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USACE / NAVFAC / AFCEA / NASA UFGS-32 12 20 (April 2006)  
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Preparing Activity: USACE Replacing without change  
UFGS-02747 (October 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 18 July 2006

Latest change indicated by CHG tags

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SECTION 32 12 20

POROUS FRICTION COURSE FOR AIRFIELDS AND ROADS  
04/06

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NOTE: This guide specification covers the requirements for bituminous porous friction course for airfields and roads.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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PART 1 GENERAL

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NOTE: When it is necessary to require Contractor mix design, the appropriate paragraphs will be carefully edited, paying close attention to the wording and in these paragraphs always changing "will" to "shall." The evaluation of aggregates and mix design development should be performed by an approved commercial testing laboratory at no expense to the Government. If Contractor mix design is used, paragraph SUBMITTALS will be edited to require certified copies of aggregate tests and job mixture proportions be submitted to the Contracting Officer for approval prior to use in the work.

Drawings should 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.

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## 1.1 REFERENCES

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

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

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

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

### ASTM INTERNATIONAL (ASTM)

ASTM C 117	(2004) Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	(2004) Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C 128	(2004a) Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C 131	(2003) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(2005) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 174/C 174M	(1997) Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C 183	(2002) Sampling and the Amount of Testing of Hydraulic Cement
ASTM C 29/C 29M	(1997; R 2003) Bulk Density ("Unit

	Weight") and Voids in Aggregate
ASTM C 88	(2005) Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D 1250	(2004) Petroleum Measurement Tables
ASTM D 140	(2001) Sampling Bituminous Materials
ASTM D 1856	(1995a; R 2003) Recovery of Asphalt from Solution by Abson Method
ASTM D 2170	(2001a) Kinematic Viscosity of Asphalts (Bitumens)
ASTM D 2172	(2001e1) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2216	(2005) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 242	(1995; R 2000e1) Mineral Filler for Bituminous Paving Mixtures
ASTM D 3381	(1992; R 1999) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 4791	(1999) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 5	(2005a) Penetration of Bituminous Materials
ASTM D 75	(2003) Sampling Aggregates
ASTM D 946	(1982; R 1999) Penetration-Graded Asphalt Cement for Use in Pavement Construction

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CDT)

CDT Test 303	(2000) Method of Test for Centrifuge Kerosene Equivalent and Approximate Bitumen Ratio (ABR)
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1.2 UNIT PRICES

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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). For lump-sum contracts, the Contractor may be required to perform all aggregate quality testing and developing the job mix formula.  
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### 1.2.1 Measurement

#### 1.2.1.1 Porous Friction Course

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

#### 1.2.1.2 Correction Factor for Aggregates Used

Quantities of paving mixtures called for are based on aggregates having a specific gravity of 2.70, as determined in accordance with the Apparent Specific Gravity paragraphs in **ASTM C 127** and **ASTM C 128**. Correction in tonnage of PFC mixtures shall be made to compensate for the difference in tonnage of the mixtures used in the project, when specific gravities of aggregates used in mixtures are more than 2.75 or less than 2.65. Tonnage paid for will be the number of tons used, proportionately corrected for specific gravities, using 2.70 as the base correctional factor.

#### 1.2.1.3 Quantity of Bituminous Materials

The amount of bituminous materials paid for will be the number of [**liters gallons** of bituminous materials used in the accepted work, corrected to **liters at 15.6 degrees C gallons at 60 degrees F**, in accordance with **ASTM D 1250**] [**metric 2000 pound** tons of material used in the accepted work].

### 1.2.2 Payment

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 shall 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.

### 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. Submittals should be kept to the minimum required for adequate quality control.**

**A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.**

**For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority.**

Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

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

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

#### SD-03 Product Data

##### Sampling and Testing Waybills and Delivery Tickets

- a. Service Record of previously developed sources of aggregates.
- b. Plan for operation of new sources of aggregate.
- c. Waybills and delivery tickets during progress of the work.

#### SD-04 Samples

##### Sampling and Testing

a. Samples for Government Prequalification Testing. Samples of aggregates, including mineral filler, shall be furnished for approval of proposed sources and aggregate stockpiles prior to the start of production, and at times during production of the PFC. Samples of materials shall be representative of those proposed for the project. Samples of materials, other than aggregates, shall be submitted accompanied by the manufacturer's test reports indicating compliance with applicable specified requirements.

b. Government Mix Design Samples. At least [\_\_\_\_\_] days prior to placement, the Contractor shall furnish samples of materials for Government mix design. Sufficient quantities of each aggregate and mineral filler (if needed) shall be submitted to provide a minimum of 112 kg 250 pounds of blended aggregate in the same approximate proportions as will be used in the project. Blending of the aggregates will be accomplished by the Government. A minimum of 20 L 5 gallons of the asphalt cement to be used in the project shall be submitted. Anti-stripping agent shall be furnished if needed to meet retained coating criteria. Results of gradation tests performed on the aggregate samples submitted shall be furnished with the samples showing that the samples can be combined to meet gradation requirements of Table I.

## 1.4 DELIVERY, STORAGE, AND HANDLING OF MATERIALS

### 1.4.1 Mineral Aggregate

Mineral aggregate shall be delivered to the site of the bituminous mixing plant and stockpiled, precluding fracturing of aggregate particles, segregation, contamination, or intermingling of different materials in the stockpiles or cold-feed hoppers. Coarse aggregate and fine aggregate shall be stockpiled separately. Mineral filler shall be delivered, stored, and introduced into the mixing plant, avoiding exposure to moisture or other detrimental conditions.

### 1.4.2 Bituminous Material

Bituminous material shall be maintained below a temperature of 150 degrees C 300 degrees F during storage and shall not be heated by the application of a direct flame to the walls of storage tanks or transfer lines. Storage tanks, transfer lines, and weigh buckets shall be thoroughly cleaned before a different type or grade of bitumen is introduced into the system.

## 1.5 PLANT, EQUIPMENT, MACHINES, AND TOOLS

The bituminous plant shall have capacity to produce the quantities of PFC mixture required. Hauling equipment, paving machines, rollers, miscellaneous equipment, and tools shall be provided 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. A sufficient number of trained personnel shall be available during paving operations to ensure production of a PFC pavement that meets the requirements of this specification.

### 1.5.1 Mixing Plants

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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.  
\*\*\*\*\*

The mixing plant shall be 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 tons per hour. Coarse aggregate, fine aggregate and natural sand (when used) shall be stored 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. The prequalification tests will include extraction and recovery of the asphalt cement in accordance with ASTM D 2172 and ASTM D 1856. The penetration of the recovered asphalt binder shall not be less than 60 percent of the penetration of the original asphalt, as measured in accordance with ASTM D 5.

### 1.5.2 Straightedge

The Contractor shall 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. Straightedge shall be made available for government use. Straightedges shall be constructed of aluminum or other



lightweight metal and shall have blades of box or box-girder cross section with flat bottom reinforced to ensure rigidity and accuracy. Straightedges shall have handles to facilitate movement on pavement.

#### 1.6 ACCESS TO PLANT AND EQUIPMENT

The Contracting Officer shall be provided access 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.

#### 1.7 SAMPLING AND TESTING

##### 1.7.1 Aggregate Sampling

Times and points of sampling will be designated by the Contracting Officer. Samples of aggregates, including mineral filler, shall be furnished by the Contractor at no cost to the Government. Samples will be the basis for approval of specific sources or stockpiles of aggregates for aggregate requirements. Unless otherwise directed, **ASTM D 75** shall be used in sampling coarse and fine aggregate, and **ASTM C 183** shall be used in sampling mineral filler. Grade mineral filler in accordance with the limits set forth in **ASTM D 242**.

##### 1.7.1.1 General Requirements

Initial prequalification testing of aggregates necessary to determine compliance with the requirements specified herein will be made by the Contracting Officer. Additional testing and inspection during construction shall be the responsibility of the Contractor under CONTRACTOR QUALITY CONTROL (CQC).

##### 1.7.1.2 Sources

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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 shall 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.

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Sources of aggregates shall be selected well in advance of the time the materials are required in the work. If a previously developed source is selected, samples shall be submitted [\_\_\_\_\_] 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, the Contractor shall indicate sources and submit samples and his 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, the material represented by the sample shall be replaced, 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.

#### 1.7.2 Bituminous Material Requirements

Samples of bituminous materials shall be obtained by the Contractor; sampling shall be in accordance with **ASTM D 140**. Tests necessary to determine conformance with requirements specified herein will be performed by the Contracting Officer without cost to the Contractor. Sources where bituminous materials are obtained shall be selected in advance of time when materials will be required in the work, and samples of the specified asphalt cement shall be submitted for testing not less than [\_\_\_\_\_] days before production of the asphalt mixture. In addition to initial qualification testing of bituminous materials, samples shall be taken and submitted 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.

#### 1.7.3 Bituminous Mixtures

Sampling and testing of bituminous mixtures will be accomplished by the Contracting Officer. The Contractor shall provide labor and facilities to assist in obtaining the samples.

#### 1.8 WAYBILLS AND DELIVERY TICKETS

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**NOTE: This paragraph will be deleted for lump-sum contract jobs.**  
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Before the final statement is allowed, the Contractor shall 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.

#### 1.9 PROTECTION OF PERSONS AND PROPERTY

Paving construction operations shall be conducted in a manner that will ensure the safety of persons and property.

#### 1.10 MAINTAINING TRAFFIC

Maintain vehicular and pedestrian traffic at all times in accordance with State or Local DOT requirements, 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.

## PART 2 PRODUCTS

### 2.1 AGGREGATES

Aggregates shall consist of natural sand, crushed stone, crushed gravel, crushed slag, and screenings, as required. 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 I. TABLE I 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 I. AGGREGATE GRADATION

Percent Passing by Weight of Total Aggregates

Sieve Designation (mm Openings)	Gradation "A", 19 mm Maximum (Compacted Nominal Thickness, 25 mm)	Gradation "B", 13 mm Maximum (Compacted Nominal Thickness, 19 mm)
19	100	100
12.5	70-100	100
9.5	45-75	80-100
4.75	25-40	25-40
2.36	10-20	10-20
0.60	3-10	3-10
0.075	0-5	0-5

TABLE I. AGGREGATE GRADATION

Percent Passing by Weight of Total Aggregates

Sieve Designation (Square Openings)	Gradation "A", 3/4 inch Maximum (Compacted Nominal Thickness, 1 inch)	Gradation "B", 1/2 inch Maximum (Compacted Nominal Thickness, 3/4 inch)
3/4 inch	100	100
1/2 inch	70-100	100
3/8 inch	45-75	80-100
No. 4	25-40	25-40
No. 8	10-20	10-20
No. 30	3-10	3-10
No. 200	0-5	0-5

#### 2.1.1 Coarse Aggregate

Coarse aggregate shall consist of clean, sound, durable particles meeting the following requirements.

#### 2.1.1.1 Abrasion

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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.

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Percentage of loss shall not exceed [\_\_\_\_\_] after 500 revolutions, as determined in accordance with [ASTM C 131](#).

#### 2.1.1.2 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 meters](#) [75 pcf](#), as determined in accordance with [ASTM C 29/C 29M](#).

#### 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.

#### 2.1.1.4 Particle Shapes

Particle shape of crushed aggregates shall be essentially cubical. The quantity of flat and elongated particles in any sieve size shall not exceed 8 percent by weight when determined in accordance with [ASTM D 4791](#).

#### 2.1.1.5 Aggregate Soundness

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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.

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Percentage of loss shall not exceed [\_\_\_\_\_] after five cycles performed in accordance with [ASTM C 88](#), using magnesium sulfate.

### 2.1.2 Fine Aggregate

Fine aggregate shall consist 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.

### 2.1.3 Bituminous Materials

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NOTE: The appropriate types and grades of bituminous materials for the pavement's use and climatic environment should be used. (Refer to TM 5-822-8, Chapters 2 and 9.) Requirements of ASTM D 946 should be used to specify penetration-graded asphalt cement, or ASTM D 3381 for viscosity-graded asphalt cement. The specification selected should be listed in proper numerical sequences in the REFERENCES paragraph.

The use of modified bituminous materials such as polymers, latex rubbers, and reclaimed tire rubber should be considered for improving PFC pavement performance.

The following rubber modified asphalt cement properties, as an example, were specified for a porous friction course pavement project in the Northwest. The rubber, 1 percent to 2 percent by weight, was added to the asphalt cement at the refinery, and is usually a Neoprene synthetic rubber latex or a synthetic styrene butadiene rubber. Refineries in the project vicinity should be contacted, and the specification limits of the asphalt cement shall be based on the pavement's use and climatic environment. (Refer to TM 5-822-8, Chapter 9.)

The following table is to be used for metric projects:

Property	ASTM No.	Specification	
		Min.	Max.
Viscosity @ 60 degrees C, Poises	ASTM D 2171	1600	2400
Viscosity @ 135 degrees C, CS	ASTM D 2170	325	
Pen @ 25 degrees C (100 gm 5 sec)	ASTM D 5	80	110
Flash Point, degrees C, C.O.C.	ASTM D 92	450	
Duct @ 25 degrees C (5 cm/min) cm	ASTM D 113	100	
Duct @ 4 degrees C (5 cm/min) cm	ASTM D 113	50	
Synthetic Rubber, Wt. percent (percent by weight rubber solids)		2.0	
Toughness, Newton-meter	*	12.4	

Property	ASTM No.	Specification	
		Min.	Max.
Tenacity, Newton-meter	*	8.5	
Spot Test, Base Asphalt	AASHTO T 102	Neg.	
		(10 percent xylene)	
Rolling Thin Film Circulating			
Oven Test	ASTM D 2872**		
Tests on Residue:			
Viscosity @ 60 degrees C, Poise	ASTM D 2171		8000
Toughness, Newton-meter	*	11.3	
Tenacity, Newton-meter	*	8.5	
Duct @ 25 degrees C (5 cm/min) cm	ASTM D 113	100	
4 degrees C (5 cm/min) cm	ASTM D 113	25	

The following table is to be used in English  
(Inch-Pound) projects:

Property	ASTM No.	Specification	
		Min.	Max.
Viscosity @ 140 degrees F, Poises	ASTM D 2171	1600	2400
Viscosity @ 275 degrees F, CS	ASTM D 2170	325	
Pen @ 77 degrees F (100 gm 5 sec)	ASTM D 5	80	110
Flash Point, degrees F, C.O.C.	ASTM D 92	450	
Duct @ 77 degrees F (5 cm/min) cm	ASTM D 113	100	
Duct @ 39 degrees F (5 cm/min) cm	ASTM D 113	50	
Synthetic Rubber, Wt. percent (percent by weight rubber solids)		2.0	
Toughness, Inch-Pounds	*	110	
Tenacity, Inch-Pounds	*	75	
Spot Test, Base Asphalt	AASHTO T 102	Neg.	
		(10 percent xylene)	
Rolling Thin Film Circulating			
Oven Test	ASTM D 2872**		
Tests on Residue:			
Viscosity @ 140 degrees F Poise	ASTM D 2171		8000
Toughness, Inch-Pounds	*	100	
Tenacity, Inch-Pounds	*	75	
Duct @ 77 degrees F (5 cm/min) cm	ASTM D 113	100	
39.2 degrees F (5 cm/min) cm	ASTM D 113	25	

\*Benson Method of Toughness and Tenacity: Scott  
Tester, newton-meter (inch-pounds) @ 25 degrees C  
(77 degrees F), 500 mm (20 inches) per minute pull.  
Tension head 22.2 mm (7/8 inch) diameter.

\*\*TFOT ASTM D 1754 may be used but Rolling Thin Film  
Circulating Oven shall be the referee method."

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Asphalt cement shall conform to [ASTM D 946], [ASTM D 3381] Grade [\_\_\_\_\_].

#### 2.1.4 Additives

Additives shall not be incorporated into the mix without prior approval or  
direction. The use of additives such as antistripping agents, antifoaming

agents, and silicone is subject to approval.

## 2.2 JOB MIX FORMULA AND RETAINED COATING

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NOTE: The procedures for determining the JMF to be used in the mixtures are described in TM 5-825-2, Chapter 2, and TM 5-822-8, 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 I, but this is acceptable.  
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### 2.2.1 Job Mix Formula (JMF)

The JMF for the bituminous mixture will be furnished to the Contractor by the Contracting Officer. No payment will be made for mixtures produced prior to receipt of the JMF by the Contractor. The estimated asphalt content (percent by weight of aggregate) to be used in the JMF will be determined by the equation  $2.0 K_c + 4.0$ , where  $K_c$ , a surface area constant, is determined by conducting CDT Test 303 tests on the proposed job aggregates. A mixing temperature to provide an asphalt viscosity of 275 plus or minus 25 sq mm/sec centistokes will be determined in accordance with ASTM D 2170. The formula will 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 II 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. Bituminous mix that deviates more than 14 degrees C 25 degrees F from JMF shall be rejected. 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 I; this will be acceptable.

TABLE II. 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
Bitumen	0.30 percent
Temperature of mixing	14 degrees C

TABLE II. 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 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 will be considered as mineral filler and will be considered in the gradation requirements. The amount of hydrated lime or antistripping agent added to the bitumen will be determined during development of the JMF and will 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 Weather Limitations

The PFC course shall be constructed only when the existing pavement is dry.

Unless otherwise directed, the PFC shall not be constructed when the temperature of the existing pavement surface is below 15 degrees C 60 degrees F.

##### 3.1.2 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, the underlying course shall be cleaned of any foreign or objectionable matter by thorough power brooming. Any underlying course showing evidence of oil or grease shall be removed and replaced.



### 3.1.3 Preparation of Bituminous Mixtures

Rates of feed of aggregates shall be regulated so that moisture content and temperature of aggregates will be within tolerances specified. Aggregates and bitumen shall be conveyed into the mixer in proportionate quantities required to meet the JMF. Mixing time shall be as required to obtain a uniform coating of the aggregate with the bituminous material. Temperature of bitumen at time of mixing shall not exceed 150 degrees C 300 degrees F. Temperature of aggregate in the mixer shall not exceed 165 degrees C 325 degrees F when bitumen is added. Overheated and carbonized mixtures or mixtures that foam shall be discarded.

#### 3.1.3.1 Water Content of Aggregates

Drying operations shall reduce the water content of the aggregate mixture to less than 0.75 percent. Water content will be determined in accordance with ASTM D 2216; weight of sample shall be at least 500 grams 500 grams. The water content shall be reported as a percentage of the total aggregate mixture.

#### 3.1.3.2 Storage of PFC

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

#### 3.1.3.3 Transportation of Bituminous Mixture

Transportation from the paving plant to the site shall be in trucks having tight, clean, smooth beds lightly coated with an approved release agent to prevent adhesion of mixture to truck bodies. Excessive release agent will be drained prior to loading. Each load shall be covered with canvas or other approved material of ample size to protect mixture from the weather and to prevent loss of heat. Loads that have crusts of cold, unworkable material or have become wet shall be rejected and discarded. The Contracting Officer shall be notified immediately if excessive drainage of the bituminous materials occurs. The cause of the excessive drainage shall be determined, and the JMF adjusted, if necessary. Hauling over freshly placed material will not be permitted.

#### 3.1.3.4 Trial Test Section

At the start of plant operation, a quantity of mixture shall be prepared 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. Mixture shall be placed, spread, and rolled with the equipment to be used in the project and in accordance with requirements specified. This test section shall be tested and evaluated as a lot and shall conform to all specified requirements. If test results are satisfactory, the test section shall remain in place as part of the completed pavement. If tests indicate that the pavement does not conform to specification requirements, necessary adjustments to plant operations and laydown procedures shall be made immediately, and additional test sections shall be constructed and sampled for conformance with specification requirements. Test section will be evaluated as specified in paragraph ACCEPTABILITY OF WORK. In no case shall the Contractor start full production of a PFC mixture without approval.

### 3.2 TACK COATING

Contact surfaces of underlying pavement, previously constructed PFC, curbs, manholes, and other structures against which new material is to be placed, shall be sprayed with a uniform light coat of bituminous material as specified in Section 32 12 10 BITUMINOUS TACK AND PRIME COATS. The amount of bituminous tack coat to be applied shall be the minimum specified in Section 32 12 10 BITUMINOUS TACK AND PRIME COATS.

### 3.3 PLACING

PFC mixtures shall not be placed 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.**  
\*\*\*\*\*

The PFC shall be placed so that longitudinal joints of the PFC will be offset from joints in the existing pavement by at least 300 mm 1 foot. Transverse joints in the PFC shall be offset 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. The mechanical spreader shall be adjusted and the speed regulated so that the surface of PFC will be smooth and continuous without tears and pulls, and of such depth that, when rolled, specified thickness is obtained. Placing of the mixture shall be as nearly continuous as possible, and speed of placing shall be adjusted as directed to permit proper rolling. If segregation occurs in the mixture during placement, the spreading operation shall be suspended 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, the screed of the mechanical spreader shall overlap the previously placed strip and be set at a sufficient height, so that after rolling a smooth uniform joint is obtained. Mixture placed on the edge of the previously placed strip by the mechanical spreader shall be removed by hand and wasted.

#### 3.3.4 Handspreading in Lieu of Machine Spreading

In isolated small areas where the use of machine spreading is impractical, mixture shall be spread by hand. Spreading shall be in a manner to prevent segregation. Mixture shall be placed and spread uniformly with hot shovels and smoothed with hot lutes in a loose layer of such thickness that, when rolled, will conform to the required thickness.

### 3.4 ROLLING OF MIXTURE

Rolling shall begin 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 to properly seat the material shall be applied to the PFC. Additional rolling shall be performed only if directed. Deficiencies shall be corrected so that the finished course will conform 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 AND SURFACE-SMOOTHNESS REQUIREMENTS 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. The surface, against which new material is placed, shall be sprayed with a uniform coat of bituminous material as specified in Section 32 12 10 BITUMINOUS TACK AND PRIME COATS. The tack coat shall be applied far enough in advance of the placement of fresh mixture to ensure adequate curing. Care shall be taken 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. In continuing the placement of a strip, the mechanical spreader shall be positioned on the transverse joint so that sufficient PFC will be spread to obtain a joint after rolling that conforms to the required thickness and smoothness specified herein.

#### 3.5.2 Longitudinal Joints

Edges of a previously placed strip shall be placed 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. Particular care shall be taken in rolling this joint. Joint edges of PFC which do not conform to these requirements shall be removed for the full width of the strip and replaced in accordance with paragraph CORRECTING DEFICIENT AREAS.

### 3.6 EDGES OF PAVEMENT

Edges of pavement adjacent to shoulders shall be trimmed neatly to line.

### 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.

\*\*\*\*\*

Mixtures of PFC that become contaminated or are defective shall be removed to the full thickness of course. Edges of the area to be removed shall be cut so that sides are perpendicular and parallel to direction of traffic and so that edges are vertical. Edges shall be lightly sprayed with bituminous materials as specified in Section 32 12 10 BITUMINOUS TACK AND PRIME COATS. Fresh PFC mixture shall be placed in the excavated areas in sufficient quantity so that the finished surface will conform to the thickness and smoothness requirements. Skin patching of an area will not be permitted. Existing underlying material damaged during removal of contaminated or defective PFC shall be [removed and replaced to match existing] [repaired as specified in paragraph Surface Preparation] before placing PFC.

### 3.8 CONTRACTOR QUALITY CONTROL (CQC)

The Contractor shall be responsible 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. Reports shall be prepared of all testing and inspection and shall be submitted within 24 hours of the time sampling or testing took place. Minimum acceptable extent of testing and inspection shall be as follows:

- a. Quality and gradation tests shall be made on samples of aggregate as it is delivered to the site, at least one for every 2250 metric tons 2500 tons of each size of aggregate.
- b. Gradation test shall be made on samples of aggregate from the cold feed, at least one for every 225 metric tons 250 tons of each size of aggregate.
- c. Depth of uncompacted bituminous courses shall be tested with a probe, immediately behind the paver and at least once for every 15 meters 50 ft of lane. No written report is necessary.
- d. Tests for asphalt content shall be made.
- e. The Contractor shall 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 shall be tested as necessary, to assure that specification requirements are attained.
- g. Placing operations, including construction of joints, shall be continuously checked for conformance with specification requirements. Problems encountered shall be reported.

### 3.9 ACCEPTABILITY OF WORK

Acceptance of the PFC mixture and completed pavement will be based on gradation, asphalt content, and smoothness. Testing for acceptability of work to determine percent payment will be performed by the Government. 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 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. The following paragraph will be edited accordingly.

\*\*\*\*\*

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 D 2172, Method A or B. Gradation shall be determined on the recovered aggregate according to ASTM C 117 and ASTM C 136.

#### 3.10.1 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 III. 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.

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#### 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
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 III. 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 III. 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

### 3.10.2 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 IV. The computed percent payment based on asphalt content will be the value obtained from TABLE IV. All Asphalt content tests will be completed and reported within 24 hours after completion of construction of each lot.

TABLE IV. 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

### 3.10.3 Surface Smoothness

\*\*\*\*\*  
 NOTE: Text in the first set of brackets will be  
 deleted for the construction of roads, and the text  
 in the second set of brackets will be used.  
 Designer will delete requirements in TABLE V which  
 are not applicable to the project.  
 \*\*\*\*\*

[After completion of rolling a lot, the finished surface will be tested by the Contracting Officer with a straightedge. Measurements will be made perpendicular to and across all joints at equal distances along the joint not to exceed 8 meters 25 feet. The location and amount of deviation from straightedge for all measurements will be recorded. 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 V, the computed percent payment for that entire lot shall not exceed 95 percent. Any joint or mat-area-surface deviation which exceeds the tolerance by more than 50 percent shall be corrected to meet the specification requirements.] [The finished surface will be tested with a straightedge by the Contracting Officer. Each measurement will be along a line parallel to the centerline. The smoothness measurements will be at equal distances parallel to the centerline, not to exceed 8 meters 25 feet. Location and amount of deviation from straightedge for all measurements will be recorded. When more than 5 percent of all measurements within a lot exceed the specified tolerance given in Table V, the computed percent payment for that lot shall not exceed 95 percent. Any localized areas that exceed the tolerance by more than 50 percent shall be corrected to meet the specification requirements.] Corrections required by this paragraph shall consist of removal and replacement as specified in paragraph CORRECTING DEFICIENT AREAS.

TABLE V. 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 V. 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



#### 3.10.4 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 C 174/C 174M. The Contractor shall fill all core holes with hot PFC mixture and compact.

#### 3.10.5 Thickness Deficiency

When the measurement of any core indicates that the pavement is deficient in thickness by more than 3 mm 1/8 inch, additional cores shall be drilled 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. The pavement area determined to be deficient in thickness shall be removed and replaced 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.

#### 3.11 PROTECTION OF PAVEMENT

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NOTE: The basic requirement is to avoid traffic damage to the PFC. The minimum suggested cure time for PFCs 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. PFCs 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, no vehicular traffic of any kind shall be permitted on the pavement for [\_\_\_\_\_] days.

-- End of Section --