



Designation: D 4832 – 02

## Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders<sup>1</sup>

This standard is issued under the fixed designation D 4832; 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 test method covers procedures for the preparation, curing, transporting and testing of cylindrical test specimens of controlled low strength material (CLSM) for the determination of compressive strength.

1.2 This test method also may be used to prepare and test specimens of other mixtures of soil and cementitious materials, such as self-cementing fly ashes.

1.3 CLSM is also known as flowable fill, controlled density fill, soil-cement slurry, soil-cement grout, unshrunkable fill, K-Krete, and other similar names.

1.4 The values stated in SI units are to be regarded as the standard. The inch-pound equivalents are shown for information only.

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.* See Section 7.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- C 31 Practice for Making and Curing Concrete Test Specimens in the Field<sup>2</sup>
- C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens<sup>2</sup>
- C 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory<sup>2</sup>
- C 470 Specification for Molds for Forming Concrete Test Cylinders Vertically<sup>2</sup>
- C 617 Practice for Capping Cylindrical Concrete Specimens<sup>2</sup>
- C 1231 Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders

D 653 Terminology Relating to Soil, Rock, and Contained Fluids<sup>3</sup>

D 3740 Practice for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction<sup>3</sup>

D 5971 Practice for Sampling Freshly Mixed Controlled Low Strength Material (CLSM)<sup>4</sup>

D 6023 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)<sup>4</sup>

D 6024 Test Method for the Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application<sup>4</sup>

D 6103 Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)<sup>4</sup>

### 3. Terminology

#### 3.1 Definitions

3.1.1 For common definitions of terms in this standard, refer to Terminology D 653.

#### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *Controlled Low Strength Material (CLSM), n*— A mixture of soil, cementitious materials, water, and sometimes admixtures, that hardens into a material with a higher strength than the soil but less than 8400 kPa (1200 psi). Used as a replacement for compacted backfill, CLSM can be placed as a slurry, a mortar, or a compacted material and typically has strengths of 350 to 700 kPa (50 to 100 psi) for most applications.

### 4. Summary of Test Method

4.1 Cylinders of CLSM are tested to determine the compressive strength of the material. The cylinders are prepared by pouring a representative sample into molds, curing the cylinders, removing the cylinders from the molds, and capping the cylinders for compression testing. The cylinders are then tested to obtain compressive strengths. Duplicate cylinders are required.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization with Admixtures.

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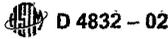
<sup>2</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.08.

<sup>4</sup> Annual Book of ASTM Standards, Vol 04.09.

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

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## 5. Significance and Use

5.1 This test method is used to prepare and test cylindrical specimens of CLSM to determine the compressive strength of the hardened material.

5.2 CLSM is typically used as a backfill material around structures, particularly in confined or limited spaces. Compressive strength testing is performed to assist in the design of the mix and to serve as a control technique during construction. Mix design is typically based on 28-day strengths and construction control tests performed 7 days after placement. The compressive strength(s) and other test age(s) will vary according to the requirements for the end product. Additional information on the use and history of CLSM is contained in Appendix X1.

5.3 This test is one of a series of quality control tests that can be performed on CLSM during construction to monitor compliance with specification requirements. The other tests that can be used during construction control of CLSM are Test Methods D 5971, D 6023, D 6024, and D 6103.

5.4 There are many other combinations of soil, cement, flyash (cementitious or not), admixtures or other materials that should be tested using this method. The mixtures would vary depending on the intended use, availability of materials, and placement requirements.

NOTE 1—The quality of the result produced by this 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 D 3740 are generally considered capable of competent and objective testing/sampling/inspection and the like. Users of this standard are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

## 6. Apparatus

6.1 *Single-Use Cylindrical Molds*—Plastic single-use 15 cm (6-in.) diameter by 30 cm (12-in.) high molds with tight fitting lids, conforming to Specification C 470. Other sizes and types of molds may be used as long as the length to diameter ratio is 2 to 1. The 15-cm by 30-cm (6 in. by 12 in.) molds are preferred because of the low strength of the material and the larger surface area of the ends of the cylinders.

6.2 *Sampling and Mixing Receptacle*—The receptacle shall be a suitable heavy-gauge container, wheelbarrow, etc. of sufficient capacity to allow easy sampling and mixing and to allow preparation of at least two cylinders and for other tests such as described in Test Methods D 5971, D 6023, PS D6024, and D 6103.

6.3 *Storage Container*—A tightly constructed, insulated, firmly braced wooden box with a cover or other suitable container for storage of the CLSM cylinders at the construction site. The container shall be equipped, as necessary, to maintain the temperature immediately adjacent to the cylinders in the range of 16 to 27°C (60 to 80°F). The container shall be marked for identification and shall be a bright color to avoid disturbance.

6.4 *Transportation Container*—A sturdy wooden box or other suitable container constructed to minimize shock, vibration, or damage to the CLSM cylinders when transported to the laboratory.

6.5 *Testing Machine*—The testing machine shall meet the requirements as described in Test Method C 39.

NOTE 2—Since the compressive strength of CLSM cylinders will typically be 100 kPa (about 15 to 1200 lb/in.<sup>2</sup>), the testing machine must have a loading range such that valid values of compressive strength can be obtained.

6.6 *Curing Environment*—A curing environment (water bath, damp sand, fog room) that meets the requirements of Method C 192. The cylinders may be cured in the same curing environment used for concrete cylinders at the laboratory performing the testing.

6.7 *Small Tools*—Tools and items that may be required such as shovels, pails, trowels, and scoops.

## 7. Hazards

7.1 *Technical Precaution*—The procedure for the preparation of CLSM test cylinders has many similarities to preparing concrete test cylinders (Practice C 31 and Practice C 192). However, the cylinders are much more fragile than concrete cylinders, and special care should be taken in their preparation, storage, and handling.

### 7.2 Safety Hazards:

7.2.1 Strictly observe the safety precautions stated in Practice C 617.

7.2.2 If the cylinders are capped with molten sulfur mortar, wear proper personnel protective equipment, including gloves with cuffs at least 15 cm (6-in.) long.

## 8. Sampling and Test Specimens

8.1 Take samples of the CLSM for each test specimen in accordance with D 5971. Record the identity of the CLSM represented and the time of casting.

8.2 The sample from the batch should be a minimum of 0.03 m<sup>3</sup> (1 ft<sup>3</sup>) for each two cylinders to be prepared. Prepare a minimum of two compressive strength cylinders for each test age to represent each sampled batch. Additional material may be required if other testing is to be performed, such as in Test Methods D 5971, D 6023, D 6024, and D 6103.

NOTE 3—In the initial stage of CLSM usage, preparation of three cylinders is recommended to obtain reliable compressive strength data for each test age. Subsequently, two cylinders may be used to maintain testing records and to ascertain an overall quality of the mix. However, since the cylinders are fragile and may be damaged during transportation, mold removal, and capping, preparation of an extra cylinder may be necessary to provide the minimum number of test specimens (see Note 8 and Note 9). In addition, it may be useful to determine the density of the test cylinders to help evaluate the uniformity of the compressive strength values.

## 9. Specimen Molding and Curing

9.1 *Place of Molding*—Mold specimens promptly on a level, rigid, horizontal surface free from vibration and other disturbances. The specimens should be prepared at a place as near as practicable to the location where they are to be stored during the first four days.

### 9.2 Placing the CLSM:

9.2.1 Thoroughly mix the CLSM in the sampling and mixing receptacle.


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9.2.2 With a bucket or pail, scoop through the center portion of the receptacle and pour the CLSM into the cylinder mold. Repeat until the mold is full. Place a lid on the mold.

NOTE 4—Use of an airtight lid has been known to cause low strength materials to crack, possibly due to a creation of a vacuum inside the mold. If an airtight lid is contemplated, its use should be evaluated before doing routine testing.

NOTE 5—Some mixtures will bleed rapidly, that is, free water will appear in the mixing receptacle and the mold. Obtaining the material to fill the cylinder must be done quickly after mixing. A few minutes after filling the mold, thoroughly mix the CLSM in the sampling and mixing receptacle and place a scoopful in the top of the mold, displacing the water. If possible, a slight mound of material should be left on the top of the mold. This refilling may be required again after about 15 min. Leave the mound on the top of the mold and cover.

### 9.3 Curing:

9.3.1 Store the cylinders at the construction site in the storage container until the fourth day after preparation.

9.3.2 The cylinders shall be stored under conditions that maintain the temperature immediately adjacent to the cylinders in the range of 16 to 27°C (60 to 80°F). The cylinders must always be protected from freezing. After the first day, provide a high humidity environment by surrounding the cylinders with wet burlap or other highly adsorbent material.

9.3.3 On the fourth day, carefully transport the cylinders to the site of the curing environment in the transportation container and place in a curing environment (see 6.6).

9.3.4 The cylinders are typically left at the construction site for four days and then transported to a curing environment. If extremely low strength CLSM (below 350 kPa) would be damaged by moving on the fourth day, then the cylinders are to be placed in a water storage tank with a temperature between 16° and 27°C (60° and 80°F) at the construction site until they are able to be moved without damage.

## 10. Capping the Cylinders

10.1 On the day of testing, carefully remove the molds from the cylinders and allow the cylinders to air-dry for 4 to 8 h before capping. If the upper surface of the cylinder is not a horizontal plane, use a wire brush to flatten the surface. Brush off all loose particles. Provide a cap for the cylinders using one of the following methods:

10.1.1 Cap the cylinders using sulfur mortar in accordance with Practice C 617.

NOTE 6—Sulfur mortars are not recommended for capping CLSM cylinders because the strength of the cap is generally significantly greater than the CLSM cylinder strength which may lead to erroneous results.

10.1.2 Cap the cylinder using gypsum plaster in accordance with Practice C 617.

10.1.3 Use elastomeric pads in accordance with Practice C 1231. The results of the qualification tests in Practice C 1231 for acceptance of the caps must not indicate a reduction of strength of more than 20 %, rather than 2 % as stated in Practice C 1231. The larger difference is acceptable because of the less critical uses of CLSM and 20 % is estimated to be the inherent variation in compressive strength results because of the lower strength values, for example 350 kPa (50 psi).

NOTE 7—Although compressive strengths below 10 MPa (1500psi) are

not within the scope of Practice C 1231, acceptable results have been found in many laboratories. Qualification testing should be performed prior to using unbonded capping systems for acceptance testing of CLSM mixtures.

10.2 Use the same capping method throughout each project to avoid any variation in the test results from using different capping systems.

NOTE 8—CLSM cylinders are more fragile than concrete cylinders and must be handled carefully during the mold removal and during capping.

NOTE 9—If sulfur mortar is used as the capping compound, oil is placed on the capping plate to ensure release of the capping material from the capping plate. More oil may be required on the capping plate when capping CLSM cylinders than is normally used when capping concrete cylinders. Capped CLSM cylinders will normally contain more air voids between the cap and the cylinder than capped concrete cylinders, and this should be considered if the caps are tapped to check for voids.

## 11. Compressive Strength Testing

11.1 *Placing the Specimen*—Place the lower bearing block, with its hardened face up, on the table or platen of the testing machine directly under the spherically seated (upper) bearing block. Wipe clean the bearing faces of the upper and lower bearing blocks and of the test specimen, and place the test specimen on the lower bearing block. Carefully align the axis of the specimen with the center of thrust of the spherically seated block. As the spherically seated block is brought to bear on the top of the specimen, rotate its movable portion gently by hand so that uniform seating is obtained.

11.2 *Rate of Loading*—Apply the load continuously and without shock. Apply the load at a constant rate such that the cylinder will fail in not less than 2 min. Make no adjustment in the controls of the testing machine while a specimen is yielding rapidly immediately before failure.

11.3 Apply the load until the specimen fails, and record the maximum load carried by the specimen during the test. For about one out of every ten cylinders, continue the loading until the cylinder breaks enough to examine the appearance of the interior of the specimen. Note any apparent segregation, lenses, pockets, and the like in the specimen.

## 12. Calculation

12.1 Calculate and record the compressive strength of the specimen as follows:

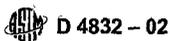
$$C = \frac{L}{\pi(D^2)/4} \quad (1)$$

where:

- $C$  = compressive strength, kPa (lbf/in.<sup>2</sup>),  
 $D$  = nominal diameter of cylinder (normally 15 cm or 6 in.), and  
 $L$  = maximum load, kN (lbf).

## 13. Report

- 13.1 The report shall include the following:
- 13.1.1 Identification, for example, mix, cylinder number, location, etc.
- 13.1.2 Diameter and length, cm (in.).
- 13.1.3 Cross-sectional area, cm<sup>2</sup> (in.<sup>2</sup>).
- 13.1.4 Maximum load, kN (lbf).



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13.1.5 Compressive strength, kPa (lbf/in.<sup>2</sup>).

13.1.6 Age of specimen.

13.1.7 Appropriate remarks as to type of failure, defects noted, or nonuniformity of material.

#### 14. Precision and Bias

14.1 *Precision*—Test data on precision is not presented due to the nature of the CLSM materials tested by this test method. It is either not feasible or too costly at this time to have ten or more laboratories participate in a round-robin testing program.

14.1.1 Subcommittee D18.15 is seeking any data from the users of this test method that might be used to make a limited statement on precision.

14.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

#### 15. Keywords

15.1 backfill; CLSM; compressive strength; construction control; mix design; quality control; soil stabilization

## APPENDIX

(Nonmandatory Information)

### X1. HISTORY

X1.1 This standard was developed to provide an accepted, consensus method of preparing and testing CLSM cylinders. Because the cylinders are more fragile than normal concrete cylinders, the standard provides a workable method of preparation and testing based on much trial and error.

X1.2 CLSM is a combination of soil, Portland cement, sometimes admixtures, and enough water so that the mixture has the consistency of a thick liquid. In this form, the CLSM flows readily into openings, filling voids, and provides a hardened material that has a strength greater than the untreated soil used in the mix. Some cementitious fly ashes have been successfully used in place of the cement.

X1.3 Although the primary use to date of CLSM or other similar materials has been as embedment for pipelines, it also has been used as trench backfill and structure backfill.<sup>5,6</sup>

X1.4 Typically, CLSM contains about 5 to 10 % cement. One of the definite advantages is that CLSM may be produced using local soils. As opposed to a lean concrete slurry, the soil for the CLSM can contain up to about 20 to 25 % nonplastic or slightly plastic fines. Although clean concrete sands have been used, the presence of fines can help keep the sand-sized particles in suspension. This allows the mixture to flow easier and helps prevent segregation. Soils that are basically sand sizes work best with the maximum particle compatible with the space to be filled. Central batch plants with the slurry delivered in ready-mix trucks and trench-side, trail-along portable batch plants have been used, with the latter normally used when the soil comes from the trench excavation.

#### X1.5 Testing Techniques:

X1.5.1 The 15 by 30-cm plastic cylinders (see 6.1) are suggested as a matter of economics; that size is not necessary based on the particle sizes normally used in CSLM. A minimum test age of 7 days is recommended for construction control testing because the cylinders may not be intact enough for transporting and testing in 3 days. In addition, the testing that has been done for 3-day strength has resulted in extremely erratic values.

X1.5.2 The mounding of the material in the cylinders was found to be necessary for mixtures that did not contain many fines; the water bled so quickly that a space was left on top of the cylinders and the hardened cylinders were not of a uniform height.

X1.5.3 At the moisture content required for the mixture to have the necessary flow properties, consolidation of the CSLM in the cylinder mold by vibration is not necessary.

#### X1.6 Typical Use:

X1.6.1 The use of CLSM as pipe embedment illustrates the relationship between the testing requirements and a typical application. For pipe installations, CLSM is used to fill the gap between the pipe and the excavated trench. The CLSM transfers the load from the pipe to the in situ material, so the native soil must be able to provide the necessary support for the pipe. The circular trench bottom shape is advantageous because it reduces excavation quantities and thus reduces handling of the soil materials. The CLSM eliminates the problem of trying to shape a cradle in the trench bottom to fit the pipe. A cradle is labor intensive and may not result in full contact between the pipe and the soil. The CLSM does ensure uniform support for the pipe. Placement of the CLSM is much faster than compacting the soil in layers alongside the pipe, and potential damage to the pipe from the compacting equipment is eliminated. It is also quicker than flooding and jetting or the saturation and vibration methods of compacting granular bedding materials. This faster installation is a distinct advantage where the construction is in populated areas or through streets.

<sup>5</sup> Lovitz, C. A., and DeGroot, G., "Soil-Cement Pipe Bedding, Canadian River Aqueduct," *Journal of the Construction Division*, ASCE, Vol 94, No. CD1, 1968.

<sup>6</sup> "Cement-Treated Pipeline Bedding," Portland Cement Association Publication No. PA0011.01



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## SUMMARY OF CHANGES

In accordance with D18 policy, this section identifies the location of changes to this standard since the last edition (95e1) that may impact the use of this standard.

(1) Titles and reference in Section 2.1 revised to reflect current editions of the standards.

(2) Deleted C172 from Section 2.1 since the standard is no longer referenced.

(3) Revised Terminology Section in accordance with D18's Standards Preparation Manual.

(4) Revised 3.2.1 to identify CLSM as a noun and the word "replaced" was changed to "placed."

(5) Revised sections 5.3, 6.2, 8.1 and 8.2 to reflect current titles of the standards.

(6) Added note 1 referencing Practice D3740 in accordance with D18 policy. Renumbered subsequent notes.

(7) Revised section 6.3 to contain mandatory language.

(8) Added note 6 regarding caution for using sulfur mortar capping systems reflecting industry findings.

(9) Added note 7 referencing limits to the scope of C 1231 and reflecting industry findings.

(10) Corrected typos in 12.1 — Equation 1.

(11) Revised section 14.1 in accordance with D18's Standards Preparation Manual.

(12) Revised entire document removing extra spaces between words and other miscellaneous "spell check" items.

(13) Updated the Summary of Changes section.

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Designation: D 5971 – 01

## Standard Practice for Sampling Freshly Mixed Controlled Low-Strength Material<sup>1</sup>

This standard is issued under the fixed designation D 5971, 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### 1. Scope\*

1.1 This practice explains the procedure for obtaining a representative sample to test of freshly mixed controlled lowstrength material (CLSM) as delivered to the project site (Note 1). This practice includes sampling from revolving-drum truck mixers and from agitating equipment used to transport central-mixed CLSM.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound equivalents are shown for information only.

NOTE 1—Composite samples are required by this practice unless specifically excepted by procedures governing the tests to be performed, such as tests to determine uniformity of consistency and mixer efficiency. Procedures used to select the specific test batches are not described in this practice. It is recommended that random sampling be used to determine overall specification compliance.

1.3 *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.*

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 judgement. 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.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

D 653 Terminology Relating to Soil, Rock, and Contained Fluids<sup>2</sup>

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction<sup>2</sup>

D 4832 Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders<sup>2</sup>

D 6023 Test Method for Unit Weight, Yield and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)<sup>3</sup>

D 6103 Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)<sup>3</sup>

### 3. Terminology

3.1 *Definitions:* For common definitions of terms in this standard, refer to Terminology D 653.

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

3.2.1 *composite sample, n*—a sample that is constructed by combining equal portions of grab samples taken at two or more regularly spaced intervals during discharge of the middle portion of the batch of CLSM.

3.2.2 *controlled low-strength material (CLSM), n*—a mixture of Portland cement, fly ash, aggregates, water, and possibly chemical admixtures that, as the cement hydrates, forms a soil replacement material. The CLSM is a self compacting, flowable, cementitious material that is primarily used as a backfill or structural fill instead of compacted fill or unsuitable native soil. Depending on the amount of water used in the CLSM mixture, it can be placed as a non-flowable compacted material or as a mortar.

3.2.3 *flow consistency, n*—measured by the average diameter of the spread achieved by removal of the flow cylinder.

### 4. Significance and Use

4.1 This practice shall be used to provide a representative sample of the material for the purpose of testing various properties. The procedures used in sampling shall include the use of every precaution that will assist in obtaining samples that are truly representative of the nature and condition of the CLSM.

NOTE 2—The quality of the result produced by this 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 D 3740 are generally considered capable of competent

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization with Admixtures.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 04.08.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 04.09.

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



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and objective testing/sampling/inspection/ and the like. Users of this standard are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors. Practice D 3740 provides a means of evaluating some of these factors.

## 5. Sampling

5.1 *Size of Sample*—The sample of CLSM for compressive strength testing shall be a minimum of 14 L (0.5 ft<sup>3</sup>). For other tests, the composite size shall be large enough to perform the test and to ensure a representative sample of the batch was taken.

## 6. Procedure

6.1 *Sampling from Revolving-Drum Truck Mixers or Agitators*—Sample the CLSM at two or more regularly spaced intervals during discharge of the middle portion of the batch. These grab samples shall be obtained within the time limit specified in 6.2 and composited into one sample for test purposes. In any case do not obtain samples until after all water has been added to the mixer; also do not obtain samples from the very first or last portions of the batch discharge. Sample by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container. Regulate the rate of discharge of the batch by the rate of revolution of the drum and not by the size of the gate opening.

Note 3—Sampling normally should be performed on the CLSM as delivered from the truck to the job site excavation.

6.2 The elapsed time between obtaining the first and final portions of the composite sample shall be as short as possible and in no instance shall it exceed 2 min.

6.3 Transport the composite samples to the place where fresh CLSM tests are to be performed or where test specimens are to be molded. The composite sample shall be combined and remixed with a shovel or scoop the minimum amount necessary to ensure uniformity and compliance with the minimum time limits specified in 6.4.

6.4 Start tests for flow consistency (Test Method D 6103), unit weight, and air content (Test Method D 6023) within 5 min after obtaining the final portion of the composite sample. Complete these tests as expeditiously as possible. Start molding specimens for strength tests (Test Method D 4832) within 10 min after obtaining the final portion of the composite sample. Keep the elapsed time between obtaining and using the sample as short as possible and protect the sample from the sun, wind, and other sources of rapid evaporation, and from contamination.

## 7. Keywords

7.1 air content; CLSM; composites; flow consistency; quality control; sampling; unit weight

## SUMMARY OF CHANGES

This section identifies the principle changes to this guide that have been incorporated since the last issue.

- (1) SI units made the standard.
- (2) Added section 1.4 the “Professional Judgement” caveat.
- (3) Revised sections 2.1 and 6.4 to reflect current titles of standards.

(4) Revised section 3 on Terminology in accordance with D18’s Standards Preparation Manual.

(5) Added Note 2 referencing Practice D3740 in accordance with D18 policy. Renumbered subsequent notes.

(6) Added “Summary of Changes” section.

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Designation: D 6023 – 02

## Standard Test Method for Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)<sup>1</sup>

This standard is issued under the fixed designation D 6023; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### 1. Scope\*

1.1 This test method explains determination of the mass per cubic foot (cubic meter) of freshly mixed Controlled Low Strength Material (CLSM) and gives formulas for calculating the yield, cement content, and the air content of the CLSM. This test method is based on Test Method C 138 for Concrete.

NOTE 1—Unit Weight is the traditional terminology used to describe the property determined by this test method. The proper term is density. It has also been termed unit mass or bulk density. To be compatible with terminology used in the concrete industry, unit weight is referenced in this test method.

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

1.2.1 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

1.3 The values stated in SI units are to be regarded as standard. The inch-pound equivalents are shown for information only.

1.4 CLSM is also known as flowable fill, controlled density fill, soil-cement slurry, soil-cement grout, unshrinkable fill, "K-Krete," and other similar names.

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 29/C29M Test Method for Unit Weight and Voids in Aggregate<sup>2</sup>

- C 125 Terminology Relating to Concrete and Concrete Aggregates<sup>2</sup>
- C 128 Test Method for Specific Gravity and Absorption of Fine Aggregates<sup>2</sup>
- C 138 Test Method for Unit Weight, Yield and Air Content (Gravimetric) of Concrete<sup>2</sup>
- C 150 Specification for Portland Cement<sup>2</sup>
- C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method<sup>2</sup>
- D 653 Terminology Relating to Soil, Rock, and Contained Fluids<sup>3</sup>
- D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as used in Engineering Design and Construction<sup>3</sup>
- D 4832 Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders<sup>3</sup>
- D 5971 Practice for Sampling Freshly Mixed Controlled Low Strength Material<sup>4</sup>
- D 6024 Test Method for the Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application<sup>4</sup>
- D 6026 Practice for Using Significant Digits in Geotechnical Data<sup>4</sup>
- D 6103 Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)<sup>4</sup>

### 3. Terminology

3.1 *Definitions*—For definitions of terms in this standard, refer to Terminology C 125 and D 653.

3.1.1 *Controlled Low Strength Material (CLSM)*, *n*— a mixture of soil or aggregates, cementitious material, fly ash, water, and sometimes chemical admixtures, that hardens into a material with a higher strength than the soil, but less than 8400 kPa (1200 psi).

3.1.1.1 *Discussion*—Used as a replacement for compacted backfill, CLSM can be placed as a slurry, a mortar, or a compacted material and typically has strengths of 350 to 700 kPa (50 to 100 psi) for most applications.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization with Admixtures.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.08.

<sup>4</sup> Annual Book of ASTM Standards, Vol 04.09.

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

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3.1.2 *mass, n*—the quantity of matter in a body. (See *weight*.)

3.1.2.1 *Discussion*—Units of mass are the kilogram (kg), the pound (lb) or units derived from these. Masses are compared by weighing the bodies, which amounts to comparing the forces of gravitation acting on them.

3.1.3 *weight, n*—the force exerted on a body by gravity. (see *mass*.)

3.1.3.1 *Discussion*—Weight is equal to the mass of the body multiplied by the acceleration due to gravity. Weight may be expressed in absolute units (newtons, poundals) or in gravitational units (kgf, lbf). Since weight is equal to mass times the acceleration due to gravity, the weight of a body will vary with the location where the weight is determined, while the mass of the body remains constant. On the surface of the earth, the force of gravity imparts to a body that is free to fall an acceleration of approximately  $9.81 \text{ m/s}^2$  ( $32.2 \text{ ft/s}^2$ ).

3.1.4 *yield*—the volume of CLSM produced from a mixture of known quantities of the component materials.

#### 4. Summary of Test Method

4.1 The density of the CLSM is determined by filling a measure with CLSM, determining the mass, and calculating the volume of the measure. The density is then calculated by dividing the mass by the volume. The yield, cement content, and the air content of the CLSM is calculated based on the masses and volumes of the batch components.

#### 5. Significance and Use

5.1 This test method provides the user with a procedure to calculate the density of freshly mixed CLSM for determination of compliance with specifications, for determining mass/volume relationships or conversions such as those found in purchase agreements, and also for quality control purposes.

5.2 This test method is intended to assist the user for quality control purposes and when specified to determine compliance for air content, yield, and cement content of freshly mixed CLSM.

5.3 This test method is not meant to predict the air content of hardened CLSM, which may be either higher or lower than that determined by this test method.

5.4 This test is one of a series of quality control tests that can be performed on CLSM during construction to monitor compliance with specification requirements. The other tests that can be used during construction control are Test Methods D 4832, D 6024, and D 6103

NOTE 2—The quality of the results produced by this 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 D 3740 are generally considered capable of competent and objective testing/sampling/inspection/ and the like. Users of this standard are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluation some of those factors.

#### 6. Apparatus

6.1 *Balance*—A balance or scale accurate to within 0.3 % of the test load at any point within the range of use. The range of use shall be considered to extend from the mass of the measure empty to the mass of the measure plus the CLSM.

6.2 *Filling Apparatus*—Scoop, bucket or pail of sufficient capacity to facilitate filling the measure in a rapid, efficient manner.

6.3 *Sampling and Mixing Receptacle*—The receptacle shall be a suitable container, wheelbarrow, and the like of sufficient capacity to allow easy sampling and remixing of the CLSM.

6.4 *Measure*—A cylindrical container made of steel or other suitable metal (Note 3). It shall be watertight and sufficiently rigid to retain its form and calibrated volume under rough usage. Measures that are machined to accurate dimensions on the inside and provided with handles are preferred. All measures, except for measuring bowls of air meters shall conform to the requirements of Test Method C 29/C 29M. The minimum capacity of the measure shall conform to the requirements of Table 1. When measuring bowls of air meters are used, they shall conform to the requirements of Test Method C 231. The top rim of the air meter bowls shall be smooth and plane within 0.01 in. (0.25 mm) (Note 4).

NOTE 3—The metal should not be readily subject to attack by cement paste. However, reactive materials such as aluminum alloys may be used in instances where, as a consequence of an initial reaction, a surface film is rapidly formed which protects the metal against further corrosion.

NOTE 4—The top rim is satisfactorily plane if a 0.01-in. (0.25-mm) feeler gage cannot be inserted between the rim and a piece of ¼ in. (6 mm) or thicker plate glass laid over the top of the measure.

6.5 *Strike-Off Plate*—A flat rectangular metal plate at least ¼ in. (6 mm) thick or a glass or acrylic plate at least ½ in. (12 mm) thick with a length and width at least 2 in. (50 mm) greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within a tolerance of ⅛ in. (1.5 mm).

6.6 *Calibration Equipment*—A piece of plate glass, preferably at least ¼ in. (6 mm) thick and at least 1 in. (25 mm) larger than the diameter of the measure to be calibrated. A thin film of vacuum, water pump or chassis grease smeared on the flange of the bowl will make a watertight joint between the glass plate and the top of the bowl.

#### 7. Sample

7.1 Obtain the sample for freshly mixed CLSM in accordance with Practice D 5971.

7.2 The size of the sample shall be approximately 125 to 200 % of the quantity required to fill the measure.

#### 8. Calibration of Measure

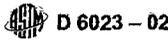
8.1 Calibrate the measure and determine the calibration factor ( $1/\text{volume}$ ), following the procedure outlined in Test Method C 29/C 29M.

TABLE 1 Minimum Capacity of Measure

Nominal Maximum Size of Coarse Aggregate <sup>a</sup>		Capacity of Measure, min <sup>b</sup>	
in.	mm	ft <sup>3</sup>	L
1	25.0	0.2	6
1½	37.5	0.4	11
2	50	0.5	14

<sup>a</sup> Aggregate of a given nominal maximum size may contain up to 10 % of particles retained on the sieve referred to

<sup>b</sup> To provide for wear, measures may be up to 5 % smaller than indicated in this table.



NOTE 5—For the calculation of unit weight, the volume of the measure in acceptable metric units should be expressed in cubic metres, or the factor as  $1/m^3$ . However, for convenience the size of the measure may be expressed in liters.

8.2 Measures shall be recalibrated at least once a year or whenever there is reason to question the accuracy of the calibration.

**9. Procedure**

9.1 Place the measure on a level, rigid, horizontal surface free from vibration and other disturbances.

9.2 *Placing the CLSM:*

9.2.1 Start this procedure within 5 min after obtaining the sample of CLSM and complete as expeditiously as possible.

9.2.2 Thoroughly mix the sample of CLSM in the sampling and mixing receptacle to ensure uniformity.

9.2.3 With the filling apparatus, scoop through the center portion of the sample and pour the CLSM into the measure. Repeat until the measure is full.

9.3 On completion of filling, the measure shall not contain a substantial excess or deficiency of CLSM. An excess of CLSM protruding approximately 1/8 in. (3 mm) above the top of the mold is optimum. To correct a deficiency, add a small quantity of CLSM.

9.4 *Strike-Off*—After filling, strike-off the top surface of the CLSM and finish it smoothly with the flat strike-off plate using great care to leave the measure just level full. The strike-off is best accomplished by pressing the strike-off plate on the top surface of the measure to cover about two thirds of the surface and withdrawing the plate with a sawing motion to finish only the area originally covered. Then place the plate on the top of the measure to cover the original two thirds of the surface and advance it with a vertical pressure and a sawing motion to cover the whole surface of the measure. Several final strokes with the inclined edge of the plate will produce a smooth finished surface.

9.5 *Cleaning and Mass Measurement*— After strike-off, clean all excess CLSM from the exterior of the measure and determine the gross mass of the CLSM in the measure to an accuracy consistent with the requirements of 6.1.

**10. Calculation**

10.1 *Density*—Calculate the mass of the CLSM in megagrams or grams (pounds) by subtracting the mass of the measure from the gross mass. Calculate the density,  $W$ , by multiplying the mass of the CLSM by the calibration factor for the measure determined in 8.1.

10.2 *Yield*—Calculate the yield as follows:

$$Y_f(\text{ft}^3) = W_1/W \tag{1}$$

or,

$$Y(\text{yd}^3) = W_1/(27W) \tag{2}$$

$$Y(\text{m}^3) = W_1/W \tag{3}$$

or,

where:

- $Y_f$  = volume of CLSM produced per batch,  $\text{ft}^3$ ,
- $Y$  = volume CLSM produced per batch,  $\text{m}^3(\text{ft}^3)$ ,

- $W$  = density of CLSM,  $\text{kg}/\text{m}^3(\text{lb}/\text{ft}^3)$ , and
- $W_1$  = total mass of all materials batched,  $\text{kg}(\text{lb})$  (Note 6).

NOTE 6—The total mass of all materials batched is the sum of the masses of the cement, the fly ash, the filler aggregate in the condition used, the mixing water added to the batch, and any other solid or liquid materials used.

10.3 *Relative Yield*—Relative yield is the ratio of the actual volume of CLSM obtained to the volume as designed for the batch calculated as follows:

$$R_y = Y/Y_d \tag{4}$$

where:

- $R_y$  = relative yield,
- $Y$  = volume CLSM produced per batch,  $\text{m}^3(\text{yd}^3)$ , and
- $Y_d$  = volume of CLSM which the batch was designed to produce,  $\text{m}^3(\text{yd}^3)$ .

NOTE 7—A value for  $R_y$  greater than 1.00 indicates an excess of CLSM being produced whereas a value less than this indicates the batch to be “short” of its designed volume.

10.4 *Cement Content* (Note 8)—Calculate the actual cement content as follows:

$$N = N_c/Y \tag{5}$$

where:

- $N$  = actual cement content  $\text{kg}/\text{m}^3(\text{lb}/\text{yd}^3)$ ,
- $N_c$  = mass of cement in the batch,  $\text{kg}(\text{lb})$ , and
- $Y$  = volume CLSM produced per batch,  $\text{m}^3(\text{yd}^3)$ .

NOTE 8—In determining cement content on CLSM’s that contain Class C fly ash, the actual mass of Class C fly ash shall be added to the mass of cement.

10.5 *Air Content*—Calculate the air content as follows:

$$A = [(T - W)/T] \times 100 \tag{6}$$

or,

$$A = [(Y_f - V)/Y_f] \times 100 \text{ (inch-pound units)} \tag{7}$$

or,

$$A = [(Y - V)/Y] \times 100 \text{ (SI units)} \tag{8}$$

where:

- $A$  = air content (percentage of voids) in the CLSM,
- $T$  = theoretical density of the CLSM computed on an air free basis,  $\text{kg}/\text{m}^3(\text{lb}/\text{ft}^3)$  (Note 7),
- $W$  = density of CLSM,  $\text{kg}/\text{m}^3(\text{lb}/\text{ft}^3)$ ,
- $Y_f$  = volume of CLSM produced per batch,  $\text{ft}^3$ ,
- $V$  = total absolute volume of the component ingredients in the batch,  $\text{ft}^3$  or  $\text{m}^3$ , and
- $Y$  = volume CLSM produced per batch,  $\text{m}^3(\text{yd}^3)$ .

NOTE 9—The theoretical density is, customarily, a laboratory determination, the value for which is assumed to remain constant for all batches made using identical component ingredients and proportions. It is calculated from the following equation.

$$T = W_1/V \tag{9}$$

The absolute volume of each ingredient in cubic feet is equal to the quotient of the mass of that ingredient divided by the product of its specific gravity times 62.4. The absolute volume of each ingredient in cubic meters is equal to the mass of the ingredient in kilograms divided by


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1000 times its specific gravity. For the aggregate components, the bulk specific gravity and mass should be determined by Test Method C 128. A value of 3.15 may be used for cements manufactured to meet the requirements of Specification C 150.

### 11. Report

11.1 Report the results for the density to the nearest 1 lb/ft<sup>3</sup> (10 kg/m<sup>3</sup>). The density may be reported as unit weight to be compatible with the terminology used in the concrete industry.

11.2 Report the following information:

11.2.1 Yield, to the second decimal.

11.2.2 Relative yield, to the second decimal.

11.2.3 Cement content, to the second decimal.

11.2.4 Air content, to the nearest 0.5 %.

### 12. Precision and Bias

12.1 *Precision*—Test data on precision is not presented due to the nature of the CLSM materials tested by this test method.

It is either not feasible or too costly at this time to have ten or more laboratories participate in a round-robin testing program.

12.1.1 The Subcommittee D18.15 is seeking any data from the users of this test method that might be used to make a limited statement on precision.

12.2 *Bias*—The procedure in this test method for measuring unit weight has no bias because the value for unit weight can be defined only in terms of a test method.

### 13. Keywords

13.1 air content; backfill; cement content; CLSM; construction control; density; flowable fill; mix design; quality control; relative yield; soil stabilization; unit weight; yield

## SUMMARY OF CHANGES

In accordance with Committee D18 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) Sections 1.2 and 1.2.1 were added in accordance with Committee D18 policy and the subsequent sections renumbered.

(2) Practice D 6026 was added to Referenced Documents section.

(3) Test Method D 6103 replaced PS 28 and Practice D 5971 replaced PS 30.

(4) Section 3 was revised to comply with Committee D18 policy.

(5) Section 5.4 was revised with the current standard designations.

(6) Note 2 was revised to comply with the current wording according to Committee D18 policy.

(7) Section 7.1 was revised with the current standard designation.

(8) The precision statement was revised to comply with Committee D18 policy as found in the Standards Preparation Manual.

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Designation: D 6024 – 02

## Standard Test Method for Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application<sup>1</sup>

This standard is issued under the fixed designation D 6024, 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 specification explains the determination of the ability of Controlled Low Strength Material (CLSM) to withstand loading by repeatedly dropping a metal weight onto the in-place material.

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

1.2.1 The method used to specify how data are collected, calculated, or recorded in this test method is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound equivalents are shown for information only.

1.4 CLSM is also known as flowable fill, controlled density fill, soil-cement slurry, soil-cement grout, unshrinkable fill, "K-Krete," and other similar names.

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 125 Terminology Relating to Concrete and Concrete Aggregates<sup>2</sup>

D 653 Terminology Relating to Soil, Rock, and Contained Fluids<sup>3</sup>

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as used in the Engineering Design and Construction<sup>3</sup>

D 4832 Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders<sup>3</sup>

D 6023 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)<sup>4</sup>

D 6026 Practice for Using Significant Digits in Geotechnical Data<sup>4</sup>

D 6103 Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)<sup>3</sup>

### 3. Terminology

3.1 *Definitions*—For definitions of terms in this test method, refer to Terminology C 125 and D 653.

#### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *Controlled Low Strength Material (CLSM), n*— a mixture of soil or aggregates, cementitious material, fly ash, water and sometimes chemical admixtures, that hardens into a material with a higher strength than the soil, but less than 8400 kPa (1200 psi).

3.2.1.1 *Discussion*—Used as a replacement for compacted backfill, CLSM can be placed as a slurry, a mortar, or a compacted material and typically has strengths of 350 to 700 kPa (50 to 100 psi) for most applications.

### 4. Summary of Test Method

4.1 A standard cylindrical weight is dropped five times from a specific height onto the surface of in-place CLSM. The diameter of the resulting indentation is measured and compared to established criteria. The indentation is inspected for any free water brought to the surface from the impact.

### 5. Significance and Use

5.1 This test method is used primarily as a field test to determine the readiness of the CLSM to accept loads prior to adding a temporary or permanent wearing surface.

5.2 This test method is not meant to predict the load bearing strength of a CLSM mixture.

5.3 This test is one of a series of quality control tests that can be performed on CLSM during construction to monitor compliance with specification requirements. The other tests

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization with Admixtures

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<sup>4</sup> Annual Book of ASTM Standards, Vol 04.09.

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

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that can be used during construction control are Test Methods D 4832, D 6023, and D 6103.

NOTE 1—The quality of the result produced by this 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 D 3740 are generally considered capable of competent and objective testing/sampling/inspection/and the like. Users of this standard are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3470 provides a means of evaluating some of those factors.

**6. Apparatus**

6.1 *Ball-drop Apparatus*—a cylinder with a hemispherically shaped bottom and handle with a mass of 14 + 0.05 kg (30 + 0.1 lb), and a stirrup or frame to guide the handle (Fig. 1).

6.1.1 *Weight*—The cylindrical weight (ball) shall be approximately 15 cm (6 in.) in diameter and 12 cm (4 7/8 in.) in height, with the top surface at right angles to the axis and the bottom in the form of a hemisphere of 75 mm (3 in.) radius. The cylindrical weight may be machined from metal stock or cast or spun provided the dimensions and weight with the handle meet requirements, and the finish is smooth.

6.1.2 *Handle*—The handle shall be a metal rod, 13 mm (1/2 in.) in diameter. The handle may be T-shaped or a closed rectangle at the top to permit grasping by the hand.

6.1.3 *Stirrup*—The stirrup shall be at least 38 mm (1 1/2 in.) in width. The stirrup frame is attached securely to blocks elevating it 9 cm (3 1/2 in.).

6.1.4 *Blocks*—pieces of wood, or ultra high molecular weight plastic (UHMW) that are 9 cm (3 1/2 in.) high are used to elevate the stirrups to the proper height. The stirrups must be centered on the blocks to avoid tipping, and attached securely to the stirrups so shifting does not occur. The blocks shall be parallel to each other and perpendicular to the main stirrup frame. The blocks must not interfere with the ball-drop apparatus. Each block shall have the minimum dimension of 9-cm (3 1/2 in.) wide by 18-cm (7-in.) long with a minimum bearing area of 155 cm<sup>2</sup> (24 in<sup>2</sup>).

6.2 *Measuring Device*—capable of measuring the diameter of the indentation. It must be capable of measuring a minimum of 3 mm (1/8 in.).

**7. Procedure**

7.1 The surface of the CLSM will need to be as level as possible either by self-leveling or by slight brooming action with hand tools. Set the elevated base of the apparatus on the leveled CLSM surface, with the handle in a vertical position and free to slide through the frame. Put slight pressure on the frame with your free hand to stabilize the device. Lift the handle as far as possible allowing the top surface of the ball to contact the underside of the stirrup frame. Release the weight allowing it to free fall to the surface of the CLSM. Repeat this for a total of five times at each location tested. Before testing a new location of the in-place CLSM remove any material that has adhered to the ball from previous testing.

7.2 Measure the diameter of the indentation left by the ball with a measuring device (Note 2). If the diameter of indentation is 76 mm (≤3 in.) then the CLSM is suitable for the load application. If the diameter of indentation is 76 mm (>3 in.) then the CLSM is unsuitable or not ready for load application.

NOTE 2—It has been shown under limited use that an indentation of ≤75 mm (3 in.) is suitable for normal load application.

7.3 Inspect the indentation for visible surface water or sheen brought to the surface by the dropping action of the ball. The surface should look similar to that before the test with the exception of an indentation. The presence of surface water indicates that the CLSM is unsuitable or not ready for load application.

**8. Report**

8.1 Report the following:

8.1.1 Project Identification,

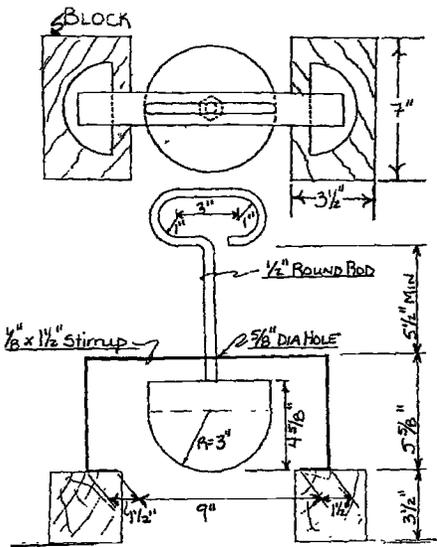
8.1.2 Location of test,

8.1.3 Identification of individual performing the test method, and

8.1.4 Date test is performed.

8.2 Report the following information:

8.2.1 Visible surface water or sheen brought to the surface by the dropping action,



Metric Equivalents			
in.	mm	in.	mm
3/8	3.2	4 5/8	117
1/2	13	5 1/2	140
5/8	16	5 9/16	143
1	25	9	228
1 1/2	38	12	305
3	76		

FIG. 1 Ball-drop Apparatus



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- 8.2.2 Irregularities on the surface of the in place CLSM such as indentations left by the blocks or severe cracking, and
- 8.2.3 Diameter of indentation to nearest 3 mm ( $\frac{1}{8}$  in.).

### 9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee D18.15 is seeking any data from users of the test method that might be used to make a limited statement on precision.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

### 10. Keywords

10.1 backfill; ball drop apparatus; bearing; CLSM; construction control; early load; flowable fill; mix design; quality control; soil stabilization; surface water; wearing surface

## SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this test method since the last edition (1996) that may impact the use of this standard.

- (1) Sections 1.2 and 1.2.1 were added in accordance with D18 policy and the subsequent sections renumbered.
- (2) C 360 was removed and Practice D 6026 was added to the list of Referenced Documents.
- (3) The designation “PS 28” was updated to Test Method D 6103 in Sections 2 and 5.3
- (4) Section 3 was revised to comply with D18 policy.
- (5) Note 1 was revised to comply with the current wording according to D18 policy.
- (6) Section 9, was revised to comply with suggested wording found in the D18 Standards Preparation Manual.

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Designation: D 6103 – 97

## Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)<sup>1</sup>

This standard is issued under the fixed designation D 6103; 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<sup>4</sup>

1.1 This test method covers the procedure for determination of the flow consistency of fresh Controlled Low Strength Material (CLSM). This test method applies to flowable CLSM with a maximum particle size of 19.0 mm ( $\frac{3}{4}$  in.) or less, or to the portion of CLSM that passes a 19.0 mm ( $\frac{3}{4}$  in.) sieve.

1.2 The values stated in SI units are to be regarded as standard. The inch-pound equivalents are given for information only.

1.3 CLSM is also known as flowable fill, controlled density fill, soil-cement slurry, soil-cement grout, unshrinkable fill, K-Krete, and other similar names.

1.4 *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 143 Test Method for Slump of Hydraulic Cement Concrete<sup>2</sup>
- C 172 Practice for Sampling Freshly Mixed Concrete<sup>2</sup>
- D 653 Terminology Relating to Soil, Rock, and Contained Fluids<sup>3</sup>
- D 3740 Practice for Minimum Requirements of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction<sup>3</sup>
- D 4832 Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders<sup>3</sup>
- D 5971 Practice for Sampling Freshly Mixed Controlled Strength Material<sup>4</sup>
- D6023 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Controlled Low Strength Material<sup>1</sup>

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization with Admixtures

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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.08.

<sup>4</sup> Annual Book of ASTM Standards, Vol 04.09.

D 6024 Test Method for Ball Drop on Controlled Low Strength Material to Determine Suitability for Load Application<sup>4</sup>

### 3. Terminology

3.1 *Definitions*—Except as follows in 3.2, all definitions are in accordance with Terminology D 653

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

3.2.1 *controlled low strength material (CLSM), n*—a mixture of soil or aggregates, cementitious material, fly ash, water and sometimes chemical admixtures, that hardens into a material with a higher strength than the soil, but less than 84 000 kPa (1200 psi). Used as a replacement for compacted backfill, CLSM can be placed as a slurry, a mortar, or a compacted material and typically has strengths of 350 to 700 kPa (50 to 100 psi) for most applications.

3.2.2 *flow consistency, n*—a measurement of the spread of a predetermined volume of CLSM achieved by removal of the flow cylinder within a specified time.

### 4. Summary of Test Method

4.1 An open-ended cylinder is placed on a flat, level surface and filled with fresh CLSM. The cylinder is raised quickly so the CLSM will flow into a patty. The average diameter of the patty is determined and compared to established criteria.

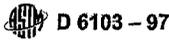
### 5. Significance and Use

5.1 This test method is intended to provide the user with a procedure to determine the fluidity of CLSM mixtures for use as backfill or structural fill.

5.2 This test method is considered applicable to fresh CLSM containing only sand as the aggregate or having coarse aggregate small than 19.0 mm ( $\frac{3}{4}$  in.). If the coarse aggregate is larger than 19.0 mm ( $\frac{3}{4}$  in.), the test method is applicable when it is made on the fraction of CLSM passing a 19.0 mm ( $\frac{3}{4}$  in.) sieve, with the larger aggregate being removed in accordance with the section on Additional Procedures for Large Maximum size Aggregate Concrete in Practice C 172.

NOTE 1—Removing the coarse aggregate will alter the characteristics of the mix and therefore will give information only about the remaining

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



material. It is suggested that for mixes containing coarse aggregate 19.0 mm ( $\frac{3}{4}$  in.) or larger, a measurement of the slump is more appropriate.

5.3 For nonflowable CLSM, or for mixtures that do not come out of the flow cylinder easily, measure the slump as outlined in Test Method C 143.

5.4 This test method is one of a series of quality control tests that can be performed on CLSM during construction to monitor compliance with specification requirements. The other tests that can be used during construction control are Test Methods D 4832, D 6023, and D 6024.

NOTE 2—Notwithstanding the statements on precision and bias contained in this test method, the precision of this test method 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 generally are considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors. Practice D 3740 provides a means of evaluating some of those factors.

## 6. Apparatus

6.1 *Flow Cylinder*—The flow cylinder shall be a 150 mm (6 in.) length of 76 mm (3 in.) inside diameter, straight tubing of steel, plastic or other non-absorbent material, non-reactive with CLSM containing Portland cement. Individual diameters and lengths shall be within  $\pm 3$  mm ( $\frac{1}{8}$  in.) of the prescribed dimensions. The flow cylinder shall be constructed such that the planes of the ends are parallel to one another and perpendicular to the longitudinal axis of the cylinder. The flow cylinder shall have a smooth interior, open at both ends and a rigid shape that is able to hold its dimensions and under conditions of severe use.

6.2 *Sampling and Mixing Receptacle*—The receptacle shall be a suitable container, wheelbarrow, etc., of sufficient capacity to allow easy sampling and remixing of the CLSM.

6.3 *Filling Apparatus*—Scoop, bucket, or pail of sufficient capacity to facilitate filling of the flow cylinder in a rapid, efficient manner.

6.4 *Nonporous Surface*—A 0.6 m (2-ft) square, or larger, made of a nonporous material that is also noncorroding, such as acrylic, cast aluminum, or stainless steel. The surface must be smooth, free of defects, and rigid.

### 6.5 Miscellaneous Equipment:

6.5.1 *Timing Device*—Watch, clock, or stopwatch capable of timing 1 s intervals.

6.5.2 *Straight edge*—A stiff metal straightedge of any convenient length but not less than 254 mm (10 in.). The total length of the straightedge shall be machined straight to a tolerance of  $+0.1$  mm ( $+0.005$  in.). The metal shall be made of suitable material that is noncorroding.

6.5.3 *Measuring device*, capable of measuring spread diameter. Must be able to measure a minimum of 6 mm ( $\frac{1}{4}$  in.).

## 7. Test Sample

7.1 Obtain the sample of freshly mixed CLSM in accordance with D 5971.

## 8. Procedure

8.1 Place the nonporous surface on a flat, level area that is free of vibration or other disturbances.

8.2 Dampen the flow cylinder with water and place it on end, on a smooth nonporous level surface. Hold firmly in place during filling.

8.3 Thoroughly remix the CLSM, the minimum amount necessary to ensure uniformity, in the sampling and mixing receptacle.

NOTE 3—The test for flow consistency, unit weight, and air content (D 6023) must be started within 5 min after obtaining the final portion of the composite sample. Complete these tests as expeditiously as possible.

8.4 With the filling apparatus, scoop through the center portion of the receptacle and pour the CLSM into the flow cylinder. Fill the flow cylinder until it is just level full or slightly overfilled.

8.5 Strike off the surface with a suitable straight edge, until the surface is flush with the top of the flow cylinder, while holding the flow cylinder in place. Remove any spillage away from the cylinder after strike off.

8.6 Within 5 s of filling and striking off, raise the flow cylinder quickly and carefully in a vertical direction. Raise the flow cylinder at least 15 cm (6 in.) by a steady upward lift with no lateral or torsional motion in a time period between 2 and 4 s. Complete the entire test from the start of filling through removal of the flow cylinder without interruption within an elapsed time of  $1\frac{1}{2}$  min.

8.7 Immediately measure the largest resulting spread diameter of the CLSM. Take two measurements of the spread diameter perpendicular to each other. The measurements are to be made along diameters which are perpendicular to one another.

NOTE 4—As the CLSM spreads, segregation may occur, with the water spreading beyond the spread of the cohesive mixture. The spread of the cohesive mixture should be measured.

NOTE 5—For ease in measuring perpendicular diameters, the surface that the flow cylinder will be placed on can be marked with perpendicular lines and the cylinder centered where the lines cross.

NOTE 6—The average diameter of the CLSM patty typically is established by the specifying organization and may vary depending on how the CLSM is being used. For flowable CLSM used to readily fill spaces (without requiring vibration), the average diameter of the patty typically is 20 to 30 cm (8 to 12 in.).

## 9. Report

9.1 Include the following information in the report:

9.1.1 Sample identification.

9.1.2 Identification of individual performing the test method.

9.1.3 Date the test is performed.

9.1.4 Record the two measurements to the nearest 1 cm ( $\frac{1}{2}$  in.). Compute the average of the two measurements rounded off to the nearest 5 mm ( $\frac{1}{4}$  in.), and report as the average flow consistency of the CLSM.


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**10. Precision and Bias**

10.1 *Precision*—Data are being evaluated to determine the precision of this test method. Additionally, Subcommittee D 18.15 is seeking pertinent data from users of the test method.<sup>5</sup>

<sup>5</sup> Anyone having data pertinent to the precision of this test method or wishing to participate in a round robin test, contact the D18.15 Subcommittee Chairman at ASTM Headquarters.

10.2 *Bias*—No statement on bias can be prepared because there are no standard reference materials.

**11. Keywords**

11.1 backfill; CLSM; construction control; flowable fill; flow consistency; flow cylinder; mix design; quality control; soil stabilization

**APPENDIX****(Nonmandatory Information)****X1. Rationale**

X1.1 This test method was developed to provide an accepted, consensus method of measuring the flow characteristics of CLSM. Although CLSM may be mixed and delivered like concrete, the mixture typically is much more fluid than

concrete so that it readily will fill voids and spaces. This test method provides a procedure to quantify the flow characteristics.

**SUMMARY OF CHANGES**

This test method previously was provisional standard (PS) 28 and has been revised and approved as a full consensus standard.

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| <p>(1) This standard previously had the designation PS 28–95, a provisional standard.</p> <p>(2) The differences between this version of the standard and the previous one are as follows:</p> <p>(3) Addition of Sections 1.3, 5.4, 6.4, 6.5, 8.1, 8.2, 8.3, 8.4,</p> | <p>Note 2, Note 4, Note 5, Note 6, Appendix X1.1 and this section.</p> <p>(4) Revised wording in Sections 3.2.1, 3.2.2, 4.1, 6.1, 8.2, 8.4, 8.5, 8.6, 9.1, 10.1, 11 and Note 4</p> <p>(5) SI units made the standard</p> |
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