Designation: C 1591 – 04

Standard Test Method for Determination of the Modulus of Elasticity of AAC[1]

This standard is issued under the fixed designation C 1591; 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 procedure covers the determination of the modulus of elasticity of Autoclaved Aerated Concrete (AAC) in compression by determining the stress-strain behavior. AAC is a cementitious product based on calcium silicate hydrates in which low density is attained by the inclusion of an agent resulting in macroscopic voids, and is subjected to high pressure steam curing.

NOTE 1—Installed units covered by this standard must be protected against direct exposure to moisture using a coating material accepted by the AAC manufacturer.

1.2 AAC tested in accordance with this test method shall comply with Specification C 1386.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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:* [2]

C 39/C 39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C 1386 Specification for Precast Autoclaved Aerated Concrete Wall Construction Units

E 4 Practices for Force Verification of Testing Machines

E 575 Practice for Reporting Data from Structural Tests of Building Constructions, Elements, Connections and Assemblies

3. Significance and Use

3.1 This test method is intended to provide simplified and economical means for obtaining data on the chord modulus of elasticity developed for different types of AAC grades.

4. Apparatus

4.1 *Testing Machine*, conforming to the requirements of Practices E 4 (Constant-Rate of-Traverse CRT-Type Testing Machine section). The spherical head and bearing blocks shall confirm to the Apparatus Section of Test Method C 39/C 39M.

4.2 *Calipers*—Calipers shall allow a reading with a precision of 0.1 mm.

4.3 *Drying Ovens*—Two ovens typically are used for this test procedure. One maintained at a temperature of 105 ± 5°C and another maintained at a temperature of 70 ± 5°C.

4.4 *Compressometer*, may be used to determine the strain behavior of the specimen during compression and shall have a precision of 0.001 mm.

5. Specimens

5.1 *Shape of Specimens*—The modulus of elasticity is determined on prisms having the dimensions of 100 mm (4 in.) by 100 mm (4 in.) by 200 mm (8 in.). Prisms of other sizes or cylindrical specimens can be used provided that the width (diameter) of such other specimens is not less than 75 mm (3 in.) and the ratio between the height and the width shall be 2.

5.2 *Number and Orientation of Specimens*—A test set shall consist of three specimens. Whenever possible one specimen shall be prepared for the upper third of the product, one from the middle third, and one from the bottom third as determined by the direction of rising of the mass during manufacturing. Specimens are prepared such that the loading is applied to the 100 mm (4 in.) by 100 mm (4 in.) surface and is perpendicular to the direction of rising during manufacture.

[1] This test method is under the jurisdiction of ASTM Committee C27 on Precast Concrete Products and is the direct responsibility of Subcommittee C27.60 on Precast Autoclaved Aerated Concrete.

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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.

5.3 *Preparation of the Specimens*—The specimens shall be dried to a moisture content between 5 and 15 % by weight. After drying and before testing the specimens shall be stored at room temperature until the specimens have reached an equilibrium temperature.

6. Procedure

6.1 *Density and Moisture Content Determination*—The dry density of comparable specimens and the moisture content of the test specimens shall be determined according to Specification C 1386.

6.2 *Determination of the Modulus of Elasticity*:

6.2.1 *Compression Testing*—The specimen is placed in the testing machine such that the 100 mm (4 in.) by 100 mm (4 in.) surfaces are load bearing without capping. The dimensions of the load bearing surfaces shall be determined and recorded with an accuracy of 3 mm (0.12 in.). No overall unit dimension (width, height, and length) shall differ by more than 3 mm (⅛ in.) from the specified standard dimension.

6.2.1.1 Electric strain gages or mechanical compressometer for determining the strain of the specimen during loading shall be attached to two opposite longitudinal surfaces of the specimen. The strain gages shall be placed within the middle third of the specimen, as close as possible to the center. The gage length when using compressometers shall be 100 ± 2 mm (4 ± 0.08 in.) and centered about the middle third of the specimen.

6.2.1.2 Use companion specimens to determine the compressive strength in accordance with Test Method C 39/C 39M prior to the test for modulus of elasticity.

6.2.1.3 The specimen is placed in the testing machine and centered such that loading is concentric. A base load is applied, which is equal to 0.33 times the ultimate expected compressive strength, f'_{aac}, for the material, and maintained for 90 seconds. The corresponding strains, ϵ_{b1} and ϵ_{b2}, are measured during the last 30 s of the applied load. If ϵ_{b1} and ϵ_{b2} deviate by more than 20 %, the applied loading is considered eccentric. The specimen shall then be unloaded, realigned, reloaded to 0.33 f'_{aac}, and the corresponding strains measured.

6.2.1.4 When the strain readings at 0.33 f'_{aac} are within 20 %, decrease the load gradually until a value of 0.05 f'_{aac} is reached (this should take approximately 30 s). This load is maintained for 90 s, and the corresponding strains, ϵ_{a1} and ϵ_{a2}, are measured during the last 30 s of the applied load. If the difference in readings from the two gages ($\epsilon_{b1} - \epsilon_{a1}$, $\epsilon_{b2} - \epsilon_{a2}$) corresponding to the applied loads of 0.33 f'_{aac} and 0.05 f'_{aac} deviate by more than 20 %, the applied loading is considered eccentric. The specimen shall then be unloaded, realigned, and the test repeated. If the difference in readings from the two gages ($\epsilon_{b1} - \epsilon_{a1}$, $\epsilon_{b2} - \epsilon_{a2}$) corresponding to the applied loads of 0.33 f'_{aac} and 0.05 f'_{aac} are within 20 % of each other, the loading cycle above is repeated. The loading is taken to 0.33 f'_{aac}; read ϵ_{b1} and ϵ_{b2} and calculate the average ϵ_b; decrease the load to 0.05 f'_{aac}; read ϵ_{a1} and ϵ_{a2} and calculate the average ϵ_a. These values will be used to calculate the modulus of elasticity, E_{aac}. After completion of this second loading cycle the compressometer shall be removed, and the specimen loaded to failure.

6.3 All of the readings are taken under the final loading cycle.

7. Calculations

7.1 The compressive load (force) in each case shall be converted to a compressive stress using the formula:

$$f = \frac{F}{A_c} \tag{1}$$

where:

f = calculated applied stress, MPa (psi),
F = measured applied load, N (lbf), and
A_c = area over which the load is applied, mm^2 (in.^{2}).

7.2 The compressive strain, ϵ, is calculated according to the following in the case of using compressometers (in the case of electric strain gages, strain readings are directly recorded):

$$\epsilon = \frac{\frac{\Delta_a + \Delta_b}{2}}{L_m} \tag{2}$$

where:

Δ_a and Δ_b, = the change in gage length, and
L_m = gage lengths.

7.3 The modulus of elasticity, E_c, is determined by:

$$E_c = \frac{f_b - f_a}{\epsilon_b - \epsilon_a} \tag{3}$$

where:

f_a = stress recorded at 0.05 f'_{aac},
f_b = stress recorded at 0.33 f'_{aac},
ϵ_a = average strain calculated at 0.05 f'_{aac}, and
ϵ_b = average strain calculated at 0.33 f'_{aac}.

8. Report

8.1 The moisture content and dry density of the material shall be determined and reported according to Specification C 1386.

8.2 The report shall be prepared in conformance with Practice E 575 and shall include the following:

8.2.1 Identification number,
8.2.2 Average width of specimen to the nearest 1.0 mm,
8.2.3 Average depth of specimen to the nearest 1.0 mm,
8.2.4 Mass of specimen, kg (lb),
8.2.5 Maximum applied load, N (lbf),
8.2.6 Modulus of Elasticity, MPa (psi),
8.2.7 Defects in specimen,
8.2.8 Description of failure,
8.2.9 AAC grade,
8.2.10 Compressive strength of AAC, MPa (psi), and
8.2.11 Dry Build Density of AAC, Kg/m^3 (pcf)

9. Precision and Bias

9.1 The precision and bias of the test procedures are being determined and will be provided when sufficient data are available to indicate acceptable tolerances in repeatability and reproducibility.