Preparing Activity: USACE Superseding
UFGS-32 11 23.23 (August 2017)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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08/22

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SECTION 32 11 23.23

BASE COURSE DRAINAGE LAYERS
08/22

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 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

1.1 UNIT PRICES

NOTE: Delete this paragraph 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 convenience.

1.1.1.1 Aggregate Drainage Layer Material

Measure the quantity of aggregate drainage layer material, completed and

accepted, in [square][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.]

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 [square][cubic] meters yards.

1.1.2 Payment

The quantities of drainage layer aggregates bituminous or cementitious stabilized drainage layer, 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 copies of waybills and delivery tickets during the progress of the work. 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.

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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 288	(2021) Standard Specification for Geosynthetic Specification for Highway Applications
AASHTO T 102	(2009; R 2013) Standard Method of Test for Spot Test of Asphaltic Materials

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
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	(2022) Standard Specification for Portland Cement
ASTM C595/C595M	(2021) Standard Specification for Blended Hydraulic Cements
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D946/D946M	(2020) Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3381/D3381M	(2018) Standard Specification for Viscosity-Graded Asphalt Binder for Use in Pavement Construction

ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D5821	(2013; R 2017) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6307	(2019) Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method
ASTM D6373	(2016) Standard Specification for Performance Graded Asphalt Binder
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.3 SUBMITTALS

****

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 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.
****

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-03 Product Data

Plants, Equipment, and Tools; G[, [_____]]

Waybills and Delivery Tickets

Releasing Agent

SD-06 Test Reports

Initial Tests; G[, [____]]

Test Section Construction Report; G[, [____]]

Job-Mix Formula; G[, [____]]

SD-07 Certificates

Geotextile

1.4 QUALITY ASSURANCE

****
NOTE: Select UFGS Section 01 45 00 for Army, Air Force, and Navy Projects, and 01 45 00.00 40 for NASA projects. Delete the others.

For Navy projects, deleted the bracketed sentence requiring MTC validation.
****

Perform sampling and testing using a laboratory approved in accordance with Section [01 45 00][01 45 00.00 40] QUALITY CONTROL. Do not start work requiring testing until the testing laboratory has been inspected and approved.[All contractor quality control testing laboratories performing acceptance testing require USACE validation by the Material Testing Center (MTC) for both parent laboratory and on-site laboratory. Validation on all laboratories is required to remain current throughout the duration of the paving project. Contact the MTC manager listed at https://mtc.erdc.dren.mil/requestvalidation.aspx# for costs and scheduling.] Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. Furnish copies of test results within 24 hours of completion of the tests.

1.4.1 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 approved methods.

1.4.2 Tests

1.4.2.1 Gradation Analyses

Perform gradation analyses in accordance with ASTM C117 and ASTM C136/C136M using sieves conforming to ASTM E11.

1.4.2.2 Compaction Tests

Perform field compaction tests in accordance with ASTM D6938 by Backscatter Method (Procedure B). 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 compaction calibration checks as described in ASTM D6938. Make the calibration checks of both the compaction and moisture gauges using the prepared containers of material method, as described in Annex A2 of ASTM D6938, on each different type of material being tested at the beginning of a job and at intervals as directed. Submit copies of field test results within [24] [____] hours after the tests are performed.

1.4.2.3 Soundness Test

Perform soundness tests in accordance with ASTM C88.

1.4.2.4 Wear Test

Perform wear tests in conformance with ASTM C131/C131M.

1.4.2.5 Flat or Elongated Particles Tests

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

1.4.2.6 Fractured Faces Tests

When aggregates are supplied from crushed gravel, test in accordance with ASTM D5821 to verify the aggregate meets the requirements for fractured faces in paragraph AGGREGATES.

1.4.2.7 Bitumen Content

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

1.4.3 Testing Frequency

1.4.3.1 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. Gradation Analysis.

b. Flat and/or elongated particles.

c. Fractured Faces.

d. Wear.

e. Soundness.

1.4.4 Approval of Materials

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

1.4.4.1 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, wear, 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.

1.4.4.2 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.

1.5 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. If the temperature falls below 2 degree C 35 degrees F, protect completed cement-stabilized mixture against detrimental effects of freezing. Bring any areas of completed cement-stabilized mixture that are damaged by freezing, rainfall, or other weather conditions to a compliant condition in conformance with this specification. Do not apply bituminous material when the atmospheric temperature is less than 10 degrees C 50 degrees F or to soils that are frozen or contain frost. If the temperature falls below 2 degrees C 35 degrees F, protect completed bitumen-stabilized areas against any detrimental effects of freezing.

1.6 ACCEPTANCE

1.6.1 Tolerances

Acceptance of the drainage layer is based on compliance with the tolerances presented in Table 1. Remove and replace any course represented by the failing tests or submit plan for approval.

TABLE 1	
Measurement	Tolerance
Grade	Plus/Minus 13 mm 1/2 inch
Smoothness	Plus/Minus 10 mm 3/8 inch
Layer Thickness	Plus/Minus 13 mm 1/2 inch
Average Job Thickness	Plus/Minus 6 mm 1/4 inch
Compaction	Based on Test Section Evaluation

1.6.2 Test Section

1.6.2.1 Data

Construct a test section to evaluate the constructability of the drainage layer including required mixing, placement, and compaction procedures as well as the ability to carry traffic. Test section data will be used to validate the required number of compaction passes given in paragraph Compaction Requirements and the field compaction requirements for full scale production.

1.6.2.2 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 testing.

1.6.2.3 Location and Size

Construct a test section [near the job site, but not as part of the production pavement area.][as part of the production paving area at an outer edge as indicated on the drawings.] Provide an underlying grade or pavement structure upon which the test section is to be constructed the same as the remainder of the course. Do not construct the drainage layer in the test section until the underlying courses and subgrade preparation, required for the pavement section, have been completed, inspected and approved. Place the test section a minimum of [30] [_____] m [100] [_____] feet long and two full paving lanes wide side by side, with a longitudinal cold joint between the lanes.

1.6.2.4 Initial Testing

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

1.6.2.5 Mixing, Placement, and Compaction

Accomplish mixing, placement, and compaction using equipment meeting the requirements of paragraph EQUIPMENT. Operate compaction equipment at speeds no greater than 2.4 km/hour 1.5 mph.

1.6.2.6 Procedure

1.6.2.6.1 General

Use the same equipment, materials, and construction techniques on the test section as proposed for use in all subsequent work. Compact the [RDM] [stabilized material] with the number of passes specified below. A pass is defined as the movement of a roller over the drainage layer area for one direction only. Divide the test section into three equal areas for the required compaction and gradation sampling. Conduct compaction tests in each area of the test section in accordance with ASTM D6938, Procedure B (Backscatter Method) until the maximum variation in compaction is less than 32 kg per cubic meter 2 pounds per cubic foot. Once a rolling pattern has been determined based on the variation in compaction, take a minimum of two gradations in each area of the test section. Evaluate the gradation results in accordance with paragraph: Evaluation. In addition, perform a minimum of two nuclear tests per area and determine the average of the six tests for establishing the compaction range for production. If compaction is not within the required maximum variation in compaction limits after the specified number of passes, perform additional passes and gradation testing, as directed

1.6.2.6.2 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 compaction achievable during field production. Compact the RDM using a minimum of 4 passes in the vibrating mode and one final pass in the static mode.

1.6.2.6.3 Bituminous/Cement Stabilized Drainage Layer

Use placement procedures and equipment as described herein. Compact the stabilized material for a minimum of 3 passes in the vibratory mode and one final pass in the static mode. Take one sample before compaction and after each subsequent compaction pass in each of the three areas of the test section as directed. Perform visual examination of each sample to determine if and when crushing of aggregate occurs. Demonstrate removal procedure and equipment for approval.

1.6.2.7 Evaluation

Within 10 days of completion of the test section, submit a Test Section Construction Report complete with all required test data and correlations. Evaluate the data as follows:

a. Plot the compaction and percent passing the 4.75 mm No. 4 and 1.18 mm No.16 sieve sizes against cumulative passes. If the percent passing the given sieve sizes is increasing, the aggregate is being broken down by the compaction effort. Maximize compaction while minimizing aggregate degradation. Establish the required compaction at plus or minus 64 kg per cubic meter 4 pounds per cubic foot from the average compaction value determined during the test section.

b. Base the required number of passes on test section observations of degradation in lieu of sieve analyses. Establish the required compaction at plus or minus 64 kg per cubic meter 4 pounds per cubic foot from the average compaction value determined during the test section.

c. Evaluate the ability to carry construction traffic for the proposed paving width using the fleet of vehicles proposed for use on the work by applying 10 passes of the highest ground pressure vehicle in the construction traffic mix. If rutting or displacement of the drainage layer occurs, adjust the equipment for drainage layer construction.

PART 2 PRODUCTS

2.1 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 must 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.

2.1.1 Aggregate Quality

Provide aggregate with a maximum soundness loss of 18 percent weighted averaged at 5 cycles when tested in magnesium sulfate or 12 percent weighted average at five cycles when tested in sodium sulfate in accordance with ASTM C88 and a maximum percentage of loss on abrasion of 40 after 500 revolutions as determined by ASTM C131/C131M. Determine the percentage of flat and/or elongated particles by ASTM D4791 Method A with the following modifications: 1) Separate the aggregates into two 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) Limit thepercentage of flat and/or elongated particles in either fraction to a maximum of 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 is required to meet the specified requirements. Manufacture crushed gravel from gravel particles 90 percent of which by weight are retained on the maximum-size sieve listed in TABLE 2. In the portion retained on each sieve specified, provide crushed gravel containing 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 is required to be at least 30 degrees in order to count as two fractured faces. Test for fractured faces in accordance with ASTM D5821.

2.1.2 Gradation Requirements

****

NOTE: Specify the gradation or gradations applicable to the specific job. Select rapid draining material (RDM) and/or open graded material (OGM) depending on the required permeability and material availability. The permeability range of RDM is 300 to 1500 meters (1000 to 5000 feet) per day. OGM provides a permeability greater than 1500 meters (5000 feet) per day.

RDM is typically well graded enough to be stable to work on, but could require stabilization if lane

width construction is not used. OGM requires asphalt cement or portland cement for stability.

For roads, where the drainage path is short and a permeability of 300 meters (1000 feet) per day is adequate, the following Optional Table 2 can be specified. Retain Note 4 below if Optional Table 2 is included.

OPTIONAL TABLE 2	
GRADATION OF DRAINAGE LAYER MATERIAL	
Percentage By Weight Passing Square-Mesh Sieve	
Sieve Designation	Rapid Draining Material (RDM)
50 mm 2 inch	100
37.50 mm 1-1/2 inch	95-100
25.00 mm 1 inch	70-100
19.00 mm 3/4 inch	60-100
12.50 mm 1/2 inch	50-76
9.50 mm 3/8 inch	40-65
4.75 No. 4	20-45
2.36 mm No. 8	17-30
1.18 mm No. 16	5-16
0.30 mm No. 50	0-5
0.15 mm No. 100	0-2.5

****

Provide drainage layer aggregates that are well graded within the limits specified in TABLE 2.

TABLE 2		
GRADATION OF DRAINAGE LAYER MATERIAL		
Percentage by Weight Passing Square-mesh Sieve		
Sieve Designation	Rapid Draining Material (RDM)	Stabilized OGM
37.50 mm 1-1/2 inch	100	100
25.00 mm 1 inch	70-100	95-100

TABLE 2		
19.00 mm 3/4 inch	55-100	---
12.50 mm 1/2 inch	40-80	25-80
9.50 mm 3/8 inch	30-65	---
4.75 mm No. 4	23-50	0-10
2.36 mm No. 8	0-25	0-5
1.18 mm No. 16	0-5	---

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

****
NOTE: Depending on the tailoring options retained, renumber the following notes.
****

NOTE 2: For RDM, maintain the coefficient of uniformity (CU) greater than 3.5 (CU = D60/D10). Adjust the RDM gradation within the ranges listed in Table 2 to provide a stable construction surface for the proposed equipment and method of transporting materials. Stabilize the RDM drainage layer with Portland cement or asphalt at no additional cost, if approved during the test section.

NOTE 3: Stabilize the OGM with asphalt cement or portland cement.

****
NOTE: Retain Note 4 if Optional Table 2 is included.
****

[NOTE 4: The Optional Table 2 gradation can be met in some areas with 77% #57 stone and 23% concrete sand blend.]

2.1.3 Bond Breaker

****
NOTE: At the Contractor's discretion but at no additional cost to the Government, an aggregate or geotextile bond breaker can be considered if a cement-stabilized drainage layer is to be overlaid with Portland cement concrete.
****

For cement-stabilized drainage layers an aggregate bond breaker or a nonwoven geotextile bond breaker can be used at no cost to the Government. Use of membrane forming curing compounds as a bond breaker is not allowed.

2.1.3.1 Aggregate Bond Breaker

Provide an aggregate bond breaker meeting the aggregate quality requirements of paragraph AGGREGATE QUALITY and the gradation of TABLE 3.

TABLE 3	
GRADATION OF AGGREGATE BOND BREAKER	
Percentage By Weight Passing Square-Mesh Sieve	
Sieve Designation	Aggregate
12.5 mm 1/2 inch	100
9.5 mm 3/8 inch	80-100
4.75 mm No. 4	23-100
2.4 mm No. 8	5-40
1.2 mm No. 16	0-10

2.1.3.2 Geotextile Bond Breaker

Provide a nonwoven geotextile certified by the manufacturer as meeting AASHTO M 288, Class 1 with a mass per unit area of 500 grams per square meter 15 ounces per square yard. A minimum of [7] [_____] days prior to scheduled use, submit manufacturer's certificate of compliance attested to by a person having legal authority to bind the geotextile manufacturer stating that the geotextile meets the requirements of this section.

2.2 BITUMINOUS MATERIALS

****
NOTE: Specify Performance Grade (PG) asphalt wherever available. Consider local experience of State Department of Transportation and availability of desired asphalt grade. Use the same grade PG binder used by the state highway department for roads and streets. For airfield projects, only specify the state PG grade. No other state DOT provisions are applicable.
****

Provide asphalt cement conforming to [ASTM D6373 Performance Grade PG [____]][ASTM D946/D946M Penetration Grade [____]] [ASTM D3381/D3381M Viscosity Grade [_____]] and showing a negative spot when subjected to the spot test in accordance with AASHTO T 102, using the standard naphtha specified.

2.3 CEMENTITIOUS MATERIALS

Provide Portland cement conforming to [ASTM C150/C150M, Type I or II] [ASTM C595/C595M, Type IP, IS or IL].

2.4 BITUMINOUS OR CEMENT STABILIZED JOB-MIX FORMULA

Provide bituminous stabilized mix consisting of a mixture of OGM and a minimum of 2 percent asphalt cement by weight. Maintain tolerances for bituminous stabilized material 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. Provide cement stabilized mix consisting 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, adjust the asphalt cement or portland cement quantities, temperatures, equipment, and procedures to produce an acceptable stabilized drainage layer. Submit a job-mix formula (JMF) for approval prior to construction of the test section and include:

a. Aggregate gradations and plots.

b. Aggregate quality test results.

c. Mill certificates for cementious materials.

d. Refinery certificates for bituminous materials.

e. Recommended proportions for proposed mixture.

f. Narrative discussing methodology on how the mix design was developed.

2.5 EQUIPMENT, TOOLS, AND MACHINES

2.5.1 Equipment

****

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

****

All plants, equipment, and tools used in the performance of the work are subject to approval before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times.

2.5.2 Placement Equipment

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

2.5.3 Compaction Equipment

Use a dual smooth 10 metric tonne short ton (min.) vibratory drum roller, which provides a maximum compactive effort without crushing the drainage layer aggregate, to compact drainage layer material.

2.5.4 Bituminous Mixing Plant

Provide mixing plants in accordance with AASHTO M 156 which are automatic or semiautomatic controlled, commercially manufactured units designed, coordinated, and operated to consistently produce a mixture within the job-mix formula (JMF). Prequalify drum or batch mixers at the production rate to be used during actual mix production.

2.5.5 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. Dry mix aggregate and cement sufficiently to prevent cement balls from forming when water is added.

2.5.6 Material Transfer Vehicle

For cement stabilized material placed with other than an asphalt paver, provide a Material Transfer Vehicle (MTV) to transfer the stabilized material from the hauling equipment to the paver. Provide a MTV capable of moving between the hauling equipment and the paver and equipped with a swing conveyor that delivers material to the paver from outside the paving lane and without making contact with the paver while allowing the paver to operate at a constant speed.

PART 3 EXECUTION

3.1 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials in the manner and at the locations designated. Stockpile aggregates on the cleared and leveled areas to prevent segregation. Stockpile materials obtained from different sources separately.

3.2 PREPARATION OF UNDERLYING COURSE

Clean the underlying course of all foreign materials prior to constructing the drainage layer. Do not construct the drainage layer on underlying course that is frozen. Construct the underlying course in accordance with Section 32 11 20 [BASE COURSE FOR RIGID][AND][SUBBASE] [SELECT-MATERIAL] [FOR FLEXIBLE PAVING]. 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. Do not allow traffic or other operations to disturb the finished underlying course and maintain in a satisfactory condition until the drainage layer is placed.

3.3 TRANSPORTING MATERIAL

3.3.1 Aggregate Drainage Layer Material

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

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

3.3.3 Cement Stabilized Material

Transport cement stabilized material from the mixing plant to the site in trucks equipped with protective covers. Reject loads that have crusts of unworkable material or have become excessively wet. Do not permit hauling over freshly placed material.

3.4 PLACING

3.4.1 General

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. Limit compacted lift thickness to a maximum of 150 mm 6 inches and a minimum of 75 mm 3 inches in compacted thickness. Place and compact lifts 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. Make adjustments in placing procedures or equipment as needed to obtain true grades and minimize segregation and degradation of the drainage layer material.

3.4.2 Placement of Stabilized Material

Reject bituminous stabilized material having temperatures less than 80 degrees C 175 degrees F when dumped into the asphalt paving machine. Adjust the paving machine so that the surface of the lift being laid is 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 an approved method. Do not permit distortion of the lift during tamping. If more than one lift is required, offset the longitudinal joint in one lift over that in the lift immediately below by at least 300 mm 1 foot; however, construct the joint in the top layer 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. Offset transverse joints in adjacent strips by 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. Use cutting and removal equipment and procedures approved during the test section. Remove material along construction joints not properly compacted.

3.4.3 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. When placing adjacent strips, operate the paving machine so that the screed overlaps the previously placed strip 75 to 100 mm 3 to 4 inches and is sufficiently high so that compaction produces a smooth, dense joint. Push back the stabilized material placed on the edge of the previously placed strip by the paver to the edge of the strip being placed. Remove and waste excess stabilized material.

3.4.4 Hand Spreading

Hand spread drainage layer material in areas where machine spreading is impractical. Spread the material uniformly in a loose layer to prevent segregation. Construct the layer so that the compacted material conforms to the required grade and thickness after compaction.

3.5 COMPACTION REQUIREMENTS

3.5.1 General

Base field compaction requirements on the results of the test section, using the materials, methods, and equipment demonstrated in the test section

3.5.2 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. Follow the rolling pattern established during the test section. Compact each lift of drainage material with the number of passes determined from successful completion of the test section in accordance with paragraph ACCEPTANCE.

3.5.3 Compaction

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. Avoid crushing of aggregate particles by excessive rolling. Begin compaction of bituminous stabilized material immediately when the material has cooled to 77 degrees C 170 degrees F. Not more than 30 minutes may elapse between the start of moist mixing of cement stabilized material and the start of field compaction. Complete field compaction within 60 minutes. In all places not accessible to the rollers, compact the drainage layer material with mechanical hand operated tampers.

3.6 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.

3.7 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 consists 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. Apply curing water 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 consists of all surfaces being thoroughly wetted and then completely covered with the sheeting. Place sheeting 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. Fold down coverings over exposed edges of slabs and secure by approved means. Immediately repair or replace sheets if tears or holes appear during the curing period

3.8 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. Roll and compact at least a 1 m 3 feet width of the shoulder simultaneously with the rolling and compacting of each lift of the drainage layer.

3.9 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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Construct the top lift so that the surface show no deviations in excess of 10 mm 3/8 inch when tested with either a 3.05 or 3.66 m 10 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.

3.10 THICKNESS CONTROL

Compact the drainage layer to a thickness that is 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, correct such areas 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 will be the average of all job measurements as specified above but within 8 mm 1/4 inch of the thickness shown on the drawings.

3.11 DEFICIENCIES

3.11.1 Grade and Thickness

Correct deficiencies in grade and thickness so that both grade and thickness tolerances are met. Do not add thin layers of material to the top surface of the drainage layer to meet grade or increase thickness. Trim the top of the drainage layer to grade and finish in accordance with paragraph FINISHING if the surface elevation is more than 13 mm 1/2 inch above the plan grade. If the elevation of the top surface of the drainage layer is 13 mm 1/2 inch or more below the required grade, scarify the

surface of the drainage layer to a depth of at least 75 mm 3 inches, add new material , and blend and recompact the layer to bring it to grade. Where the measured thickness of the drainage layer is more than 13 mm 1/2 inch deficient, correct such areas by excavating to the required depth and replace with new material to obtain a compacted lift thickness of at least 75 mm 3 inches. Control the depth of required excavation to keep the final surface elevation within grade requirements and to preserve layer thicknesses of materials below the drainage layer.

3.11.2 Density

Density will be considered deficient if the field dry density test results are below the dry density specified by the Contracting Officer. Roll the layer with 2 additional passes of the specified roller if the densities are deficient. 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.

3.11.3 Smoothness

Correct deficiencies in smoothness as if they are deficiencies in grade or thickness. Maintain all tolerances for grade and thickness while correcting smoothness deficiencies.

-- End of Section --