



# Standard Guide for Materials and Construction of Open-Graded Friction Course Plant Mixtures<sup>1</sup>

This standard is issued under the fixed designation D6932/D6932M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This guide covers the construction of bituminous open-graded friction course plant mixtures. End-use specifications should be adopted to conform to job and user requirements. Where applicable, Specification **D3666** should be applied as a minimum for agencies testing and inspecting road and paving materials.

1.2 Bituminous open-graded friction courses are placed as the final wearing course for highways and airfields.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

## 2. Referenced Documents

### 2.1 *ASTM Standards:*<sup>2</sup>

- C29/C29M** Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
- C88** Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
- C127** Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
- C128** Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
- C131** Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- C136** Test Method for Sieve Analysis of Fine and Coarse Aggregates
- C1252** Test Methods for Uncompacted Void Content of Fine

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee **D04** on Road and Paving Materials and is the direct responsibility of Subcommittee **D04.23** on Plant-Mixed Bituminous Surfaces and Bases.

Current edition approved Dec. 1, 2013. Published February 2014. Originally approved in 2004. Last previous edition approved in 2008 as D6932/D6932M – 08. DOI: 10.1520/D6932\_D6932M-08R13.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)

- D75** Practice for Sampling Aggregates
- D140** Practice for Sampling Bituminous Materials
- D448** Classification for Sizes of Aggregate for Road and Bridge Construction
- D946** Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
- D1461** Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures
- D2419** Test Method for Sand Equivalent Value of Soils and Fine Aggregate
- D2995** Practice for Estimating Application Rate of Bituminous Distributors
- D3381** Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction
- D3666** Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
- D4791** Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
- D5821** Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
- D6114** Specification for Asphalt-Rubber Binder
- D6307** Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method
- D6373** Specification for Performance Graded Asphalt Binder
- D6390** Test Method for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures
- D7064** Practice for Open-Graded Friction Course (OGFC) Mix Design

### 2.2 *Other References:*

- TRB NCHRP Synthesis 284** Performance Survey on Open-Graded Friction Course Mixes
- NCAT Report No. 2001-01** Design, Construction and Performance of New Generation Open-Graded Friction Courses
- FAA-RD-73-197**
- FAA-RD-74-38**

## 3. Terminology

### 3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *open-graded friction course (OGFC), n*—special type of hot mix asphalt surface mixture used for reducing hydroplaning and potential for skidding, where the function of the mixture is to provide a free-draining layer that permits surface water to migrate laterally through the mixture to the edge of the pavement.

3.1.1.1 *Discussion*—Example gradings can be found in [Appendix X1](#).

## 4. Significance and Use

4.1 This guide provides information to assist engineers with the design requirements and construction guidelines for paving an Open-Graded Friction Course (OGFC) surface layer. An OGFC is primarily used to improve the skid resistance and wear resistance of a bituminous pavement by providing an escape route for surface water beneath a moving wheel load. The mixture is typically produced with a low amount of fine aggregate particles and high air void content to provide a passageway of interconnected voids for moisture to drain away from the travelway. The film thickness of the asphalt and overall asphalt content is important for better stripping resistance and durability and aging properties.

NOTE 1—OGFCs may also be placed to reduce the tire-pavement interface noise and may also be placed to reduce the occurrence and severity of reflective cracking.

## 5. Types of Specification Information

5.1 Contract documentation for bituminous OGFC typically includes the following information:

5.1.1 Type of asphalt (for example, asphalt cement, polymer modified asphalt, asphalt rubber) and specification designation;

5.1.2 Grade of asphalt;

5.1.3 Quantity of asphalt required;

5.1.4 Type of aggregate (for example, crushed stone, crushed gravel, crushed slag, gravel, slag) specification designation;

5.1.5 Aggregate quality requirements (for example, coarse aggregate angularity, fine aggregate angularity, L.A. abrasion, soundness, water absorption, sand equivalent);

5.1.6 Size or sizes of aggregate to be furnished;

5.1.7 Quantity of additive, or anti-stripping agent, or both;

5.1.8 Quantity of open-graded mix; and

5.1.9 Special requirements.

## 6. Aggregate

6.1 Aggregate shall conform to Classification [D448](#) except where noted in this guide.

6.2 *Size*—Aggregate should be as close to one size as is economically practical, preferably in the range of 12.5 to 4.75 mm [ $\frac{1}{2}$  in. to No. 4], for OGFC with up to 25 mm [1.0 in.] in compacted thickness.

6.3 *Shape*—The ideal shape is cubical or angular. To achieve adequate angularity it is suggested that the coarse aggregate have at least 95 % one-fractured face and 90 % two-fractured face as measured by Test Method [D5821](#). To help achieve a more cubical shape it is suggested that the coarse aggregate maximum amount of flat or elongated particles as measured by Test Method [D4791](#) not exceed 10 %

with a ratio of 5 to 1 in maximum dimension to minimum dimension. Rounded particles are not acceptable. The uncompacted void content (fine aggregate angularity-FAA) as measured by Test Methods [C1252](#) should be 40 % or greater.

6.4 *Cleanliness*—It is important that the aggregate be clean. The sand equivalent value of the fine aggregate passing the 2.36 mm [No. 8] sieve according to Test Method [D2419](#) should be at least 45 % or greater. It is recommended that the material to be tested be separated on the 2.36 mm [No. 8] sieve because of the coarse grading of the aggregate. It is also very important to remove any coatings or fines adhering to the coarse material.

## 7. Asphalt Binder

7.1 Asphalt cement shall conform to Specifications [D946](#), [D3381](#), or [D6373](#).

7.2 When modified asphalt is used, it shall conform to Specification [D6373](#).

7.3 When asphalt-rubber is used, it shall conform to Specification [D6114](#).

NOTE 2—The asphalt type and grade to be used depends on the type of construction, climatic conditions, amount and nature of traffic.

## 8. Composition of Open-Graded Mixtures

8.1 The asphalt content shall be determined in accordance with the owner's selection method or Practice [D7064](#).

8.2 The asphalt cement open-graded mixture will typically consist of 93 to 95 % aggregate and 5 to 7 % asphalt by weight of total mixture.

8.3 The modified asphalt open-graded mixture typically consists of 92 to 94 percent aggregate and 6 to 8 % modified asphalt by weight of total mixture.

8.4 The asphalt-rubber open-graded mixture typically consists of 90 to 91.5 percent aggregate and 8.5 to 10 % asphalt-rubber by weight of total mixture.

NOTE 3—Due to the open-graded nature of the mixture it may be advisable to add 1 to 2 % cement or hydrated lime or a suitable anti-stripping agent to prevent stripping.

NOTE 4—The selected asphalt content should be checked by performing a suitable asphalt draindown test such as Test Method [D6390](#). Draindown may be reduced by using cellulose or mineral fiber. Typically the dosage is in the range of 0.2 to 0.5 % by mixture mass as per the mix design procedure test results. Polymer modified asphalt or asphalt-rubber mixes may not require fiber additives to obtain good performance or control draindown.

## 9. Production and Placement

9.1 Bituminous OGFC should not be placed during periods of cold or wet weather, or both. The existing surface shall be warm, clean, and dry while paving the OGFC.

9.1.1 Typically the minimum air temperature should be 16°C [60°F] in the shade and rising and the minimum surface temperature should be 21°C [70°F] in the shade and rising before starting the operation. Open-graded mixtures placed 12.5 mm [0.5 in.] to 25 mm [1.0 in.] in thickness will cool very rapidly and thus a higher minimum air and surface temperature may be advisable. Thus the specifying agency in setting the minimum air and surface temperature should consider their normal good paving practices and as a minimum the operation

should not be permitted when the temperature falls below such normal agency temperature thresholds.

NOTE 5—The specifying organization may want to consider setting or designating paving seasons to ensure optimal paving conditions.

9.1.2 The operation should not be carried out in the rain, or when rain is threatening.

9.1.3 The open-graded mixture should be placed as the final surface course with its edges exposed to ensure free draining at the edges. If it is placed in a curb and gutter section, it should be placed above the gutter.

9.1.4 The open-graded mixture is not a structural pavement layer and thus should not be expected to correct obvious pavement structural defects such as potholes or weak underlying pavement or foundation support. Some caution should be exercised in placing this mix on a surface that might be permeable or a cracked surface that would allow water to enter.

## 10. Method of Sampling and Testing

10.1 Calibrate bituminous distributors for proper application rate for tack coat using Practice **D2995**.

10.2 Sample bituminous materials according to Practice **D140** and test for conformance with the designated specification according to test methods indicated in that specification.

10.3 Sample all aggregates according to Practice **D75**. Test the aggregate according to the test methods listed in 6.3 and 6.4, according to the following test methods, as necessary.

10.3.1 *Bulk Density of Aggregates*—Test Method **C29/C29M**.

10.3.2 *Sulfate Soundness*—Test Method **C88**.

10.3.3 *Specific Gravity and Absorption*—Test Method **C127** or **C128** as applicable.

10.3.4 *Resistance to Degradation*—Test Method **C131**.

10.3.5 *Sieve Analysis*—Test Method **C136**.

10.4 Samples of the open-graded mix should be taken at the discretion of the engineer and tested for asphalt binder content using Test Method **D6307** and/or moisture content using Test Method **D1461** or by using methods as approved by the engineer.

10.5 Cores should be taken at the discretion of the engineer to verify the thickness of the open-graded mix.

## 11. Construction Procedure

11.1 Patch potholes, fill cracks, and repair damaged areas in existing pavements.

11.2 The surface to be covered should be cleaned with rotary broom or other approved means.

11.3 A tack coat should be applied to the paved surface before placement of the open-graded friction course.

NOTE 6—For asphalt-rubber open-graded mixtures, the tack coat is typically a paving grade liquid asphalt applied at the rate of 0.4 L/m<sup>2</sup> [0.08 gal/yd<sup>2</sup>].

11.4 The temperature of the asphalt cement open-graded mixture during compaction should be at least 93°C [200°F].

11.5 The temperature of the modified asphalt cement open-graded mixture during compaction should be in the range of 93 to 135°C [200 to 275°F].

NOTE 7—It is advised that the supplier of the modified asphalt binder be consulted for the proper mixing and compaction temperature ranges to be used in the field.

11.6 The temperature of the asphalt-rubber open-graded mixture during compaction should be at least 135°C [275°F].

11.7 Compact the OGFC by using self-propelled rollers, either steel wheel or pneumatic, in the non-vibratory mode following immediately behind the laydown machine.

NOTE 8—For asphalt-rubber open-graded mixtures, only steel wheeled rollers should be used for compaction, due to the high probability for particle pick-up by pneumatic tired rollers.

NOTE 9—The compaction equipment and method of rolling should be selected and done in a manner that it does not fracture the aggregate or damage the mix.

11.8 It may be advisable to place a test section to determine an adequate rolling pattern (typically 2 to 3 passes) and to ensure adequate compaction.

## 12. Keywords

12.1 asphalt cement; asphalt rubber; modified asphalt cement; open-graded friction course

## APPENDIX

### (Nonmandatory Information)

#### X1. OGFC MIXTURE DESIGNS

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**TABLE X1.1 Summary of 9.5 mm [ $\frac{3}{8}$  in.] Open-Graded Friction Course Mixture Designs**

Grading	Arizona [Unmodified AC]		Arizona [Asphalt Rubber]		California		Florida		Nevada		Wyoming		Georgia	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
12.5 mm [ $\frac{1}{2}$ in.]	100		100		100		100		100		100		100	
9.5 mm [ $\frac{3}{8}$ in.]	100		100		90	100	85	100	95	100	97	100	85	100
4.75 mm [No. 4]	35	55	30	45	29	36	10	40	40	65	25	45	20	40
2.36 mm [No. 8]	9	14	4	8	7	18	—	—	—	—	10	25	5	10
2.00 mm [No. 10]	—	—	—	—	—	—	4	12	—	—	—	—	—	—
1.18 mm [No. 16]	—	—	—	—	—	—	—	—	12	22	—	—	—	—
0.075 mm [No. 200]	0	2.5	0	2.5	0	0	2	5	0	4	2	7	2	4
Asphalt Binder Type	PG 64-16	PG 64-16 plus 20 % rubber	AR 4000 AR 8000 or PBA-6		AC 30 plus 12 % rubber		AC 20P or AC 30		PG 64-22 or PG 70-28				PG 67-22	
Content	6.0 %	8.5 to 10 %	6.5 to 8 %		5.5 to 7.0 %		6.5 % typical		6.3 to 6.8 %				6.0 to 7.3 %	

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