Designation: C689 – 09 (Reapproved 2014)

Standard Test Method for Modulus of Rupture of Unfired Clays[1]

This standard is issued under the fixed designation C689; 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 covers the determination of the modulus of rupture of ceramic whiteware clays both dry and after conditioning at 50 or 80 % relative humidity, or both.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C322 Practice for Sampling Ceramic Whiteware Clays

3. Significance and Use

3.1 The purpose of this test method is to obtain values of rupture modulus of clays before firing, under various processing conditions (relative humidity).

4. Apparatus

4.1 *Conditioning Cabinet*—Any suitable airtight cabinet with means for circulating air, or vacuum desiccator, wherein prescribed specimens can be conditioned as desired before testing. Specimens for dry strength shall be stored with silica gel desiccant. Specimens for 50 % relative humidity shall be stored over a saturated solution of sodium dichromate ($Na_2CR_2O_7{\cdot}2H_2O$), and specimens for 80 % relative humidity shall be stored over a saturated solution of ammonium chloride (NH_4Cl).

4.2 *Testing Machine*—Any suitable testing machine may be used, provided a uniform rate of direct loading can be maintained at no more than 1 lb/min (4.4 N/min) using the prescribed specimens. For the support of the test specimen, two steel bars having a diameter of 0.5-in. (12.7-mm) shall be provided. The load shall be applied by means of a third steel bar having a diameter of 0.5-in. (12.7-mm). All three bars are to be smooth polished steel without surface defects such as scratches or gouges.

5. Test Specimen Preparation

5.1 *Preparation of Extruded Specimens*— 100 % clay specimen preparation: The test sample shall be blunged with sufficient distilled water to give complete dispersion and produce a slip of sufficient viscosity to avoid noticeable settling of particles (usually in the range of 25 to 50 percent solids). Slip shall be sieved through a No. 120 (125 µm) sieve or equivalent. After aging 24 h the slip shall be dewatered to a plastic condition preferably by filter pressing. At this point the moisture content must be adjusted to optimum conditions for forming by some measure of plasticity such as Pfefferkorn apparatus, plumb bob penetration, or other acceptable means. After the water of plasticity has been adjusted (usually will range from 20 to 50 %), test specimens shall be formed by extrusion. Where hand-operated extruder is used without vacuum, the plastic clay shall be thoroughly hand-wedged to eliminate entrapped air as a preliminary to forming test pieces. Where a vacuum extruder is used, a vacuum of not less than 25 in. (635 mm) Hg shall be maintained during forming operation.

5.1.1 *Clay-Flint Specimens*—to be used in the case of strong clays that are considered bonding materials. Prepare specimens as in 5.1 using a mixture of clay and 200 mesh potters flint in a 1/1 ratio blend that has been thoroughly dry mixed.

5.1.2 *Solid Cast Specimens*—100 % clay and clay-flint specimens should be prepared by making a high solids slurry deflocculated to minimum viscosity. Adjust the solids content of the slurry to obtain a viscosity between 100-500 cps. The slurry should be cast in plaster molds until solid, and the bars then dried in accordance to the procedure outlined in 5.3 and 5.4.

5.2 *Dimension*—The test specimens shall be round bars of 0.50 (12.8 mm) diameter, and at least 4.5 in. (114 mm) in length to permit an overhang of at least 0.25 in. at each end when mounted on the supports.

[1] This test method is under the jurisdiction of ASTM Committee C21 on Ceramic Whitewares and Related Productsand is the direct responsibility of Subcommittee C21.04 on Raw Materials.

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

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

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5.3 *Handling and Warpage*—All due precaution shall be observed in the forming and drying to produce straight test specimens. No specimen shall be used that shows a warpage greater than 1 % of its overall length. The bars shall be checked from time to time during drying for straightness, and before they stiffen, corrective straightening may be encouraged by rotating the bars so that drying occurs from another surface region. Defective bars due to warpage, flaws, or voids shall be rejected.

5.4 *Drying and Storage*—The extruded specimens shall be placed on a lightly oiled pallet and allowed to dry at room atmospheric conditions 68 to 104°F (20 to 40°C) for 24 h. Then the specimens shall be dried in a drier at 140°F (60°C) and low relative humidity for 6 h, or until moisture content is less than 0.5 %. The bars shall be loosely stacked in the desiccator to permit rapid cooling. Bars should be cooled to near room temperature but not longer than one (1) hour. After the initial drying period, the specimens for dry strength shall be further dried at 212 to 230°F (100 to 110°C) for 24 h and then cooled in a desiccator before testing. The bars shall be loosely stacked in the desiccator to permit rapid cooling. Bars should be cooled to near room temperature but not longer than one (1) hour. After the initial drying, the specimens for testing at 50 or 80 % relative humidity shall be placed into the conditioning cabinet with circulating air (or in partial vacuum) with a saturated solution of sodium dichromate or ammonium chloride, respectively, and in each case, stored for 24 h to allow equilibrium conditions to be reached.

6. Procedure

6.1 Test at least ten specimens at room temperature for each condition, whether dry or conditioned, at 50 or 80 % relative humidity.

6.2 Remove the test specimen from storage, one at a time, and immediately place on the round bar supports of the testing machine. These supports shall be spaced 4 in. (102 mm) apart, depending on the type machine and type clay, and test specimen must overlap each support by at least 0.25 in. (6.4 mm). Apply the load at right angles to the specimen and midway between the supports. Apply the load at a uniform rate not to exceed 1 lb-f/min (4.4 N/min) until failure occurs. The loading rate should be such as to cause failure in approximately one minute. Measure the diameter at the break to the nearest 0.001 in. (0.03 mm). Use the average of at least three diameter readings around the bar.

7. Calculation

7.1 Calculate the modulus of rupture for each specimen as follows:

$$M = 8PL/\pi d^3 \quad (1)$$

where:

M = modulus of rupture, psi (or MPa),
P = load at rupture, lbf (or N),
L = distance between supports, in. = 2.0 or 4.0 (51 or 102 mm), and
d = diameter of specimen, in. (or mm).

8. Report

8.1 Report the following information:

8.1.1 Identification of the material tested,

8.1.2 Data and computed modulus of rupture for each specimen,

8.1.3 Adjusted average of the computed modulus of rupture values (discarding those values from the bars which, upon inspection, show obvious defects), or deviate more than ± 10% from the adjusted avaerage. Average again.

8.1.4 Drying and storage conditions; that is, whether the test specimens were bone dry, or conditioned at 50 or 80 % relative humidity,

8.1.5 Percent moisture of extruded bars,

8.1.6 Nominal diameter of bars,

8.1.7 Length of span (distance between supports).

8.2 The report may also include:

8.2.1 Percent moisture of each specimen at testing,

8.2.2 Description of type of fracture and the behavior under load of each specimen,

8.2.3 Name and rating of the machine used to make the test, and

8.2.4 Curve sheet showing the individual values of modulus of rupture arranged in ascending order.

9. Precision and Bias

9.1 *Precision*—The precision of this test method is approximately ±10 % of the average modulus of rupture value for the bone dry specimens when the measurements are made by an experienced operator.

9.2 *Bias*—The bias of this test method cannot be specified.

10. Keywords

10.1 clay; modulus of rupture

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