Designation: ~~D4223/D4223M – 12~~ D4223/D4223M – 20

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

This standard is issued under the fixed designation D4223/D4223M; 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~~standard covers the selection and proportioning of soils and emulsified or cutback asphalts and the fabrication of 100-mm [4-in.] diameter by 65-mm [2.5-in.] high test specimens.

1.2 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.2.1 The procedures used to specify how data are collected/recorded or calculated in the standard are regarded as industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the users objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering design.

1.3 *Units*—The values stated in either SI units or inch-pound units [presented in brackets] 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.

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. The rationalized slug unit is not given, unless dynamic (F=ma) calculations are involved.

1.3.2 It is common practice in the engineering/construction profession to concurrently use pounds to represent both a unit of mass (lbm) and of force (lbf). This implicitly combines two separate systems of units; that is, 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, this standard includes the gravitational system of inch-pound units and does not use/present the slug unit for mass. However, the use of balances or scales recording pounds of mass (lbm) or recording in lbm/ft^3 shall not be regarded as nonconformance with this standard.

1.4 *This ~~practice~~standard 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~~standard 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] ~~This practice is~~These practices are under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization With Admixtures.

Current edition approved ~~Jan. 1, 2012~~Nov. 1, 2020. Published ~~February 2012~~November 2020. Originally approved in 1983. Last previous edition approved in ~~2006~~2012 as ~~D4223–99(2006).~~D4223/D4223M–12. DOI: 10.1520/D4223_D4223M-12.

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

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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C117 Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates
D8 Terminology Relating to Materials for Roads and Pavements
D75 Practice for Sampling Aggregates
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D977 Specification for Emulsified Asphalt
D1074 Test Method for Compressive Strength of Asphalt Mixtures
D1188 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples
~~D1559 Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (Withdrawn 1998)~~[3]
D1560 Test Methods for Resistance to Deformation and Cohesion of Asphalt Mixtures by Means of Hveem Apparatus
D1561 Practice for Preparation of Bituminous Mixture Test Specimens by Means of California Kneading Compactor
D2026 Specification for Cutback Asphalt (Slow-Curing Type)
D2027 Specification for Cutback Asphalt (Medium-Curing Type)
D2028 Specification for Cutback Asphalt (Rapid-Curing Type)
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2397 Specification for Cationic Emulsified Asphalt
D2419 Test Method for Sand Equivalent Value of Soils and Fine Aggregate
D2726 Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Asphalt Mixtures
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4123 Test Method for Indirect Tension Test for Resilient Modulus of Bituminous Mixtures (Withdrawn 2003)[3]
D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D6026 Practice for Using Significant Digits in Geotechnical Data
D6926 Practice for Preparation of Asphalt Mixture Specimens Using Marshall Apparatus

3. Terminology

3.1 Refer to Terminology D653 for terms relating to soils and to Terminology D8 for terms relating to asphalt.

4. Summary of Practice

4.1 This standard provides two different compaction method alternatives to produce samples for evaluating the performance of various percentages of asphalt emulsions or cutbacks mixed with fine grained soils.

5. Significance and Use

5.1 This ~~practice~~standard is intended for the preparation of standard specimens of soil-asphalt mixtures suitable for tests of Test Methods ~~D1559,~~ D1560, D1561, D4123, and other tests using specimens of the above dimensions. This ~~practice~~standard is limited to only fine-grained soils as defined in ~~6.1~~7.1.

NOTE 1—The quality of the results produced by this ~~practice~~standard 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 D3740 are generally considered capable of competent and objective testing, sampling, inspection, and so forth. Users of this ~~practice~~standard are cautioned that compliance with Practice D3740 does not in itself ensure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

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

[3] The last approved version of this historical standard is referenced on www.astm.org.

~~4. Terminology~~

~~4.1 Refer to Terminology D653 for terms relating to soils and to Terminology D8 for terms relating to asphalt.~~

6. Apparatus

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

7. Materials

7.1 *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 4.75 mm (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 D2419, and the product obtained by ~~mutiplying~~multiplying the plasticity index as determined in accordance with Test Method D4318, by the percent passing the 75 µm (No. 200) sieve will not be more than 60.

7.1.1 Soils having more than 25 % passing the 745 µm (No. 200) sieve or a sand equivalent value below 25 are considered borderline prospects for suitable stabilization with asphalt. Continuation under this ~~practice~~standard 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.

7.2 *Bituminous Material,* shall be an emulsified asphalt as specified in Specifications D977 or D2397, or a cutback asphalt as specified in Specifications D2026, D2027, or D2028, the type and grade to be as specified.

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

8. Preparation of Soil

8.1 Sample the soil in accordance with Practice D75.

8.2 Pulverize approximately 4.5 kg [10 lb] 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 4.75-mm (No. 4) sieve. Record the percentage retained on the 4.75-mm (No. 4) sieve. Screen the soil passing the 4.75-mm (No. 4) sieve through the 2.00-mm (No. 10) sieve, and if soil-binder aggregations are retained on the 2.00-mm (No. 10) sieve, further pulverize them to break down the aggregations without reducing the individual particle sizes.

8.3 Combine and thoroughly mix the material passing the 4.75-mm (No. 4) sieve with the material passing the 2.00-mm (No. 10) sieve and store in tightly closed containers.

8.4 The material retained on the 4.75-mm (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 19.0-mm (¾-in.) sieve.

9. Water Content, Sieve Analysis, and Sand Equivalent

9.1 *Water Content*—Determine the water content of at least a 500-g [1 lb] sample of the air-dried soil in accordance with Method D2216. Record water content for use in calculating the dry mass of air-dried soil.

9.2 *Sieve Analysis*—Determine the amount passing the 75 µm (No. 200) sieve on the dry soil of ~~8.1~~9.1 in accordance with Test Method C117 (wash test). Determine grain size distribution on the same sample in accordance with Method C136 using the following sieve sizes: Nos. 4, 8, 16, 30, 50, 100, and 200.

9.3 *Sand Equivalent*—Determine the sand equivalent value on a representative sample of the air-dried soil in accordance with Test Method D2419.

10. Preparation of Mixtures

10.1 *Emulsified Asphalt:*

10.1.1 *Mix Proportions*—The emulsified asphalt contents of three trial mixes are estimated by using the centrifuge kerosene equivalent (CKE) test.[4] 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.

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

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

10.1.3 *Mixing Test:*

10.1.3.1 To evaluate the ability of the emulsified asphalt to disperse uniformly throughout the mix and to judge mix workability, weigh out approximately 500 g [1 lb] of dry soil (corrected for water content recorded in ~~8.1~~9.1), 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.

10.1.3.2 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 procedures described in ~~9.1.3.1~~10.1.3.1 and ~~9.1.3.2~~10.1.3.2 until a mix of adequate appearance and workability is obtained.

10.1.3.3 Should mixes become excessively watery 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.

10.1.3.4 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.

10.1.3.5 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.

10.2 *Cutback Asphalt:*

10.2.1 *Mix Proportions*—The cutback asphalt contents for three trial mixes are estimated by the centrifuge kerosene equivalent (CKE) test.[5] 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.

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

11.1 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.

[4] See "Mix Design Methods," *Manual Series No. 2*, The Asphalt Institute, reprinted 1997.
[5] See "A Basic Asphalt Emulsion Manual," *Manual Series No. 19*, The Asphalt Institute, March 1979.

11.1.1 Determine water content of air-dried soil in accordance with Method D2216,

11.1.2 Record tare mass (weight) of mixing container,

11.1.3 Record mass (weight) of mixing water added,

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

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

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

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

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

11.1.9 Determine the bulk relative mass density (specific gravity) of the compacted mixture either in accordance with Test Method D1188 or Test Method D2726.

12. Specimen Fabrication by Kneading Compaction

12.1 *Emulsified Asphalt Mixtures:*

12.1.1 *Kneading Compaction*—Using the mix proportions and mixing fluid content of ~~9.1.3~~10.1.3, mix sufficient material (approximately 1150 g [2.5 lb]) to make a 100-mm [4.0-in.] diameter by 65-mm [2.5-in.] high specimen. Uniformly spread the mix on the feeder trough of the kneading compactor and proceed as follows:

12.1.1.1 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.

12.1.1.2 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.

12.1.1.3 Start the compactor, adjust tamper foot pressure to 1725 kPa [250 psi], 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 6 mm [0.25 in.], discontinue tamping and proceed to the next step.

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

12.1.2 *Double Plunger Compaction*—Remove the mold from the holder of kneading compactor and apply a 180-MN [40 000-lb] static load in accordance with the double-plunger procedure of Test Method D1074. Maintain full load for 60 s and release. If fluids exude from base of mold during load application or while sustaining the 180-MN [40 000-lb] 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 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.

12.1.3 *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 soil-asphalt-water is to be as required in the method to be used.

12.2 *Cutback Asphalt Mixtures:*

12.2.1 *Kneading Compaction*—Using the mix proportions of ~~9.2.1~~10.2.1, 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