

ASTM C109

Standard Test Method for Compressive Strength of
Hydraulic Cement Mortars (Using 50-mm Cube
Specimens)

**Understanding ASTM International Test Procedures
for Cement and Concrete - Staying Up to Standard**

Anthony F. Bentivegna, Ph.D., P.E.

May 9, 2016



Objectives

- ▶ Objectives
- ▶ Related Procedures
- ▶ Scope/Significance and Use
- ▶ Identify Necessary Equipment
- ▶ Temperature and Humidity
- ▶ Test Specimens
- ▶ Preparation of Specimen Molds
- ▶ Procedure
- ▶ Understand Limitations of Procedure
- ▶ Calculation

www.CTLGroup.com



Outline

- ▶ Define Key Terminology
- ▶ Identify Necessary Equipment
- ▶ Understand Sources of Errors
- ▶ Understand Limitations of Procedure

www.CTLGroup.com



Related Procedures

- ▶ ASTM C91 – Specification for Masonry Cement
- ▶ ASTM C114 – Test Methods for Chemical Analysis of Hydraulic Cement
- ▶ ASTM C150 – Specification for Portland Cement
- ▶ ASTM C230 – Specification for Flow Table for Use in Tests of Hydraulic Cement
- ▶ ASTM C305 – Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
- ▶ ASTM C349 – Test Method for Compressive Strength of Hydraulic-Cement Mortars (Using Portions of Prisms Broken in Flexure)
- ▶ ASTM C511 – Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes

www.CTLGroup.com



Related Procedures

- ▶ ASTM C595 – Specification for Blended Hydraulic Cements
- ▶ ASTM C618 – Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
- ▶ ASTM C670 – Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- ▶ ASTM C778 – Specification for Sand
- ▶ ASTM C989 – Specification for Slag Cement for Use in Concrete and Mortars
- ▶ ASTM C1005 – Specification for Reference Masses and Devices for Determining Mass and Volume for Use in the Physical Testing of Hydraulic Cements
- ▶ ASTM C1157 – Performance Specification for Hydraulic Cement

www.CTLGroup.com



Related Procedures

- ▶ ASTM C1328 – Specification for Plastic (Stucco) Cement
- ▶ ASTM C1329 – Specification for Mortar Cement
- ▶ ASTM C1437 – Test Method for Flow of Hydraulic Cement Mortar
- ▶ ASTM E4 – Practices for Force Verification of Testing Machines
- ▶ IEEE/ASTM SI-10 – Standard for Use of the International System of Units (SI): The Modern Metric System

www.CTLGroup.com



Scope/Significance and Use

- ▶ **Scope:** This test method covers determination of the compressive strength of hydraulic cement mortars, using 50-mm cube specimens
- ▶ **Significance and Use:** 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.

www.CTLGroup.com



Summary of Test Method

- ▶ Mortar used consists of 1 part cement and 2.75 parts graded standard sand (by mass).
- ▶ Portland or air-entraining portland cements are mixed at specified water/cement ratios.
- ▶ Water content for other cements is that sufficient to obtain a flow of 110 ± 5 in 25 drops of the flow table.
- ▶ 50-mm test cubes are compacted by tamping in two layers
- ▶ The cubes are cured one day in the molds and stripped and immersed in lime water until tested.

www.CTLGroup.com



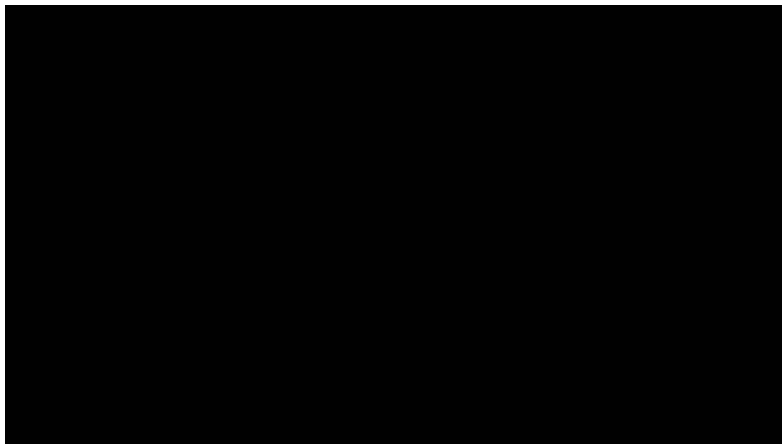
Apparatus

- ▶ Weights and Weighing Devices
- ▶ Glass Graduates
- ▶ Specimen Molds
- ▶ Mixer, Bowl and Paddle
- ▶ Flow Table and Flow Mold
- ▶ Tamper
- ▶ Trowel
- ▶ Moist Cabinet or Room
- ▶ Testing Machine

www.CTLGroup.com



Apparatus

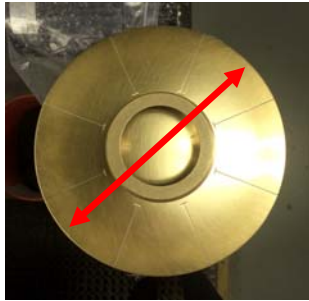


www.CTLGroup.com



Apparatus: Flow Table, Flow Mold, and Caliper (1/2)

► Flow Table



Diameter: 255 ± 2.5 mm



Raised Height: 12.7 ± 0.13 mm

www.CTLGroup.com



Apparatus: Flow Table, Flow Mold, and Caliper (2/2)

► Conical Mold and Caliper



Diameter Top: 70 ± 0.5 mm
Diameter Bottom: 100 ± 0.5 mm
Height: 50 ± 0.5 mm



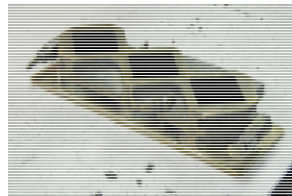
Distance to Zero: 100 ± 0.25 mm

www.CTLGroup.com



Apparatus: Specimen Molds

- ▶ The molds should be made of hard metal not attacked by the cement mortar.
- ▶ The sides of the molds should be sufficiently rigid to prevent spreading or warping.
- ▶ The interior faces of the molds should be plane surfaces.



www.CTLGroup.com

CTLGROUP

Apparatus: Other

- ▶ **Mixer, Paddle and Bowl:** shall conform to Practice C305
- ▶ **Weights and Weighing Devices:** shall conform to C1005
- ▶ **Glass Graduates:** of 250-mL capacity, conforming to the requirements of Specifications E438 and E694.



www.CTLGroup.com

CTLGROUP

Apparatus: Tamper and Tapping Stick

- ▶ **Tamper:** conforming to the requirements of Test Method C109. The tamping face of the tamper shall be flat and at right angles to the length of the tamper.
- ▶ **Trowel:** having a steel blade 100 to 150 mm in length, with straight edges.



www.CTLGroup.com

CTLGROUP

Apparatus: Moist Cabinet or Room

- ▶ Must conform to the requirements of Specification C511.



www.CTLGroup.com

CTLGROUP

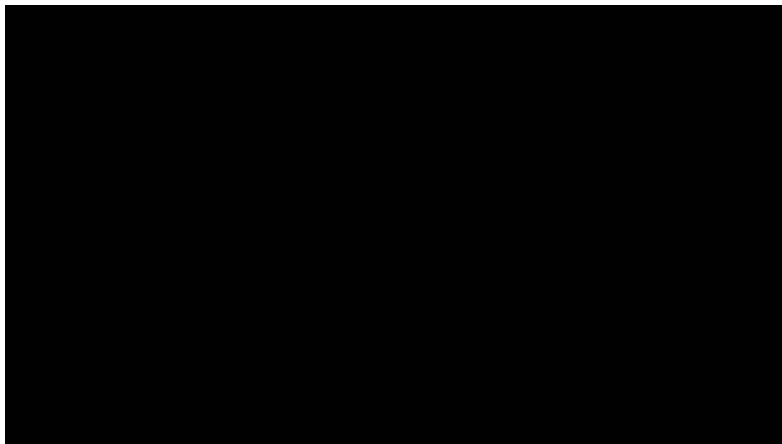
Apparatus: Compression Testing Machine

- ▶ Compression testing machine, either hydraulic or 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.
- ▶ Load applied to the test specimen shall be indicated by a dial pointer or digital pointer.
- ▶ Movable platen and fixed base of compression testing machine.

www.CTLGroup.com



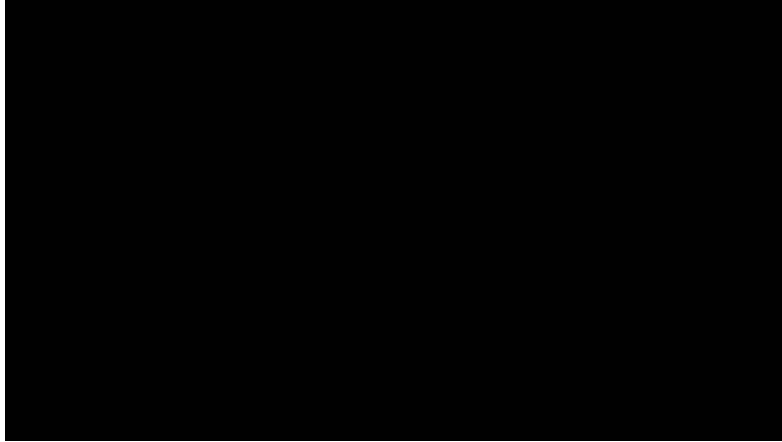
Materials: Graded Standard Sand



www.CTLGroup.com



Temperature and Humidity



www.CTLGroup.com



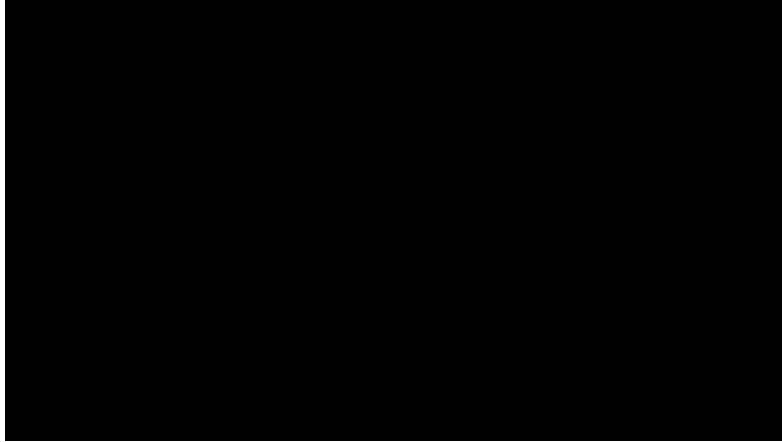
Test Specimens

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

www.CTLGroup.com



Preparation of Specimen Molds



www.CTLGroup.com



Preparation of Specimen Molds

- ▶ 1. Apply thin coat of release agent.
- ▶ 2. Seal molds to base plates with paraffin wax.



www.CTLGroup.com



Procedure: Composition and Mixing Mortars

- ▶ Mortar consists of 1 part cement and 2.75 parts of graded sand.
- ▶ Use water/cement = 0.485 for portland cements and 0.460 for air-entrained portland cements.
- ▶ Mix per ASTM C305.



Number of Specimens	6	9	12
Cement, g	500	740	1060
Sand, g	1375	2035	2915
Water, mL			
Portland (0.485)	242	359	514
Air-entraining portland (0.460)	230	340	488
Other (to flow of 110 ± 5)

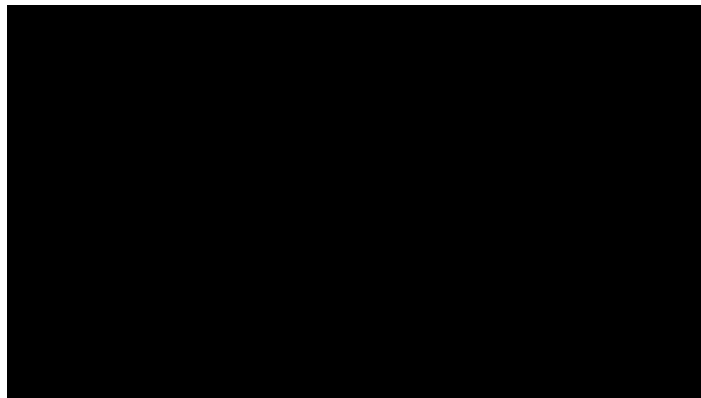
www.CTLGroup.com

Source: ASTM C109



Procedure: Determination of Flow

- ▶ The flow of mortar is determined in accordance with the test method C1437.



www.CTLGroup.com



Procedure: Determination of Flow

- ▶ Determine flow per ASTM C1437

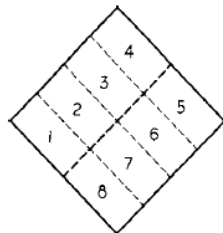


www.CTLGroup.com

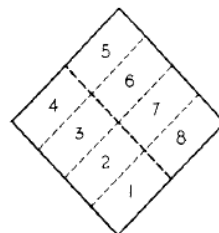
CTLGROUP

Procedure: Molding Test Specimens

- ▶ The specimen molds are prepared by following specified guidelines.
- ▶ Consolidate the sample mortar in the mold by hand tamping.



Rounds 1 and 3



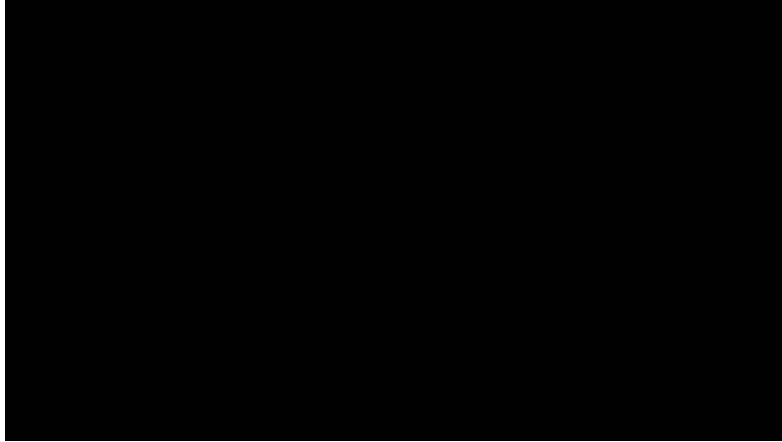
Rounds 2 and 4

www.CTLGroup.com

Source: ASTM C109

CTLGROUP

Procedure: Molding Test Specimens



www.CTLGroup.com



Procedure: Molding Test Specimens



1. Place 25 mm Layer



2. Tamp 32 Times.



3. Fill Mold, Tamp as Specified, and Bring in Forced out Mortar.

www.CTLGroup.com



Procedure: Molding Test Specimens



4. Draw Flat Side Trowel at Right Angle to Length of Mold.

www.CTLGroup.com



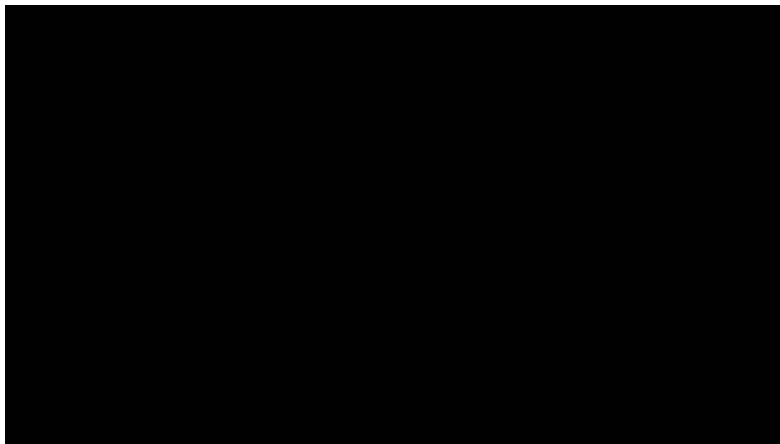
5. Draw Flat Side of Trowel Lightly Down Length of Mold.



6. Cut off Mortar By Drawing Trowel with A Sawing Motion.

CTLGROUP

Procedure: Determination of Compressive Strength



www.CTLGroup.com

CTLGROUP

Procedure: Determination of Compressive Strength

- ▶ Immediately after completing the molding process, place the test specimens in a moist closet or room.
- ▶ Test the concrete cube specimens immediately after removing from the moist closet in the case of 24-hr specimens.

Test Age	Permissible Tolerance
24 h	±½ h
3 days	±1 h
7 days	±3 h
28 days	±12 h

Source: ASTM C109

- ▶ If more than one specimen is removed from curing, keep the samples in water at $23 \pm 2^\circ\text{C}$

www.CTLGroup.com



Procedure: Determination of Compressive Strength



1. Wipe Specimen to SSD and Remove Loose Grains.



2. Check the Faces by Applying Straightedge.



3. Note: If there is any Appreciable Curvature, Grind the faces.

www.CTLGroup.com



Procedure: Determination of Compressive Strength

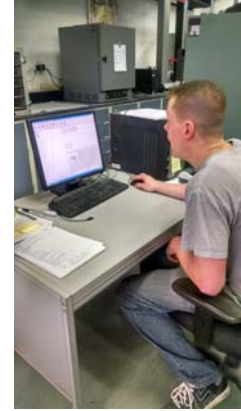


4. Check Spherical Seating Block is Free to Tilt.

www.CTLGroup.com



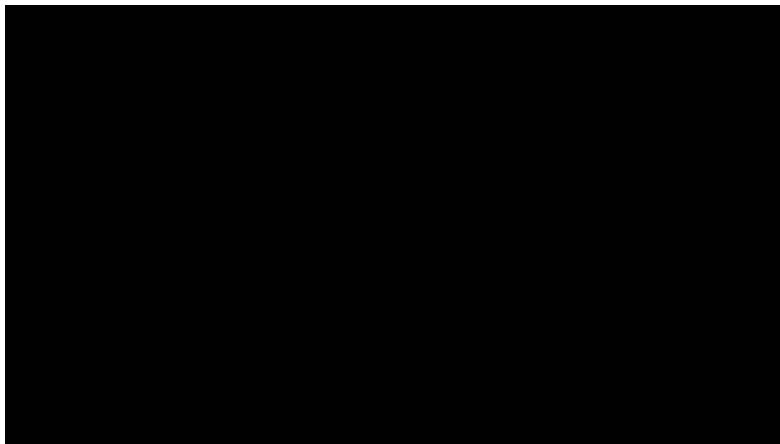
5. Center Specimen below Upper loading Block. Apply Load to True Plane Surfaces.



6. Apply Load at 900 to 1800 N/s.

CTLGROUP

Procedure: Determination of Compressive Strength



www.CTLGroup.com

CTLGROUP

Calculation

- ▶ Compressive strength, f_m (MPa)

$$= P/A$$

Where:

P = total maximum load (N)

A = area of loaded surface (mm²)

www.CTLGroup.com



Report

- ▶ Report the flow to the nearest 1% and the water used to the nearest 0.1%.
- ▶ Average compressive strength of all specimens from the same sample shall be reported to the nearest 0.1 MPa.

www.CTLGroup.com



Limitations and Errors

- ▶ Room temperature and curing environment should be well maintained as per test requirement.
- ▶ Tamping at an angle is common mistake.
- ▶ Compressive strengths of mortars should not be related to concrete.
- ▶ Making specimens free of bug holes and voids is paramount to repeatability.
- ▶ Quality True/Square Molds are Paramount. Avoid Plastic Molds.
- ▶ Excess mortar brought in during tamping.

www.CTLGroup.com



Questions & Answers