# Basic Concrete Tests

Plastic Concrete

# Basic Tests

Cylinder Compression

Splitting Tension

Beam Flexure

Elastic Modulus

Slump

Unit Weight and Yield

Air Content

# Slump

The concrete slump test measures the workability of fresh concrete by indirectly assessing the shearing resistance of the plastic concrete under its own weight. The test specification (ASTM C143) dates all the way back to 1922!

Designation: C 143/C 143M – 05a

# Standard Test Method for Slump of Hydraulic-Cement Concrete[1]

This standard is issued under the fixed designation C 143/C 143M; 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.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope*

1.1 This test method covers determination of slump of hydraulic-cement concrete, both in the laboratory and in the field.

1.2 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not 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 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

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

The vertical distance between the original and displaced position of the center of the top surface of the concrete is measured and reported as the slump of the concrete.

## 4. Significance and Use

4.1 This test method is intended to provide the user with a procedure to determine slump of plastic hydraulic-cement concretes.

NOTE 1—This test method was originally developed to provide a technique to monitor the consistency of unhardened concrete. Under laboratory conditions, with strict control of all concrete materials, the slump is generally found to increase proportionally with the water content of a given concrete mixture, and thus to be inversely related to concrete strength. Under field conditions, however, such a strength relationship is not clearly and consistently shown. Care should therefore be taken in relating slump results obtained under field conditions to strength.

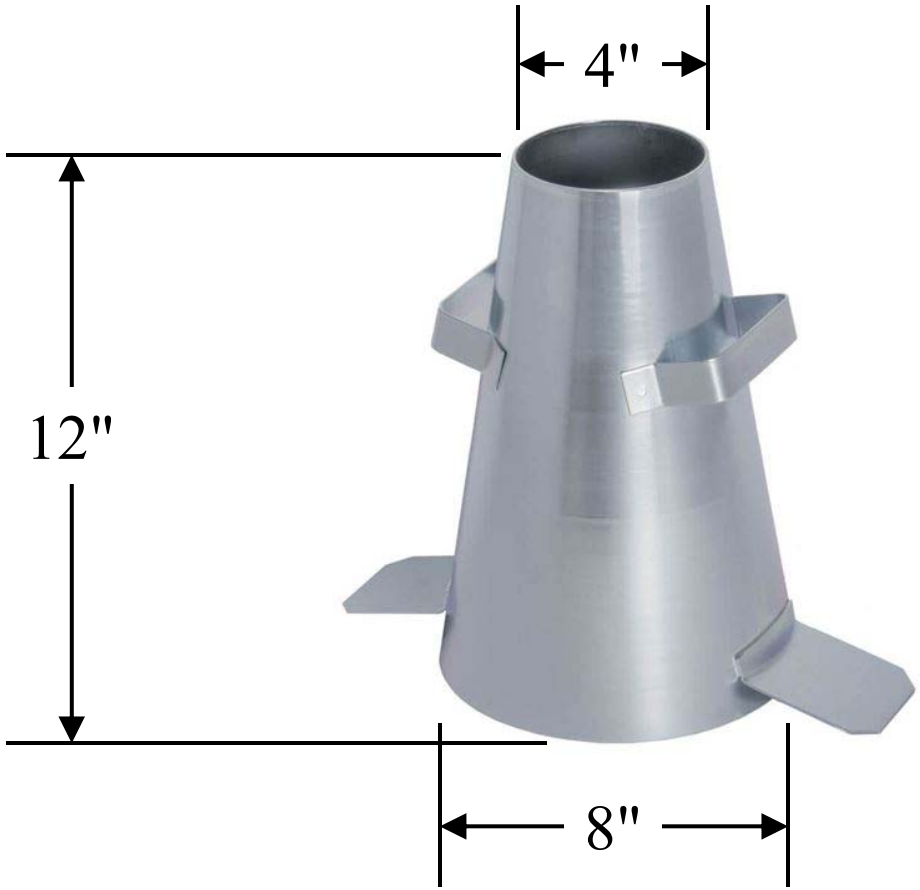
4.2 This test method is considered applicable to plastic concrete having coarse aggregate up to 1½ in. [37.5 mm] in size. If the coarse aggregate is larger than 1½ in. [37.5 mm] in size, the test method is applicable when it is performed on the

# Slump

To perform the test, a conical metal mold called a slump cone is filled with fresh concrete. The slump cone is 12" tall and has a diameter of 4" at the top and 8" at the bottom.

As with the dry-rodded unit weight test for aggregate, the mold is filled in three lifts of equal volume and each lift is rodded 25 times with a tamping rod to eliminate any voids in the specimen.

# Slump Cone

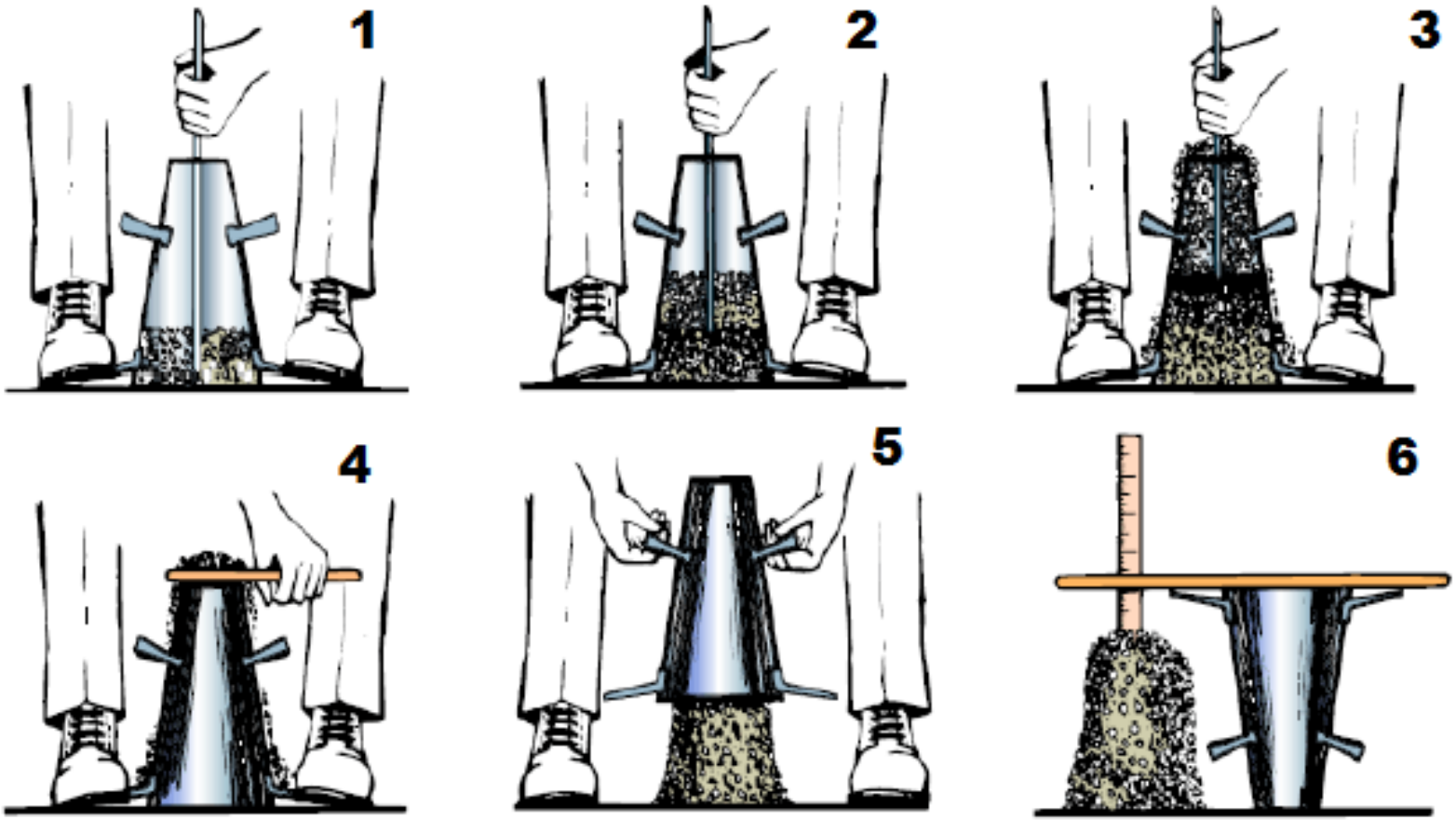


# Slump

The concrete is then struck off level with the top of the mold and the mold is carefully lifted vertically upwards, allowing the now-unsupported concrete to subside (slump).

The test measurement is the change in the height of the concrete from the supported to the unsupported condition. This is called the slump, and is measured to the nearest ¼ inch.

# Slump Test



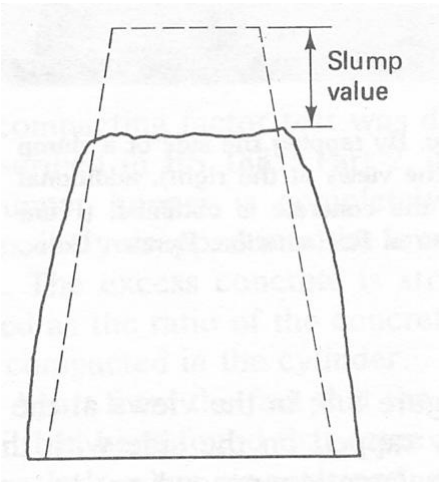

http://cemsolutions.org/concrete-slump-test/

# Slump

The slump test is an index test. The higher the slump the more fluid is the concrete. Thus, it can tell you something about the ***consistency*** of the concrete.

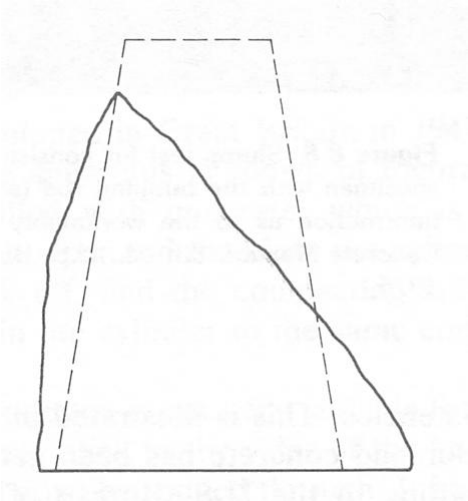
The shape of the slumped concrete can also tell you something about the ***cohesion*** of the concrete. A shear slump indicates a lack of cohesion and possible segregation. A collapse slump suggests a mix that is too wet or has too little cement and may be harsh.

# Slump Types



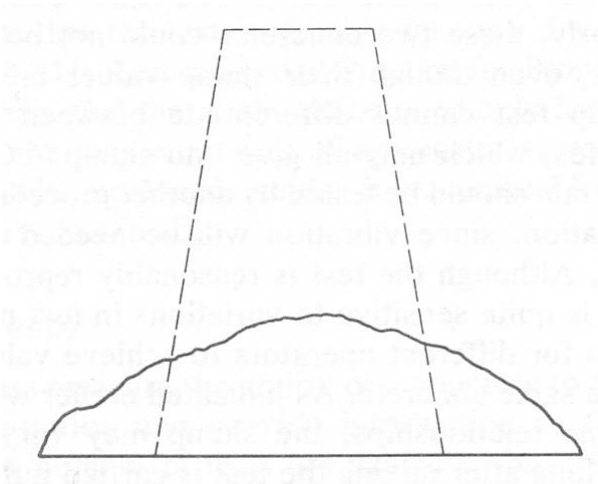

**"True" slump**

Good cohesion
Good consistency



**Shear Slump**

Lacks cohesion
May segregate



**Collapse Slump**

Too lean or too wet
May be harsh

# Basic Tests

Cylinder Compression

Splitting Tension

Beam Flexure

Elastic Modulus

Slump

Unit Weight and Yield

Air Content

Designation: C138/C138M – 17a

American Association State
Highway and Transportation Officials Standard
AASHTO No.: T121

# Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete[1]

This standard is issued under the fixed designation C138/C138M; 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.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope*

1.1 This test method covers determination of the density (see Note 1) of freshly mixed concrete and gives formulas for calculating the yield, cement content, and air content of the concrete. Yield is defined as the volume of concrete produced from a mixture of known quantities of the component materials.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. 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 non-conformance with the standard.

NOTE 1—Unit weight was the previous terminology used to describe the property determined by this test method, which is mass per unit volume.

*mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[3]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

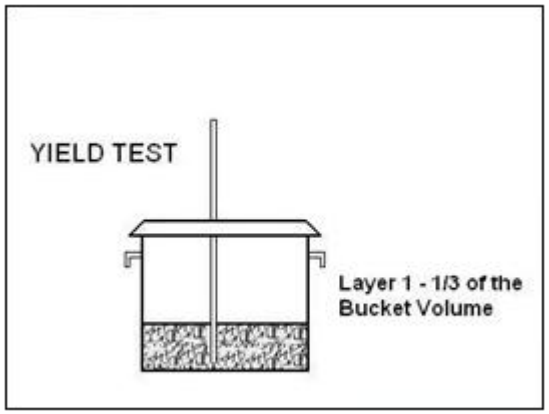
C143/C143M Test Method for Slump of Hydraulic-Cement Concrete

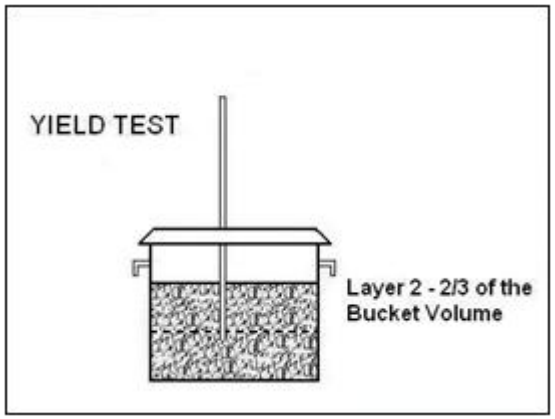
C150/C150M Specification for Portland Cement

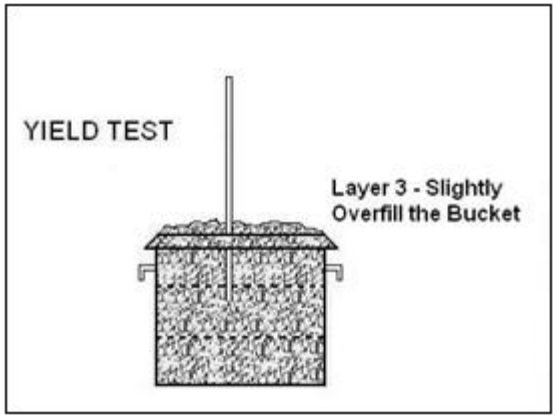
C172/C172M Practice for Sampling Freshly Mixed Concrete

C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

# Unit Weight




http://www.dot.state.oh.us

# Unit Weight

$$D = \frac{M_c - M_m}{V_m}$$

$D$ = unit weight (density) of concrete (lb/ft$^3$)
$M_c$ = mass of unit weight measure filled with concrete (lb)
$M_m$ = mass of unit weight measure empty (lb)
$V_m$ = volume of unit weight measure (ft$^3$)

Typical values are 140 lb/ft$^3$ to 150 lb/ft$^3$!

# Yield

$$Y = \frac{M}{27D}$$

$Y$ = yield (volume of concrete produced per batch) ($yd^3$)
$M$ = total mass of ingredients in each batch (lb)
$D$ = unit weight of concrete ($lb/ft^3$)

Yield is used for quality control purposes

# Relative Yield

$$R_y = \frac{Y}{Y_d}$$

$R_y$ = relative yield (dimensionless)
$Y$ = yield (volume of concrete produced) ($yd^3$)
$Y_d$ = volume of concrete intended ($yd^3$)

Sometimes expressed as $ft^3$ per $yd^3$ since mix designs are typically done for 1 $yd^3$

# Cement Content

$$C = \frac{C_b}{Y}$$

$C$ = cement content (lb/yd$^3$)
$C_b$ = mass of cement in the batch (lb or kg)
$Y$ = yield (volume of concrete produced) (yd$^3$ or m$^3$)

Sometimes divided by 94 lb per sack of cement
to get cement content in "bags" (e.g., a 7-bag mix)

# Gravimetric Air Content

$$A = \frac{T - D}{T} \times 100\%$$

$A$ = air content (% by volume)
$D$ = actual density of the concrete (lb/ft$^3$)
$T$ = theoretical air-free density of the concrete (lb/ft$^3$)

# Gravimetric Air Content

$$A = \left(1 - \frac{D}{T}\right) \times 100\%$$

$A$ = air content (% by volume)
$D$ = actual density of the concrete (lb/ft$^3$)
$T$ = theoretical air-free density of the concrete (lb/ft$^3$)

This is the same calculation we did for the void content of aggregate!

# Theoretical Air-Free Density

$$T = \frac{M}{V}$$

$T$ = theoretical air-free density of the concrete (lb/ft$^3$)
$M$ = total mass of batched ingredients (lb)
$V$ = total absolute volume of batched ingredients (ft$^3$)

$$V = \sum_{i=1}^{n} \frac{M_i}{RD_i\ \gamma_w}$$

# Example

Assume a 10-$yd^3$ batch of concrete requires

3200 lb of water (RD = 1.00)

5800 lb of cement (RD = 3.15)

19,400 lb of gravel (RD = 2.68)

11,100 lb of sand (RD = 2.65)

# Example (cont.)

$$W_{water} = \quad 3{,}200 \text{ lb} \qquad V_{water} = \frac{3200}{1.00(62.4)} = \quad 51.3 \text{ ft}^3$$

$$W_{cement} = \quad 5{,}800 \text{ lb} \qquad V_{cement} = \frac{5800}{3.15(62.4)} = \quad 29.5 \text{ ft}^3$$

$$W_{gravel} = 19{,}400 \text{ lb} \qquad V_{gravel} = \frac{19{,}400}{2.68(62.4)} = 116.0 \text{ ft}^3$$

$$W_{sand} = 11{,}100 \text{ lb} \qquad V_{sand} = \frac{11{,}100}{2.65(62.4)} = \quad 67.1 \text{ ft}^3$$

$$M = 39{,}500 \text{ lb} \qquad V = 263.9 \text{ ft}^3$$

# Example (cont.)

$$T = \frac{M}{V} = \frac{39{,}500}{263.9} = 150\,\frac{lb}{ft^3}$$

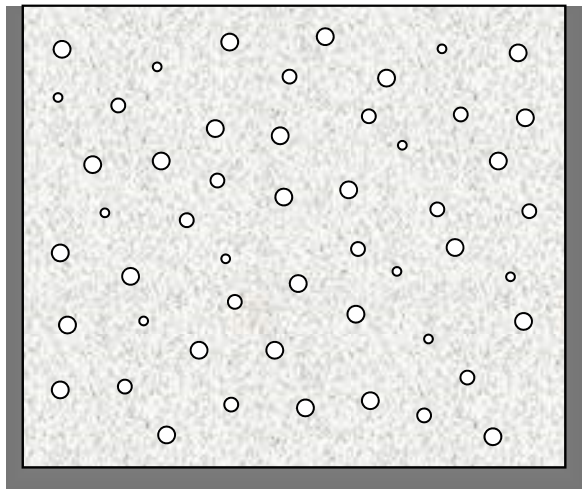
$T$ = theoretical air-free density of the concrete (lb/ft$^3$)
$M$ = total mass of batched ingredients (lb)
$V$ = total absolute volume of batched ingredients (ft$^3$)

# Example (cont.)

$V_m = 0.251\ \text{ft}^3$

$M_m = 8.3\ \text{lb}$

$M_c = 45.0\ \text{lb}$



$V_m$ should be measured to 3 significant digits
Masses should be measured to nearest 0.1 lb

# Example (cont.)

$$D = \frac{M_c - M_m}{V_m} = \frac{45.0 - 8.3}{0.251} = \frac{36.7}{0.251} = 146\ \frac{lb}{ft^3}$$

$M_c$ = mass of unit weight measure filled with concrete (lb)
$M_m$ = mass of unit weight measure empty (lb)
$V_m$ = volume of unit weight measure ($ft^3$)
$D$ = unit weight (density) of concrete ($lb/ft^3$)

Typical values are 140 $lb/ft^3$ to 150 $lb/ft^3$!

# Example (cont.)

$$Y = \frac{M}{27D} = \frac{39{,}500}{27 \times 146} = 10.02\ yd^3$$

$M$ = total mass of ingredients in each concrete batch (lb)
$D$ = unit weight of concrete ($lb/ft^3$)
$Y$ = yield (volume of concrete produced per batch) ($yd^3$)

# Relative Yield

$$R_y = \frac{Y}{Y_d} = \frac{10.02}{10} = 1.002$$

$Y$ = yield (volume of concrete actually produced per batch) ($yd^3$)
$Y_d$ = volume of concrete batch was designed to produce ($yd^3$)
$R_y$ = relative yield (dimensionless)

A value less than 1.00 indicates the batch produced is "short" of its design volume

# Cement Content

$$C = \frac{C_b}{Y} = \frac{5800}{10.02} = 579\,\frac{lb}{yd^3}$$

$C_b$ = mass of cement in the batch (lb or kg)
$Y$ = yield (volume of concrete actually produced per batch) ($yd^3$ or $m^3$)
$C$ = cement content ($lb/yd^3$)

$$\mathrm{C} = \frac{579\ lb/yd^3}{94\ lb/bag} = 6.2 \text{ bags per cubic yard}$$

# Gravimetric Air Content

$$A = \left(1 - \frac{D}{T}\right) \times 100\% = \left(1 - \frac{146}{150}\right) \times 100\% = 2.7\%$$

$A$ = air content (% by volume)
$D$ = actual density of the concrete (lb/ft$^3$)
$T$ = theoretical air-free density of the concrete (lb/ft$^3$)

This is the same calculation we did for the void content of aggregate!

# Basic Tests

Cylinder Compression

Split Tension

Beam Flexure

Elastic Modulus

Slump

Unit Weight and Yield

Air Content

Designation: C 173/C 173M – 07

# Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method[1]

This standard is issued under the fixed designation C 173/C 173M; 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.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope*

1.1 This test method covers determination of the air content of freshly mixed concrete containing any type of aggregate, whether it be dense, cellular, or lightweight.

1.2 The values stated in either inch-pound or SI units shall be regarded separately as standard. The SI units are shown in brackets. The values stated are not exact equivalents; therefore each system must be used independently of the other. Combining values from the two units may result in nonconformance.

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.*(**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

## 2. Referenced Documents

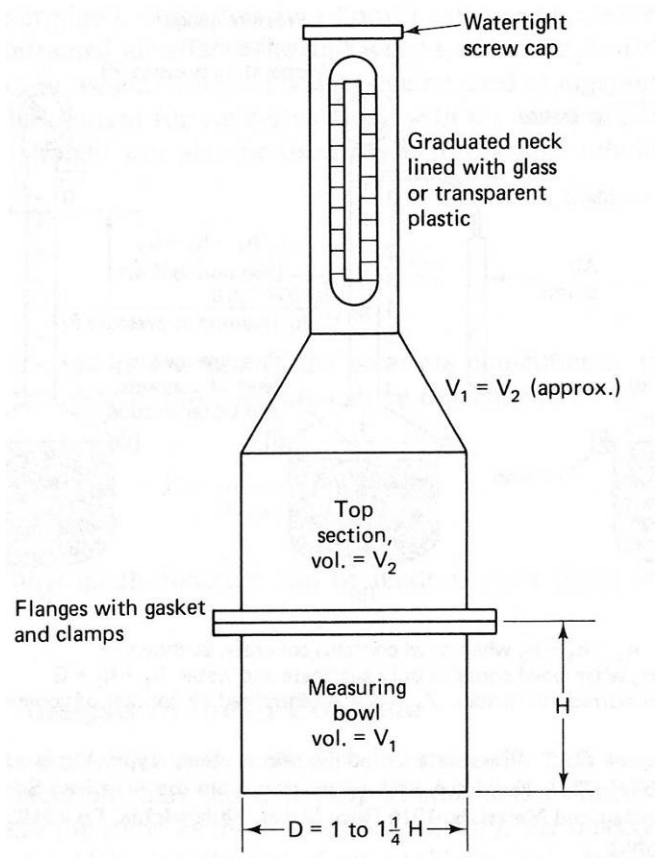
in the mortar fraction of the concrete, but is not affected by air that may be present inside porous aggregate particles.

3.1.1 Therefore, this is the appropriate test to determine the air content of concretes containing lightweight aggregates, air-cooled slag, and highly porous or vesicular natural aggregates.

3.2 This test method requires the addition of sufficient isopropyl alcohol, when the meter is initially being filled with water, so that after the first or subsequent rollings little or no foam collects in the neck of the top section of the meter. If more foam is present than that equivalent to 2 % air above the water level, the test is declared invalid and must be repeated using a larger quantity of alcohol. Addition of alcohol to dispel foam any time after the initial filling of the meter to the zero mark is not permitted.

3.3 The air content of hardened concrete may be either higher or lower than that determined by this test method. This depends upon the methods and amounts of consolidation effort applied to the concrete from which the hardened concrete

# Volumetric Method




The measuring bowl is filled with concrete, the device is assembled, and water is added to reach the zero mark in the neck. As the device is agitated ("rolled"), the air in the concrete is replaced by water from the top section and the water level in the neck drops in proportion to the air content.

# Volumetric Method


"roller meter"

Designation: C 231 – 04

# Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[1]

This standard is issued under the fixed designation C 231; 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.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope*

1.1 This test method covers determination of the air content of freshly mixed concrete from observation of the change in volume of concrete with a change in pressure.

1.2 This test method is intended for use with concretes and mortars made with relatively dense aggregates for which the aggregate correction factor can be satisfactorily determined by the technique described in Section 6. It is not applicable to concretes made with lightweight aggregates, air-cooled blast-furnace slag, or aggregates of high porosity. In these cases, Test Method C 173/C 173M should be used. This test method is also not applicable to nonplastic concrete such as is commonly used in the manufacture of pipe and concrete masonry units.

1.3 The text of this test method references notes and footnotes that provide explanatory information. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this standard.

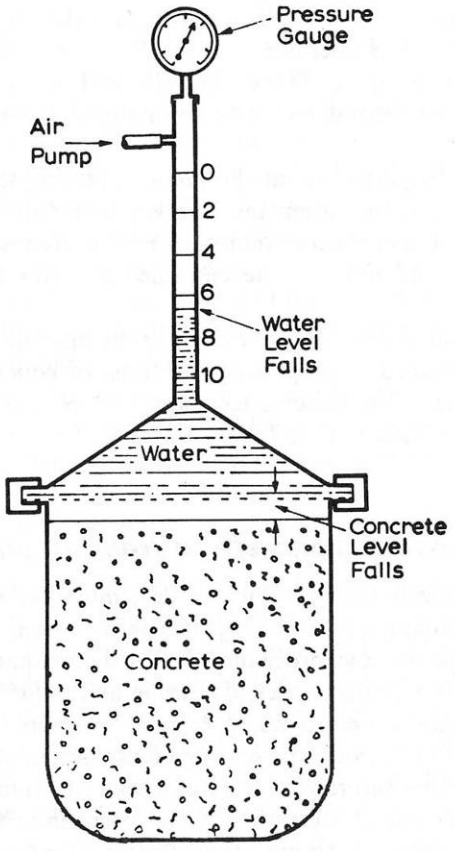
1.4 The values stated in inch-pound units are to be regarded

C 138/C 138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
C 172 Practice for Sampling Freshly Mixed Concrete
C 173/C 173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
C 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

## 3. Significance and Use

3.1 This test method covers the determination of the air content of freshly mixed concrete. The test determines the air content of freshly mixed concrete exclusive of any air that may exist inside voids within aggregate particles. For this reason, it is applicable to concrete made with relatively dense aggregate particles and requires determination of the aggregate correction

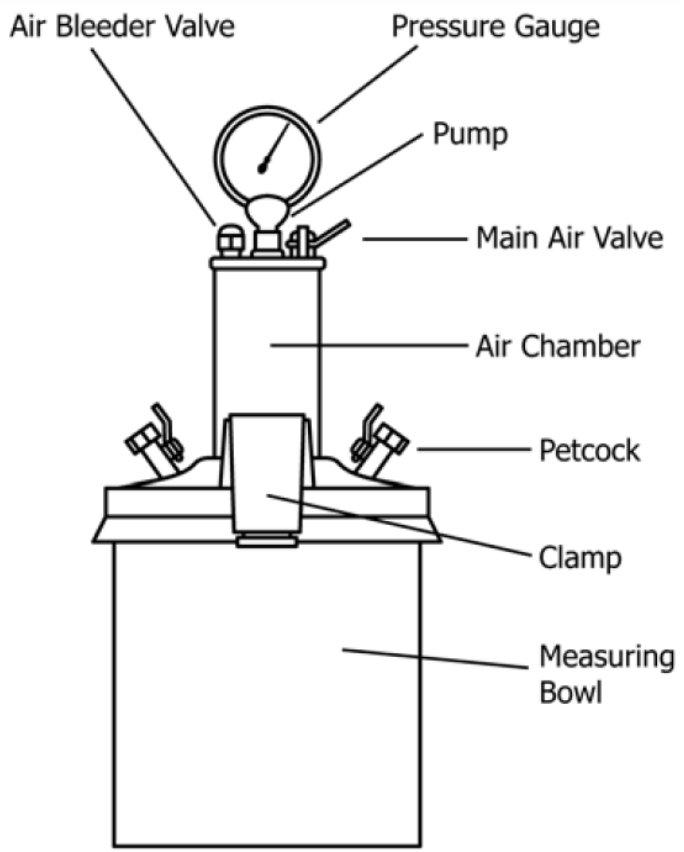
# Pressure Method (Type A)




The bowl is filled with concrete, the device is assembled, and water is added to reach the zero mark in the neck. As the unit is pressurized, the air bubbles compress, the concrete surface falls and the water level drops in proportion to the change in air volume.

# Type A Pressuremeter

# Pressure Method (Type B)




The bowl is filled with concrete, the device is assembled, and the air chamber is pressurized. When the air pressure is released into the bowl, the air bubbles compress, the concrete surface falls and the chamber pressure drops in proportion to the change in air volume.

# Type B Pressuremeter