

**337 ASPHALT CONCRETE FRICTION COURSES.**  
**(REV 6-13-05) (FA 7-26-05) (1-06)**

SECTION 337 (Pages 269-278) is deleted and the following substituted:

**SECTION 337**  
**ASPHALT CONCRETE FRICTION COURSES**

**337-1 Description.**

Construct an asphalt concrete friction course pavement with the type of mixture specified in the Contract, or when offered as alternates, as selected. This Section specifies mixes designated as FC-5, FC-9.5, and FC-12.5.

Meet the plant and equipment requirements of Section 320, as modified herein. Meet the general construction requirements of Section 330, as modified herein.

**337-2 Materials.**

**337-2.1 General Requirements:** Meet the requirements specified in Division III as modified herein. The Engineer will base continuing approval of material sources on field performance.

**337-2.2 Asphalt Binder:** Meet the requirements of Section 336, and any additional requirements or modifications specified herein for the various mixtures. When called for in the Contract Documents, use a PG 76-22 asphalt binder meeting the requirements of 916-1. For projects with a total quantity of FC-5, FC-9.5, or FC-12.5 less than 500 tons [500 metric tons], the Contractor may elect to substitute a PG 76-22 for the ARB-12 or ARB-5, meeting the requirements of 916-1.

**337-2.3 Coarse Aggregate:** Meet the requirements of Section 901, and any additional requirements or modifications specified herein for the various mixtures.

**337-2.4 Fine Aggregate:** Meet the requirements of Section 902, and any additional requirements or modifications specified herein for the various mixtures.

**337-2.5 Hydrated Lime:** Meet the requirements of AASHTO M303 Type 1.

Provide certified test results for each shipment of hydrated lime indicating compliance with the specifications.

**337-2.6 Fiber Stabilizing Additive (Required for FC-5 only):** Use either a mineral or cellulose fiber stabilizing additive. Meet the following requirements:

**337-2.6.1 Mineral Fibers:** Use mineral fibers (made from virgin basalt, diabase, or slag) treated with a cationic sizing agent to enhance the disbursement of the fiber, as well as to increase adhesion of the fiber surface to the bitumen. Meet the following requirements for physical properties:

1. Size Analysis

Average fiber length 0.25 inch [6.0 mm] (maximum)

Average fiber thickness...0.0002 inch [0.005 mm] (maximum)

2. Shot Content (ASTM C612)

Percent passing No. 60 [250 μm] Sieve..... 90 - 100

Percent passing No.230 [63 μm] Sieve..... 65 - 100

Provide certified test results for each batch of fiber material indicating compliance with the above tests.

**337-2.6.2 Cellulose Fibers:** Use cellulose fibers meeting the following requirements:

1. Fiber length .....0.25 inch [6.0 mm] (maximum)
2. Sieve Analysis
  - a. Alpine Sieve Method  
Percent passing No. 100 [150 μm] sieve 60-80
  - b. Ro-Tap Sieve Method  
Percent passing No. 20 [850 μm] sieve 80-95  
Percent passing No. 40 [425 μm] sieve 45-85  
Percent passing No. 100 [150 μm] sieve.. 5-40
3. Ash Content: ..... 18% non-volatiles (±5%)
4. pH:.....7.5 (±1.0)
5. Oil Absorption: .....5.0 (±1.0) (times fiber weight)
6. Moisture Content: .....5.0 (maximum)

Provide certified test results for each batch of fiber material indicating compliance with the above tests.

### **337-3 General Composition of Mixes.**

**337-3.1 General:** Use a bituminous mixture composed of aggregate (coarse, fine, or a mixture thereof), asphalt rubber binder, and in some cases, fibers and/or hydrated lime. Size, uniformly grade and combine the aggregate fractions in such proportions that the resulting mix meets the requirements of this Section. The use of RAP material will not be permitted.

#### **337-3.2 Specific Component Requirements by Mix:**

##### **337-3.2.1 FC-5:**

**337-3.2.1.1 Aggregates:** Use an aggregate blend which consists of either 100% crushed granite or 100% crushed Oolitic limestone.

In addition to the requirements of Section 901, meet the following coarse aggregate requirements. Use either crushed granite or crushed limestone. Use crushed limestone from the Oolitic formation, which contains a minimum of 12% non-carbonate material (as determined by FM 5-510), and has been approved for this use.

In addition to the requirements of Section 902, meet the following fine aggregate requirements. Use either crushed granite screenings, or crushed Oolitic limestone screenings for the fine aggregate.

**337-3.2.1.2 Asphalt Binder:** Use an ARB-12 asphalt rubber binder. If called for in the Contract Documents, use a PG 76-22 asphalt binder.

**337-3.2.1.3 Hydrated Lime:** Add the lime at a dosage rate of 1.0% by weight of the total dry aggregate to mixes containing granite.

**337-3.2.1.4 Fiber Stabilizing Additive:** Add either mineral fibers at a dosage rate of 0.4% by weight of the total mix, or cellulose fibers at a dosage rate of 0.3% by weight of total mix.

##### **337-3.2.2 FC-9.5 and FC-12.5:**

**337-3.2.2.1: Aggregates:** In addition to the requirements of Sections 901 and 902, use coarse and fine aggregate components which also meet the aggregate requirements for an SP-9.5 or SP-12.5 Superpave mix, respectively, as specified in Section 334.

Use an aggregate blend that consists of crushed granite, crushed Oolitic limestone, or a combination of the two. (Aggregates other than those listed above may be used if approved by the Engineer for use in friction courses.) Crushed limestone from the Oolitic

formation may be used if it contains a minimum of 12% non-carbonate material as determined by FM 5-510 and the Engineer grants approval of the source prior to its use. As an exception, mixes that contain a minimum of 60% crushed granite may contain up to 40% fine aggregate from other approved sources.

**337-3.2.2.2: Asphalt Binder:** Use an ARB-5 asphalt rubber binder. If called for in the Contract, use a PG 76-22 asphalt binder.

**337-3.3 Grading Requirements:**

**337-3.3.1 FC-5:** Use a mixture having a gradation at design within the ranges shown in Table 337-1.

Table 337-1 FC-5 Gradation Design Range									
3/4 inch [19.0 mm]	1/2 inch [12.50 mm]	3/8 inch [9.50 mm]	No. 4 [4.75 mm]	No. 8 [2.36 mm]	No. 16 [1.18 mm]	No. 30 [600 :m]	No. 50 [300 :m]	No. 100 [150 :m]	No. 200 [75 :m]
100	85-100	55-75	15-25	5-10	--	--	--	--	2-4

**337-3.3.2 FC-9.5:** Meet the design gradation requirements for a SP-9.5 Superpave fine mix as defined in 334-3.2.2.

**337-3.3.3 FC-12.5:** Meet the design gradation requirements for a SP-12.5 Superpave fine mix as defined in 334-3.2.2.

**337-4 Mix Design.**

**337-4.1 FC-5:** The Department will design the FC-5 mixtures. Furnish the materials and all appropriate information (source, gradation, etc.) as specified in 334-3.2.7. The Department will have two weeks to design the mix.

The Department will establish the design binder content for FC-5 within the following ranges based on aggregate type:

Aggregate Type	Binder Content
Crushed Granite	5.5 - 7.0
Crushed Limestone (Oolitic)	6.5 - 8.0

**337-4.2 FC-9.5 and FC-12.5:** Provide a mix design conforming to the requirements of 334-3.2 for Traffic Level C unless otherwise designated in the plans. Develop the mix design using an ARB-5 or PG 76-22 asphalt binder if called for in the Contract Documents.

**337-4.3 Revision of Mix Design:** For FC-5, FC-9.5 and FC-12.5, meet the requirements of 334-3.3. For FC-5, all revisions must fall within the gradation limits defined in Table 337-1.

**337-5 Contractor's Process Control.**

Provide the necessary process control of the friction course mix and construction in accordance with the applicable provisions of 330-2 and 334-4 for FC-5, and 330-2 and 334-4 for FC-9.5 and FC-12.5.

The Engineer will monitor the spread rate periodically to ensure uniform thickness. Provide quality control procedures for daily monitoring and control of spread rate variability. If the spread rate varies by more than 5% of the spread rate set by the Engineer in accordance with

337-9, immediately make all corrections necessary to bring the spread rate into the acceptable range.

**337-6 Acceptance of the Mixture.**

**337-6.1 FC-9.5 and FC-12.5:** Meet the requirements of 334-5.

**337-6.2 FC-5:** Meet the requirements of 334-5 with the following exceptions:

1. The mixture will be accepted with respect to gradation (P<sub>-3/8</sub>, P<sub>-4</sub>, and P<sub>-8</sub>), and asphalt binder content (P<sub>b</sub>) only.
2. Testing in accordance with AASHTO T312-04 and FM 1-T 209 (and conditioning prior to testing) will not be required as part of 334-5.1.1.
3. The standard LOT size of FC-5 will be 2,000 tons [2,000 metric tons], with each LOT subdivided into four equal sublots of 500 tons [500 metric tons] each.
4. Initial production requirements of 334-5.3 do not apply.
5. The Between-Laboratory Precision Values described in Table 334-5 are modified to include (P<sub>-3/8</sub>, P<sub>-4</sub>, and P<sub>-8</sub>) with a maximum difference per FM 1-T 030 (Figure 2).
6. Table 334-4 (Master Production Range) is replaced by Table 337-2.
7. The mixture will be accepted on the roadway with respect to surface tolerance in accordance with the applicable requirements of 334-5.8. No density testing will be required for these mixtures.

Table 337-2 FC-5 Master Production Range	
Characteristic	Tolerance (1)
Asphalt Binder Content (%)	Target ± 0.60
Passing 3/8 inch [9.50 mm] Sieve (%)	Target ± 7.50
Passing No. 4 [4.75 mm] Sieve (%)	Target ± 6.00
Passing No. 8 [2.36 mm] Sieve (%)	Target ± 3.50
(1) Tolerances for sample size of n = 1 from the verified mix design	

**337-6.2.1 Individual Test Tolerances for FC-5 Production:** In the event that an individual Quality Control test result of a subplot for gradation (P<sub>-3/8</sub>, P<sub>-4</sub>, and P<sub>-8</sub>), does not meet the requirements of Table 337-2, take steps to correct the situation and report them to the Engineer.

In the event that two consecutive individual Quality Control test results for gradation (P<sub>-3/8</sub>, P<sub>-4</sub>, and P<sub>-8</sub>) or an individual test result for asphalt binder content does not meet the requirements of Table 337-2, the LOT will be automatically terminated and production of the mixture stopped until the problem is adequately resolved (to the satisfaction of the Engineer), unless it can be demonstrated to the satisfaction of the Engineer that the problem can immediately be (or already has been) resolved. Address any material represented by the failing test result in accordance with 334-5.9.5.

**337-7 Special Construction Requirements.**

**337-7.1 Hot Storage of FC-5 Mixtures:** When using surge or storage bins in the normal production of FC-5, do not leave the mixture in the surge or storage bin for more than one hour.

**337-7.2 Longitudinal Grade Controls for Open-Graded Friction Courses:** On FC-5, use either longitudinal grade control (skid, ski or traveling stringline) or a joint matcher.

### **337-7.3 Temperature Requirements for FC-5:**

**337-7.3.1 Air Temperature at Laydown:** Spread the mixture only when the air temperature (the temperature in the shade away from artificial heat) is at or above 65°F [18°C]. As an exception, place the mixture at temperatures lower than 65°F [18°C], only when approved by the Engineer based on the Contractor's demonstrated ability to achieve a satisfactory surface texture and appearance of the finished surface. In no case shall the mixture be placed at temperatures lower than 60°F [16°C].

**337-7.3.2 Temperature of the Mix:** Heat and combine the asphalt rubber binder and aggregate in a manner to produce a mix having a temperature, when discharged from the plant, meeting the requirements of 330-6.3. Meet all requirements of 330-9.1.2 at the roadway. The target mixing temperature shall be established at 320°F [160°C].

**337-7.4 Compaction of FC-5:** Provide two, static steel-wheeled rollers, with an effective compactive weight in the range of 135 to 200 PLI [2.4 to 3.6 kg/mm], determined as follows:

Non SI Units

$$PLI = \frac{\text{Total Weight of Roller (pounds)}}{\text{Total Width of Drums (inches)}}$$

SI Units

$$\frac{\text{kg}}{\text{mm}} = \frac{\text{Total Weight of Roller (kilograms)}}{\text{Total Width of Drums (millimeters)}}$$

(Any variation of this equipment requirement must be approved by the Engineer.) Establish an appropriate rolling pattern for the pavement in order to effectively seat the mixture without crushing the aggregate. In the event that the roller begins to crush the aggregate, reduce the number of coverages or the PLI of the rollers. If the rollers continue to crush the aggregate, use a tandem steel-wheel roller weighing not more than 135 lb/in (PLI) [2.4 kg/mm] of drum width.

### **337-7.5 Temperature Requirements for FC-9.5 and FC-12.5:**

**337-7.5.1 Air Temperature at Laydown:** Spread the mixture only when the air temperature (the temperature in the shade away from artificial heat) is at or above 45°F [7°C].

**337-7.5.2 Temperature of the mix:** Heat and combine the asphalt rubber binder and aggregate in a manner to produce a mix having a temperature, when discharged from the plant, meeting the requirements of 330-6.3. Meet all requirements of 330-9.1.2 at the roadway.

**337-7.6 Prevention of Adhesion:** To minimize adhesion to the drum during the rolling operations, the Contractor may add a small amount of liquid detergent to the water in the roller.

At intersections and in other areas where the pavement may be subjected to cross-traffic before it has cooled, spray the approaches with water to wet the tires of the approaching vehicles before they cross the pavement.

**337-7.7 Transportation Requirements of Friction Course Mixtures:** Cover all loads of friction course mixtures with a tarpaulin.

### 337-8 Thickness of Friction Courses.

**337-8.1 FC-12.5 and FC-9.5:** The thickness of the friction course layer will be the plan thickness as shown in the Contract Documents. For construction purposes, the plan thickness will be converted to spread rate as defined in 334-1.4.

Plan quantities are based on a  $G_{mm}$  of 2.540, corresponding to a spread rate of 110 lbs/yd<sup>2</sup>-in [23.6 kg/m<sup>2</sup>/10 mm]. Pay quantities will be based on the actual maximum specific gravity of the mix being used.

**337-8.2 FC-5:** The total thickness of the FC-5 layer will be the plan thickness as shown in the Contract Documents. For construction purposes, the plan thickness will be converted to spread rate based on the combined aggregate bulk specific gravity of the asphalt mix being used as shown in the following equation:

#### Non-SI Units

$$\text{Spread rate (lbs/yd}^2\text{)} = t \times G_{sb} \times 40.5$$

Where:  $t$  = Thickness (in.) (Plan thickness)  
 $G_{sb}$  = Combined aggregate bulk specific gravity from the verified mix design

#### SI Units

$$\text{Spread rate (kg/m}^2\text{)} = t \times G_{sb} \times 0.83$$

Where:  $t$  = Thickness (mm) (Plan thickness)  
 $G_{sb}$  = Combined aggregate bulk specific gravity from the verified mix design

The weight of the mixture shall be determined as provided in 320-2.2.

Plan quantities are based on a  $G_{sb}$  of 2.635, corresponding to a spread rate of 80 lbs/yd<sup>2</sup> [44 kg/m<sup>2</sup>]. Pay quantities will be based on the actual combined aggregate bulk specific gravity ( $G_{sb}$ ) of the mix being used.

### 337-9 Special Equipment Requirements for FC-5.

**337-9.1 Fiber Supply System:** Use a separate feed system to accurately proportion the required quantity of mineral fibers into the mixture in such a manner that uniform distribution is obtained. Interlock the proportioning device with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes. Control the proportion of fibers to within plus or minus 10% of the amount of fibers required. Provide flow indicators or sensing devices for the fiber system, interlocked with plant controls so that the mixture production will be interrupted if introduction of the fiber fails.

When a batch plant is used, add the fiber to the aggregate in the weigh hopper or as approved and directed by the Engineer. Increase the batch dry mixing time by 8 to 12 seconds, or as directed by the Engineer, from the time the aggregate is completely emptied into the pugmill. Ensure that the fibers are uniformly distributed prior to the addition of asphalt rubber into the pugmill.

When a drum-mix plant is used, add and uniformly disperse the fiber with the aggregate prior to the addition of the asphalt rubber. Add the fiber in such a manner that it will not become entrained in the exhaust system of the drier or plant.

**337-9.2 Hydrated Lime Supply System:** For FC-5 mixes containing granite, use a

separate feed system to accurately proportion the required quantity of hydrated lime into the mixture in such a manner that uniform coating of the aggregate is obtained prior to the addition of the asphalt rubber. Add the hydrated lime in such a manner that it will not become entrained in the exhaust system of the drier or plant. Interlock the proportioning device with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes and to ensure that all mixture produced is properly treated with hydrated lime. Control the proportion of hydrated lime to within plus or minus 10% of the amount of hydrated lime required. Provide and interlock flow indicators or sensing devices for the hydrated lime system with plant controls so that the mixture production will be interrupted if introduction of the hydrated lime fails. The addition of the hydrated lime to the aggregate may be accomplished by Method (A) or (B) as follows:

**337-9.2.1 Method (A) - Dry Form:** Add hydrated lime in a dry form to the mixture according to the type of asphalt plant being used.

When a batch plant is used, add the hydrated lime to the aggregate in the weigh hopper or as approved and directed by the Engineer. Increase the batch dry mixing time by eight to twelve seconds, or as directed by the Engineer, from the time the aggregate is completely emptied into the pugmill. Uniformly distribute the hydrated lime prior to the addition of asphalt rubber into the pugmill.

When a drum-mix plant is used, add and uniformly disperse the hydrated lime to the aggregate prior to the addition of the asphalt rubber. Add the hydrated lime in such a manner that it will not become entrained in the exhaust system of the drier or plant.

**337-9.2.2 Method (B) - Hydrated Lime/Water Slurry:** Add the required quantity of hydrated lime (based on dry weight) in a hydrated lime/water slurry form to the aggregate. Provide a solution consisting of hydrated lime and water in concentrations as directed by the Engineer. Use a plant equipped to blend and maintain the hydrated lime in suspension and to mix it with the aggregates uniformly in the proportions specified.

**337-9.3 Hydrated Lime Pretreatment:** For FC-5 mixes containing granite, as an alternative to 337-10.2, pretreat the aggregate with hydrated lime prior to incorporating the aggregate into the mixture. Use a feed system to accurately proportion the aggregate and required quantity of hydrated lime, and mix them in such a manner that uniform coating of the aggregate is obtained. Control the proportion of hydrated lime to within  $\pm 10\%$  of the amount required. Aggregate pretreated with hydrated lime in this manner shall be incorporated into the asphalt mixture within 45 days of pretreatment.

**337-9.3.1 Hydrated Lime Pretreatment Methods:** Pretreat the aggregate using one of the following two methods:

**Pretreatment Method A – Dry Form:** Add the required quantity of hydrated lime in a dry form to the aggregate. Assure that the aggregate at the time of pretreatment contains a minimum of 3% moisture over saturated surface dry (SSD) conditions. Utilize equipment to accurately proportion the aggregate and hydrated lime and mix them in such a manner as to provide a uniform coating.

**Pretreatment Method B – Hydrated Lime/Water Slurry:** Add the required quantity of hydrated lime (based on dry weight) in a hydrated lime/water slurry form to the aggregate. Provide a solution consisting of hydrated lime and water in a concentration to provide effective treatment. Use equipment to blend and maintain the hydrated lime in suspension, to accurately proportion the aggregate and hydrated lime/water slurry, and to mix them to provide a uniform coating.

**337-9.3.2 Blending Quality Control Records:** Maintain adequate Quality Control records for the Engineer's review for all pretreatment activities. Include as a minimum the following information (for each batch or day's run of pretreatment): pretreatment date, aggregate certification information, certified test results for the hydrated lime, aggregate moisture content prior to blending, as-blended quantities of aggregate and hydrated lime, project number, customer name, and shipping date.

**337-9.3.3 Certification:** In addition to the aggregate certification, provide a certification with each load of material delivered to the HMA plant, that the material has been pretreated in conformance with these specifications. Include also the date the material was pretreated.

### **337-10 Failing Material.**

Meet the requirements of 334-5.9. For FC-5, use the Master Production Range defined in Table 337-2 in lieu of Table 334-4.

### **337-11 Method of Measurement.**

For the work specified under this Section (including the pertinent provisions of Sections 320 and 330), the quantity to be paid for will be the weight of the mixture, in tons [metric tons]. The pay quantity will be based on the average spread rate for the project, limited to a maximum of 105% of the spread rate set by the Engineer in accordance with 337-8.

The bid price for the asphalt mix will include the cost of the asphalt binder (asphalt rubber (or polymer), asphalt cement, ground tire rubber, anti-stripping agent, blending and handling) and the tack coat application as directed in 300-8, as well as fiber stabilizing additive and hydrated lime (if required). There will be no separate payment or unit price adjustment for the asphalt binder material in the asphalt mix. The weight will be determined as provided in 320-2 (including the provisions for the automatic recordation system).

Prepare a Certification of Quantities, using the Department's current approved form, for the certified asphalt concrete friction course pay item. Submit this certification to the Engineer no later than Twelve O'clock noon Monday after the estimate cut-off or as directed by the Engineer, based on the quantity of asphalt produced and accepted on the Contract. The certification must include the Contract Number, FPID Number, Certification Number, Certification Date, period represented by Certification and the tons [metric tons] produced for each asphalt pay item.

### **337-12 Basis of Payment.**

**337-12.1 General:** Price and payment will be full compensation for all the work specified under this Section (including the applicable requirements of Sections 320 and 330).

Based upon the quality of the material, a pay adjustment will be applied to the bid price of the material as determined on a LOT by LOT basis. The pay adjustment will be assessed by calculating a Pay Factor for individual quality characteristics. The pay adjustment will be computed by multiplying a Composite Pay Factor for the LOT by the bid price per ton [metric ton]. Perform all calculations with the Department's Asphalt Plant - Pay Factor Worksheets (Form No. 675-030-22).

**337-12.2 FC-9.5 and FC-12.5:** Meet the requirements of 334-8.

**337-12.3 FC-5:** Meet the requirements of 334-8 with the following exceptions:

1. Pay factors will be calculated for asphalt binder content and the percentages passing the 3/8 inch [9.50 mm], the No. 4 [4.75 mm], and the No. 8 [2.36 mm] sieves only.

2. Table 337-3 replaces Table 334-6.
3. Table 337-4 replaces Table 334-7.
4. The Composite Pay Factor equation in 334-8.3 is replaced with the following:

$$\text{CPF} = [(0.20 \times \text{PF } 3/8 \text{ inch [9.50 mm]}) + (0.30 \times \text{PF No. 4 [4.75 mm]}) + (0.10 \times \text{PF No. 8 [2.36 mm]}) + (0.40 \times \text{PF AC})]$$

Table 337-3 Small Quantity Pay Table for FC-5		
Pay Factor	1-Test Deviation	2-Test Average Deviation
Asphalt Binder Content (%)		
1.00	0.00-0.50	0.00-0.35
0.90	0.51-0.60	0.36-0.42
0.80	>0.60	>0.42
3/8 inch [9.50 mm] Sieve (%)		
1.00	0.00-6.50	0.00-4.60
0.90	6.51-7.50	4.61-5.30
0.80	>7.50	>5.30
No. 4 [4.75 mm] Sieve (%)		
1.00	0.00-5.00	0.00-3.54
0.90	5.01-6.00	3.55-4.24
0.80	>6.00	>4.24
No. 8 [2.36 mm] Sieve (%)		
1.00	0.00-3.00	0.00-2.12
0.90	3.01-3.50	2.13-2.47
0.80	>3.50	>2.47

Table 337-4 Specification Limits for FC-5	
Quality Characteristic	Specification Limits
Asphalt Binder Content (%)	Target $\pm$ 0.45
Passing 3/8 inch [9.50 mm] sieve (%)	Target $\pm$ 6.00
Passing No. 4 [4.75 mm] sieve (%)	Target $\pm$ 4.50
Passing No. 8 [2.36] sieve (%)	Target $\pm$ 2.50

**337-12.4 Payment:** Payment will be made under:

- Item No. 337- 7- Asphaltic Concrete Friction Course -per ton.
- Item No. 2337- 7- Asphaltic Concrete Friction Course -per metric ton.