Designation: D 4832 – 95$^{\epsilon 1}$

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
Reprinted from the Annual Book of ASTM Standards. Copyright ASTM

Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders[1]

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 (ε) indicates an editorial change since the last revision or reapproval.

ϵ^1 NOTE—Editorial changes were made in January 1997.

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, unshrinkable 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 Method of Making and Curing Concrete Test Specimens in the Field[2]

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[2]

C 172 Method of Sampling Freshly Mixed Concrete[2]

C 192 Method of Making and Curing Concrete Test Specimens in the Laboratory[2]

C 470 Specification for Molds for Forming Concrete Test Cylinders Vertically[2]

C 617 Practice for Capping Cylindrical Concrete Specimens[2]

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[3]

PS 28 Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)[4]

PS 29 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)[4]

PS 30 Practice for Sampling Freshly Mixed Controlled Low Strength Material (CLSM)[4]

PS 31 Test Method for the Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application[4]

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)*—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 replaced 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.

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.

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

Current edition approved Dec. 10, 1995. Published May 1996. Originally published as D 4832 – 88. Last previous edition D 4832 – 88.

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

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

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

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

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 PS 28, PS 29, PS 30, and PS 31.

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

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-gage 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 PS 28, PS 29, PS 30, and PS 31.

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 should be marked for identification and should 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 1—Since the compressive strength of CLSM cylinders will typically be 100 kPa (about 15 to 1200 lbf/in.^{2}), 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 (Method C 31 and Method 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 PS 30. 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^3 (1 ft^3) 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 PS 28, PS 29, PS 30,, and PS 31.

NOTE 2—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 5 and Note 6). 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.

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

NOTE 4—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 contruction 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 the following methods:

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

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).

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

NOTE 5—CLSM cylinders are more fragile than concrete cylinders and must be handled carefully during the mold removal and during capping.

NOTE 6—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:

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

where:

C = compressive strength, kPa (lbf/in.^{2}),
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^2 (in.^{2}).

13.1.4 Maximum load, kN (lbf).

13.1.5 Compressive strength, kPa (lbf/in.^{2}).

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 The precision and bias of this test method have not yet been determined. Data are being sought that will be suitable for use in developing precision and bias statements.

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.[5,6]

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.

[5] Lowitz, C. A., and DeGroot, G., "Soil-Cement Pipe Bedding, Canadian River Aqueduct," *Journal of the Construction Division*, ASCE, Vol 94, No. C01, 1968.

[6] "Cement-Treated Pipeline Bedding," Portland Cement Association Publication No. PA0011.01.

SUMMARY OF CHANGES

This section identifies the location of changes to this test method since the last edition.

(1) The term "soil-cement slurry" was changed to "Controlled Low-Strength Material (CLSM)" and the definition modified.

(2) Capping methods expanded to include gypsum mortar and elastomeric pads.

(3) Reference made to other test methods for CLSM and procedure modified to include necessary interaction with the other standards.

(4) SI units made the standard.

(5) Additional section on keywords added.