elevations and the cross sections shown and shall vary not more than 15 mm 0.6 inch from the plan grade established and approved at site of work. Finished surfaces at juncture with other pavements shall coincide with finished surfaces of abutting pavements.

-- End of Section --