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USACE / NAVFAC / AFCEC / NASA **UFGS-32 12 16 (August 2009)**

Preparing Activity: USACE **Superseding UFGS-32 12 16 (August 2008)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2020
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 32 12 16

HOT-MIX ASPHALT (HMA) FOR ROADS
08/09

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NOTE: This guide specification covers the requirements for hot-mix asphalt (HMA) courses (central-plant hot-mix) for roads.

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).
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PART 1 GENERAL

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NOTE: Modifications must be made to this guide specification during conversion to a project specification in accordance with the NOTES which are located throughout the document. These NOTES are instructions to the designer, and will not appear in the project specification.

This guide specification only pertains to the hot-mix asphalt aspects of the project and not to any surface preparation requirements dealing with aggregate base courses, milling, or tack and prime coats. Surface preparation requirements should be covered by either including them in this guide specification or by adding pertinent sections to the project documents.

This specification utilizes a Quality Assurance and Quality Control (QA/QC) construction management philosophy. Quality Assurance refers to the actions performed by the Government or designated representative to assure the final product meets the job requirements. This specification has been developed for QC testing to be used as a basis of pay. The Government's QA testing should include as a minimum 10 percent of the QC tests. The specification can be edited to utilize QA testing results (similar to Section 32 12 15.13 HOT-MIX ASPHALT AIRFIELD PAVING) in determining the basis for pay. Quality Control refers to the actions of the Contractor to monitor the Contractor's construction and production processes and to correct these processes when out of control. Results of QC testing are reported daily on the process control charts maintained by the Contractor. Quality Control is covered in paragraph CONTRACTOR QUALITY CONTROL. Quality Control also includes the testing for pay and is covered in paragraphs MATERIAL ACCEPTANCE and PERCENT PAYMENT.

For projects less than 500 metric tons, State DOT material's requirements may be specified. Only material requirements may be substituted as an option. The designer should select which DOT mix design is appropriate for the project. Construction procedures and acceptability of work requirements must stay the same. The lot size should be the entire paving portion of the project. Designer has the option to eliminate submittal requirement for material samples for this size project.

For projects requiring 500 metric tons to 1000 metric tons this guide may be used "as is". The lot size should contain the entire paving limits.

For projects over 1000 metric tons use this guide as is. Lot size should be specified appropriately.

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1.1 UNIT PRICES

1.1.1 Method of Measurement

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NOTE: This paragraph will be deleted if the project's paving portion of the work is in one lump sum contract price. lump sum contracts should not be used when the job exceeds 1000 metric tons.

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The amount paid for will be the number of metric short tons of hot-mix asphalt mixture used in the accepted work. Weigh hot-mix asphalt mixture after mixing, and no separate payment will be made for weight of asphalt cement material incorporated herein.

1.1.2 Basis of Payment

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NOTE: Delete the first paragraph if the asphalt paving will be bid as part of a lump sum procurement. For lump sum payment, include prescriptive unit price based on the Government estimate. Delete the second paragraph if the asphalt paving will be bid as unit price item. lump sum contracts should not be used when the job exceeds 1000 metric tons.

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[Quantities of hot-mix asphalt mixtures, determined as specified above, will be paid for at respective contract unit prices or at reduced prices adjusted in accordance with paragraphs MATERIAL ACCEPTANCE and PERCENT PAYMENT. Payment will constitute full compensation for furnishing all materials, equipment, plant, and tools; and for all labor and other incidentals necessary to complete work required by this section of the specification.]

[The measured quantity of hot-mix asphalt will be paid for and included in the lump sum contract price. Payment will constitute full compensation for furnishing all materials, equipment, plant, and tools; and for all labor and other incidentals necessary to complete work required by this section of the specification. If less than 100 percent payment is due based on the pay factors stipulated in paragraphs MATERIAL ACCEPTANCE and PERCENT PAYMENT, use a unit price of [_____] per metric short ton for purposes of calculating the payment reduction.]

1.1.3 Percent Payment

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NOTE: On critical projects, it is recommended that testing for pay be changed to a QA responsibility and an independent material testing company be hired by the Government to provide the testing for pay. The basis of pay testing program includes material tests to determine laboratory air voids and in-place density, which are needed to determine percent payment.

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Submit pay calculations. When a lot of material fails to meet the specification requirements for 100 percent pay, as outlined in the following paragraphs, that lot shall be removed and replaced, or accepted at a reduced price which will be computed by multiplying the unit price by the lot's pay factor. The lot pay factor is determined by taking the lowest computed pay factor based on either laboratory air voids, in-place density, grade or smoothness (each discussed below). At the end of the project, an average of all lot pay factors will be calculated. If this average lot pay factor equals or exceeds 95.0 percent, and no individual lot has a pay factor less than 75.1 percent, then the percent payment for the entire project will be 100 percent of the unit bid price. If the average lot pay factor is less than 95.0 percent, then each lot will be paid for at the unit price multiplied by the lot's pay factor. For any lots which are less than 2000 metric 2000 short tons, a weighted lot pay factor will be used to calculate the average lot pay factor.

1.1.4 Laboratory Air Voids and Theoretical Maximum Density

Laboratory air voids will be calculated by determining the Marshall or Superpave density of each lab compacted specimen using the laboratory-prepared, thoroughly dry method of ASTM D2726/D2726M and determining the theoretical maximum density of every other sublot sample using ASTM D2041/D2041M. Laboratory air void calculations for each sublot will use the latest theoretical maximum density values obtained, either for that sublot or the previous sublot. The mean absolute deviation of the four laboratory air void contents (one from each sublot) from the JMF air void content will be evaluated and a pay factor determined from Table 1. All laboratory air void tests will be completed and reported within 24 hours after completion of construction of each lot.

1.1.5 Mean Absolute Deviation

An example of the computation of mean absolute deviation for laboratory air voids is as follows: Assume that the laboratory air voids are determined from 4 random samples of a lot (where 3 specimens were compacted from each sample). The average laboratory air voids for each sublot sample are determined to be 3.5, 3.0, 4.0, and 3.7. Assume that the target air voids from the JMF is 4.0. The mean absolute deviation is then:

Mean Absolute Deviation = (|3.5 - 4.0| + |3.0 - 4.0| + |4.0 - 4.0| + |3.7 - 4.0|/4

= (0.5 + 1.0 + 0.0 + 0.3)/4 = (1.8)/4 = 0.45

The mean absolute deviation for laboratory air voids is determined to be 0.45. It can be seen from Table 1 that the lot's pay factor based on laboratory air voids, is 100 percent.

Table 1. Pay Factor Based on Laboratory Air Voids

Mean Absolute Deviation of Lab Air Voids from JMF	Pay Factor, percent
0.60 or less	100
0.61 - 0.80	98
0.81 - 1.00	95
1.01 - 1.20	90
Above 1.20	reject (0)

1.1.6 In-place Density

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NOTE: Designer should edit paragraph below if asphalt layers are required to be 25 mm 1 inch or less.

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For determining in-place density, one random core (100 mm 4 inches or 150

mm 6 inches in diameter) will be taken by the Government from the mat (interior of the lane) of each sublot, and one random core will be taken from the joint (immediately over joint) of each sublot. Each random core will be full thickness of the layer being placed. When the random core is less than 25 mm 1 inch thick, it will not be included in the analysis. In this case, another random core will be taken. After air drying to a constant weight, cores obtained from the mat and from the joints will be used for in-place density determination.

1.1.7 Mat and Joint Densities

The average in-place mat and joint densities are expressed as a percentage of the average TMD for the lot. The TMD for each lot will be determined as the average TMD of the two random samples per lot. The average in-place mat density and joint density for a lot are determined and compared with Table 2 to calculate a single pay factor per lot based on in-place density, as described below. First, a pay factor for both mat density and joint density are determined from Table 2. The area associated with the joint is then determined and will be considered to be 1.5 m 5 feet wide times the length of completed longitudinal construction joint in the lot. This area will not exceed the total lot size. The length of joint to be considered will be that length where a new lane has been placed against an adjacent lane of hot-mix asphalt pavement, either an adjacent freshly paved lane or one paved at any time previously. The area associated with the joint is expressed as a percentage of the total lot area. A weighted pay factor for the joint is determined based on this percentage (see example below). The pay factor for mat density and the weighted pay factor for joint density is compared and the lowest selected. This selected pay factor is the pay factor based on density for the lot. When the TMD on both sides of a longitudinal joint is different, the average of these two TMD will be used as the TMD needed to calculate the percent joint density. All density results for a lot will be completed and reported within 24 hours after the construction of that lot.

Table 2. Pay Factor Based on In-place Density

Average Mat Density (4 Cores) (Percent of TMD)	Pay Factor, Percent	Average Joint Density (4 Cores) (Percent of TMD)
94.0 - 96.0	100.0	92.5 or above
93.9	100.0	92.4
93.8 or 96.1	99.9	92.3
93.7	99.8	92.2
93.6 or 96.2	99.6	92.1
93.5	99.4	92.0
93.4 or 96.3	99.1	91.9
93.3	98.7	91.8

Table 2. Pay Factor Based on In-place Density		
Average Mat Density (4 Cores) (Percent of TMD)	Pay Factor, Percent	Average Joint Density (4 Cores) (Percent of TMD)
93.2 or 96.4	98.3	91.7
93.1	97.8	91.6
93.0 or 96.5	97.3	91.5
92.9	96.3	91.4
92.8 or 96.6	94.1	91.3
92.7	92.2	91.2
92.6 or 96.7	90.3	91.1
92.5	87.9	91.0
92.4 or 96.8	85.7	90.9
92.3	83.3	90.8
92.2 or 96.9	80.6	90.7
92.1	78.0	90.6
92.0 or 97.0	75.0	90.5
below 92.0 or above 97.0	0.0 (reject)	below 90.5

1.1.8 Pay Factor Based on In-place Density

An example of the computation of a pay factor (in I-P units only) based on in-place density, is as follows: Assume the following test results for field density made on the lot: (1) Average mat density = 93.2 percent of TMD. (2) Average joint density = 91.5 percent of TMD. (3) Total area of lot = 30,000 square feet. (4) Length of completed longitudinal construction joint = 2000 feet.

1.1.8.1 Step 1

Determine pay factor based on mat density and on joint density, using Table 2:

Mat Density	93.2 percent	equals	98.3 pay factor
Joint Density	91.5 percent	equals	97.3 pay factor

1.1.8.2 Step 2

Determine ratio of joint area (length of longitudinal joint x 5 ft) to mat area (total paved area in the lot): Multiply the length of completed longitudinal construction joint by the specified 5 ft. width and divide by the mat area (total paved area in the lot).

(2000 ft. x 5 ft.)/30,000 sq.ft. = 0.3333 ratio of joint area to mat area (ratio).

1.1.8.3 Step 3

Weighted pay factor (wpf) for joint is determined as indicated below:

wpf = joint pay factor + (100 - joint pay factor) (1 - ratio)
wpf = 97.3 + (100-97.3) (1-.3333) = 99.1 percent

1.1.8.4 Step 4

Compare weighted pay factor for joint density to pay factor for mat density and select the smaller:

a. Pay factor for mat density: 98.3 percent. Weighted pay factor for joint density: 99.1 percent

b. Select the smaller of the two values as pay factor based on density: 98.3 percent

1.1.9 Pay Factor for Grade

When more than 5 percent of all measurements made within a lot are outside the 15 mm 0.05 foot tolerance, the pay factor based on grade for that lot will be 95 percent. In areas where the grade exceeds the tolerance by more than 50 percent, remove the surface lift full depth and replace the lift with hot-mix asphalt to meet specification requirements, at no additional cost to the Government.

1.1.10 Payment Adjustment for Smoothness

1.1.10.1 Straightedge Testing

Record location and deviation from straightedge for all measurements. When between 5.0 and 10.0 percent of all measurements made within a lot exceed the tolerance specified in paragraph Smoothness Requirements above, after any reduction of high spots or removal and replacement, the computed pay factor for that lot based on surface smoothness, will be 95 percent. When more than 10.0 percent of all measurements exceed the tolerance, the computed pay factor will be 90 percent. When between 15.0 and 20.0 percent of all measurements exceed the tolerance, the computed pay factor will be 75 percent. When 20.0 percent or more of the measurements exceed the tolerance, the lot shall be removed and replaced at no additional cost to the Government. Regardless of the above, any small individual area with surface deviation which exceeds the tolerance given above by more than 50 percent, shall be corrected by diamond grinding to meet the specification requirements above or shall be removed and replaced at no additional cost to the Government.

1.1.10.2 Profilograph Testing

Record location and data from all profilograph measurements. When the Profile Index of a 0.1 km 0.1 mile segment of a lot exceeds the tolerance specified in paragraph Smoothness Requirements above by 16 mm/km 1.0 inch/mile, but less than 32 mm/km 2.0 inches/mile, after any reduction of high spots or removal and replacement, the computed pay factor for that lot based on surface smoothness will be 95 percent. When the Profile Index exceeds the tolerance by 32 mm/km 2.0 inches/mile, but less than 47 mm/km 3.0 inches/mile, the computed pay factor will be 90 percent. When the Profile Index exceeds the tolerance by 47 mm/km 3.0 inches/mile, but less than 63 mm/km 4.0 inches/mile, the computed pay factor will be 75 percent. When the Profile Index exceeds the tolerance by 63 mm/km 4.0 inches/mile or more, the lot shall be removed and replaced at no additional cost to the Government. Regardless of the above, any small individual area with surface deviation which exceeds the tolerance given above by more than 79 mm/km 5.0 inches/mile or more, shall be corrected by grinding to meet the specification requirements above or shall be removed and replaced at no additional cost to the Government.

1.1.10.3 Bumps ("Must Grind" Areas)

Any bumps ("must grind" areas) shown on the profilograph trace which exceed 7.5 mm 0.3 inch in height shall be reduced by diamond grinding until they do not exceed 7.5 mm 0.3 inch when retested. Such grinding shall be tapered in all directions to provide smooth transitions to areas not requiring grinding. The following will not be permitted: (1) skin patching for correcting low areas, (2) planing or milling for correcting high areas. At the Contractor's option, pavement areas, including ground areas, may be rechecked with the profilograph in order to record a lower Profile Index.

1.2 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 you add 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 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 320	(2017) Standard Specification for Performance-Graded Asphalt Binder
AASHTO T 304	(2011; R 2015) Standard Method of Test for Uncompacted Void Content of Fine Aggregate

ASPHALT INSTITUTE (AI)

AI MS-2	(2015) Asphalt Mix Design Methods
AI MS-22	(2001; 2nd Ed) Construction of Hot-Mix Asphalt Pavements
AI SP-2	(2001; 3rd Ed) Superpave Mix Design

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 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 C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying

ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D242/D242M	(2009; R 2014) Mineral Filler for Bituminous Paving Mixtures
ASTM D946/D946M	(2020) Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
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 D2419	(2014) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2489/D2489M	(2016) Standard Test Method for Estimating Degree of Particle Coating of Asphalt Mixtures
ASTM D2726/D2726M	(2019) Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D2950/D2950M	(2014) Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D3381/D3381M	(2018) Standard Specification for Viscosity-Graded Asphalt Binder for Use in Pavement Construction
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D3666	(2016) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
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 D4867/D4867M	(2009; R 2014) Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D5444	(2015) Mechanical Size Analysis of

	Extracted Aggregate
ASTM D6307	(2019) Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method
ASTM D6925	(2014) Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
ASTM D6926	(2020) Standard Practice for Preparation of Asphalt Mixture Specimens Using Marshall Apparatus
ASTM D6927	(2015) Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

CTM 526	(2012) Method of Test for Operation of California Profilograph and Evaluation of Profiles

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 171	(1995) Standard Test Method for Determining Percentage of Crushed Particles in Aggregate

1.3 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.

The "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING. Locate the "S" submittal under the SD number that best describes the submittal item.

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.] Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Mix Design; G[, [_____]]

Quality Control; G[, [_____]]

Material Acceptance; G[, [_____]]

Percent Payment; G[, [_____]]

SD-04 Samples

Asphalt Cement Binder

Aggregates

SD-06 Test Reports

Aggregates; G[, [_____]]

QC Monitoring

SD-07 Certificates

Asphalt Cement Binder; G[, [_____]]

Testing Laboratory

1.4 ENVIRONMENTAL REQUIREMENTS

Do not place the hot-mix asphalt upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 3. The temperature requirements may be waived by the Contracting Officer, if requested; however, meet all other requirements, including compaction.

Table 3. Surface Temperature Limitations of Underlying Course	
Mat Thickness, mm inches	Degrees C F
75 3 or greater	4 40
Less than 75 3	7 45

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. HMA designed and constructed in accordance with this section shall conform to the lines, grades, thicknesses, and typical cross sections indicated. Construct each course to the depth, section, or elevation required by the drawings and roll, finish, and approve it before the placement of the next course.

2.1.1 Asphalt Mixing Plant

Plants used for the preparation of hot-mix asphalt shall conform to the requirements of AASHTO M 156 with the following changes:

2.1.1.1 Truck Scales

Weigh the asphalt mixture on approved, certified scales at the Contractor's expense. Inspect and seal scales at least annually by an approved calibration laboratory.

2.1.1.2 Testing Facilities

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

2.1.1.3 Inspection of Plant

Provide the Contracting Officer with access at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government to procure any desired samples.

2.1.1.4 Storage bins

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

a. The asphalt mixture may be stored in non-insulated storage bins for a period of time not exceeding 3 hours.

b. The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 8 hours. The mix drawn from bins shall meet the same requirements as mix loaded directly into trucks.

2.1.2 Hauling Equipment

Provide trucks for hauling hot-mix asphalt having tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum based products shall not be used as a release agent. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers (tarps) shall be securely fastened.

2.1.3 Asphalt Pavers

Provide asphalt pavers which are self-propelled, with an activated screed, heated as necessary, and capable of spreading and finishing courses of hot-mix asphalt which will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

2.1.3.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

2.1.3.2 Automatic Grade Controls

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NOTE: Delete information on automatic grade control if not needed. Automatic grade control is needed when the design requires elevations for the hot-mix asphalt surface.
****

Equip the paver with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. A transverse slope controller shall not be used to control grade. Provide controls capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 9.14 m 30 feet in length.

b. Taut stringline set to grade.

c. Short ski or shoe for joint matching.

d. Laser control.

2.1.4 Rollers

Rollers shall be in good condition and shall be operated at slow speeds to

avoid displacement of the asphalt mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

2.2 AGGREGATES

Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. Submit sufficient materials to produce 90 kg 200 lb of blended mixture for mix design verification. The portion of material retained on the 4.75 mm No. 4 sieve is coarse aggregate. The portion of material passing the 4.75 mm No. 4 sieve and retained on the 0.075 mm No. 200 sieve is fine aggregate. The portion passing the 0.075 mm No. 200 sieve is defined as mineral filler. Submit all aggregate test results and samples to the Contracting Officer at least 14 days prior to start of construction.

2.2.1 Coarse Aggregate

****

NOTE: The requirement for magnesium sulfate or sodium sulfate (requirement b., below) may be deleted in climates where freeze-thaw does not occur. However, in these areas where freeze-thaw does not occur, requirement b., should remain if experience has shown that this test separates good performing aggregates from bad performing aggregates.

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Provide coarse aggregate consisting of sound, tough, durable particles, free from films of material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. All individual coarse aggregate sources shall meet the following requirements:

a. The percentage of loss shall not be greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131/C131M.

b. The percentage of loss shall not be greater than 18 percent after five cycles when tested in accordance with ASTM C88 using magnesium sulfate [or 12 percent when using sodium sulfate].

c. At least 75 percent by weight of coarse aggregate shall have at least two or more fractured faces when tested in accordance with COE CRD-C 171. Fractured faces shall be produced by crushing.

d. The particle shape shall be essentially cubical and the aggregate shall not contain more than 20 percent percent, by weight, of flat and elongated particles (3:1 ratio of maximum to minimum) when tested in accordance with ASTM D4791.

e. Slag shall be air-cooled, blast furnace slag, with a compacted weight of not less than 1200 kg/cubic meter 75 lb/cu ft when tested in accordance with ASTM C29/C29M.

f. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.2.2 Fine Aggregate

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NOTE: The lower limit for uncompacted void content (requirement b., below) should be set at 45 for fine aggregate angularity unless local experiences indicate that a lower value can be used. There are some aggregates which have a good performance record and have an uncompacted void content less than 45. In no case should the limit be set less than 43.

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Fine aggregate shall consist of clean, sound, tough, durable particles free from coatings of clay, silt, or any objectionable material and containing no clay balls.

a. All individual fine aggregate sources shall have a sand equivalent value not less than 45 when tested in accordance with ASTM D2419.

b. The fine aggregate portion of the blended aggregate shall have an uncompacted void content not less than 45.0 percent when tested in accordance with AASHTO T 304 Method A.

c. The quantity of natural sand (noncrushed material) added to the aggregate blend shall not exceed 25 percent by weight of total aggregate.

d. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M

2.2.3 Mineral Filler

Mineral filler shall be nonplastic material meeting the requirements of ASTM D242/D242M.

2.2.4 Aggregate Gradation

****

NOTE: Delete from Table 4, the gradations that will not be used as a part of this project. Generally, the layer thickness should be at least 57 mm 2.25 inches for gradation 1, 37 mm 1.5 inches for gradation 2, and 28 mm 1 inch for gradation 3 shown in Table 4.

****

The combined aggregate gradation shall conform to gradations specified in Table 4, when tested in accordance with ASTM C136/C136M and ASTM C117, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grade uniformly from coarse to fine.

Table 4. Aggregate Gradations			
Sieve Size, mm inch	Gradation 1 Percent Passing by Mass	Gradation 2 Percent Passing by Mass	Gradation 3 Percent Passing by Mass
25.0 1	100	---	---
19.0 3/4	76-96	100	---
12.5 1/2	68-88	76-96	100
9.5 3/8	60-82	69-89	76-96
4.75 No. 4	45-67	53-73	58-78
2.36 No. 8	32-54	38-60	40-60
1.18 No. 16	22-44	26-48	28-48
0.60 No. 30	15-35	18-38	18-38
0.30 No. 50	9-25	11-27	11-27
0.15 No. 100	6-18	6-18	6-18
0.075No. 200	3-6	3-6	3-6

2.3 ASPHALT CEMENT BINDER

****

NOTE: Performance Grade (PG) asphalt should be specified wherever available. When selecting PG asphalt cements, it is recommended that 98 percent reliability be used. For Design Indexes (DI) of 3 and below use a 50 percent reliability. Also, consider local experience of State Department of Transportation and availability of desired asphalt grade.

****

Submit a 20 L 5 gallon sample for mix design verification. Asphalt cement binder shall conform to AASHTO M 320 Performance Grade (PG) [_____].[As an alternate, ASTM D3381/D3381M Table 4, Viscosity Grade [_____] or ASTM D946/D946M penetration grade [_____] may be used.] Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Submit copies of these certifications to the Contracting Officer. The supplier is defined as the last source of any modification to the binder. The Contracting Officer may sample and test the binder at the mix plant at any time before or during mix production. Obtain samples for this verification testing in accordance with ASTM D140/D140M and in the presence of the Contracting Officer. Furnish these samples to the Contracting Officer for the verification testing, which shall be at no cost to the Contractor. Submit samples of the asphalt cement specified for approval not less than 14 days

before start of the test section. Submit copies of certified test data, amount, type and description of any modifiers blended into the asphalt cement binder.

2.4 MIX DESIGN

****

NOTE: Use Superpave only when the work involves long stretches of highway.

For state DOT Superpave mixes, specify the design EASLs from site-specific traffic studies or the following:

Design EASLs (millions)	Typical Roadway Application
< 0.3	Very light traffic; no trucks (local/county roads, city streets)
0.3 to < 3	Medium traffic (collector roads, most county roads)
3 to 30	High traffic (most of interstate system, climbing lanes, truck weigh stations)

Specify the nominal maximum aggregate size (NMAS) in accordance with state DOT guidance.

****

a. Develop the mix design. The asphalt mix shall be composed of a mixture of well-graded aggregate, mineral filler if required, and asphalt material. The aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF). Submit proposed JMF; do not produce hot-mix asphalt for payment until a JMF has been approved. The hot-mix asphalt shall be designed in accordance with Marshall (MS-02), Superpave (SP-2), or Hveem (MS-02) procedures and the criteria shown in Table 5. Use the hand-held hammer to compact the specimens for Marshall mix design. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867/D4867M is less than 75, the aggregates shall be rejected or the asphalt mixture treated with an approved anti-stripping agent. The amount of anti-stripping agent added shall be sufficient to produce a TSR of not less than 75. Provide an antistrip agent, if required, at no additional cost. Sufficient materials to produce 90 kg 200 pound of blended mixture shall be provided to the Contracting Officer for verification of mix design at least 14 days prior to construction of test section.

b. At the option of the Contractor, a currently used DOT Superpave hot mix may be used in lieu of developing a Marshall hot mix design as described herein. Design the Superpave volumetric mix in accordance with AI SP-2 and ASTM D6925. The nominal maximum aggregate size (NMAS) shall be [37.5] [25.0] [19.0] [12.5] [9.5] mm [1-1/2] [1] [3/4] [1/2] [3/8] inch. Other DOT hot mix design methods (Hveem, etc.) may be suitable, as determined by the Contracting Officer. The number of compaction gyrations, Ndes, shall be based on a design traffic of

[_____] equivalent single axle loads (EASLs).

c. Design Superpave mixes with the number of gyrations specified in Table 5, unless the DOT option is chosen.

2.4.1 JMF Requirements

****

NOTE: In Table 5, use a 75 Blow or 75 gyration compactive effort for all asphalt mixtures designed for tire pressures of 690 kPa 100 psi or higher. For mixtures designed for tire pressures less than 690 kPa 100 psi, use a 50 Blow or 50 gyration compactive effort. Also, use a 50 Blow or 50 gyration compactive effort for shoulder pavement mixtures.

In Table 5, delete the column which does not apply, unless the project includes both 75 Blow or 75 gyration and 50 Blow or 50 gyration mixes. If both mixes are used on a project, identify which mix is applicable to which location.

Select the appropriate gradation and VMA requirements in Table 5 to be consistent with the gradation chosen in Table 4 and delete the other two lines.

Remove item t., below if RAP is not used in the job.

****

Submit in writing the job mix formula for approval at least 14 days prior to the start of the test section including as a minimum:

a. Percent passing each sieve size.

b. Percent of asphalt cement.

c. Percent of each aggregate and mineral filler to be used.

d. Asphalt viscosity grade, penetration grade, or performance grade.

e. Number of blows of hand-held hammer per side of molded specimen. (NA for Superpave)

f. Number of gyrations of Superpave gyratory compactor, (NA for Marshall mix design)

g. Laboratory mixing temperature.

h. Lab compaction temperature.

i. Temperature-viscosity relationship of the asphalt cement.

j. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

k. Graphical plots of stability (NA for Superpave), flow (NA for Superpave), air voids, voids in the mineral aggregate, and unit weight

versus asphalt content as shown in AI MS-2.

l. Specific gravity and absorption of each aggregate.

m. Percent natural sand.

n. Percent particles with 2 or more fractured faces (in coarse aggregate).

o. Fine aggregate angularity.

p. Percent flat or elongated particles (in coarse aggregate).

q. Tensile Strength Ratio(TSR).

r. Antistrip agent (if required) and amount.

s. List of all modifiers and amount.

t. Correlation of hand-held hammer with mechanical hammer (NA for Superpave).

u. Percentage and properties (asphalt content, binder properties, and aggregate properties) of reclaimed asphalt pavement (RAP) in accordance with paragraph RECYCLED HOT-MIX ASPHALT, if RAP is used.

Table 5. Mix Design Criteria

Test Property	50 Blows or Mix Gyrations	75 Blows or Mix Gyrations
Stability, N pounds, minimum (NA for Superpave)	*44501000	*80001800
Flow,0.25 mm 0.01 inch, (NA for Superpave)	8-18	8-16
Air voids, percent	3-5	3-5
Percent Voids in mineral aggregate (VMA),(minimum)		
Gradation 1	13.0	13.0
Gradation 2	14.0	14.3
Gradation 3	15.0	15.0
TSR, minimum percent	75	75
* This is a minimum requirement. The average during construction shall be significantly higher than this number to ensure compliance with the specifications.		
** Calculate VMA in accordance with AI MS-2, based on ASTM C127 and ASTM C128 bulk specific gravity for the aggregate.		

2.4.2 Adjustments to Field JMF

Keep the Laboratory JMF for each mixture in effect until a new formula is approved in writing by the Contracting Officer. Should a change in sources of any materials be made, perform a new laboratory jmf design and a new JMF approved before the new material is used. The Contractor will be allowed to adjust the Laboratory JMF within the limits specified below to optimize mix volumetric properties with the approval of the Contracting Officer. Adjustments to the Laboratory JMF shall be applied to the field (plant) established JMF and limited to those values as shown. Adjustments shall be targeted to produce or nearly produce 4 percent voids total mix (VTM).

TABLE 6. Field (Plant) Established JMF Tolerances

Sieves, mm	Adjustments (plus or minus), percent
12.5 1/2 inch	3
4.75 No. 4	3
2.36 No. 8	3
0.075No. 200	1
Binder Content	0.4

If adjustments are needed that exceed these limits, develop a new mix design. Tolerances given above may permit the aggregate grading to be outside the limits shown in Table 4; while not desirable, this is acceptable, except for the 0.075 mm No. 200 sieve, which shall remain within the aggregate grading of Table 4.

2.5 RECYCLED HOT MIX ASPHALT

****

NOTE: Reclaimed Asphalt Pavement (RAP)can be used up to 30 percent as long as the resulting recycled mix meets all requirements that are specified for virgin mixtures. The 30 percent is a general limit. If the existing asphalt pavement is relatively old, the amount of RAP used will not approach this limit. If the recycling involves relatively new RAP materials, the percentage of RAP specified below could be greater than 30 percent. Remove these paragraphs if RAP is not used. In addition to MS-02, refer to UFC 3-250-03, "Standard Practice Manual for Flexible Pavements" for further design guidance.

****

Recycled HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement to produce a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed 50 mm 2 inches. Design the recycled HMA mix using procedures contained in AI MS-2 and AI MS-22. The job mix shall meet the requirements of paragraph MIX

DESIGN. The amount of RAP shall not exceed 30 percent.

2.5.1 RAP Aggregates and Asphalt Cement

The blend of aggregates used in the recycled mix shall meet the requirements of paragraph AGGREGATES. Establish the percentage of asphalt in the RAP for the mixture design according to ASTM D2172/D2172M or ASTM D6307 using the appropriate dust correction procedure.

2.5.2 RAP Mix

****

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

****

The blend of new asphalt cement and the RAP asphalt binder shall meet [the dynamic shear rheometer at high temperature and bending beam at low temperature] [penetration] [viscosity] requirements in paragraph ASPHALT CEMENT BINDER. The virgin asphalt cement shall not be more than two standard asphalt material grades different than that specified in paragraph ASPHALT CEMENT BINDER.

PART 3 EXECUTION

****

NOTE: For Performance Graded (PG) asphalt cements, insert the plant temperature range from the Table below into the last sentence of the following paragraph.

Performance Graded Asphalt Plant Mixing Temperatures	
Binder Grade	**Mixing Temp Range (Deg C) (Deg F)**
PG 46-28	**115 - 146240 - 295**
PG 46-34	**115 - 146240 - 295**
PG 46-40	**115 - 146240 - 295**
PG 52-28	**115 - 149240 - 300**
PG 52-34	**115 - 149240 - 300**
PG 52-40	**115 - 149240 - 300**
PG 52-46	**115 - 149240 - 300**
PG 58-22	**127 - 154260 - 310**

Performance Graded Asphalt Plant Mixing Temperatures	
Binder Grade	Mixing Temp Range (Deg C) (Deg F)
PG 58-28	127 - 154260 - 310
PG 58-34	127 - 154260 - 310
PG 64-22	129 - 160265 - 320
PG 64-28	129 - 160265 - 320
PG 64-34	129 - 160265 - 320
PG 67-22	135 - 163275 - 325
PG 70-22	138 - 166280 - 330
PG 70-28	135 - 163275 - 325
PG 76-22	141 - 168285 - 335
PG 76-28	138 - 166280 - 330
PG 82-22	143 - 171290 - 340

****

3.1 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt cement material avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. The temperature of unmodified asphalts shall be no more than 160 degrees C 325 degrees F when added to the aggregates. Performance-Graded (PG) asphalts shall be within the temperature range of [_____] degreesC F when added to the aggregate.

3.2 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate for the mixture prior to mixing. No damage shall occur to the aggregates due to the maximum temperature and rate of heating used. The temperature of the aggregate and mineral filler shall not exceed 175 degrees C 350 degrees F when the asphalt cement is added. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.3 PREPARATION OF HOT-MIX ASPHALT MIXTURE

The aggregates and the asphalt cement shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. Mix the combined materials until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but no less than 25 seconds for batch plants. Establish the wet mixing time for all plants based on the procedure for determining the

percentage of coated particles described in ASTM D2489/D2489M, for each individual plant and for each type of aggregate used. The wet mixing time will be set to at least achieve 95 percent of coated particles. The moisture content of all hot-mix asphalt upon discharge from the plant shall not exceed 0.5 percent by total weight of mixture as measured by ASTM D1461.

3.4 PREPARATION OF THE UNDERLYING SURFACE

****

NOTE: If the underlying surface to be paved is an unbound granular layer, a prime coat should be applied, especially if this layer will be exposed to weather for an extended period of time prior to covering with an asphalt mixture. The prime coat may be deleted if the base course is covered with hot mix within 7 days and no significant rainfall is anticipated. If the base course is to receive traffic prior to application of the surface course, it should first be primed and cured.

If the underlying surface to be paved is an existing asphalt or concrete layer, a tack coat should always be used to ensure an adequate bond between layers.

Delete requirement for prime coat if a drainage layer is used beneath the hot mix layer.

****

Immediately before placing the hot mix asphalt, clean the underlying course of dust and debris. Apply a [prime coat] [and/or] [tack coat] in accordance with the contract specifications.

3.5 TEST SECTION

****

NOTE: Delete requirement for a test section if the project requires less than 2000 metric tons.

****

Prior to full production, place a test section for each JMF used. Construct a test section 75 - 150 m 250 - 500 feet long and two paver passes wide placed for two lanes, with a longitudinal cold joint. The test section shall be of the same thickness as the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment and personnel used in construction of the test section shall be the same equipment to be used on the remainder of the course represented by the test section. Place the test section as part of the project pavement, as approved by the Contracting Officer.

3.5.1 Sampling and Testing for Test Section

****

NOTE: Table 7 applies only to the test section. The limits in Tables 6, 7, and 8, apply to the results of 4 full scale production tests run for each lot. This is why the limits listed in Table 7

are different from those listed in Tables 6, 7, and 8.

Select the appropriate VMA requirement to match the selected gradation. Select the appropriate stability and flow value to match the laboratory compactive effort (50 or 75 blows).

****

Take one random sample at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. Test a portion of the same sample for theoretical maximum density (TMD), aggregate gradation and asphalt content. Take four randomly selected cores from the finished pavement mat, and four from the longitudinal joint, and tested for density. Random sampling shall be in accordance with procedures contained in ASTM D3665. The test results shall be within the tolerances shown in Table 7 for work to continue. If all test results meet the specified requirements, the test section shall remain as part of the project pavement. If test results exceed the tolerances shown, the test section shall be removed and replaced at no cost to the Government and another test section shall be constructed. The test section shall be paid for with the first lot of paving

Table 7. Test Section Requirements for Material and Mixture Properties

Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
4.75 mm No. 4 and larger	JMF plus or minus 8
2.36, 1.18, 0.60, and 0.30 mmNo. 8, No. 16, No. 30, and No. 50	JMF plus or minus 6
0.15 and 0.075 mmNo. 100 and No. 200	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0
VMA, Percent (Average of 3 specimens)	[13] [14] [15] minimum
Stability, newtons pounds (Average of 3 specimens) (NA for Superpave)	[4450 1000 minimum for 50 blows][8000 1800 minimum for 75 blows]
Flow, 0.25 mm 0.01 inch (Average of 3 specimens) (NA for Superpave)	[8 - 18 for 50 blows][8 - 16 for 75 blows]
Mat Density, Percent of TMD (Average of 4 Random Cores)	92.0 - 96.0

Table 7. Test Section Requirements for Material and Mixture Properties	
Property	Specification Limit
Joint Density, Percent of TMD (Average of 4 Random Cores)	90.5 - 92.5

3.5.2 Additional Test Sections

If the initial test section should prove to be unacceptable, make the necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures and place a second test section. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable section has been constructed and accepted.

3.6 TESTING LABORATORY

Submit certification of compliance and Plant Scale Calibration Certification. Use a laboratory to develop the JMF that meets the requirements of ASTM D3666. The Government will inspect the laboratory equipment and test procedures prior to the start of hot mix operations for conformance to ASTM D3666. The laboratory shall maintain the Corps certification for the duration of the project. A statement signed by the manager of the laboratory stating that it meets these requirements or clearly listing all deficiencies shall be submitted to the Contracting Officer prior to the start of construction. The statement shall contain as a minimum:

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

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

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

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

3.7 TRANSPORTING AND PLACING

3.7.1 Transporting

****

NOTE: A material transfer vehicle has been shown to provide a pavement with improved smoothness and less segregation. A material transfer vehicle is recommended when doing major road construction. The designer should look at design index, speed of vehicle utilizing road and other factors in determining the requirement for a material load transfer vehicle. Remove last sentence if material transfer vehicle is not used.

****

Transport the hot-mix asphalt from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of

mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material will not be permitted until the material has been compacted as specified, and allowed to cool to 60 degrees C 140 degrees F. To deliver mix to the paver, use a material transfer vehicle operated to produce continuous forward motion of the paver.

3.7.2 Placing

Place and compact the mix at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, place the mixture to the full width by an asphalt paver; it shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and conform to the grade and contour indicated. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips having a minimum width of 3 m 10 feet. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 300 mm 1 foot; however, the joint in the surface course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 3 m 10 feet from transverse joints in the previous course. Transverse joints in adjacent lanes shall be offset a minimum of 3 m 10 feet. On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools.

3.8 COMPACTION OF MIXTURE

After placing, the mixture shall be thoroughly and uniformly compacted by rolling. Compact the surface as soon as possible without causing displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened but excessive water will not be permitted. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers. Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective shall be removed full depth, replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching will not be allowed.

3.9 JOINTS

The formation of joints shall be performed ensuring a continuous bond between the courses and to obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.9.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing material at the joint. Remove the cutback material from the project. In both methods, all contact surfaces shall be given a light tack coat of asphalt material before placing any fresh mixture against the joint.

3.9.2 Longitudinal Joints

Longitudinal joints which are irregular, damaged, uncompacted, cold (less than 80 degrees C 175 degrees F at the time of placing adjacent lanes), or otherwise defective, shall be cut back a maximum of 75 mm 3 inches from the top of the course with a cutting wheel to expose a clean, sound vertical surface for the full depth of the course. All cutback material shall be removed from the project. All contact surfaces shall be given a light tack coat of asphalt material prior to placing any fresh mixture against the joint. The Contractor will be allowed to use an alternate method if it can be demonstrated that density, smoothness, and texture can be met.

3.10 QUALITY CONTROL

****

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

****

3.10.1 General Quality Control Requirements

Develop and submit an approved Quality Control Plan. Submit aggregate and QC test results. Do not produce hot-mix asphalt for payment until the quality control plan has been approved addressing all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design

b. Aggregate Grading

c. Quality of Materials

d. Stockpile Management

e. Proportioning

f. Mixing and Transportation

g. Mixture Volumetrics

h. Moisture Content of Mixtures

i. Placing and Finishing

j. Joints

k. Compaction

l. Surface Smoothness

3.10.2 Testing Laboratory

****

NOTE: For projects less than 1000 metric tons delete the requirements for a job site laboratory. For small projects the Contractor may use a commercially approved laboratory.

****

Provide a fully equipped asphalt laboratory located at the plant or job site and meeting the pertinent requirements in ASTM D3666. Laboratory facilities shall be kept clean and all equipment maintained in proper working condition. The Contracting Officer shall be permitted unrestricted access to inspect the Contractor's laboratory facility, to witness quality control activities, and to perform any check testing desired. The Contracting Officer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are corrected.

3.10.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. The testing program shall include, but shall not be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability (NA for Superpave), flow (NA for Superpave), in-place density, grade and smoothness. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.10.3.1 Asphalt Content

A minimum of two tests to determine asphalt content will be performed per lot (a lot is defined in paragraph MATERIAL ACCEPTANCE and PERCENT PAYMENT) 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 ASTM D6307, or the nuclear method in accordance with ASTM D4125/D4125M. Calibrate the ignition oven or the nuclear gauge 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. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture.

3.10.3.2 Gradation

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of recovered aggregate in accordance with ASTM D5444. When asphalt content is determined by the ignition oven or nuclear method,

aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix plants. For batch plants, test aggregates in accordance with ASTM C136/C136M using actual batch weights to determine the combined aggregate gradation of the mixture.

3.10.3.3 Temperatures

Check temperatures at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.10.3.4 Aggregate Moisture

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

3.10.3.5 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.

3.10.3.6 Laboratory Air Voids, Marshall Stability and Flow

Take mixture samples at least four times per lot compacted into specimens, using [50] [75] blows per side with the hand-held Marshall hammer as described in ASTM D6926. When the Superpave gyratory compactor is used, mixes will be compacted to [50] [75] gyrations in accordance with ASTM D6925. Hot-mix provided under the DOT Superpave option shall be compacted in accordance with the DOT requirements. After compaction, determine the laboratory air voids of each specimen. Stability and flow shall be determined for the Marshall-compacted specimens, in accordance with ASTM D6927.

3.10.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge may be used to monitor pavement density in accordance with ASTM D2950/D2950M.

3.10.3.8 Grade and Smoothness

****

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

****

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraphs MATERIAL ACCEPTANCE and PERCENT PAYMENT.

3.10.3.9 Additional Testing

Any additional testing, which the Contractor deems necessary to control the process, may be performed at the Contractor's option.

3.10.3.10 QC Monitoring

Submit all QC test results to the Contracting Officer on a daily basis as the tests are performed. The Contracting Officer reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.10.4 Sampling

When directed by the Contracting Officer, sample and test any material which appears inconsistent with similar material being produced, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

3.10.5 Control Charts

****
NOTE: For projects less than 2000 metric tons the control chart requirements may be deleted
****

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 8, as a minimum. These control charts shall be posted as directed by the Contracting Officer and kept current at all times. The control charts shall identify the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 8 applicable to the test parameter being plotted, and the Contractor's test results. Target values from the JMF shall also be shown on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts. The Quality Control Plan shall indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
4.75 mm No. 4 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	6	8	4	5
0.6 mm No. 30 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	4	6	3	4

Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts				
	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
0.075 mm No. 200 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	1.4	2.0	1.1	1.5
Stability, newtons pounds (minimum) (NA for Superpave)				
75 Blow JMF	80001800	75601700	84401900	80001800
50 Blow JMF	44501000	4000900	49001100	44501000
Flow, 0.25 mm 0.01 inch (NA for Superpave)				
75 Blow JMF	8 min.	7 min.	9 min.	8 min.
	16 max.	17 max.	15 max.	16 max.
50 Blow JMF	8 min.	7 min.	9 min.	8 min.
	18 max.	19 max.	17 max.	18 max.
Asphalt content, percent deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Laboratory Air Voids, percent deviation from JMF target value	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Mat Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Joint Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			

3.11 MATERIAL ACCEPTANCE

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NOTE: As written, this specification requires the Contractor to hire an independent material testing laboratory to perform the testing listed in this Section. The results are required to be forwarded daily to the Contracting Officer as the basis for acceptance.

The project engineer may choose to have additional tests conducted by the QA test agency to monitor aggregate gradation, asphalt content, Marshall stability and flow (NA for Superpave). These tests would serve as a check to the Contractor's QC

testing. Marshall stability and flow could be done at minimal cost since the specimens have to be made anyway for laboratory air void determination.

For lot size determination, use a lot size that will represent an amount of asphalt placed in one day or any half day's pavement production, depending on the extent of the project. The lot size should not be small enough to overburden the testing laboratory but large enough to get a representative sample of the work being performed.

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Testing for acceptability of work will be performed by an independent laboratory hired by the Contractor. Forward test results and payment calculations daily to the Contracting Officer. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. A standard lot for all requirements will be equal to [_____] [2000 metric 2000 short tons] [8 hours of production]. Where appropriate, adjustment in payment for individual lots of hot-mix asphalt will be made based on in-place density, laboratory air voids, grade and smoothness in accordance with the following paragraphs. Grade and surface smoothness determinations will be made on the lot as a whole. Exceptions or adjustments to this will be made in situations where the mix within one lot is placed as part of both the intermediate and surface courses, thus grade and smoothness measurements for the entire lot cannot be made. In order to evaluate laboratory air voids and in-place (field) density, each lot will be divided into four equal sublots.

3.11.1 Sublot Sampling

One random mixture sample for determining laboratory air voids, theoretical maximum density, and for any additional testing the Contracting Officer desires, will be taken from a loaded truck delivering mixture to each sublot, or other appropriate location for each sublot. All samples will be selected randomly, using commonly recognized methods of assuring randomness conforming to ASTM D3665 and employing tables of random numbers or computer programs. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with ASTM D6926. The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

3.11.2 Additional Sampling and Testing

The Contracting Officer reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Government. Testing in these areas will be in addition to the lot testing, and the requirements for these areas will be the same as those for a lot.

3.11.3 Grade

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NOTE: The grade and surface smoothness requirements specified below are for the final wearing surface only. If there is a requirement to test and control

the grade and smoothness for the intermediate courses, i.e., when the intermediate courses will be exposed to traffic, slight modifications to this specification will be required.

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The final wearing surface of pavement shall conform to the elevations and cross sections shown and shall vary not more than 15 mm 0.05 foot from the plan grade established and approved at site of work. Finished surfaces at juncture with other pavements shall coincide with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. The grade will be determined by running lines of levels at intervals of 7.6 m 25 feet, or less, longitudinally and transversely, to determine the elevation of the completed pavement surface. Within 5 working days, after the completion of a particular lot incorporating the final wearing surface, test the final wearing surface of the pavement for conformance with the specified plan grade. Diamond grinding may be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted.

3.11.4 Surface Smoothness

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NOTE: Edit these paragraphs as appropriate to the project. Specify the profilograph method for testing in the longitudinal direction for road length exceeding 0.4 km 1/4 mile. Specify the straightedge method for longitudinal testing on road lengths less than 0.4 km 1/4 mile and for all transverse smoothness testing. Use straightedge testing in both longitudinal and transverse directions for parking lots and all other roads and for roads with design speeds less than 50 km/hr 30 mph.

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Use one of the following methods to test and evaluate surface smoothness of the pavement. Perform all testing in the presence of the Contracting Officer. Keep detailed notes of the results of the testing and furnish a copy to the Government immediately after each day's testing. [Use the profilograph method for all longitudinal testing, except where the runs would be less than 60 m 200 feet in length and the ends where the straightedge will be used.] Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), the surface shall be finished to meet the approval of the Contracting Officer.

3.11.4.1 Smoothness Requirements

3.11.4.1.1 Straightedge Testing

The finished surfaces of the pavements shall have no abrupt change of 6 mm 1/4 inch or more, and all pavements shall be within the tolerances of 6 mm 1/4 inch in both the longitudinal and transverse directions, when tested with an approved 4 m 12 feet straightedge.

3.11.4.1.2 Profilograph Testing

The finished surfaces of the pavements shall have no abrupt change of 3 mm 1/8 inch or more, and each 0.1 km 0.1 mile segment of each pavement lot shall have a Profile Index not greater than 140 mm/km 9 inches/mile when tested with an approved California-type profilograph. If the extent of the pavement in either direction is less than 60 m 200 feet, that direction shall be tested by the straightedge method and shall meet requirements specified above.

3.11.4.2 Testing Method

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. Separate testing of individual sublots is not required. If any pavement areas are ground, these areas shall be retested immediately after grinding. Test each lot of the pavement in both a longitudinal and a transverse direction on parallel lines. Set the transverse lines 4.5 m 15 feet or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane for lanes less than 6.1 m 20 feet wide and at the third points for lanes 6.1 m 20 feet or wider. Also test other areas having obvious deviations. Longitudinal testing lines shall be continuous across all joints.

3.11.4.2.1 Straightedge Testing

Hold the straightedge in contact with the surface and move it 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.

3.11.4.2.2 Profilograph Testing

Perform profilograph testing using approved equipment and procedures described in CTM 526. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for each 0.1 km 0.1 mile segment of each pavement lot. Grade breaks on parking lots shall be accommodated by breaking the profile segment into shorter sections and repositioning the blanking band on each segment. The "blanking band" shall be 5 mm 0.2 inches wide and the "bump template" shall span 25 mm 1 inch with an offset of 7.5 mm 0.3 inch. Compute the Profile Index for each pass of the profilograph in each 0.1 km 0.1 mile segment. The Profile Index for each segment shall be the average of the Profile Indices for each pass in each segment. The profilograph shall be operated by a DOT approved operator. Furnish a copy of the reduced tapes to the Government at the end of each day's testing.

-- End of Section --