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USACE / NAVFAC / AFCEC / NASA **UFGS-32 11 10 (August 2008)**

Preparing Activity: USACE **Superseding UFGS-32 11 10 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2014
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DIVISION 32 - EXTERIOR IMPROVEMENTS

SECTION 32 11 10

DRAINAGE LAYER

08/08

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SECTION 32 11 10

DRAINAGE LAYER
08/08

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NOTE: This guide specification covers the requirements for a drainage layer under roads, streets and airfield pavements.

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 items(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

1.1 UNIT PRICES

****
NOTE: This paragraph will be deleted when the work is covered by a lump-sum contract price.
****

1.1.1 Measurement

Deductions will be made for any material wasted, unused, rejected, or used for the convenience of the Contractor.

1.1.1.1 Aggregate Drainage Layer Material

Measure the quantity of aggregate drainage layer material, completed and accepted, in cubic meters yards. Determine the volume of aggregate

drainage layer material, in place and accepted, by the average job thickness obtained in accordance with paragraph THICKNESS CONTROL and the dimensions indicated. The choke stone shall be considered as part of the drainage layer thickness and shall not be measured separately.

1.1.1.2 Bituminous or Cement Stabilized Drainage Layer

Measure the quantity of bituminous or cement stabilized drainage layer material, completed and accepted, in metric 2000 pound tons, excluding the weight of the asphalt or portland cement used in the mix.

1.1.1.3 Bituminous Material

Measure the quantity of asphalt cement, used in the bituminous stabilized mix, by the number of liters gallons of material used in the accepted work corrected to liters at 16 degrees C gallons at 60 degrees F in accordance with ASTM D1250.

1.1.1.4 Cementitious Material

Measure the quantity of portland cement, used in the cement stabilized mix, by the number of 50 kilogram short hundred-weight (cwt) units of cement used in the accepted work.

1.1.2 Payment

The quantities of drainage layer aggregates and bituminous or cementitious materials, as specified above, will be paid for at the contract unit prices, which will constitute full compensation for the construction and completion of the drainage layer, including the test section, and the furnishing of all other necessary labor and incidentals.

1.1.3 Waybills and Delivery Tickets

Submit certified waybills and delivery tickets for all aggregates, bituminous, and cementitious materials actually used. Before the final payment is allowed, file certified waybills and certified delivery tickets for all aggregates, bituminous, and cementitious materials actually used.

1.2 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	(2010) Standard Specification for Performance-Graded Asphalt Binder
AASHTO T 102	(2009) Standard Method of Test for Spot Test of Asphaltic Materials

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C595/C595M	(2013) Standard Specification for Blended Hydraulic Cements
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D1250	(2008) Standard Guide for Use of the Petroleum Measurement Tables
ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D2172/D2172M	(2011) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3381/D3381M	(2013) Viscosity-Graded Asphalt Cement for Use in Pavement Construction

ASTM D4791	(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D6307	(2010) Asphalt Content of Hot Mix Asphalt by Ignition Method
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2009) Standard Practice for Sampling Aggregates
ASTM D946/D946M	(2009a) Penetration-Graded Asphalt Cement for Use in Pavement Construction

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST IR 91-4756	(1991) Laboratory Accreditation Activities in the United States

1.3 SYSTEM DESCRIPTION

****
NOTE: The Designer will select the appropriate drainage layer materials, delete the other subparagraphs, and edit the specification accordingly. The intent is to allow the Contractor all possible material options.
****

Build a drainage layer under the pavements, as indicated on drawings, consisting of [Rapid Draining Material (RDM)][Open Graded Material stabilized with a choke stone][Open Graded Material stabilized with cement or bituminous].

1.3.1 Equipment

****
NOTE: If desirable, include requirements for specific types of equipment applicable to methods of construction based on local conditions.
****

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times.

1.3.2 Placement Equipment

Use an asphalt paving machine to place drainage layer material. Alternate methods may be used if it can be demonstrated in the test section that these methods obtain the specified results.

1.3.3 Compaction Equipment

Use a dual or single smooth 10 metric- 2000 lb- tons (min.) vibratory drum

roller, which provides a maximum compactive effort without crushing the drainage layer aggregate, to compact drainage layer material.

1.3.4 Bituminous Mixing Plant

Provide a bituminous mixing plant that is an automatic or semiautomatic controlled, commercially manufactured unit capable of producing a bituminous stabilized aggregate mixture consistent with the job-mix formula (JMF).

1.3.5 Cementitious Mixing Plant

Provide a cementitious mixing plant that is an automatic or semiautomatic controlled, commercially manufactured unit capable of producing a cement stabilized aggregate mixture consistent with the job mix formula determined by the Government. Aggregate and cement shall be dry mixed sufficiently to prevent cement balls from forming when water is added.

1.4 SUBMITTALS

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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.

The Guide Specification technical editors have designated 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 System. Only add a "G" to an item, 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.

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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.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Waybills and Delivery Tickets

SD-06 Test Reports

Sampling and Testing
Approval of Materials[; G][; G, [_____]]
Evaluation

1.5 QUALITY ASSURANCE

1.5.1 Sampling and Testing

Submit copies of field test results within 24 hours of completion of tests. Sampling and testing are the responsibility of the Contractor to be performed by an approved commercial testing laboratory, or by the Contractor subject to approval. If the Contractor elects to establish testing facilities of its own, approval of such facilities will be based on compliance with NIST IR 91-4756, and no work requiring testing will be permitted until the Contractor's facilities have been inspected and approved. The first inspection of the facilities will be at the expense of the Government and any subsequent inspections required because of failure of the first inspection shall be at the expense of the Contractor. Such costs will be deducted from the total amount due the Contractor. Test drainage layer materials to establish compliance with the specified requirements.

1.5.2 Sampling

Take aggregate samples in accordance with ASTM D75/D75M. Take bituminous samples in accordance with ASTM D140/D140M. Take bituminous or cement stabilized mixture samples using methods approved by the Contracting Officer.

1.5.3 Test Methods

1.5.3.1 Sieve Analyses

Make sieve analyses in accordance with ASTM C117 and ASTM C136.

1.5.3.2 Density Tests

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NOTE: Nuclear gauge density testing may not be accurate for gradations of RDM with a small percentage of fines. The testing may still indicate segregation or consistency in placement of the material.
****

Perform field density tests for RDM drainage layers in accordance with ASTM D6938 by Direct Transmission Method for the full depth of the lift, use ASTM D6938 to determine the moisture content of the aggregate drainage layer material. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938. The calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as described in

paragraph "Calibration" of ASTM D6938, on each different type of material being tested at the beginning of a job and at intervals as directed by the Contracting Officer.

1.5.3.3 Soundness Test

Perform soundness tests in accordance with ASTM C88.

1.5.3.4 Los Angeles Abrasion Test

Perform Los Angeles abrasion tests in accordance with ASTM C131.

1.5.3.5 Flat or Elongated Particles Tests

Perform flat and/or elongated particles tests in accordance with ASTM D4791.

1.5.3.6 Fractured Faces Tests

When aggregates are supplied from crushed gravel, use approved test methods to ensure the aggregate meets the requirements for fractured faces in paragraph AGGREGATES.

1.5.3.7 Bitumen Content

Perform bitumen extraction tests in accordance with ASTM D2172/D2172M or ignition tests in accordance with ASTM D6307.

1.5.4 Initial Tests

Perform one of each of the following tests on the proposed material, prior to commencing construction, to demonstrate that the proposed material meets all specified requirements when furnished. If materials from more than one source are going to be utilized, complete the following tests for each source.

a. Sieve Analysis including 75 µm No. 200 sieve size material.

b. Flat and/or elongated particles

c. Fractured Faces

d. Los Angeles abrasion.

e. Soundness.

1.5.5 Testing Frequency

1.5.5.1 Aggregate Layer

Perform field density and moisture content tests at a rate of at least one test for every [2000] [_____] square meters yards of completed area and not less than one test for each day's production. Sieve analyses shall be performed at a rate of at least one test for every [6000] [_____] square meters yards of completed area. Perform soundness tests, Los Angeles abrasion tests, fractured faces tests and flat and/or elongated particles tests at the rate of one test for every 12,000 square meters square yards of production.

1.5.5.2 Stabilized Layer

Perform sieve analyses on aggregates prior to addition of asphalt or portland cement, at a rate of at least one test for every [6000] [_____] square meters yards of completed area and not less than one test for each days production. Make extraction tests on bituminous stabilized material at the same frequency. Perform soundness tests, Los Angeles abrasion tests, fractured faces tests, and flat and/or elongated particles tests at the rate of one test for every 12,000 square meters yards of production.

1.5.6 Approval of Materials

Submit material sources and material test results prior to field use.

1.5.6.1 Aggregate

Select the aggregate source at least [60] [_____] days prior to field use in the test section. Tentative approval of the source will be based on certified test results to verify that materials proposed for use meet the contract requirements. Final approval of both the source and the material will be based on test section performance and tests for gradation, soundness, Los Angeles abrasion, flat and/or elongated particles tests and fractured faces tests. For aggregate drainage layer materials, perform these tests on samples taken from the completed and compacted drainage layer course within the test section. For bituminous or cement stabilized drainage layer material, perform these tests on aggregate samples taken prior to addition of bituminous or cementitious material and subsequent placement in the test section.

1.5.6.2 Bituminous or Cementitious Materials

Submit bituminous or cementitious sources and certified material test results for approval not less than [60] [_____] days prior to field use in the test section.

1.6 ENVIRONMENTAL REQUIREMENTS

Place drainage layer material when the atmospheric temperature is above 2 degrees C 35 degrees F. Correct areas of completed drainage layer or underlying courses that are damaged by freezing, rainfall, or other weather conditions or by contamination from sediments, dust, dirt, or foreign material to meet specified requirements.

PART 2 PRODUCTS

2.1 GOVERNMENT APPROVAL

Asphalt or cement stabilized material will require Government notification and delivery of approved materials in accordance with paragraph BITUMINOUS OR CEMENT STABILIZED JOB-MIX FORMULA.

2.2 AGGREGATES

Provide aggregates consisting of clean, sound, hard, durable, angular particles of crushed stone, crushed slag, or crushed gravel which meet the specification requirements. Slag shall be an air-cooled, blast-furnace product having a dry weight of not less than 1040 kg per cubic meter 65 pcf determined by ASTM C29/C29M. Provide aggregates free of silt and clay as defined by ASTM D2487, vegetable matter, and other objectionable materials

or coatings.

2.2.1 Aggregate Quality

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NOTE: A percentage of loss on abrasion of 40 will be used except that a value up to 50 percent may be used where experience with local materials indicates such an increase is justified. A percentage of soundness loss of 18 has proven effective in many localities. The Designer will insert in the blank spaces the applicable losses in percent for the specific job based on the knowledge of both coarse and fine aggregates in the areas that have been previously approved and have a satisfactory service record for at least 5 years. The percent of fractured faces may be reduced to 75 if the required CBR is 50 or less.

****

The aggregate shall have a soundness loss not greater than [18] [_____] percent weighted averaged at 5 cycles when tested in magnesium sulfate in accordance with ASTM C88 and a percentage of loss on abrasion not to exceed [40] [_____] after 500 revolutions as determined by ASTM C131. Determine the percentage of flat and/or elongated particles by ASTM D4791 with the following modifications: 1) The aggregates shall be separated into 2 size fractions, particles greater than 12.5 mm 1/2 inch sieve and particles passing the 12.5 mm 1/2 inch sieve and retained on the 4.75 mm No. 4 sieve. 2) The percentage of flat and/or elongated particles in either fraction shall not exceed 20. 3) A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. 4) When the aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements. When the aggregate is supplied from crushed gravel it shall be manufactured from gravel particles, 90 percent of which by weight are retained on the maximum-size sieve listed in TABLE I. In the portion retained on each sieve specified, the crushed gravel shall contain at least [90] [75] percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of the smallest midsectional area of the face. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as 2 fractured faces.

2.2.2 Gradation Requirements

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NOTE: The gradation or gradations applicable to the specific job will be specified. The designer will select rapid draining material (RDM) and/or open graded material (OGM) depending on the required permeability and material availability. RDM should provide a permeability of 300 to 1500 meters (1000 to 5000 feet) per day. OGM should provide a permeability greater than 1500 meters (5000 feet) per day. RDM is well graded enough to be stable to work on, however OGM will require choke stone, asphalt cement, or portland cement for stability. The gradation for the choke stone matches ASTM gradation No. 8.

For roads, where the drainage path is short and a permeability of 300 meters (1000 feet) per day is adequate, the Contractor can be permitted to use the following Optional Table I. Add the following "Note 5. The Optional Table I gradation can be meet in some areas with 77 percent #57 stone and 23 percent concrete sand blend."

OPTIONAL TABLE I
GRADATION OF DRAINAGE LAYER MATERIAL
Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	Rapid Draining Material (RDM)
50.00 mm	100
37.50 mm	95-100
25.00 mm	70-100
19.00 mm	60-100
12.50 mm	50-76
9.50 mm	40-65
4.75 mm	20-45
2.36 mm	17-30
1.18 mm	5-16
0.30 mm	0-5
0.15 mm	0-2.5

OPTIONAL TABLE I.
GRADATION OF DRAINAGE LAYER MATERIAL

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	Rapid Draining Material (RDM)
2 inch	100
1-1/2 inch	95-100
1 inch	70-100
3/4 inch	60-100
1/2 inch	50-76
3/8 inch	40-65
No. 4	20-45
No. 8	12-30
No. 16	5-16
No. 50	0-5
No. 100	2-2.5

****

Drainage layer aggregates shall be well graded within the limits specified in TABLE I.

TABLE I. GRADATION OF DRAINAGE LAYER MATERIAL

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	Rapid draining Material (RDM)	Open Graded Material (OGM)	Choke Stone	OGM Stabilized
37.50 mm	100	100	100	100
25.00 mm	70-100	95-100	100	95-100

TABLE I. GRADATION OF DRAINAGE LAYER MATERIAL

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	Rapid draining Material (RDM)	Open Graded Material (OGM)	Choke Stone	OGM Stabilized
19.00 mm	55-100	---	100	---
12.50 mm	40-80	25-80	100	25-80
9.50 mm	30-65	---	80-100	---
4.75 mm	10-50	0-10	10-100	0-10
2.36 mm	0-25	0-5	5-40	0-5
1.18 mm	0-5	---	0-10	---

TABLE I. GRADATION OF DRAINAGE LAYER MATERIAL

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	Rapid draining Material (RDM)	Open Graded Material (OGM)	Choke Stone	OGM Stabilized
1-1/2 inch	100	100	100	100
1 inch	70-100	95-100	100	95-100
3/4 inch	55-100	---	100	---
1/2 inch	40-80	25-80	100	25-80
3/8 inch	30-65	---	80-100	---
No. 4	10-50	0-10	10-100	0-10
No. 8	0-25	0-5	5-40	0-5
No. 16	0-5	---	0-10	---

NOTE 1: The values are based on aggregates of uniform specific gravity, and the percentages passing the various sieves may require appropriate correction by the Contracting Officer when aggregates of varying specific gravities are used.

NOTE 2: Choke stone is required to stabilize the OGM for constructability of the overlying layer. If approved by the COR, the OGM can be constructed without choke stone, provided equipment is not operated on the finished surface of the OGM. Choke stone shall be made up of hard, durable, crushed aggregate having 90 percent of the stone with fractured faces. The gradation for the choke stone shall be based on the following criteria:

a. The ratio of the D15 of the OGM to the D15 of the choke stone shall be less than 5.

b. The ratio of the D50 of the OGM to the D50 of the choke stone shall be greater than 2.

NOTE 3: For RDM, the coefficient of uniformity (CU) shall be greater than 3.5. (CU = D60/D10). The Contractor is responsible for adjusting the RDM gradation within the ranges listed in Table I to provide a stable construction surface for the proposed equipment and method of transporting materials or the drainage layer can be stabilize with portland cement or asphalt at no additional cost to the government, if approved during the test section.

NOTE 4: Asphalt cement or portland cement will be required to stabilize the OGM.

2.3 BITUMINOUS MATERIALS

****
NOTE: The appropriate type and grade of bituminous material will be based on information provided in UFC 3-250-03. Use a grade of asphalt that is available in the project location. A stiff asphalt is desirable. On performance graded asphalt modifiers should not be required and the low temperature grade of -28 should be adequate for typical projects.
****

Asphalt cement to be mixed with aggregates shall conform to [ASTM D946/D946M Penetration Grade [____]] [ASTM D3381/D3381M viscosity Grade AASHTO M 320PG [____]]. In addition, the asphalt cement shall show a negative spot when subjected to the spot test in accordance with AASHTO T 102, using the standard naphtha specified.

2.4 CEMENTITIOUS MATERIALS

Portland cement to be mixed with aggregates shall conform to [ASTM C150/C150M, Type I, IA, II or IIA] [ASTM C595/C595M, Type IS or IS (A)].

2.5 BITUMINOUS OR CEMENT STABILIZED JOB-MIX FORMULA

The bituminous stabilized mix shall consist of a mixture of OGM and a minimum of 2 percent asphalt cement by weight. Tolerances for bituminous stabilized material shall be maintained for field production at plus or minus 0.25 percent for asphalt cement and plus or minus 14 degrees C 25 degrees F for mixing temperatures. The cement stabilized mix shall consist of OGM and a minimum of 90 kg 200 pounds of portland cement per cubic meter yard with a water/cement ratio of 0.37. Based on the test section performance, the Contractor shall be responsible for adjustments (increases) in asphalt cement or portland cement quantities to ensure the stabilized drainage layer will not rut or be disturbed by the Contractor's proposed paving method. Submit a job-mix formula (JMF) with the test section report for Contracting Officer approval.

PART 3 EXECUTION

3.1 STOCKPILING AGGREGATES

Stockpile aggregates at locations designated by the Contracting Officer. Clear and level stockpile areas prior to stockpiling aggregates to prevent segregation and contamination. Aggregates obtained from different sources shall be stockpiled separately.

3.2 TEST SECTION

3.2.1 Data

Construct a test section to evaluate the ability to carry traffic, including placement of overlaying material and the constructability of the drainage layer including required mixing, placement, and compaction procedures. Test section data will be used by the Contracting Officer to validate the required number of compaction passes given in paragraph

Compaction Requirements and the field dry density requirements for full scale production.

3.2.2 Schedule/Evaluation

Construct the test section a minimum of [30] [_____] days prior to the start of full scale production to provide sufficient time for an evaluation of the proposed materials, equipment and procedures including Government QA testing.

3.2.3 Location and Size

Place the test section [inside the production paving limits][outside production paving limits in an area with similar subgrade and subbase conditions approved by the Contracting Officer]. The underlying courses and subgrade preparation, required for the pavement section, shall be completed, inspected and approved in the test section prior to constructing the drainage layer. The test section shall be a minimum of [30] [_____] m [100] [_____] feet long and two full paving lanes wide side by side.

3.2.4 Initial Testing

Provide certified test results, approved by the Contracting Officer prior to the start of the test section, to verify that the materials proposed for use in the test section meet the contract requirements.

3.2.5 Mixing, Placement, and Compaction

Accomplish mixing, placement, and compaction using equipment meeting the requirements of paragraph EQUIPMENT. Compaction equipment speed shall be no greater than 2.4 km/hour 1.5 mph. Start compaction from the outside edges of the paving lane and proceed to the centerline of the lift being placed. The roller shall stay a minimum of one half the roller width from the outside edge of the drainage layer being placed until the desired density is obtained. The outside edge shall then be rolled.

3.2.6 Procedure

3.2.6.1 RDM Aggregate Drainage Layer Tests

Construct the test section with aggregate in a wet state so as to establish a correlation between number of roller passes and dry density achievable during field production. Designate three separate areas within the test section, test each area for density, moisture, and gradation. Complete all testing in the middle third of the test section being placed. Conduct density and moisture content tests in accordance with ASTM D6938. Conduct sieve analysis tests on samples, taken adjacent to the density test locations. Take one set of tests (i.e. density, moisture, and sieve analysis) before the third compaction pass and after each subsequent compaction pass at three separate locations as directed by the Contracting Officer. Define a pass as the movement of a roller over the drainage layer area for one direction only. Compaction for the RDM shall consist of a maximum of 5 passes in the vibrating state and one final pass in the static state. Continue compaction passes and density readings until the difference between the average dry densities of any two consecutive passes is less than or equal to 16 kg per cubic meter 1.0 pcf.

3.2.6.2 Bituminous/Cement Stabilized Drainage Layer

Construct the test section with the same equipment used for production. Designate three separate areas within the test section for sampling. Complete all testing in the middle third of the test section being placed. The Contracting Officer will perform visual examination of each sample to determine if and when crushing of aggregate occurs. Take one sample before compaction and after each subsequent compaction pass at three separate locations as directed by the Contracting Officer. Continue compaction for a maximum of 6 passes. Define a pass as the movement of a roller over the drainage layer area for one direction only. Placement procedures and equipment shall be as described herein. The Contracting Officer will determine the number of passes required for compaction from the test section.

3.2.6.3 OGM with Choke Stone

Construct the test section with aggregate in a moist state. When the OGM gradation is used, density testing is not required, only gradation testing is required. Designate three separate areas within the test section for sampling. Complete all testing in the middle third of the test section being placed. The maximum number of passes per lift shall be 8. Define a pass as the movement of a roller over the drainage layer area for one direction only. Placement procedures and equipment will be as described herein. Conduct sieve analysis tests on samples. Take one set of sieve tests before the third compaction pass and after each subsequent compaction pass at three separate locations as directed by the Contracting Officer. Compaction for the OGM shall consist of first 5 passes in the vibrating state and one final pass in the static state. The Contracting Officer will determine the number of passes required for production from the results of the test section. If choke stone is used to stabilize the surface of OGM, place the choke stone after final static compaction of the OGM. Spread the choke stone in a thin layer no thicker than 13 mm 1/2 inch and worked into the surface of the OGM using two additional passes of a vibratory roller and wetting. Sieve testing is not required after the compaction of the choke stone.

3.2.7 Evaluation

****

NOTE: The Designer will evaluate the data from the test section. To do this for RDM aggregate drainage layer material, it is suggested that the in-place density and percent passing the 4.75 mm (No. 4) and 1.18 mm (No. 16) sieve sizes be plotted against cumulative passes. With these results, the designer should try to maximize dry density while minimizing aggregate degradation. Generally, after between 3 and 6 passes, only slight increases in dry density (16 kg per cubic meters (1.0 pcf)) will be achieved. At this point the measured field density is at or near the optimum density obtainable for this material, for the given field conditions and the number of roller passes at this point can be determined. If local experience indicates more than 6 passes maybe required, edit the specification accordingly. The Contractor is required by the specification to to use 4 vibratory and one static roller passes on the drainage material. If the test

section indicated more or less is rolling is appropriate, a field modification should be written.. The required field dry density should be set slightly lower than this optimum field dry density. It is suggested that the field dry density be set at 98 percent of the optimum density obtained in the test section. The data on the percent passing should be looked at closely to determine if degradation of the aggregate is occurring. If the percent passing the given sieve sizes is increasing, then the aggregate is being broken down by the compaction effort. If this is occurring, selection of a field control density will be more difficult. The field density selected will have to be balanced between aggregate degradation, dry density and stability of the drainage layer surface. Stability of the layer surface should take precedence. For OGM material with a choke stone drainage layer, plot cumulative passes against sieve analyses and watch for degradation similar to the RDM. For bituminous or cement stabilized drainage layer material, the required number of passes should be based on visual observations by the designer in the field test section of degradation in lieu of sieve analyses.
****

Within 10 days of completion of the test section, submit to the Contracting Officer a Test Section Construction Report complete with all required test data and correlations. The Contracting Officer will evaluate the data and validate the required number of passes of the roller, the need for a final static pass of the roller, and provide the dry density for field density control during construction.

3.3 PREPARATION OF UNDERLYING COURSE

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NOTE: Retain only the reference to the specification section that covers the preparation of the underlying course for the particular project.
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Prior to constructing the drainage layer, clean the underlying course of all foreign materials. During construction, the underlying course shall contain no frozen material. The underlying course shall conform to Section 32 11 16.16 SUBBASE COURSES. Correct ruts or soft yielding spots in the underlying courses having inadequate compaction and deviations of the surface from the requirements set forth herein by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line, and grade, and recompacting to specified density. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained in a satisfactory condition until the drainage layer is placed.

3.4 TRANSPORTING MATERIAL

3.4.1 Aggregate Drainage Layer Material

Transport aggregate drainage layer material to the site in a manner which prevents segregation and contamination of materials.

3.4.2 Bituminous Stabilized Material

Transport bituminous stabilized material from the mixing plant to the site in trucks having tight, clean, smooth beds lightly coated with an approved releasing agent to prevent adhesion of the stabilized material to the truck beds. Drain excessive releasing agent prior to loading. Cover each load with canvas or other approved material of ample size to protect the stabilized material 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.

3.4.3 Cement Stabilized Material

Transport cement stabilized material from the mixing plant to the site in trucks equipped with protective covers. Loads that have crusts of unworkable material or have become excessively wet will be rejected. Hauling over freshly placed material will not be permitted.

3.5 PLACING

3.5.1 General Requisites

Place drainage layer material on the underlying course in lifts of uniform thickness using equipment meeting the requirements of paragraph EQUIPMENT. When a compacted layer 150 mm 6 inches or less in thickness is required, place the material in a single lift. When a compacted layer in excess of 150 mm 6 inches is required, place the material in lifts of equal thickness. No lift shall exceed 150 mm 6 inches or be less than 75 mm 3 inches when compacted. The lifts when compacted after placement shall be true to the grades or levels required with the least possible surface disturbance. Where the drainage layer is placed in more than one lift, clean the previously constructed lift of loose and foreign material. Such adjustments in placing procedures or equipment shall be made to obtain true grades and minimize segregation and degradation of the drainage layer material. Spread choke stone used to stabilize the surface of the OGM in a thin layer no thicker than 13 mm 1/2 inch. The OGM shall be brought to grade and the choke stone placed and rolled as described in paragraph; TEST SECTION.

3.5.2 Placement of Stabilized Material

Bituminous stabilized material having temperatures less than 80 degrees C 175 degrees F when dumped into the asphalt paving machine will be rejected. Adjust the paving machine so that the surface of the lift being laid will be smooth and continuous without tears and pulls. Correct irregularities in alignment of the lift left by the paving machine by trimming directly behind the machine. Immediately after trimming, thoroughly compact the edges of the lift by a method approved by the Contracting Officer. Distortion of the lift during tamping will not be permitted. If more than one lift is required, offset the longitudinal joint in one lift that in the lift immediately below by at least 300 mm 1 foot; however, the joint in the top layer shall be at the centerline of the pavement. Offset transverse joints in one layer by at least 600 mm 2 feet from transverse joints in the previous layer. Transverse joints in adjacent strips shall be offset a minimum of 3 meters 10 feet. At the end of each day's construction, form a straight transverse construction joint by cutting back into the completed work to form a true vertical face free of loose or shattered material. Remove material along construction joints

not properly compacted.

3.5.3 Placing Adjacent Stabilized Strips

Place the stabilized material in consecutive adjacent strips having a minimum width of 3 meters 10 feet, except where edge lanes require strips less than 3 meters 10 feet to complete the area. In placing adjacent strips, the screed of the paving machine shall overlap the previously placed strip 75 to 100 mm 3 to 4 inches and shall be sufficiently high so that compaction will produce a smooth, dense joint. The stabilized material placed on the edge of the previously placed strip by the paver shall be pushed back to the edge of the strip being placed. Remove and waste excess stabilized material.

3.5.4 Hand Spreading

Spread by hand drainage layer material in areas where machine spreading is impractical. The material shall be spread uniformly in a loose layer to prevent segregation. The material shall conform to the required grade and thickness after compaction.

3.6 COMPACTION REQUIREMENTS

3.6.1 Field Compaction

Base field compaction requirements on the results of the test section, using the materials, methods, and equipment proposed for use in the work.

3.6.2 Number of Passes

Accomplish compaction using rollers meeting the requirements of paragraph EQUIPMENT and operating at a rolling speed of no greater than 2.4 km 1.5 miles per hour. Compact each lift of drainage material, including shoulders when specified under the shoulders, with the number of passes of the roller as follows: for RDM material use 4 passes in the vibratory state and one in the static. For cement or Bituminous stabilized OGM material use 3 passes in the vibratory state and one in the static state. For OGM stabilized with choke stone use 4 passes in the vibratory state on OGM and 2 additional roller passes on the choke stone in the vibratory state with wetting. The Contracting Officer will validate the number of roller passes after the test section is evaluated and before production starts.

3.6.3 Dry Density

In addition, maintain a minimum field dry density as specified by the Contracting Officer. If the required field dry density is not obtained, adjust the number of roller passes in accordance with paragraph DEFICIENCIES. Compact aggregate in a moisture state as determined in the test section. Excessive rolling resulting in crushing of aggregate particles shall be avoided. Choke stone used to stabilize the surface of the OGM shall be worked into the surface of the OGM by two passes of a vibratory roller and wetting. Begin compaction of bituminous stabilized material immediately when the material has cooled to 77 degrees C 170 degrees F. Not more than 30 minutes shall elapse between the start of moist mixing of cement stabilized material and the start of field compaction, which shall be completed within 60 minutes. In all places not accessible to the rollers, compact the drainage layer material with mechanical hand operated tampers.

3.7 FINISHING

Finish the top surface of the drainage layer after final compaction, as determined from the test section. Make adjustments in rolling and finishing procedures to obtain grades and minimize segregation and degradation of the drainage layer material.

3.8 CURING OF CEMENT STABILIZED MATERIAL

Cure the completed cement stabilized drainage layer with water for a period of 12 hours following completion of compaction. Commence curing operations within 3 hours after compaction. Curing shall consist of one of the following: 1) Sprinkling the surface of the drainage layer with a fine spray of water every 2 hours for the required 12 hour period, 2) by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap, 3) Impervious sheet curing. Curing water shall be applied so that the cement paste on the surface of the mixture will not be eroded. Water trucks will not be permitted on the completed cement stabilized drainage layer. Impervious sheeting curing shall consist of all surfaces being thoroughly wetted and then completely covered with the sheeting. Sheeting shall be at least 450 mm 18 inches wider than the stabilized drainage layer surface to be covered. Lay covering with light-colored side up. Lap covering not less than 300 mm 12 inches; securely weight covering to prevent displacement so that it remains in contact with the surface during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears of holes appear during the curing period

3.9 EDGES OF DRAINAGE LAYER

Place shoulder material along the edges of the drainage layer course in a quantity that will compact to the thickness of the layer being constructed. At least 1 m 3 feet width of the shoulder shall be rolled and compacted simultaneously with the rolling and compacting of each lift of the drainage layer.

3.10 SMOOTHNESS TEST

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NOTE: A 3.66 m (12 foot) straightedge with the deviations unchanged may be specified instead of a 3.05 m (10 foot) straightedge, especially if the paving specifications call for a 3.66 m (12 foot) straight edge.

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The surface of the top lift shall not deviate more than 10 mm 3/8 inch when tested with either a 3.05 or 3.66 m10 or 12 foot straightedge applied parallel with and at right angles to the centerline of the area to be paved. Correct deviations exceeding 10 mm 3/8 inch in accordance with paragraph DEFICIENCIES.

3.11 THICKNESS CONTROL

The completed thickness of the drainage layer shall be within 13 mm 1/2 inch of the thickness indicated. Measure thickness at intervals providing at least one measurement for each 500 square meters yards of drainage layer. Make measurements in test holes at least 75 mm 3 inches in diameter unless

the Contractor can demonstrate, for COR approval, that a steel rod pushed through the drainage layer clearly stops at the material interface. Where the measured thickness is more than 13 mm 1/2 inch deficient, such areas shall be corrected in accordance with paragraph DEFICIENCIES. Where the measured thickness is 13 mm 1/2 inch more than indicated, it will be considered as conforming to the requirements plus 13 mm 1/2 inch, provided the surface of the drainage layer is within 13 mm 1/2 inch of established grade. The average job thickness shall be the average of all job measurements as specified above but within 8 mm 1/4 inch of the thickness shown on the drawings.

3.12 DEFICIENCIES

3.12.1 Grade and Thickness

Correct deficiencies in grade and thickness so that both grade and thickness tolerances are met. Thin layers of material shall not be added to the top surface of the drainage layer to meet grade or increase thickness. If the elevation of the top of the drainage layer is more than 13 mm 1/2 inch above the plan grade it shall be trimmed to grade and finished in accordance with paragraph FINISHING. If the elevation of the top surface of the drainage layer is 13 mm 1/2 inch or more below the required grade, the surface of the drainage layer shall be scarified to a depth of at least 75 mm 3 inches, new material shall be added, and the layer shall be blended and recompacted to bring it to grade. Where the measured thickness of the drainage layer is more than 13 mm 1/2 inch deficient, such areas shall be corrected by excavating to the required depth and replaced with new material to obtain a compacted lift thickness of at least 75 mm 3 inches. The depth of required excavation shall be controlled to keep the final surface elevation within grade requirements and to preserve layer thicknesses of materials below the drainage layer.

3.12.2 Density

Density will be considered deficient if the field dry density test results are below the dry density specified by the Contracting Officer. If the densities are deficient, the layer shall be rolled with 2 additional passes of the specified roller. If the dry density is still deficient, work will be stopped until the cause of the low dry densities can be determined and reported to the Contracting Officer.

3.12.3 Smoothness

Correct deficiencies in smoothness as if they are deficiencies in grade or thickness. All tolerances for grade and thickness shall be maintained while correcting smoothness deficiencies.

-- End of Section --