Designation: D 4223 – 99

Standard Practice for Preparation of Test Specimens of Asphalt-Stabilized Soils[1]

This standard is issued under the fixed designation D 4223; 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 (ε) indicates an editorial change since the last revision or reapproval.

1. Scope *

1.1 This practice covers the selection and proportioning of soils and emulsified or cutback asphalts and the fabrication of 4-in. (102-mm) diameter by 2.5-in. (54-mm) high test specimens.

1.2 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026.

1.3 The values stated in inch-pound units are to be regarded as standard, except as noted as follows. The values given in parentheses are mathematical conversions to SI units, and are provided for information only and are not considered standard.

1.3.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.3.2 The slug unit of mass is almost never used in commercial practice (density, scales, balances, and so forth). Therefore, the standard unit for mass in this practice is either kilogram (kg) or gram (g), or both. Also, the equivalent inch-pound unit (slug) is not given.

1.3.3 It is common practice in the engineering/construction profession in the United States to concurrently use pound to represent both a unit of mass (lbm) and of force (lbf). This use combines two separate system of units, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. As stated in 1.3.2, this practice uses the gravitational system and does not present the slug unit for mass. However, the use of scales or balances recording pounds of mass (lbm) or the recording of density in lbm/ft^3 shall not be regarded as nonconformance with this practice.

1.4 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 117 Test Method for Material Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing[2]

C 136 Method for Sieve Analysis of Fine and Coarse Aggregates[2]

D 8 Terminology Relating to Materials for Roads and Pavements[3]

D 75 Practice for Sampling Aggregates[3]

D 653 Termonology Relating to Soil, Rock, and Contained Fluids[4]

D 977 Specification for Emulsified Asphalt[3]

D 1074 Test Method for Compressive Strength of Bituminous Mixtures[3]

D 1188 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens[3]

D 1559 Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus[3]

D 1560 Test Methods for Resistance to Deformation and Cohesion of Bituminous Mixtures by Means of Hveem Apparatus[3]

D 1561 Practice for Preparation of Bituminous Mixture Test Specimens by Means of California Kneading Compactor[3]

D 2026 Specification for Cutback Asphalt (Slow-Curing Type)[3]

D 2027 Specification for Cutback Asphalt (Medium-Curing Type)[3]

D 2028 Specification for Cutback Asphalt (Rapid-Curing Type)[3]

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock Soil-Aggregate Mixtures[4]

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization with Admixtures.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.03.

[4] *Annual Book of ASTM Standards*, Vol 04.08.

***A Summary of Changes section appears at the end of this standard.**

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D 2397 Specification for Cationic Emulsified Asphalt[3]
D 2419 Test Method for Sand Equivalent Value of Soils and Fine Aggregate[3]
D 2726 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens[3]
D 3740 Practice for the Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock Used in Engineering Design and Construction[4]
D 4123 Method of Indirect Tension Test for Resilient Modulus of Bituminous Mixtures[3]
D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[4]
D 6026 Practice for Using Significant Digits in Calculating and Reporting Geotechnical Test Data[5]

3. Significance and Use

3.1 This practice is intended for the preparation of standard specimens of soil-asphalt mixtures suitable for tests of Test Methods D 1559, D 1560, D 1561, D 4123, and other tests using specimens of the above dimensions. This practice is limited to only fine-grained soils as defined in 6.1.

NOTE 1—The quality of the results produced by this practice is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing, sampling, inspection, and so forth. Users of this practice are cautioned that compliance with Practice D 3740 does not in itself ensure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

4. Terminology

4.1 Refer to Terminology D 653 for terms relating to soils and to Terminology D 8 for terms relating to asphalt.

5. Apparatus

5.1 All testing equipment is described in the appropriate standards given in Section 2 of this practice.

6. Materials

6.1 *Soils*, shall be combinations of sand, silt, and clay-size materials generally encountered in ground deposits and containing not more than 25 % of material larger than the No. 4 sieve. The types of soils considered to be suitable for stabilization with emulsified or cutback asphalts are sands, silty sands, and other fine-grained soils of low plasticity. Generally, a suitable soil will have a sand equivalent test value not less than 25 determined in accordance with Test Method D 2419, and the product obtained by mutiplying the plasticity index as determined in accordance with Test Method D 4318, by the percent passing the No. 200 sieve will not be more than 60.

6.1.1 Soils having more than 25 % passing the No. 200 sieve or a sand equivalent value below 25 are considered borderline prospects for suitable stabilization with asphalt. Continuation under this practice for such soils should be considered exploratory. However, a soil may still be judged suitable on the basis of subsequent testing, depending on criteria set for the specific objective of the stabilization project.

6.2 *Bituminous Material*, shall be an emulsified as specified in Specifications D 977 or D 2397, or a cutback asphalt as specified in Specifications D 2026, D 2027, or D 2028, the type and grade to be as specified.

6.3 *Potable Water*, shall be used in preparing mixtures where required.

7. Preparation of Soil

7.1 Sample the soil in accordance with Practice D 75.

7.2 Pulverize approximately 4.5 kg of the air-dry soil in such a manner as to separate the soil particles without reducing the individual particle sizes and screen through a No. 4 (4.75-mm) sieve. Record the percentage retained on the No. 4 sieve. Screen the soil passing the No. 4 sieve through the No. 10 (2.00-mm) sieve, and if soil-binder aggregations are retained on the No. 10 sieve, further pulverize them to break down the aggregations without reducing the individual particle sizes.

7.3 Combine and thoroughly mix the material passing the No. 4 sieve with the material passing the No. 10 sieve and store in tightly closed containers.

7.4 The material retained on the No. 4 sieve may be reintroduced into the mix at this point, provided it does not exceed 10 % of the total combined weight of all fractions, and the maximum size is not greater than the ¾-in. (19.0-mm) sieve.

8. Water Content, Sieve Analysis, and Sand Equivalent

8.1 *Water Content*—Determine the water content of at least a 500-g sample of the air-dried soil in accordance with Method D 2216. Record water content for use in calculating the dry mass of air-dried soil.

8.2 *Sieve Analysis*—Determine the amount passing the No. 200 sieve on the dry soil of 8.1 in accordance with Test Method C 117 (wash test). Determine grain size distribution on the same sample in accordance with Method C 136 using the following sieve sizes: Nos. 4, 8, 16, 30, 50, 100, and 200.

8.3 *Sand Equivalent*—Determine the sand equivalent value on a representative sample of the air-dried soil in accordance with Test Method D 2419.

9. Preparation of Mixtures

9.1 *Emulsified Asphalt*:

9.1.1 *Mix Proportions*—The emulsified asphalt contents of three trial mixes are estimated by using the centrifuge kerosine equivalent (CKE) test.[6] The oil ratio determined by the CKE test is multiplied by the factors of 1.1, 1.4, and 1.7 to establish the emulsion contents, in percent by dry weight of soil, for the trial mixes.

9.1.2 Should the residue asphalt content of the emulsion be other than 60 %, a correction should be made as follows:

$$\text{Corrected emulsion content, \%} = \frac{\text{emulsion content, \%} \times 0.60}{\text{actual residue, \%}} \quad (1)$$

[5] *Annual Book of ASTM Standards*, Vol 04.09.

[6] See "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types," *Manual Series No. 2*, The Asphalt Institute, March 1974.

9.1.3 *Mixing Test*:

9.1.3.1 To evaluate the ability of the emulsified asphalt to disperse uniformly throughout the mix and to judge mix workability, weigh out 500 g of dry soil (corrected for water content recorded in 8.1), place in mixing bowl, and add the minimum amount of water to achieve wetting, and mix for 30 s. Normally, this is just enough water to darken the aggregate particles.

9.1.3.2 Add emulsified asphalt in the amount of 1.4 × CKE oil ratio by dry weight of soil, and mix for an additional 30 s with the laboratory mechanical mixer to simulate field mixing operations (if laboratory mixer is not available, a 2-min spoon bowl mixing is sufficient). Reject a mix which strips or stiffens excessively and make an additional mixture with an additional increment of water. Repeat until a mix of adequate appearance and workability is obtained.

9.1.3.3 Should mixes become excessively soupy and segregate on standing without passing through an adequate appearing and workable phase as additional increments of water are added, start over with another type or grade of asphalt emulsion being considered for the project.

9.1.3.4 Take approximately 200 g of the above satisfactory mix and allow it to air dry at room temperature. An electric fan or a warm plate may be used to accelerate drying. Rate the appearance of the air-dry soil-asphalt mixture by visually estimating the percent total aggregate surface that is coated with asphalt. Record this value as percent coating. A minimum coating of 50 % shall be attained before the mix is considered suitable for fabrication of test specimens. Spottiness denotes an unsatisfactory mix, usually due to insufficient water or improper mixing properties of the emulsion, and is cause for rejection. Report the type(s) of emulsified asphalts and the corresponding optimum fluid content of mixing. Fluid content is the percent asphalt emulsion plus the percent mixing water, both as percent by weight of dry soil. This represents *minimum* fluid content for field mixing.

9.1.3.5 The total fluid content for mixing established by the mixing test is also used for preparing soil-asphalt mixtures using emulsified asphalt contents for the other two trial mixes by adding or subtracting water to compensate for the changes in emulsion content.

9.2 *Cutback Asphalt*:

9.2.1 *Mix Proportions*—The cutback asphalt contents for three trial mixes are estimated by the centrifuge kerosine equivalent (CKE) test.[7] The oil ratio determined by the CKE test is multiplied by the factors of 0.8, 1.1, and 1.4 to establish the three cutback asphalt contents, in percent by dry weight of soil, for the trial mixes.

10. Determination of Mixing Fluids Content, Compaction Fluids Content, and Bulk Specific Gravity of Compacted Samples

10.1 During the mixing and compaction process, a number of masses (weights) must be recorded or determined if the mixing fluids content, compaction fluids content, and bulk specific gravity of the compacted samples are to be determined. The following must be determined in all mixing and compaction operations.

10.1.1 Determine water content of air-dried soil in accordance with Method D 2216,

10.1.2 Record tare mass (weight) of mixing container,

10.1.3 Record mass (weight) of mixing water added,

10.1.4 Record mass (weight) of emulsion or cutback added,

10.1.5 Record mass (weight) of mixing container and ingredients after mixing,

10.1.6 Record mass (weight) of mixing container and ingredients immediately prior to compaction,

10.1.7 Determine the mass (weight) of the compacted sample immediately after compaction and extrusion,

10.1.8 Determine the mass (weight) of the compacted sample immediately prior to testing, and

10.1.9 Determine the bulk relative mass density (specific gravity) of the compacted mixture either in accordance with Test Method D 1188 or Test Method D 2726.

11. Specimen Fabrication by Kneading Compaction

11.1 *Emulsified Asphalt Mixtures*:

11.1.1 *Kneading Compaction*—Using the mix proportions and mixing fluid content of 9.1.3, mix sufficient material (approximately 1150 g) to make a 4.0-in. (102-mm) diameter by 2.5-in. (64-mm) high specimen. Uniformly spread the mix on the feeder trough of the kneading compactor and proceed as follows:

11.1.1.1 Record tare mass of the mold and place it on mold holder with metal insert plate (that is, spacer bar) under bottom edge of mold to give temporary support to the mold during preliminary compaction, and insert a filter paper on the base of mold holder.

11.1.1.2 Using the paddle, push one half of the mix on the trough into the mold. Rod the mix 20 times in the center of the mass and 20 times around the edge of the mold. Push the remainder of mix into the mold and repeat rodding procedure.

11.1.1.3 Start the compactor, adjust tamper foot pressure to 250 psi (1725 kPa), insert rubber disk on specimen surface, and apply approximately 20 tamps on the surface of the specimen, removing spacer bar after the fifth tamp. The number of tamps can be varied between 10 and 50 depending on the amount of distortion of the material. If the compactor foot penetrates surface of specimen more than 0.25 in. (6 mm), discontinue tamping and proceed to the next step.

11.1.1.4 Record total number of tamps applied and proceed to double plunger compaction.

11.1.2 *Double Plunger Compaction*—Remove the mold from the holder of kneading compactor and apply a 40 000-lb (178-MN) static load in accordance with the double-plunger procedure of Test Method D 1074. Maintain full load for 60 s and release. If fluids exude from base of mold during load application or while sustaining the 178-MN load, discontinue compaction, release load, and record pressure and time at which exudation occurred. Should exudation be excessive during compaction procedure and result in a specimen of questionable composition, the specimen should be rejected and a new specimen prepared at a lower mixing fluid content, either by aerating the mix in a thin lift at room temperature with the

[7] See "A Basic Asphalt Emulsion Manual," *Manual Series No. 19*, The Asphalt Institute, March 1979.

aid of a fan or by producing a new mix at reduced mixing fluid content consistent with meeting the mix test requirements of coating and workability.

11.1.3 *Number of Specimens*—Using the above procedure, specimens can be prepared over a range of fluid contents for each of the trial mixes, provided that the mixing fluid is first used to prepare the mix and a reduction in fluid content is accomplished by controlled evaporation of water. The number of specimens of any given proportion of soilasphalt-water is to be as required in the method to be used.

11.2 *Cutback Asphalt Mixtures*:

11.2.1 *Kneading Compaction*—Using the mix proportions of 9.2.1, prepare a batch of mix by adding the cutback asphalt to the unheated, air-dried soil at a minimum temperature of the cutback asphalt necessary to obtain a uniform blend of mixing in the mechanical mixer for 30 s. Transfer mixed material to a flat pan and place in a forced-draft oven for a 15-h curing period at 140 ± 5°F (60 ± 3°C). Sufficient material should be mixed to fabricate the number of 4-in. (102-mm) diameter by 2.5-in. (64-mm) high test specimens desired at each mix proportion (allow 1150 g per specimen). Uniformly spread 1150 g of the prepared mix on the feeder trough of the kneading compactor and proceed as follows:

11.2.1.1 Record tare mass of the mold and place it on the mold holder with metal insert plate (that is, spacer bar) under bottom edge of mold to give temporary support to the mold during preliminary compaction, and insert a filter paper on a base of the mold holder.

11.2.1.2 Using the paddle, push one half of mix on trough of kneading compactor. Rod the mix 20 times around the edge of the mold. Push remainder of mix into mold and repeat rodding procedure.

11.2.1.3 Start the compactor, adjust tamper foot pressure to 250 psi (1725 kPa), insert rubber disk on specimen surface, and apply approximately 20 tamps on the surface of the specimen, removing spacer bar after the fifth tamp. The number of tamps can be varied between 10 and 50 depending on distortion of the material. If tamper foot penetrates the surface of specimen more than 0.25 in. (6 mm), discontinue tamping and proceed to next step.

11.2.1.4 Record total number of tamps applied and proceed to double plunger compaction.

11.2.2 *Double Plunger Compaction*—Remove mold from mold holder of kneading compaction and apply 40 000-lbf (178-MN) load in accordance with the double-plunger procedure of Method D 1074. Maintain full load for 60 s and release.

11.2.3 *Number of Specimens*—Using above procedure, specimens can be fabricated for each of the trial mixes in the numbers required in the method to be used.

12. Specimen Fabrication by Marshall Compaction

12.1 *Emulsified Asphalt or Cutback Asphalt Mixtures*:

12.1.1 *Marshall Compaction*—Using the mix proportions and mixing fluid contents of 9.1.2 (emulsified asphalt mixtures) or 9.2.1 (cutback asphalt mixtures), mix sufficient material (approximately 1150 g) to make a 4.0-in. (102-mm) diameter by 2.5-in. (64-mm) high specimen and proceed as follows:

12.1.1.1 Record tare weight of the mold and place it in the Marshall mold assembly, and insert filter paper in bottom mold. Follow cutback asphalt mixtures curing procedures given in 11.2.1 before placing mixture in mold, and use heated spatula or trowel for spading.

12.1.1.2 Place the entire batch in the mold and spade the mixture vigorously with a spatula or a trowel 15 times around the perimeter and 10 times over the interior.

12.1.1.3 Remove the collar and smooth the surface to a slightly rounded shape.

12.1.1.4 Replace the collar and place the mold assembly on the compaction pedestal in the mold holder and apply 50 blows with the compaction hammer.

12.1.1.5 Remove the mold from the mold assembly, invert, and replace it.

12.1.1.6 Apply 50 blows with the compaction hammer to the face of the inverted specimen.

12.1.1.7 Remove the specimen from the mold by means of an extrusion jack or other device and place on a smooth flat surface. The number of blows may be varied depending on intended service, or as called for in the method to be used subsequently.

12.1.2 *Number of Specimens*—For emulsified asphalt mixtures, the specimens can be prepared by the above procedure over a range of fluid contents for each of the trial mixes, provided that the mixing fluid content is first used to prepare the mix and a reduction in fluid content is accomplished by controlled evaporation of water. The number of specimens of any given proportion of soil-asphalt-water are to be as required in the method to be used. For cutback asphalt mixtures, the specimens can be fabricated for each of the trial mixes in the numbers required in the method to be used.

13. Report

13.1 *Soil*:

13.1.1 Results of wash and grading analysis on Sieve Nos. 4, 8, 15, 30, 50, 100, and 200.

13.1.2 Oil ratio value by centrifuge kerosine equivalent test.

13.2 *Emulsified Asphalt*—All soil-emulsified asphalt specimens fabricated by the procedures of 11.1 and 12.1 shall have the following information reported:

13.2.1 Emulsified asphalt content as percent of dry mass (weight) of soil,

13.2.2 Mixing fluids content (emulsified asphalt content plus water content plus added water content) as percent of dry mass (weight) of soil,

13.2.3 Compaction fluids content (after aeration and immediately prior to compaction) as percent of dry soil,

13.2.4 Number of tamps in kneading compactor or in Marshall compactor,

13.2.5 Static pressure and, if applicable, time to exudation,

13.2.6 Height of specimen to nearest 0.01 in. (0.2 mm), and

13.2.7 Dry unit weight of compacted specimen to nearest 0.10 lb/ft^3 (0.2 kN/m^3).

13.3 *Cutback Asphalt*—All soil-cutback asphalt specimens fabricated by the procedures of 11.2 or 12.1 shall have the following information reported:

13.3.1 Cutback asphalt content added to soil as percent of dry mass (weight) of soil,

13.3.2 Loss in mass (weight) during oven curing as percent of dry mass (weight) of soil,

13.3.3 Number of tamps in kneading compactor or in Marshall compactor,

13.3.4 Height of specimen to the nearest 0.01 in. (2 mm), and

13.3.5 Moist (total) Unit mass (weight) to the nearest 0.10 lbf/ft^3 (0.2 kN/m^3).

14. Keywords

14.1 asphalt-stabilization; soil stabilization; specimen preparation; test specimens

SUMMARY OF CHANGES

In accordance with Committee D-18 policy, this section identifies the location of changes to this standard since the last edition (1996) that may impact the use of this standard.

(*1*) Added 1.2 on significant digits. Renumbered remaining paragraphs

(*2*) Revised 1.3 to provide more information on units.

(*3*) Added 1.4 to include engineering judgement caveat. Renumbered remaining paragraph.

(*4*) Added Terminologies D 8 and D 653 and Practices D 3740 and D 6026 to Section 2 and deleted Practice D 421.

(*5*) Added Note 1 immediately after paragraph 3.1 to reference Practice D 3740.

(*6*) Added Section 4 on Terminology, Renumbered remaining sections.

(*7*) Added reference to Test Method D 4318 in 6.1.

(*8*) Corrected units in 7.2, 8.1, 9.1.3.1, 9.1.3.4, 11.1.1, 11.2.1, and 12.1.1.

(*9*) Changed “weight” to “mass” in 8.1, 11.1.1.1, and 11.2.1.1.

(*10*) Updated Summary of Changes.

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