UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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RESIN-MODIFIED ASPHALT PAVING WEARING COURSES

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USACE / NAVFAC / AFCEC / NASA **UFGS-32 12 19.16 (November 2019)**

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SECTION 32 12 19.16

RESIN-MODIFIED ASPHALT PAVING WEARING COURSES
11/19

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NOTE: This guide specification covers the requirements for resin-modified asphalt paving wearing courses.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

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

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

PART 1 GENERAL

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NOTE: Consult a representative of the Airfield and Pavements Branch, Geotechnical and Structures Laboratory, U.S. Army Engineer Research and Development Center (CERDC) in the planning and designing of a Resin Modified Pavement (RMP).
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1.1 REFERENCES

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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 user adds a Reference Identifier (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 user chooses to reconcile references in the publish print process.

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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 156	(2013; R 2017) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
AASHTO M 320	(2017) Standard Specification for Performance-Graded Asphalt Binder

ASTM INTERNATIONAL (ASTM)

ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C127	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2020) Standard Specification for Portland Cement
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM C618	(2019) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM D70	(2018a) Standard Test Method for Density of Semi-Solid Bituminous Materials (Pycnometer Method)
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D1461	(2017) Standard Test Method for Moisture or Volatile Distillates in Asphalt Mixtures
ASTM D2041/D2041M	(2011) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D3381/D3381M	(2018) Standard Specification for Viscosity-Graded Asphalt Binder for Use in Pavement Construction
ASTM D4125/D4125M	(2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D5444	(2015) Mechanical Size Analysis of Extracted Aggregate
ASTM D6307	(2019) Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method

1.2 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification

technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control (QC) System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Open Graded Bituminous Job Mix Formula

Job Mix Formula for Slurry Grout

SD-06 Test Reports

Coarse and Fine Aggregates; G[, [_____]]

Coarse Aggregate; G[, [_____]]

Open-Graded Mix Aggregate; G[, [_____]]

Slurry Grout Sand; G[, [_____]]

Filler (Fly Ash); G[, [_____]]

Bituminous Material; G[, [_____]]

Job Mix Formula for Slurry Grout; G[, [_____]]

Contractor Quality Control; G[, [_____]]

SD-07 Certificates

Cement; G[, [_____]]

Cross Polymer Resin; G[, [_____]]

Curing Compound; G[, [_____]]

1.3 QUALITY ASSURANCE

Provide the Contracting Officer access to the bituminous plant, for checking adequacy of equipment in use; inspecting operation of the plant; verifying weights, proportions, and character of materials; and checking temperatures maintained in preparation of the mixtures.

1.3.1 Aggregates

1.3.1.1 Sampling and Testing

Use ASTM D75/D75M in sampling coarse and fine aggregates. Points of sampling will be designated by the Contracting Officer. Conduct tests to determine compliance with the specified requirements, using a Corps of Engineers certified commercial laboratory.

1.3.1.2 Sources

Select sources of aggregates well in advance of the time when the materials are required in the work. Submit samples 30 days before starting production. If a sample of material fails to meet the specified requirements, replace the material represented by the sample, and the cost of testing the replaced sample will 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.

1.3.2 Bituminous Materials

Obtain samples of bituminous materials in accordance with ASTM D140/D140M. Select sources well in advance of the time materials are required for the work. Coordinate with the DWG, client, and testing laboratory to ensure that the required qualification testing can be completed and reported to the client and the information can be reviewed and approved prior to the beginning of construction. In addition to the initial qualification, obtain samples and test before and during construction when shipments of bituminous materials are received, to assure that some condition of handling or storage has not been detrimental to the bituminous material.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Mineral Aggregates

Deliver mineral aggregates to the site of the bituminous mixing plant and stockpile them in such a manner as to preclude segregation or contamination with objectionable material.

1.4.2 Bituminous Materials

Maintain bituminous materials below a temperature of 150 degrees C 300 degrees F during storage. Clean storage tanks, transfer lines and weigh buckets before a different type or grade of bitumen is introduced into the system.

1.4.3 Slurry Grout Sand

Store slurry grout sand at the grout production site to prevent contamination with foreign materials and saturation with rain water. Submit aggregate and QC test results. Conduct slurry grout viscosity tests immediately prior to application on the pavement surface and 30 minutes thereafter. Determine moisture content of this sand just prior to grout production so that corrections to the job mix formula (JMF) water content can be made to compensate for moisture in the sand.

1.4.4 Cementitious Materials

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

1.4.5 Open Graded Bituminous Mixture

Do not store the open graded bituminous mixture for longer than one hour prior to hauling to the job site.

1.5 ENVIRONMENTAL REQUIREMENTS

Do not place the bituminous mixture upon a wet surface, unprotected in the 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, place protective materials consisting of rolled polyethylene sheeting at least 0.1 mm 4 mils thick, of sufficient length and width to cover the mixture. If the open graded bituminous mixture becomes saturated, allow the pavement voids to dry out prior to applying the slurry grout.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Asphalt Mixing Plant

Provide a bituminous asphalt plant with enough capacity to produce the quantities of bituminous mixtures required for the project and conforming to the requirements of AASHTO M 156, with the following changes:

2.1.1.1 Testing Facilities

Provide laboratory facilities at the plant for the use of the Government's acceptance testing and the Contractor's QC testing.

2.1.1.2 Storage Bins

Permit use of insulated storage bins for temporary storage of hot-mix asphalt for a period of time not exceeding 1 hour.

Provide hauling equipment, paving machines, rollers, miscellaneous

equipment, and tools in sufficient numbers, capacity and in proper working condition to place the asphalt paving mixtures at a rate equal to the plant output.

2.1.2 Asphalt Paver

Provide asphalt paver that is self-propelled, with a vibrating screed, heated, and capable of spreading and finishing courses of hot-mix asphalt meeting the specified thickness, smoothness, and grade. Use a paver with sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

2.1.3 Receiving hopper

Use a paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation. Equip the hopper with a distribution system to place the mixture uniformly in front of the screed without segregation. Check that the screed produces a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

2.1.4 Automatic Grade Control

If an automatic grade control device is used, equip the paver with a control system capable of automatically maintaining the specified screed elevation. Use a control system that is automatically actuated from either a reference line and/or through a system of mechanical sensors, or sensor-directed mechanisms or devices that maintains the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. Use a transverse slope controller capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. Do not use the transverse slope controller to control grade. Use controls capable of working in conjunction with the following attachments:

a. Ski-type device of not less than 9 m 30 ft in length.

b. Taut stringline set to grade.

c. Short ski or shoe for joint matching.

d. Laser control.

2.1.5 Slurry Grout

Provide 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 Resin Modified Pavement (RMP) for production of slurry grout for the RMP.

2.2 AGGREGATE

Provide aggregate consisting of crushed stone, or crushed gravel without sand or other inert finely divided mineral aggregate. Coarse aggregate is the portion of materials retained on the 4.75 mm No. 4 sieve. Fine aggregate is the portion of material passing the 4.75 mm No. 4 sieve and retained on the 0.075 mm No. 200 sieve. Conduct sieve analysis of coarse and fine aggregates in accordance with ASTM C136/C136M.

2.2.1 Coarse Aggregate

Provide coarse aggregate consisting of sound, tough, durable particles, free from adherent films of matter that would prevent coating with the bituminous material. Do not allow the percentage of wear to be greater than 40 percent when tested in accordance with ASTM C131/C131M. Do not allow the magnesium sulfate soundness loss to exceed 18 percent, after five cycles, when tested in accordance with ASTM C88. Provide aggregate containing at least 75 percent by weight of crushed pieces having two or more fractured faces. Check that the area of each fractured face is equal to at least 75 percent of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, check that the angle between the planes of fractures is at least 30 degrees to count as two fractured faces. Obtain fractured faces by artificial crushing.

2.2.1.1 Crushed Aggregates

Particle shape of crushed aggregates are to be cubical. Do not allow the quantity of flat (width to thickness ratio greater than 3) and elongated particles (width to length ratio greater than 3) in any sieve size to exceed 8 percent by weight, when determined in accordance with ASTM D4791.

2.2.2 Open-Graded Mix Aggregate

The gradations in Table I represent the limits that determine the suitability of open-graded mix aggregate for use from the sources of supply. Use aggregate having a gradation within the limits designated in Table I and that does not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but is uniformly graded from coarse to fine.

TABLE I
OPEN-GRADED MIX AGGREGATE

Sieve Size	Percent by Weight Passing
19 mm 3/4 in	100
12.5 mm 1/2 in	54-76
9.5 mm 3/8 in	38-60
4.75 mm No. 4	10-20
2.36 mm No. 8	8-16
0.60 mm No. 30	4-10
0.075 mm 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.

2.2.3 Slurry Grout Sand

Provide slurry grout sand consisting of clean, sound, durable, particles of processed silica sand that meet the requirements for wear and soundness specified for coarse aggregate. Use sand containing no clay, silt, or other objectionable matter. The gradations in Table II represent the limits which 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 No. 16	100
0.60 mm No. 30	95-100
0.075 mm No. 200	0-2

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

2.2.4 Filler (Fly Ash)

Provide fly ash having at least 95 percent by weight of material passing the 0.075 mm No. 200 sieve and conforming to ASTM C618 Class F requirements.

2.3 BITUMINOUS MATERIAL

Provide bituminous material conforming to the requirements of [ASTM D3381/D3381M with a viscosity grade [AC-10] [AC-20] [AC-30] [AR-4000] [AR-8000] and an original penetration of 40 to 100.][AASHTO M 320 Performance Grade (PG) [_____]].

2.4 CEMENT

Use Portland cement in the slurry grout in accordance with ASTM C150/C150M, Type [I] [II] [III] [V]. Submit copies of conformance certificates for cement, cross polymer resin and curing compound.

2.5 CROSS POLYMER RESIN

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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)".

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Utilize a cross polymer resin of styrene and butadiene, Prosalvia L7, as a plasticizing and strength producing agent. After mixing the resin into the slurry grout, check that the mixture has a viscosity that 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 in base inside diameter, tapering 315 mm 12-3/8 in to a tip inside diameter of 10 mm 3/8 in. The 10 mm 3/8 in diameter neck has a length of 60 mm 2-3/8 in.

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

2.6 CURING COMPOUND

Use membrane-forming curing compound with white pigmented compounds conforming to ASTM C309.

2.7 JMF FOR OPEN-GRADED ASPHALT AND SLURRY GROUT

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NOTE: It is recommended that the JMF 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 paving process.

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

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2.7.1 Open Graded Bituminous Job Mix Formula

Provide the JMF for the open graded bituminous mixture for approval by the Government. No payment will be made for mixtures produced prior to the approval of the JMF by the Contracting Officer.

a. Quantities of the materials required to produce the open graded bituminous mixture and slurry grout JMFs are indicated below. Use aggregate stockpiles in the production of the open-graded bituminous mixture having the quantities below.

Aggregate	45 kg 100 lbs ea

Bituminous Material	19 liters 5 gal
Slurry Grout Sand	23 kg 50 lbs
Fly Ash	23 kg 50 lbs
Cement	23 kg 50 lbs
Cross Polymer Resin	4 liters l gallon

b. Along with the Contractor's preliminary JMFs, deliver material samples, 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.

2.7.1.1 Initial Laboratory Procedure

a. Sample aggregates according to ASTM D75/D75M and asphalt cement according to ASTM D140/D140M. An open-graded asphalt concrete mix design requires a minimum of 45 kg 100 lbs of each aggregate stockpile and 15 L 4 gal of asphalt cement.

b. Oven dry aggregate stockpile samples and conduct a sieve analysis (ASTM C136/C136M) on each sample. Determine the combination of aggregate stockpiles that results in a gradation closest to the center of the limiting gradation band in Table I. Use this stockpile combination as the blending formula for the open-graded asphalt concrete.

c. Measure apparent specific gravity of aggregates (ASTM C127 and ASTM C128) 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 D70).

d. 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

e. 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 D2041/D2041M.

2.7.1.2 Specimen Production

Using the five mix design asphalt contents, produce three 100 mm 4 in diameter Marshall specimens at each asphalt content. Use approximately 800 g 1.8 lbs of combined aggregates following the previously determined aggregate blending formula for each specimen. Before mixing, check that the temperature of the aggregates is 145 ± 5 degrees C 290 ± 9 degrees F and the asphalt cement is 135 ± 5 degrees C 275 ± 9 degrees F. With normal mixing procedures, the temperature of the asphalt mixture during compaction is 120 ± 5 degrees C 250 ± 9 degrees F. Compact the open-graded asphalt concrete specimens with 25 blows from a 4.5 kg 10 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.

2.7.1.3 Measuring voids total mix (VTM)

a. Measure the VTM of each open-graded specimen using the following formula:

   VTM = (1 - WTAIR /Volume * 1/SGT) * 100 VTM = [1 - WTAIR /Volume * 1/(SGT * 62.4lbs/CF)] * 100

   where

   WTAIR = dry weight of specimen in g lbs
   Volume =0.785(D)^2(H) cubic cm cubic ft
   D = diameter in cm ft
   H = height in cm ft
   SGT = maximum theoretical specific gravity

b. 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, base the JMF 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.

2.7.1.4 Job-Mix Formula Submittal

Check that the open-graded asphalt concrete JMF consists of the following information:

(1) Percentage of each aggregate stockpile.
(2) Percentage passing each sieve size for the blended aggregate.
(3) Percentage of bitumen.
(4) Temperature of discharged asphalt mixture.
(5) Voids total mix percentage.

The target temperature of the asphalt mixture when it is discharged from the mixing plant is 125 ± 5 degrees C 257 ± 9 degrees F. 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.

2.7.2 Job Mix Formula for Slurry Grout

Provide the JMF for the slurry grout for approval by the Government. Develop the slurry grout JMF using the proportions given in Table IV.

TABLE IV 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

Use approximately 12 to 15 kg 22 to 28 lbs of mixed slurry grout to fill in one square m square yd (25 mml inch thickness) of open graded bituminous mixture with 25 to 35 percent voids total mix.

2.7.2.1 Initial Laboratory Procedure

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

b. Using the grout material proportions specified in Table V, develop a matrix of initial JMFs 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. Use the initial formulations so 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 water/cement (w/c) ratios and the maximum allowable amount of resin additive.

c. Use a w/c ratio between 0.65 to 0.75 for the grout, unless approved by the Contracting Officer. 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 produces 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.

d. The standard laboratory grout batch size is 4 to 5 kg 9 to 11 lbs. 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. Keep dry ingredient batches in air-tight containers to prevent loss of material or contamination before mixing. Replicate two samples per blend for grout viscosity

testing.

2.7.2.2 Mixing

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.

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 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.

2.7.2.3 Viscosity Testing

a. The equipment needed to measure grout viscosity includes a Marsh Flow Cone, a 1 L 0.25 gal glass or clear plastic graduated cylinder beaker, a 1.5 L 0.38 gal (approximately) empty beaker or bucket, and a stopwatch.

b. Immediately after mixing the grout, transfer the grout from the mixing bowl to the empty beaker or bucket. Take note of 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 1.1 L 0.28 gal of grout. A consistent head of grout in the flow cone is achieved for viscosity tests by marking an 1.1 L 0.28 gal fill line inside the flow cone. Plug the flow cone outlet by simply placing one's finger over the outlet opening. Immediately after the flow cone is filled to the 1.1 L 0.28 gal fill line, position the cone over the 1 L 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.

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

(1) Grout viscosity between 8.0 and 10.0 seconds is acceptable. When field construction temperatures are expected to be high (greater than 32 degrees C 90 degrees F) or the open-graded asphalt concrete voids are expected to be low (less than 30 percent), lower viscosity grouts help to ensure 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.

(2) Select a grout JMF 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 to meet viscosity requirements.

(3) Select low w/c ratios, within the viscosity criteria, to produce grout with higher strengths; reduce the chances for drying shrinkage cracking; and produce grout that is more consistent and better able to keep the sand in suspension during mixing and placement.

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

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

2.7.2.4 Job-Mix Formula Submittal

Provide the grout JMF consisting of the following information:

a. Percentage (by weight) of each mixture ingredient rounded to the nearest tenth of a percent.

b. Type and source of Portland cement.

c. Source of fly ash, silica sand, and resin additive.

d. Marsh Flow Cone viscosity of JMF grout.

PART 3 EXECUTION

3.1 PREPARATION OF OPEN GRADED MIXTURES

Regulate rates of feed of aggregates so that moisture content and temperature of aggregates are within tolerances specified. Convey aggregates and bitumen into the mixer in proportionate quantities required to meet the JMF. Require mixing time to obtain a uniform coating of the aggregate with the bituminous material. Do not allow the temperature of bitumen at time of mixing to exceed 135 degrees C 275 degrees F. Do not allow the temperature of aggregate in the mixer to exceed 150 degrees C 300 degrees F when bitumen is added. Reject overheated and carbonized mixtures or mixtures that foam.

3.2 WATER CONTENT OF AGGREGATES

Reduce the water content of mixture to less than 0.75 percent by drying operations. Determine water content in accordance with ASTM D2216; use weight of sample at least 500 g 17.6 oz. Report the water content as a percentage of the total mixture.

3.3 TRANSPORTATION OF MIXTURE

Accomplish transportation from the mixing plant to the job site by trucks having tight, clean, smooth beds lightly coated with an approved releasing agent to prevent adhesion of mixture to truck bodies. Do not use diesel fuel as a releasing agent. Drain excessive release agent prior to loading. Cover each load with canvas or other approved material of ample size to protect mixture from the weather and to prevent loss of heat.

Reject loads that have crusts of cold, unworkable material or have become wet. Do not permit hauling over freshly placed material.

3.4 TEST SECTION

Prior to full production, and in the presence of the Contracting Officer, prepare and place a quantity of open graded bituminous mixture and slurry grout according to the JMFs. Place the test section a minimum of 30 m 1OO ft long and 6 m 20 ft wide placed in one section and of the same depth specified for the construction of the course that it represents. Use the same equipment in construction of the test section to be used on the remainder of the course represented by the test section. Check that the test section meets the requirements specified in paragraph ACCEPTABILITY OF WORK. If the test section fails to meet these requirements, make adjustments to the mix design, plant operation, and/or construction procedures. Construct additional test sections, as required, and evaluate them for conformance to the specifications at the Contractor's expense. Require a representative for the resin manufacturer to be on site during the test section construction and during the initial placement.

3.5 SURFACE PREPARATION OF UNDERLYING COURSE

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

3.6 TACK COATING

Immediately before placing open-graded asphalt mix, spray contact surfaces of previously constructed pavement with a coat of bituminous material as specified in Section 32 12 13 BITUMINOUS TACK AND PRIME COATS.

3.7 PLACING OPEN GRADED BITUMINOUS MIXTURE

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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. Determine the actual number of required passes and temperature range for rolling during construction and subsequent evaluation of the test section.

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Place the mix at a temperature of not less than 80 degrees C 175 degrees F. Upon arrival, spread the mixture to the full width (minimum 3 m 10 ft) by a bituminous paver. Strike off the mix in a uniform layer to a depth that, when the work is completed, produces the required thickness indicated. Regulate the speed of the paver to eliminate pulling and tearing of the bituminous mat. Unless otherwise directed, begin placement of the mixture along the center line of a crowned pavement or along the highest side of a sloped cross-section. Place the mixture in consecutive adjacent strips. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, allow the mixture to be spread, raked, and luted by hand tools. Offset

the longitudinal joint in the RMP from the longitudinal joint in the underlying asphalt pavement by at least 300 mm 1 ft.

3.7.1 Rollers

Use small (1.8 metric ton 2-ton maximum) tandem steel wheel vibratory rollers to smooth over the surface of freshly placed open graded bituminous mixture. Turn off the vibratory unit during smoothing of the bituminous mixture. Keep rollers in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. Use the number, type, and weight of rollers sufficient to roll the mixture to the voids total mix requirement of 25 to 35 percent while it is still in a workable condition. Do not permit the use of equipment which causes excessive crushing of the aggregate.

3.7.2 Smoothing of Open Graded Bituminous Mixture

Smooth the open graded bituminous mixture with one to three passes of the prescribed roller without vibration. Check that the temperature of the freshly placed open graded bituminous mixture is low enough to prevent excessive shoving or cutting of the mat under the roller.

3.7.3 Protection of Ungrouted Pavement

Protect the ungrouted pavement and its appurtenances from traffic and against contamination from mud, dirt, wind blown debris, waterborne material, or other contamination which could enter the void spaces of the open graded bituminous mixture before grout application. Accomplish protection against contamination 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. Use protective materials consisting of rolled polyethylene sheeting as described in paragraph WEATHER LIMITATIONS. Allow the sheeting to be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the pavement surface.

3.8 PREPARATION OF SLURRY GROUT

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NOTE: Generally, add the cross polymer resin 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, add the cross polymer resin to the grout mixture at the job site.

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

3.9 PLACING SLURRY GROUT

Check that the temperature of the bituminous mixture is less than 38 degrees C 100 degrees F before applying grout. Test each batch of slurry grout at the job site immediately before placement and used in the

finished product only if it meets the requirements specified in paragraph ACCEPTABILITY OF WORK. Spread the slurry grout over the bituminous mixture using a spreader or squeegees. Apply the slurry grout to fill the internal voids of the open graded bituminous mixture. Begin the grouting operation 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. Place the slurry grout in successive paving lanes with a maximum width of 6 m 20 ft. 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. Perform the grouting operation in the same direction as used to pave the open graded bituminous mixture. Use the small (1.8 metric ton 2 ton maximum) tandem steel wheel roller (vibratory mode) passing over the grout covered bituminous mixture to promote full penetration of the slurry grout into the void spaces.

3.10 JOINTS

3.10.1 Joints Between Successive Lanes of RMP

Make joints between successive lanes of RMP ensuring a continuous bond between the paving lanes. Ensure RMP joints have the same texture, density, and smoothness as other sections of the course.

3.10.2 Joints Between RMP and Adjacent Pavements

Saw cut the joints between the RMP and surrounding pavement surfaced with Portland cement concrete to the full thickness of the RMP layer and fill them with a joint sealant material approved by the Contracting Officer.

3.11 CURING

Apply the curing compound to the finished pavement surface, by means of a pressurized spraying machine, within 2 hours of the completed slurry grout application. Apply the curing compound uniformly in one or two coats with a total application rate of not more than 10 square m/L 400 square ft/gal.

3.12 PROTECTION OF GROUTED PAVEMENT

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. Repair damage to the pavement occurring prior to final acceptance or replace the pavement at the Contractor's expense. In order to properly protect the pavement against the effects of rain before the pavement is sufficiently hardened have available materials for the protection of the edges and surfaces of the unhardened RMP. Use the protective materials and method of application as described in paragraph WEATHER LIMITATIONS. When rain appears imminent, stop paving operations, and cover the surface of the hardened RMP with protective covering.

3.13 CONTRACTOR QUALITY CONTROL

3.13.1 General Quality Control Requirements

Develop a QC Plan for approval. Do not produce hot-mix asphalt for payment until the QC Plan has been approved. Develop the plan addressing 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. Mixture Volumetrics

h. Moisture Content of Mixtures

i. Placing and Finishing

j. Joints

k. Compaction

l. Surface Smoothness

3.13.2 Quality Control Testing

Perform QC tests, applicable to these specifications, as set forth in the QC Program. Include 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 in the testing program. Develop a QC Testing Plan as part of the QC Program.

3.13.3 Asphalt Content

Perform a minimum of two tests to determine asphalt content per days production of open-graded asphalt mix, by one of the following methods: the extraction method in accordance with ASTM D2172/D2172M, Method A or B, the ignition method in accordance with the ASTM D6307, or the nuclear method in accordance with ASTM D4125/D4125M, provided the nuclear gauge is calibrated for the specific mix being used. For the extraction method, determine the weight of ash, as described in ASTM D2172/D2172M, 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. Use the last weight of ash value obtained in the calculation of the asphalt content for the mixture.

3.13.4 Gradation

Determine aggregate gradations a minimum of twice per day from mechanical analysis of recovered aggregate in accordance with ASTM D5444. When asphalt content is determined by the nuclear method, determine aggregate gradation from hot bin samples on batch plants, or from the cold feed on drum mix plants. For batch plants, test aggregates in accordance with ASTM C136/C136M using actual batch weights to determine the combined aggregate gradation of the mixture.

3.13.5 Temperatures

Check temperatures at least four times per day 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.

3.13.6 Aggregate Moisture

Determine the moisture content of aggregate used for production a minimum of once per day in accordance with ASTM C566.

3.13.7 Moisture Content of Mixture

Determine the moisture content of the mixture at least once per lot in accordance with ASTM D1461 or an approved alternate procedure.

3.13.8 Air Voids

Determine voids total mix from random core samples taken from in-place open-graded asphalt mixture. Calculate sample voids as outlined in the JMF criteria. Check that voids are between 25 and 35 percent. Remove and replace material not meeting the void criteria at no additional cost to the Government.

3.13.9 Grade and Smoothness

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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. Evaluate projects for the possibility of standing water before removing the grade requirements.

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Conduct the checks to ensure the grade and smoothness requirements are met in accordance with paragraph ACCEPTABILITY OF WORK.

3.13.9.1 Grade

Test the final wearing surface of the pavement for conformance with specified plan grade requirements, before grout is applied. Determine the grade by running lines of levels at intervals of 7 m 25 ft, 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.

3.13.9.2 Smoothness

Perform testing in the presence of the Contracting Officer. Notify the Contracting Officer [_____] days prior to testing to schedule testing availability. Keep detailed notes of the results of the testing and provide a copy to the Government immediately after each day's testing. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), finish the surface to meet the approval of the Contracting Officer. After the slurry grout has sufficiently cured, but not later than 48 hours after placement, test the surface of the pavement in such a manner as to reveal surface irregularities exceeding the 6 mm

1/4 in tolerances. Test the entire area of the pavement in both a longitudinal and a transverse direction on parallel lines. Test transverse lines 8 m 25 ft or less apart. Test longitudinal lines at the centerline of each paving lane for lines less than 6 m 20 ft and at the third points for lanes 6 m 20 ft or greater. Also test other areas having obvious deviations. Test longitudinal lines continuously across joints. Hold the straightedge in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity 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.

3.13.10 Job-Mix-Formula

Perform routine testing for acceptability of work by a Corps of Engineers certified commercial laboratory and approved by the Contracting Officer. Perform additional tests required to determine acceptability of non-conforming material at the Contractor's expense. Use a Marsh Flow Cone for testing the viscosity of grout.

3.14 ACCEPTABILITY OF WORK

3.14.1 General

When a section of pavement fails to meet the specification requirements, remove and replace the section 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.

3.14.2 Field Sampling of RMP Materials

3.14.2.1 Open Graded Bituminous Mixture

Take samples of open graded bituminous mixture from loaded trucks for every 1000 square m square yds 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. Compact laboratory specimens of open graded bituminous material in 102 mm 4 in diameter molds to a 51 mm 2 in thickness using 25 blows on one side from a Marshall hand hammer. Compare test results from the sampled open graded bituminous mixture to the approved JMF for acceptance by the Contracting Officer. Apply the tolerances given in Table V for sieve analysis, bitumen content, and temperature to QC test results on the open graded bituminous mixture as discharged from the mixing plant.

TABLE V
JMF TOLERANCES

Material	Tolerance, Plus or Minus
Aggregate passing 4.75 mm No.4 or larger sieves	4 percent
Aggregate passing 2.36 and 0.60 mm Nos. 8 and 30 sieves	3 percent

TABLE V JMF TOLERANCES	
Material	Tolerance, Plus or Minus
Aggregate passing 0.075 mm No. 200 sieve	1 percent
Bitumen	0.20 percent
Temperature of discharge mix	10 degrees C 50 degrees F
Voids Total Mix	2 percent

3.14.2.2 Slurry Grout

Test each batch of slurry grout for viscosity at the jobsite after mixing and before application. Reject the batch of slurry grout failing to meet the specified viscosity and remove it from the jobsite. Reject slurry grout with visible amounts of sand settling out of suspension during application and remove from the jobsite.

3.14.2.3 Core Samples

Take random core samples from the in-place open graded bituminous mixture before and after application of the slurry grout. Take at least two field core samples before grout application and two after grout application for every 1000 square m square yds of finished RMP. Take half of the core samples taken after grout application from joints between successive grouting lanes. Extract field core samples 102 or 152 mm 4 or 6 in diameter and extend the full depth of the RMP surface layer. Test the ungrouted core samples for thickness. Visually inspect the grouted core samples for acceptable grout penetration. Check for acceptable grout penetration as 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, turn over cores to the Contracting Officer. Fill core holes in ungrouted RMP with hot open graded bituminous material and leveled to match the surrounding pavement surface. Fill core holes in grouted RMP within 24 hours from the time of coring with RMP material, low-shrinkage Portland cement concrete material, or other approved patching material.

3.14.3 Thickness, Grade and Surface-Smoothness Requirements

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NOTE: Increase the surface smoothness requirements specified below to 9 to 12 mm 3/8 to 1/2 in for tank trails and non-critical pavements.
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Check that the finished surface of RMP, when tested as specified below, conforms to the thickness and grade specified and to surface smoothness requirements of 6 mm 1/4 in in the longitudinal and transverse direction of testing. In areas where the thickness, grade or smoothness exceeds the tolerance, remove the surface lift to full depth; replace the lift with open graded bituminous mixture to meet specification requirements, at no additional cost to the Government. Allow use of diamond grinding, after grout has cured, to remove high spots to meet grade or smoothness requirements. Do not permit skin patching for correcting low areas or

planing or milling for correcting high areas.

3.14.3.1 Thickness

Check that the thickness of the RMP meets the requirements shown on the contract drawings. Do not allow the measured thickness of the RMP to exceed the design thickness by more than 13 mm 1/2 in, or be deficient in thickness by more than 6 mm 1/4 in.

3.14.3.2 Surface Smoothness

Do not allow finished surfaces to deviate from testing edge of a 3.7 m 12 ft straightedge more than 6 mm 1/4 in in the longitudinal or transverse direction of testing.

3.14.3.3 Surface Texture

Check that the surface texture is uniform and free of excess cement grout. Remove grout below the top of the open-graded asphalt concrete.

3.14.3.4 Grade

Check that the finished surface of pavement conform to the elevations and the cross sections shown on the plan and do not vary by more than 15 mm 0.6 in from the plan grade established and approved at site of work. Check that finished surfaces at juncture with other pavements coincide with finished surfaces of abutting pavements.

-- End of Section --