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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)[1]

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

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 The values stated in SI units are to be regarded as standard. The inch-pound equivalents are shown 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 29/C29M Test Method for Unit Weight and Voids in Aggregate[2]

C 125 Terminology Relating to Concrete and Concrete Aggregates[2]

C 128 Test Method for Specific Gravity and Absorption of Fine Aggregates[2]

C 138 Test Method for Unit Weight, Yield and Air Content (Gravimetric) of Concrete[2]

C 150 Specification for Portland Cement[2]

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[3]

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[3]

D 4832 Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders[3]

D 6024 Test Method for the Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application[3]

PS 28 Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)[3]

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

3. Terminology

3.1 *Definitions*—Except as follows in 3.2, all definitions are in accordance with Terminology C 125 and D 653.

3.1.1 *Controlled Low Strength Material (CLSM)*—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.

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

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[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.**

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 m/s^2 (32.2 ft/s^2).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *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 Method D 4832, Provision Test Methods PS 28 and PS 31.

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 which meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this method are cautioned that compliance with Practice D 3740 does not in itself ensure reliable testing. Reliable testing depends on several 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 1⁄16 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 PS 30.

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/volume), following the procedure outlined in Test Method C 29/C 29M.

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*:

TABLE 1 Minimum Capacity of Measure

Nominal Maximum Size of Coarse Aggregate[A]		Capacity of Measure, min[B]	
in.	mm	ft^3	L
1	25.0	0.2	6
1½	37.5	0.4	11
2	50	0.5	14

[A] Aggregate of a given nominal maximum size may contain up to 10 % of particles retained on the sieve referred to.

[B] To provide for wear, measures may be up to 5 % smaller than indicated in this table.

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 ⅛ 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, ft^3,
Y = volume CLSM produced per batch, $\text{m}^3(\text{ft}^3)$,
W = density of CLSM, $\text{kg/m}^3(\text{lb/ft}^3)$, and
W_1 = total mass of all materials batched, kg (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:

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

where:

N = actual cement content $\text{kg/m}^3(\text{lb/yd}^3)$,
N_t = mass of cement in the batch, kg (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, $\text{kg/m}^3(\text{lb/ft}^3)$ (Note 7),
W = density of CLSM, $\text{kg/m}^3(\text{lb/ft}^3)$,
Y_f = volume of CLSM produced per batch, ft^3,
V = total absolute volume of the component ingredients in the batch, ft^3 or 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 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^3 (10 kg/m^3). 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*—Data are being evaluated to determine the precision of this test method. In addition, Subcommittee D18.15 is seeking pertinent data from users of the test method.

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

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

(1) This test method previously had the designation PS 29 – 95, a provisional test method.
(2) The differences between this version of the test method and the previous one are as follows:
(3) Sections 1.3, 3.1.2.1, 3.1.3.1, 3.2 and 5.4, Note 1, Note 2, and Note 5 were added.
(4) SI units were made the standard, unit weight was changed to density, weight was changed to mass.
(5) Sections 3.2, 4.1, 8.1, 11.1 and 12 were rewritten.
(6) Units in Table 1 were corrected.
(7) In 6.6 vacuum grease was added.
(8) Composite sample was changed to sample in 9.2.1 and 9.2.2.
(9) Section 13, additional keywords were added.