
USACE / NAVFAC / AFCEA / NASA UFGS-32 12 43.16 (August 2008)

Preparing Activity: USACE Superseding
UFGS-32 12 20 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2013

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SECTION 32 12 43.16

POROUS FRICTION COURSE FOR AIRFIELDS AND ROADS 08/08

NOTE: This guide specification covers the requirements for bituminous porous friction course for airfields and 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 items(s) or insert appropriate information.

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

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

PART 1 GENERAL

NOTE: The evaluation of aggregates and mix design development should be performed by an approved commercial testing laboratory at no expense to the Government. Certified copies of aggregate tests and job mixture proportions must be submitted to the Contracting Officer for approval prior to use in the work.

Drawings must indicate plan of porous friction course paving showing the thickness, after compaction, of the aggregate base course, bituminous base course, and porous friction surface course.

1.1 UNIT PRICES

NOTE: Paragraphs Measurement and Payment will be deleted if the work covered by this section is included in one lump-sum contract price. Lump-sum contracts will not be used when the job exceeds 500 metric tons (tons).

1.1.1 Measurement

Porous friction course (PFC) tonnage paid for will be the number of metric 2000 pound tons of bituminous mixture used in the accepted work. Weigh bituminous mixture after mixing; no deduction will be made for weight of bituminous materials incorporated in the mixture.

1.1.2 Payment

NOTE: For unit-price contracts, include first set of bracketed sentences and delete the second set. For lump-sum contracts, delete the first set of bracketed sentences and include the second set. Include prescriptive unit price based on the Government/Engineer estimate for payment adjustment. Lump-sum contracts should not be used when the job exceeds 1000 metric tons (tons).

[Quantities of PFC mixtures and bituminous materials determined as specified above will be paid for at respective contract unit prices or at reduced prices adjusted in accordance with paragraph ACCEPTABILITY OF WORK. Payment will constitute full compensation for preparing and/or reconditioning existing pavement; 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 specifications.] [The measured quantity of hot-mixed asphalt will be paid for and included in the lump-sum contract price. If less than 100 percent payment is due based on the pay factors stipulated in paragraph PERCENT PAYMENT, a unit price of [_____] per ton shall be used for purposes of calculating the payment reduction.]

1.1.3 Waybills and Delivery Tickets

NOTE: This paragraph will be deleted for lump-sum contract jobs.

Before the final statement is allowed, file with the Contracting Officer certified waybills and certified delivery tickets for all aggregates and bituminous materials actually used in the construction and covered by the contract.

1.2 PERCENT PAYMENT

NOTE: The lot size can be specified on the basis of working hours (i.e., 4 hours, 1 day, etc.) or amount

of production (i.e., 500 metric tons (tons), 1000 metric tons (tons), etc.). If the lot size is based on amount of production, it should be selected to be approximately equal to the amount of the PFC mix produced in one day's operation. Generally, the lot size should not exceed 1000 metric tons (tons) of PFC mix. When a lump-sum contract is used, the lot size becomes the total job; thus the penalty is assessed to the contract price. For lump sum contracts retain the last sentence.

A lot shall be that quantity of construction that will be evaluated for compliance with specification requirements for payment. A lot shall be equal to [[_____] metric tons tons] [[_____] hours production]. When a lot of material fails to meet the specifications requirements, that lot shall be removed and replaced or accepted at a reduced price. The lowest computed percent payment determined for gradation, asphalt content, and smoothness discussed below shall be the actual percent payment for the PFC mixture in that lot. The actual percent payment is applied to the bid price for PFC mixture to determine actual payment. No such adjustments in payment will be made to the bid price for bituminous material (asphalt cement). In order to evaluate aggregate gradation and asphalt content, each lot shall be divided into four equal sublots. One random sample shall be taken from loaded trucks or other selected locations for each subplot of plant-produced material. Prior to placing the material, test samples of the mixture shall be taken for aggregate gradation determination and asphalt content. Each random sample shall weigh at least 1 kg 2.2 pounds. The asphalt content of these samples shall be determined by ASTM D2172/D2172M, Method A or B, ASTM D4125/D4125M or ASTM D6307. Gradation shall be determined on the recovered aggregate according to ASTM C117 and ASTM C136.[For lump sum contracts the assumed cost per ton for the material for percent payment purposes shall be \$[_____] /ton.]

1.2.1 Aggregate Gradation

The mean absolute deviation of the four subplot aggregate gradations from the JMF for each sieve size shall be determined and compared with TABLE I. The computed percent payment based on aggregate gradation will be the lowest value determined for any sieve size shown in TABLE III. All tests for aggregate gradation shall be completed and reported within 24 hours after completion of construction of each lot.

EXAMPLE

The computation of mean absolute deviation and percent payment for aggregate gradation is illustrated below for a typical series of gradation tests. Assume the following JMF and subplot test results for aggregate gradation.

Percent by Weight Passing Sieves

Sieve Size	JMF	Test No. 1	Test No. 2	Test No. 3	Test No. 4
19.0 mm	100	100	100	100	100
12.5 mm	88	87	88	90	88
9.5 mm	60	57	62	63	59
4.74 mm	35	31	36	38	33

Percent by Weight Passing Sieves

Sieve Size	JMF	Test No. 1	Test No. 2	Test No. 3	Test No. 4
2.36 mm	15	12	18	19	14
0.60 mm	8	5	11	12	7
0.075 mm	4	2	5	6	4

Percent by Weight Passing Sieves

Sieve Size	JMF	Test No. 1	Test No. 2	Test No. 3	Test No. 4
3/4 inch	100	100	100	100	100
1/2 inch	88	87	88	90	88
3/8 inch	60	57	62	63	59
No. 4	35	31	36	38	33
No. 8	15	12	18	19	14
No. 30	8	5	11	12	7
No. 200	4	2	5	6	4

Mean Absolute Deviation for 0.075 mm No. 200 Sieve = ((Absolute value of 2-4) + (Absolute value of 5-4) + (Absolute value of 6-4) + (Absolute value of 4-4))/4 = (2+1+2+0)/4 = 1.25. The mean absolute deviation for other sieve sizes can be determined in a similar way for this example to be:

Sieve Size	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	0.60 mm
Mean Absolute Deviation	0	0.75	2.25	2.50	2.75	2.75

Sieve Size	3/4 inch	1/2 inch	3/8 inch	NO. 4	NO. 8	NO. 30
Mean Absolute Deviation	0	0.75	2.25	2.50	2.75	2.75

The least percent payment determined for any sieve size listed in TABLE III would be 98 percent for the 0.075 mm No. 200 sieve. Therefore for this example, the computed percent payment based on aggregate gradation is 98 percent.

End of Example

TABLE I. PERCENT PAYMENT BASED ON MEAN ABSOLUTE DEVIATION
OF AGGREGATE GRADATIONS FROM JMF

Percent Payment Based On Mean Absolute Deviation From JMF							
Sieve Size	0.0- 1.0	1.1- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	Above 6.0
19.0 mm	100	100	100	100	98	95	90
12.5 mm	100	100	100	100	98	95	90
9.5 mm	100	100	100	100	98	95	90
4.75 mm	100	100	100	100	98	95	90
2.36 mm	100	100	100	98	95	90	reject
0.60 mm	100	100	100	98	95	90	reject
0.075 mm	100	98	90	reject	reject	reject	reject

TABLE I. PERCENT PAYMENT BASED ON MEAN ABSOLUTE DEVIATION
OF AGGREGATE GRADATIONS FROM JMF

Percent Payment Based On Mean Absolute Deviation From JMF							
Sieve Size	0.0- 1.0	1.1- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	Above 6.0
3/4 inch	100	100	100	100	98	95	90
1/2 inch	100	100	100	100	98	95	90
3/8 inch	100	100	100	100	98	95	90
No. 4	100	100	100	100	98	95	90
No. 8	100	100	100	98	95	90	reject
No. 30	100	100	100	98	95	90	reject
No. 200	100	98	90	reject	reject	reject	reject

1.2.2 Asphalt Content

The mean of the absolute deviations of the four asphalt contents (one from each subplot) from that of the JMF will be evaluated and compared with TABLE II. The computed percent payment based on asphalt content will be the value obtained from TABLE II. Complete and report all asphalt content tests within 24 hours after completion of construction of each lot.

TABLE II. PERCENT PAYMENT BASED ON ASPHALT CONTENT

Mean Absolute Deviation of Extracted Asphalt Contents from JMF	Percent Payment
0.30	100
0.31-0.35	98
0.36-0.40	95
0.41-0.50	90
Above 0.50	reject

1.2.3 Surface Smoothness

NOTE: Select between the two editing options for preference of performing smoothness testing for each lot or for the completed surface. Testing of the completed surface may be more appropriate for a lump sum contract.

Test with a straightedge [after completion of rolling a lot,] the finished surface. Make measurements perpendicular to and across all joints at equal distances along the joint not to exceed 8 meters 25 feet. Record the location and amount of deviation from straightedge for all measurements. When more than 5 percent of all measurements along the joints or along the mat within a lot exceed the specified tolerance given in Table III, the computed percent payment for that entire lot shall not exceed 95 percent. Correct any joint or mat-area-surface deviation that exceeds the tolerance by more than 50 percent to meet the specification requirements. Corrections required by this paragraph shall consist of removal and replacement as specified in paragraph CORRECTING DEFICIENT AREAS.

TABLE III. SURFACE-SMOOTHNESS TOLERANCES

Pavement Category	Direction of Testing	PFC Course Tolerance, mm
Runways and taxiways	Longitudinal	3
	Transverse	6
Roads	Longitudinal	6
	Transverse	6

TABLE III. SURFACE-SMOOTHNESS TOLERANCES

Pavement Category	Direction of Testing	PFC Course Tolerance, inch
Runways and taxiways	Longitudinal	1/8
	Transverse	1/4
Roads	Longitudinal	1/4
	Transverse	1/4

1.2.4 Thickness Determination

The thickness of the PFC will be determined by the Government on the basis of measurements made on cores drilled by the Contractor from points where directed in the pavement selected in a random fashion, with a minimum of one test per subplot. Cores shall be 100 mm 4 inch in diameter and shall become the property of the Government. Measurements of individual cores will be determined in accordance with ASTM C174/C174M. Fill all core holes with hot PFC mixture and compact.

1.2.5 Thickness Deficiency

When the measurement of any core indicates that the pavement is deficient

in thickness by more than 3 mm 1/8 inch, drill additional cores parallel to the centerline of the lane at 8 meter 25 foot intervals on each side of the deficient core until the cores indicate that the deficiency in thickness is 3 mm 1/8 inch or less. Remove and replace the pavement area determined to be deficient in thickness in accordance with paragraph CORRECTING DEFICIENT AREAS. The area of the deficient pavement shall be considered to be the full paving lane width and midway between cores showing deficient thickness and those meeting the permissible deviations. The measured thickness of the PFC shall not exceed the thickness shown on the drawings by more than 6 mm 1/4 inch nor be deficient in thickness more than 3 mm 1/8 inch.

1.3 REFERENCES

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

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

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

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 320	(2010) Standard Specification for Performance-Graded Asphalt Binder
AASHTO T 308	(2010) Standard Method of Test for Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
AASHTO T 326	(2005; R 2009) Standard Method of Test for Uncompacted Void Content of Coarse Aggregate (As Influenced by Particle Shape, Surface Texture, and Grading)

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2004) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
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ASTM C1252	(2006) Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)
ASTM C127	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C174/C174M	(2012) Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C183	(2008) Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement
ASTM C29/C29M	(2009) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2005) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D140/D140M	(2009) Standard Practice for Sampling Bituminous Materials
ASTM D2172/D2172M	(2011) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D2216	(2010) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2419	(2009) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D242/D242M	(2009) Mineral Filler for Bituminous Paving Mixtures
ASTM D4125/D4125M	(2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D5148	(2010) Standard Test Method for Centrifuge Kerosine Equivalent
ASTM D6307	(2010) Asphalt Content of Hot Mix Asphalt by Ignition Method
ASTM D75/D75M	(2009) Standard Practice for Sampling Aggregates

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 171

(1995) Standard Test Method for
Determining Percentage of Crushed
Particles in Aggregate

1.4 SYSTEM DESCRIPTION

Provide a bituminous plant with enough capacity to produce the quantities of PFC mixture required. Provide hauling equipment, paving machines, rollers, miscellaneous equipment, and tools in sufficient numbers and capacity, and in proper working condition, to ensure proper placement of the PFC mixtures at a rate that will permit proper construction of the PFC. Make available a sufficient number of trained personnel during paving operations to ensure production of a PFC pavement that meets the requirements of this specification. Submit the proposed [Placement Plan](#) for approval, indicating lane widths, and longitudinal and transverse joints for each course or lift.

1.4.1 Mixing Plants

**NOTE: The capacity shall be the minimum required to
produce the required tonnage within the specified
time limits and in no case should the capacity be
less than 100 metric tons (tons) per hour.**

Provide a mixing plant which is a commercially manufactured unit, automatically or semiautomatically controlled, designed, and operated to consistently produce a mixture meeting the requirements of the job mix formula (JMF). The plant shall have a minimum capacity of [____] **metric tons** per hour. Store coarse aggregate, fine aggregate and natural sand (when used) in and dispensed from separate cold storage bins. When drum mixers are used, they shall be prequalified at the production rate to be used during actual mix production. Determine asphalt content by one of the following methods: extraction method in accordance with [ASTM D2172/D2172M](#), Method A or B, the ignition method in accordance with the [AASHTO T 308](#), [ASTM D6307](#), or the nuclear method in accordance with [ASTM D4125/D4125M](#), provided each method is calibrated for the specific mix being used. For the extraction method, the weight of ash, as described in [ASTM D2172/D2172M](#), shall be determined as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture. Plant shall be appropriately equipped for addition of the type of stabilizing fibers used, if any.

1.4.2 Straightedge

Furnish and maintain at the site, in good condition, one **3.7 m 12 foot** straightedge for each bituminous paver, for use in the testing of the finished surface. Make available a straightedge for government use. Straightedges shall be constructed of aluminum or other lightweight metal with blades of box or box-girder cross section, with flat bottom reinforced to ensure rigidity and accuracy and with handles to facilitate movement on pavement.

1.4.3 Access to Plant and Equipment

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

1.5 SUBMITTALS

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

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

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

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

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

SD-02 Shop Drawings

Placement Plan[; G][; G, [_____]]

SD-03 Product Data

Job Mix Formula (JMF)[; G][; G, [_____]]
Contractor Quality Control (CQC)[; G][; G, [_____]]

SD-04 Samples

Asphalt Cement Binder
Aggregates

SD-06 Test Reports

Aggregates[; G][; G, [____]]

SD-07 Certificates

Asphalt Cement Binder[; G][; G, [____]]
Testing Laboratory

1.6 QUALITY ASSURANCE

1.6.1 Aggregate Sampling and Testing

NOTE: Satisfactory service record for an aggregate will be determined based on the aggregate's ability to resist polishing, raveling, stripping, and degradation under traffic and climatic conditions similar to those expected during its use. If performance data indicate that an aggregate is susceptible to one or more of the above-mentioned problems, that source of aggregate must be rejected. The prequalification testing of aggregate from a proven source requires 20 days. Testing of new sources of aggregates requires 30 days. This is actual testing time. Two weeks should be added to cover the submittal process.

a. Perform sampling and testing of aggregates, including mineral filler. Samples will be the basis for approval of specific sources or stockpiles of aggregates for aggregate requirements. Unless otherwise directed, use **ASTM D75/D75M** in sampling coarse and fine aggregate, and use **ASTM C183** in sampling mineral filler. Grade mineral filler in accordance with the limits set forth in **ASTM D242/D242M**.

b. Select sources of aggregates well in advance of the time the materials are required in the work. If a previously developed source is selected, submit samples [____] days before starting production, with evidence that central-plant, hot-mix bituminous pavements or porous friction courses constructed with the aggregates have had a satisfactory service record of at least five years under similar climatic and traffic conditions. When new sources are developed, indicate sources and submit samples and a plan for operation [____] days before starting production. The Contracting Officer will make such tests and other investigations as necessary to determine whether aggregates meeting the requirements specified herein can be produced from proposed sources. If a sample of material from any source fails to meet specification requirements, replace the material represented by the sample, and the cost of testing the replaced sample shall be at the Contractor's expense. Approval of source of aggregate does not relieve the Contractor of the responsibility to deliver at the jobsite aggregates that meet the specified requirements.

1.6.2 Bituminous Material Requirements

Obtain samples of bituminous materials in accordance with **ASTM D140/D140M**. Perform tests necessary to determine conformance with requirements specified herein. Select sources where bituminous materials are obtained in advance of time when materials will be required in the work, and submit samples of the specified asphalt cement for testing not less than [_____] days before production of the asphalt mixture. In addition to initial qualification testing of bituminous materials, take and submit samples for testing before and during construction when shipments of bituminous materials are received or when necessary to assure that handling or storage has not been detrimental to the bituminous material. Accomplish sampling and testing of bituminous mixtures.

1.6.3 Protection of Persons and Property

Conduct paving construction operations in a manner that will ensure the safety of persons and property.

1.6.4 Traffic Control

Provide traffic control in accordance with Chapter 6 of the Federal Highway Administration Manual of Uniform Traffic Control Devices, by keeping open vehicular traffic lanes or by providing detour routes. Barricade and post with warning signs for safety and directing traffic. Provide flashing warning lights during non daylight hours.

1.7 DELIVERY, STORAGE, AND HANDLING

1.7.1 Mineral Aggregate

Deliver mineral aggregate to the site of the bituminous mixing plant and stockpile it, precluding fracturing of aggregate particles, segregation, contamination, or intermingling of different materials in the stockpiles or cold-feed hoppers. Stockpile coarse aggregate and fine aggregate separately. Deliver, store, and introduce mineral filler into the mixing plant, avoiding exposure to moisture or other detrimental conditions.

1.7.2 Bituminous Material

Maintain bituminous material below a temperature of **150 degrees C 300 degrees F** during storage; bituminous material shall not be heated by the application of a direct flame to the walls of storage tanks or transfer lines. Thoroughly clean storage tanks, transfer lines, and weigh buckets before a different type or grade of bitumen is introduced into the system.

1.7.3 Stabilizing Fiber

Ship and store stabilizing fiber in sealed bags or bulk containers prepared by the manufacturer, and store on site as recommended by the manufacturer.

1.7.4 Storage of PFC

The PFC paving mixture shall not be stored for longer than 15 minutes prior to hauling to the jobsite.

1.8 PROJECT/SITE CONDITIONS

Construct the PFC course only when the existing pavement is dry. Unless otherwise directed, do not construct the PFC when the temperature of the existing pavement surface is below 15 degrees C 60 degrees F.

PART 2 PRODUCTS

2.1 AGGREGATES

Provide aggregates consisting of natural sand, crushed stone, crushed gravel, crushed slag, and screenings, as required. Submit sufficient materials to produce 90 kg 200 lb of blended mixture for mix design certification. Submit aggregate and QC test results. The portion of materials retained on the 4.75 mm No. 4 sieve shall be known as coarse aggregate, the portion passing the 4.75 mm No. 4 sieve and retained on the 0.075 mm No. 200 sieve as fine aggregate, and the portion passing the 0.075 mm No. 200 sieve as mineral filler. Aggregate gradation shall be in accordance with TABLE IV. TABLE IV is based on aggregates of uniform specific gravity; the percentage passing various sieves may be changed by the Contracting Officer when aggregates of varying specific gravities are used. Adjustments of percentages passing various sieves may be directed by the Contracting Officer when aggregates vary more than 0.2 in specific gravity.

TABLE IV. AGGREGATE GRADATION

Proposed 19 mm Max. Aggre. Size Gradation			Proposed 13 mm Max. Aggre. Size Gradation		
Sieve, mm	Min.	Max.	Min.	Max.	
19	100	100			
12.5	80	95	100	100	
9.5	40	70	80	95	
4.75	15	30	20	40	
2.36	8	20	10	25	
1.18	4	10	4	10	
0.075	2	5	2	5	

TABLE IV. AGGREGATE GRADATION

Proposed 3/4 inch Max. Aggre. Size Gradation			Proposed 1/2 inch Max. Aggre Size Gradation		
Sieve, inch	Min	Max.	Min.	Max.	
3/4	100	100			
1/2	80	95	100	100	
3/8	40	70	80	95	
No. 4	15	30	20	40	
No. 8	8	20	10	25	
No. 30	4	10	4	10	
No. 200	2	5	2	5	

2.1.1 Coarse Aggregate

Provide coarse aggregate consisting of clean, sound, durable particles meeting the following requirements.

2.1.1.1 Abrasion

NOTE: The Los Angeles abrasion test is used in excluding aggregates known to be unsatisfactory or for evaluating aggregates from new sources. The percentage of loss will be inserted in the blanks. The values inserted will be based on aggregates in the area that have been previously approved or that have a satisfactory service record in bituminous pavement construction for at least 5 years. Upper limits of 25 percent for airfields and 40 percent for roads are recommended.

Percentage of loss shall not exceed 30 after 500 revolutions, as determined in accordance with [ASTM C131](#).

[2.1.1.2 Stone-on-Stone Contact

NOTE: Retain this paragraph for large projects and paragraph Crushed Gravel for small projects.

Stone-on-stone contact shall be required for the coarse aggregate fraction of the project blend. The coarse aggregate fraction of the blend for determination of stone-on-stone contact is that portion of the total aggregate retained on the breakpoint sieve. The breakpoint sieve is defined as the finest (smallest) sieve to retain 10 percent of the aggregate gradation. The voids in coarse aggregate for the coarse aggregate fraction shall be determined by the dry rodding method in accordance with [ASTM C29/C29M](#). The project blend shall be compacted at the optimum asphalt cement content with 50 revolutions of the Superpave gyratory compactor. Stone-on-stone contact shall be determined to exist when the voids in the compacted mix with asphalt cement are less than or equal to the voids in material retained on the breakpoint sieve.

] [2.1.1.3 Crushed Gravel

Crushed gravel retained on the [4.75 mm No. 4](#) sieve and each coarser sieve shall contain at least 90 percent by weight of crushed pieces having at least one fractured face and 75 percent by weight of crushed pieces having two or more fractured faces, with the area of each face equal to at least 75 percent of the smallest midsectional area of piece. When two fractures are contiguous, the angle between planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be determined in accordance with [COE CRD-C 171](#).

] 2.1.1.4 Coarse Aggregate Angularity

Coarse aggregate angularity shall be determined for the material in the project blend retained on the No. 4 sieve. The coarse aggregate portion of the blended aggregate shall have an uncompacted void content greater than 45.0 percent when tested in accordance with [AASHTO T 326](#).

2.1.1.5 Crushed Slag

Slag shall be air cooled blast furnace slag. Other slag will not be permitted. The dry weight of crushed slag shall not be less than 1200 kg/cubic m 75 pcf, as determined in accordance with ASTM C29/C29M.

2.1.1.6 Aggregate Soundness

NOTE: The values of percentage of loss will be based on knowledge of aggregates in the area that have been previously approved or that have a satisfactory service record in PFCs or other bituminous pavements of at least 5 years.

For airfield pavements, the percentage of soundness loss shall not exceed 12 percent. This should not be confused with the less restrictive 18 percent for dense graded mixtures.

Percentage of loss shall not exceed 12 percent after five cycles using sodium sulfate, performed in accordance with ASTM C88, or 15 percent using magnesium sulfate.

2.1.1.7 Absorption

Maximum absorption for the aggregate blend shall not exceed 2 percent when tested in accordance with ASTM C127

2.1.2 Fine Aggregate

Provide fine aggregate consisting of clean, sound, durable, angular particles produced by crushing stone, slag, or gravel that meets quality requirements specified for coarse aggregate. Fine aggregate produced by crushing gravel shall have at least 90 percent by weight of crushed particles having two or more fractured faces in the portion retained on the 0.6 mm No. 30 sieve. This requirement shall apply to material before blending with natural sand, when blending is necessary. The quantity of natural sand to be added to the PFC shall not exceed 5 percent by weight of total aggregate. Natural sand shall be clean and free from clay and organic matter.

2.1.2.1 Fine Aggregate Angularity

Fine aggregate angularity shall be determined for the material in the project blend passing the 4.75 mm No. 4 sieve. The fine aggregate portion of the blended aggregate shall have an uncompacted void content greater than 45.0 percent when tested in accordance with ASTM C1252 Method A.

2.1.2.2 Cleanliness

Fine aggregate cleanliness shall be determined for the material in the project blend passing the 4.75 mm No. 4 sieve. The fine aggregate portion of the blended aggregate shall have a sand equivalent value greater than 50 percent when tested in accordance with ASTM D2419.

2.1.3 Bituminous Materials

NOTE: Performance Graded (PG) asphalt binders should be specified wherever available. The same grade PG binder used by the state highway department in the area should be considered as the base grade for the project (e.g. the grade typically specified in that specific location for dense graded mixes on highways with design ESALS less than 10 million). The sum of the high and low temperature grades should exceed 92 (i.e. PG 64-22 = 86). Intent is to ensure asphalt cement binder is polymer modified. The exception would be that grades with a low temperature higher than PG XX-22 should not be used (e.g. PG XX-16 or PG XX-10), unless the Engineer has had successful experience with them.

Typically, rutting is not a problem on airport runways. However, at airports with a history of stacking on end of runways and taxiway areas, rutting has accrued due to the slow speed of loading on the pavement. If there has been rutting on the project or it is anticipated that stacking may accrue during the design life of the project, then the following grade "bumping" should be applied for the top 125 mm (5 inches) of paving in the end of runway and taxiway areas: for aircraft tire pressure between 0.7 and 1.4 MPa (100 and 200 psi), increase the high temperature one grade; for aircraft tire pressure greater than 1.4 MPa (200 psi), increase the high temperature two grades. For Navy projects, a high temperature increase of two grades is required. Each grade adjustment is 6 degrees C. Polymer Modified Asphalt, PMA, has shown to perform very well in these areas. The low temperature grade should remain the same. The Engineer may lower the low temperature grade to comply with the recommendations of the FHWA's software program "LTPPBIND", if it is believed to be appropriate.

Asphalt cement binder shall conform to AASHTO M 320 Performance Grade (PG) [____]. Submit 20 L 5 gallon sample for mix design verification. Certified 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/Engineer. The supplier is defined as the last source of any modification to the binder. The Contracting Officer/Engineer 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/Engineer. Furnish these samples to the Contracting Officer/Engineer for the verification testing, which shall be at no cost to the Contractor (FDKD1). Submit samples of the asphalt cement specified for approval not less than 14 days before start of the test section.

2.1.4 Additives

Do not incorporate additives into the mix without prior approval or direction. The use of additives such as antistripping agents, antifoaming agents, and silicone is subject to approval by the Contracting Officer.

2.1.5 Stabilizing Fibers

Fibers may be either cellulose or mineral, and may be used in either loose or pelletized forms. Cellulose fibers may be used to a rate of 0.3 percent, and mineral fibers may be used to a rate of 0.4 percent, by total mass of the mixture.

2.2 JOB MIX FORMULA AND MOISTURE SUSCEPTIBILITY

NOTE: The procedures for determining the JMF to be used in the mixtures are described in UFC 3-260-01, Chapter 2, and UFC 3-250-03, Chapter 9.

Proportioning of the aggregates for the JMF should be carefully determined because the gradations will be those on which the tolerances will be applied. Application of these tolerances may cause the gradation to be outside the limits of the gradation in Table IV, but this is acceptable.

2.2.1 Job Mix Formula (JMF)

Submit the proposed JMF for the bituminous mixture to the Contracting Officer for approval. No payment will be made for mixtures produced prior to approval of the JMF by the Contracting Officer. The estimated asphalt content (percent by weight of aggregate) to be used in the JMF shall be determined by the equation $2.0 K_c + 4.0$, where K_c is a surface area constant in accordance with ASTM D5148 on the proposed job aggregates. The mixing temperature shall be as recommended by the supplier. The formula shall indicate the percentage of each stockpile (as based on samples furnished) and mineral filler, the percentage passing each sieve size, the percentage of bitumen, the amount of anti-stripping agent, if needed, and the temperature of the completed mixture when discharged from the mixer. Tolerances are given in TABLE V for bitumen content, temperature, and aggregate grading for tests conducted on the mix as discharged from the mixing plant; however, the final evaluation of aggregate gradation and asphalt content will be based on paragraph ACCEPTABILITY OF WORK. Reject bituminous mix that deviates more than 14 degrees C 25 degrees F from JMF. The JMF may be adjusted during construction to improve paving mixtures, as directed by the Contracting Officer, without adjustments in the contract unit prices. Tolerances shown may permit the aggregate gradation to be outside the band specified in TABLE IV; this will be acceptable.

TABLE V. JOB-MIX TOLERANCES

Material	Tolerance, Plus or Minus
Aggregate passing 4.75 mm or larger sieves	4 percent
Aggregate passing 2.36 and 0.60 mm sieves	3 percent
Aggregate passing 0.075 mm sieve	1 percent

TABLE V. JOB-MIX TOLERANCES

Material	Tolerance, Plus or Minus
Bitumen	0.30 percent
Temperature of mixing	14 degrees C

TABLE V. JOB-MIX TOLERANCES

Material	Tolerance, Plus or Minus
Aggregate passing No. 4 sieve or larger sieves	4 percent
Aggregate passing Nos. 8 and 30 sieves	3 percent
Aggregate passing No. 200 sieve	1 percent
Bitumen	0.30 percent
Temperature of mixing	25 degrees F

2.2.2 Retained Coating

NOTE: The antistripping agent, when added to the mix, must provide a mixture which will have a retained coating area of at least 95 percent.

The aggregate passing the 10 mm 3/8 inch (FDKD) sieve and retained on the 6 mm 1/4 inch sieve shall have a retained coating area of at least 95 percent. When the retained coating area is less than 95 percent, the aggregate stripping tendencies shall be countered by the use of hydrated lime or by treating the bitumen with an approved antistripping agent as furnished by the Contractor. The hydrated lime shall be considered as mineral filler and shall be considered in the gradation requirements. The amount of hydrated lime or antistripping agent added to the bitumen shall be determined during development of the JMF and shall be sufficient to produce a retained coating area greater than 95 percent. Use of additional antistripping agent may be directed during progress of the work, if necessary. No additional payment will be made to the Contractor for addition of antistripping agent required.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Surface Preparation

NOTE: Appropriate statements covering the required conditioning of existing pavement will be inserted. Deficiencies in surface smoothness must be remedied by repairing or patching localized areas or by placing a leveling course.

Prior to placing of PFC, clean the underlying course of any foreign or objectionable matter by thorough power brooming. Remove and replace any

underlying course showing evidence of oil or grease.

3.1.2 Preparation of Bituminous Mixtures

Regulate rates of feed of aggregates so that moisture content and temperature of aggregates stay within tolerances specified. Convey aggregates and bitumen into the mixer in proportionate quantities required to meet the JMF. Add stabilizing fibers at the appropriate location for the given plant type in accordance with the process recommended by the manufacturer. Mixing time shall be as required to obtain a uniform coating of the aggregate with the bituminous material, and achieve thorough blending of the stabilizing fiber if used. Temperature of the asphalt cement and aggregates shall be as recommended by the bituminous materials supplier. Discard overheated and carbonized mixtures or mixtures that foam.

3.1.2.1 Water Content of Aggregates

Reduce the water content of the aggregate mixture to less than 0.50 percent by drying operations. Determine water content in accordance with [ASTM D2216](#); weight of sample shall be at least **500 grams 12 ounces**. Report the water content as a percentage of the total aggregate mixture.

3.1.2.2 Transportation of Bituminous Mixture

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 runway construction. Remove last two sentences if material transfer vehicle is not used.

Transport from the paving plant to the site in trucks having tight, clean, smooth beds lightly coated with an approved release agent to prevent adhesion of mixture to truck bodies. Drain excess release agent prior to loading. Cover each load with canvas or other approved material of ample size to protect mixture from the weather and to prevent loss of heat. Reject and discard loads that have crusts of cold, unworkable material or have become wet. Notify the Contracting Officer immediately if excessive drainage of the bituminous materials occurs. Determine the cause of the excessive drainage, and adjust the JMF, if necessary. Do not permit hauling over freshly placed material. To deliver mix to the paver, use a material transfer vehicle which shall be operated to produce continuous forward motion of the paver. Provide a material transfer vehicle with remixing and storage capability and that operates independently of the paver.

3.1.2.3 Trial Test Section

At the start of plant operation, prepare a quantity of mixture to construct a test section at least **15 meters 50 feet** long, two spreader-widths wide and of the thickness to be used in the project. Place, spread, and roll mixture with the equipment to be used in the project and in accordance with requirements specified. Test and evaluate this test section as a lot and conforming to all specified requirements. If test results are satisfactory, keep the test section in place as part of the completed pavement. If tests indicate that the pavement does not conform to specification requirements, make necessary adjustments to plant operations

and laydown procedures, construct additional test sections sampled for conformance with specification requirements. Evaluate test section as specified in paragraph ACCEPTABILITY OF WORK. In no case start full production of a PFC mixture without approval from the Contracting Officer.

3.2 TACK COAT

Spray contact surfaces of underlying pavement, curbs, manholes, and other structures against which new material is to be placed, with a uniform light coat of bituminous material as specified in Section 32 12 10 BITUMINOUS TACK AND PRIME COATS. Ensure that tack coat is not applied to PFC mat joints perpendicular to the direction of drainage so that lateral drainage is not impeded. Apply the amount of bituminous tack coat to at least the minimum specified in Section 32 12 10 BITUMINOUS TACK AND PRIME COATS.

3.3 PLACING

Do not place PFC mixtures without ample time to complete spreading and rolling during daylight hours, unless satisfactory approved artificial lighting is provided.

3.3.1 Offsetting Joints

**NOTE: Delete the first sentence when this
specification is used for a road pavement.**

Place the PFC so that longitudinal joints of the PFC are offset from joints in the existing pavement by at least 300 mm 1 foot. Offset transverse joints in the PFC by at least 600 mm 2 feet from transverse joints in the existing pavement.

3.3.2 Requirements for Use of Mechanical Spreader

The allowable temperature range of mixtures, when dumped into the mechanical spreader, shall be as directed by the Contracting Officer. Mixtures having temperatures less than 105 degrees C 225 degrees F when ready to dump into the mechanical spreader shall not be placed in the mechanical spreader, but shall be wasted. Adjust and regulate the mechanical spreader so that the surface of PFC is smooth and continuous without tears and pulls, and of such depth that, when rolled, specified thickness is obtained. Place the mixture as nearly continuous as possible, and adjust the speed of placing as directed to permit proper rolling. If segregation occurs in the mixture during placement, suspend the spreading operation until the cause is determined and corrected and the segregated mix is removed.

3.3.3 Placing Strips Succeeding Initial Strips

In placing each succeeding strip after the initial strip has been spread and rolled, overlap the screed of the mechanical spreader to the previously placed strip approximately 13 mm 1/2 inch (FDKD4) and set at a sufficient height such that, after rolling, a smooth uniform joint is obtained. Remove by hand and waste mixture placed on the edge of the previously placed strip by the mechanical spreader.

3.3.4 Handspreading in Lieu of Machine Spreading

In isolated small areas where the use of machine spreading is impractical, spread the mixture by hand. Spread in a manner to prevent segregation. Place and spread mixture uniformly with hot shovels and smoothed with rakes in a layer of such thickness that, when rolled, shall conform to the required thickness.

3.4 ROLLING OF MIXTURE

Begin rolling as soon after placing as mixture will bear roller without undue displacement. Delays in rolling freshly spread mixture will not be permitted. Two complete passes with a 9 metric ton 10 ton double-drum steel-wheel roller in static mode to properly seat the material shall be applied to the PFC. Perform additional rolling only if directed. Correct deficiencies so that the finished course conforms to requirements for thickness and smoothness specified. Thickness and smoothness will be checked in each lot of completed pavement by the Contracting Officer for compliance and will be evaluated as specified in paragraphs THICKNESS DETERMINATION, SURFACE SMOOTHNESS, and ACCEPTABILITY OF WORK.

3.5 JOINTS

Joints between old and new pavements, between successive days' work, or joints that have become cold shall be made to ensure continuous bond between old and new sections of the course. Joints shall have the same texture and smoothness as other sections of the course. Contact surfaces of previously constructed PFC coated by dust, sand, or other objectionable material shall be cleaned by brushing, or shall be cut back as directed. Except for PFC joints perpendicular to the direction of drainage, spray the surface against which new material is placed, with a uniform coat of bituminous material as specified in Section 32 12 10 BITUMINOUS TACK AND PRIME COATS. Apply the tack coat far enough in advance of the placement of fresh mixture to ensure adequate curing. Take care to prevent damage or contamination of the sprayed surface.

3.5.1 Transverse Joints

The roller shall pass over the unprotected end of a strip of freshly placed material only when placing is discontinued or delivery of mixture is interrupted to the extent that material in place may become cold. In all cases, prior to continuing placement, the edge of previously placed pavement shall be cut back to expose an even, vertical surface for the full thickness of the course and shall receive a tack coat in accordance with paragraph JOINTS.. In continuing the placement of a strip, position the mechanical spreader on the transverse joint so that sufficient PFC be spread to obtain a joint after rolling that conforms to the required thickness and smoothness specified herein.

3.5.2 Longitudinal Joints

Place edges of a previously placed strip so that the pavement in and immediately adjacent to the joint between this strip and the succeeding strip meets the requirements for thickness and smoothness. Take particular care in rolling this joint. Remove joint edges of PFC that do not conform to these requirements for the full width of the strip and replaced in accordance with paragraph CORRECTING DEFICIENT AREAS.

3.6 EDGES OF PAVEMENT

Trim and shape edges of pavement adjacent to shoulders neatly to line to provide a smooth vertical open face providing free drainage from the PFC.

3.7 CORRECTING DEFICIENT AREAS

NOTE: Use the second bracketed statement when a
detailed SURFACE PREPARATION paragraph is developed
for this Section. Otherwise, use the first
bracketed statement.

Remove mixtures of PFC that become contaminated or that are defective to the full thickness of course. Cut edges of the area to be removed so that sides are perpendicular and parallel to direction of traffic and so that edges are vertical. Lightly spray edges with bituminous materials as specified in paragraph JOINTS. Tack coat small patches on all sides. Large patches that, in the Contracting Officer's opinion, will significantly impact lateral drainage shall not be tacked on the joints transverse to the direction of drainage. Place fresh PFC mixture in the excavated areas in sufficient quantity so that the finished surface conforms to the thickness and smoothness requirements. Skin patching of an area will not be permitted. [Remove and replace to match] [Repair as specified in paragraph Surface Preparation] existing underlying material damaged during removal of contaminated or defective PFC before placing PFC.

3.8 CONTRACTOR QUALITY CONTROL (CQC)

Submit certification of compliance. Provide for CQC testing and inspection during construction. The extent and frequency of such CQC testing and inspection shall be sufficient to assure that all materials, operations, and finished products meet all requirements of these specifications. All testing shall be performed by and approved commercial testing laboratory, unless the Contractor has an in house testing laboratory which has been inspected and approved by the Contracting Officer. The methods used for sampling and testing shall be the same as those specified for Government quality assurance testing. Prepare reports of all testing and inspection and submit within 24 hours of the time sampling or testing took place. Minimum acceptable extent of testing and inspection shall be as follows:

- a. Quality, cleanliness, and gradation tests on samples of aggregate, as it is delivered to the site, at a minimum of one test per lot for each size of aggregate.
- b. Gradation test on samples of aggregate from the cold feed, at a minimum of one test per lot for each size of aggregate.
- c. Depth of compacted PFC tested as specified.
- d. Tests for asphalt content and gradation as specified. Obtain samples at the back of the paver.
- e. Check and recalibrate scales, other measuring devices and batching or proportioning equipment prior to starting production and at least once every 4500 metric tons 5000 tons of PFC produced.
- f. Surface smoothness as specified, to assure that specification

requirements are attained.

g. Placing operations, including construction of joints, continuously checked for conformance with specification requirements. Report problems encountered.

3.9 ACCEPTABILITY OF WORK

Acceptance of the PFC mixture and completed pavement will be based on gradation, asphalt content, and smoothness. Perform testing for acceptability of work to determine percent payment. The Contracting Officer reserves the right to sample and test any area which appears to deviate from the specification requirements. Testing in these areas can be considered a separate lot for determining payment.

3.10 PROTECTION OF PAVEMENT

NOTE: The basic requirement is to avoid traffic damage to the PFC. The minimum suggested cure time for PFC's on roads is 12 hours. The time requirements can be shortened provided that no sharp turning or stopping of the traffic on the PFC is allowed. PFC's on airfield pavement require an absolute minimum of 2 days to cure sufficiently to be able to satisfactorily handle carefully controlled aircraft traffic. Short or locked wheel turns should never be permitted on the PFC.

After final rolling, do not permit vehicular traffic of any kind on the pavement for [_____] days.

-- End of Section --