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## **Standard Method of Test for**

# **Compressive Strength of Hydraulic Cement Mortar (Using 50-mm or 2-in. Cube Specimens)**

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**AASHTO Designation: T 106M/T 106-22**

**Technically Revised: 2022**

**Technical Subcommittee: 3a, Cement, Lime, and Concrete Materials**

**ASTM Designation: C109/C109M-21**



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## 1. SCOPE

- 1.1. This test method covers determination of the compressive strength of hydraulic cement mortar using 50-mm [or 2-in.] cube specimens (see Note 1).  
**Note 1**—ASTM C349 provides an alternative procedure for this determination (not to be used for acceptance tests).
- 1.2. This test method covers the application of the test using either inch-pound or SI units. The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.
- 1.3. Values in SI units shall be obtained by measurement in SI units or by appropriate conversion, using the Rules for Conversion and Rounding given in Standard IEEE/ASTM SI 10, of measurements made in other units.
- 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.*  
**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.
- 1.5. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

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## 2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
- M 85, Portland Cement
  - M 152M/M 152, Flow Table for Use in Tests of Hydraulic Cement

- M 201, Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
- M 240M/M 240, Blended Hydraulic Cement
- M 295, Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
- M 302, Slag Cement for Use in Concrete and Mortars
- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- T 105, Chemical Analysis of Hydraulic Cement
- T 162, Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency

2.2.

*ASTM Standards:*

- C91/C91M, Standard Specification for Masonry Cement
- C349, Standard Test Method for Compressive Strength of Hydraulic-Cement Mortars (Using Portions of Prisms Broken in Flexure)
- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- C778, Standard Specification for Standard Sand
- C1005, Standard Specification for Reference Masses and Devices for Determining Mass and Volume for Use in the Physical Testing of Hydraulic Cements
- C1157/C1157M, Standard Performance Specification for Hydraulic Cement
- C1328/C1328M, Standard Specification for Plastic (Stucco) Cement
- C1329/C1329M, Standard Specification for Mortar Cement
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E2877, Standard Guide for Digital Contact Thermometers

2.3.

*IEEE/ASTM Standard:*

- SI10, American National Standard for Metric Practice

2.4.

*International Electrotechnical Commission Standard:*

- IEC 60584-1:2013 Thermocouples - Part 1: EMF Specifications and Tolerances

### 3.

## SUMMARY OF TEST METHOD

3.1.

The mortar used consists of one part cement and 2.75 parts of sand proportioned by mass. Portland, air-entraining portland, portland-limestone, or air-entrained portland-limestone cements are mixed at a specified water content. Water content for other cements is that sufficient to obtain a flow of  $110 \pm 5$  in 25 drops of the flow table. Fifty-millimeter [or 2-in.] test cubes are compacted by tamping in two layers. The cubes are cured 24 h in the molds, and then stripped and immersed in lime water until tested.

### 4.

## SIGNIFICANCE AND USE

4.1.

This test method provides a means of determining the compressive strength of hydraulic cement and other mortars, and results may be used to determine compliance with specifications. Further, this test method is referenced by numerous other specifications and test methods. Caution must be exercised in using the results of this test method to predict the strength of concretes.

## 5. APPARATUS

- 5.1. *Weights and Weighing Devices*—Shall conform to the requirements of ASTM C1005. The weighing device shall be evaluated for precision and accuracy at a total load of 2000 g.
- 5.2. *Glass Graduates*—Of suitable capacities (preferably large enough to measure the mixing water in a single operation) to deliver the indicated volume at 20°C. The permissible variation shall be  $\pm 2$  mL. These graduates shall be subdivided to at least 5 mL, except that the graduation lines may be omitted for the lowest 10 mL for a 250-mL graduate and for the lowest 25 mL for a 500-mL graduate. The main graduation lines shall be circles and shall be numbered. The least graduations shall extend at least one-seventh of the way around, and intermediate graduations shall extend at least one-fifth of the way around.
- 5.3. *Specimen Molds*—For the 50-mm [or 2-in.] cube specimens shall be tight fitting. The molds shall have no more than three cube compartments and shall be separable into no more than two parts. The parts of the molds when assembled shall be positively held together. The molds shall be made of hard metal not attacked by the cement mortar. For new molds, the Rockwell hardness number of the metal shall be not less than 55 HRB. The sides of the molds shall be sufficiently rigid to prevent spreading or warping. The interior faces of the molds shall be plane surfaces and shall conform to the tolerances of Table 1.

**Table 1**—Permissible Variations of Specimen Molds

| Parameter                                 | 50-mm Cube Molds             |                              | 2-in. Cube Molds                |                                 |
|-------------------------------------------|------------------------------|------------------------------|---------------------------------|---------------------------------|
|                                           | New                          | In Use                       | New                             | In Use                          |
| Planeness of sides                        | <0.025 mm                    | <0.05 mm                     | <0.001 in.                      | <0.002 in.                      |
| Distance between opposite sides           | 50 mm $\pm$ 0.13 mm          | 50 mm $\pm$ 0.50 mm          | 2 in. $\pm$ 0.005               | 2 in. $\pm$ 0.02                |
| Height of each compartment                | 50 mm + 0.25 mm to – 0.13 mm | 50 mm + 0.25 mm to – 0.38 mm | 2 in. + 0.01 in. to – 0.005 in. | 2 in. + 0.01 in. to – 0.015 in. |
| Angle between adjacent faces <sup>a</sup> | 90 $\pm$ 0.5°                | 90 $\pm$ 0.5°                | 90 $\pm$ 0.5°                   | 90 $\pm$ 0.5°                   |

<sup>a</sup> Measured at points slightly removed from the intersection. Measured separately for each compartment between all the interior faces and the adjacent face and between interior faces and top and bottom planes of the mold.

- 5.4. *Mixer, Bowl, and Paddle*—An electrically driven mechanical mixer of the type equipped with paddle and mixing bowl, as specified in T 162.
- 5.5. *Flow Table and Flow Mold*—Conforming to the requirements of M 152M/M 152.
- 5.6. *Tamper*—A nonabsorptive, nonabrasive, nonbrittle material such as a rubber compound having a Shore A durometer hardness of  $80 \pm 10$  or seasoned oak wood rendered nonabsorptive by immersion for 15 min in paraffin at approximately 200°C [392°F], using a thermometer that shall meet the requirements of M 339M/M 339 to measure a temperature of 200°C (392°F) with an accuracy of  $\pm 5^\circ\text{C}$  [ $\pm 9^\circ\text{F}$ ] (see Note 2), and shall have a cross section of 13 by 25 mm [ $\frac{1}{2}$  by 1 in.] and a convenient length of about 120 to 150 mm [5 to 6 in.]. The tamping face shall be flat and at right angles to the length of the tamper.
- Note 2**—Thermometer types suitable for use include ASTM E1 mercury thermometer; bimetal stem thermometer; ASTM E2877 digital metal stem thermometer; IEC 60584 thermocouple thermometer Type T, Class 1 or 2; or ASTM E230/E230M thermocouple thermometer, Type T Standard.
- 5.6.1. Tampers shall be checked for conformance to the design and dimensional requirements of this test method at least once every six months.

**Note 3**—A visual inspection of the tamper should be performed each day before use to confirm that the end is flat and at a right angle to the long axis of the tamper. Rounded or peeling tampers should not be used.

- 5.7. *Trowel*—Having a steel blade 100 to 150 mm [4 to 6 in.] in length, with straight edges.
- 5.8. *Moist Cabinet or Room*—Conforming to the requirements of M 201.
- 5.9. *Testing Machine*—Either the hydraulic or the screw type, with sufficient opening between the upper bearing surface and the lower bearing surface of the machine to permit the use of verifying apparatus. The load applied to the test specimen shall be indicated with an accuracy of  $\pm 1.0$  percent. If the load applied by the compression machine is registered on a dial, the dial shall be provided with a graduated scale that can be read to at least the nearest 0.1 percent of the full scale load (see Note 4). The dial shall be readable within 1 percent of the indicated load at any given load level within the loading range. In no case shall the loading range of a dial be considered to include loads below the value that is 100 times the smallest change of load that can be read on the scale. The scale shall be provided with a graduation line equal to zero and so numbered. The dial pointer shall be of sufficient length to reach the graduation marks, and the width of the end of the pointer shall not exceed the clear distance between the smallest graduations. Each dial shall be equipped with a zero adjustment that is easily accessible from the outside of the dial case, and with a suitable device that at all times, until reset, will indicate to within 1 percent accuracy the maximum load applied to the specimen.

**Note 4**—“As close as can be read” is considered 0.5 mm [0.02 in.] along the arc described by the end of the pointer. Also, one half of the scale interval is about as close as can reasonably be read when the spacing on the load indicating mechanism is between 1 mm [0.04 in.] and 1.6 mm [0.0625 in.]. When the spacing is between 1.6 mm [0.0625 in.] and 3.2 mm [0.125 in.], one third of the scale interval can be read with reasonable certainty. When the spacing is 3.2 mm [ $\frac{1}{8}$  in.] or more, one fourth of the scale interval can be read with reasonable certainty.

- 5.9.1. If the testing machine load is indicated in digital form, the numerical display must be large enough to be easily read. The numerical increment must be equal to or less than 0.10 percent of the full scale load of a given loading range. In no case shall the verified loading range include loads less than the minimum numerical increment multiplied by 100. The accuracy of the indicated load must be within 1.0 percent for any value displayed within the verified loading range. Provision must be made for adjusting to indicate true zero at zero load. There shall be provided a maximum load indicator that at all times, until reset, will indicate within 1 percent system accuracy the maximum load applied to the specimen.
- 5.9.2. The upper bearing assembly shall be a spherically seated, hardened metal block firmly attached at the center of the upper head of the machine. The center of the sphere shall coincide with the surface of the bearing face within a tolerance of  $\pm 5$  percent of the radius of the sphere. Unless otherwise specified by the manufacturer, the spherical portion of the bearing block and the seat that holds this portion shall be cleaned and lubricated with a petroleum-type oil such as motor oil at least every 6 months. The block shall be closely held in its spherical seat, but shall be free to tilt in any direction. A hardened metal bearing block shall be used beneath the specimen to minimize wear of the lower platen of the machine. To facilitate accurate centering of the test specimen in the compression machine, one of the two surfaces of the bearing blocks shall have a diameter or diagonal between 70.7 mm [2.83 in.] (see Note 5) and 73.7 mm [2.9 in.]. When the upper block bearing surface meets this requirement, the lower block bearing surface shall be greater than 70.7 mm [2.83 in.]. When the lower block bearing surface meets this requirement, the diameter or diagonal of upper block bearing surface shall be between 70.7 and 79.4 mm [2.83 and  $3\frac{1}{8}$  in.]. When the lower block is the only block with a diameter or diagonal between 70.7 and 73.7 mm [2.83 and 2.9 in.], the lower block shall be used to center the test specimen. In that case, the lower block shall be centered with respect to the upper bearing block and held in position by suitable means. The bearing block surfaces intended for contact with the specimen shall have a Rockwell

hardness number not less than 60 HRC. These surfaces shall not depart from plane surfaces by more than 0.013 mm [0.0005 in.] when the blocks are new and shall be maintained within a permissible variation of 0.025 mm [0.001 in.].

**Note 5**—The diagonal of the 50-mm [2-in.] cube is 70.7 mm [2.83 in.].

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## 6. MATERIALS

### 6.1. *Graded Standard Sand:*

- 6.1.1. The sand (see Note 6) used for making test specimens shall be natural silica sand conforming to the requirements for graded standard sand in ASTM C778.

**Note 6**—*Segregation of Graded Sand*—The graded standard sand should be handled in such a manner as to prevent segregation because variations in the grading of the sand cause variation in the consistency of the mortar. In emptying bins or sacks, care should be exercised to prevent the formation of mounds of sand or craters in the sand, down the slopes of which the coarser particles will roll. Bins should be of sufficient size to permit these precautions. Devices for drawing the sand from bins by gravity should not be used.

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## 7. TEMPERATURE AND HUMIDITY

- 7.1. For tests under laboratory conditions, the storage, mixing, and curing environment shall be in accordance with M 201, using thermometers meeting the requirements of M 339M/M 339.

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## 8. TEST SPECIMENS

- 8.1. Make two or three specimens from a batch of mortar for each period of test or test age.

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## 9. PREPARATION OF SPECIMEN MOLDS

- 9.1. Apply a thin coating of release agent to the interior faces of the mold and nonabsorptive base plates. Apply oils and greases using an impregnated cloth or other suitable means. Wipe the mold faces and the base plate with a cloth as necessary to remove any excess release agent and to achieve a thin, even coating on the interior surfaces. When using an aerosol lubricant, spray the release agent directly onto the mold faces and base plate from a distance of 150 to 200 mm [6 to 8 in.] to achieve complete coverage. After spraying, wipe the surface with a cloth as necessary to remove any excess aerosol lubricant. The residue coating should be just sufficient to allow a distinct fingerprint to remain following light finger pressure (see Note 7).

**Note 7**—Because aerosol lubricants evaporate, molds should be checked for a sufficient coating of lubricant immediately prior to use. If an extended period of time has elapsed since treatment, retreatment may be necessary.

- 9.2. Seal the surfaces where the halves of the mold join by applying a coating of light cup grease such as petrolatum. The amount should be sufficient to extrude slightly when the two halves are tightened together. Remove any excess grease with a cloth.

- 9.3. Seal molds to their base plates with a watertight sealant. Use microcrystalline wax or a mixture of three parts paraffin to five parts rosin by mass. Paraffin wax is permitted as a sealant with molds that clamp to the base plate. Liquefy the wax by heating it to a temperature of between 110 and 120°C [230 and 248°F]. Effect a watertight seal by applying the liquefied sealant at the outside contact lines between the mold and its base plate (see Note 8). The thermometer for measuring the temperature of the wax or paraffin / rosin mixture shall meet the requirements of M 339M/M 339