Designation: C1314 – 10

Standard Test Method for
Compressive Strength of Masonry Prisms[1]

This standard is issued under the fixed designation C1314; 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 procedures for masonry prism construction and testing, and procedures for determining the compressive strength of masonry, f_{mt}, used to determine compliance with the specified compressive strength of masonry, f'_m. When this test method is used for research purposes, the construction and test procedures within serve as a guideline and provide control parameters.

1.2 This test method also covers procedures for determining the compressive strength of prisms obtained from field-removed masonry specimens.

1.3 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.

1.4 *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]

C67 Test Methods for Sampling and Testing Brick and Structural Clay Tile

C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

C140 Test Methods for Sampling and Testing Concrete Masonry Units and Related Units

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

C144 Specification for Aggregate for Masonry Mortar

C270 Specification for Mortar for Unit Masonry

C476 Specification for Grout for Masonry

C780 Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry

C1019 Test Method for Sampling and Testing Grout

C1093 Practice for Accreditation of Testing Agencies for Masonry

C1532 Practice for Selection, Removal, and Shipment of Manufactured Masonry Units and Masonry Specimens from Existing Construction

C1552 Practice for Capping Concrete Masonry Units, Related Units and Masonry Prisms for Compression Testing

C1587 Practice for Preparation of Field Removed Manufactured Masonry Units and Masonry Specimens for Testing

E105 Practice for Probability Sampling of Materials

E111 Test Method for Young's Modulus, Tangent Modulus, and Chord Modulus

3. Terminology

3.1 *Definitions:*

3.1.1 *set*—a set consists of at least three prisms constructed of the same material and tested at the same age.

3.2 *Notations:*

3.2.1 f'_m—specified compressive strength of masonry.

3.2.2 f_{mt}—compressive strength of masonry.

3.2.3 h_p—prism height.

3.2.4 t_p—least actual lateral dimension of prism.

4. Significance and Use

4.1 This test method provides a means of verifying that masonry materials used in construction result in masonry that meets the specified compressive strength.

4.2 This test method provides a means of evaluating compressive strength characteristics of in-place masonry construction through testing of prisms obtained from that construction when sampled in accordance with Practice C1532. Decisions made in preparing such field-removed prisms for testing, determining the net area, and interpreting the results of compression tests require professional judgment.

4.3 If this test method is used as a guideline for performing research to determine the effects of various prism construction or test parameters on the compressive strength of masonry,

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

deviations from this test method shall be reported. Such research prisms shall not be used to verify compliance with a specified compressive strength of masonry.

Note 1—The testing laboratory performing this test method should be evaluated in accordance with Practice C1093.

4.3.1 Appendix X2 includes guidance information for the researcher on aspects of materials, construction, and analysis.

5. Masonry Prism Construction

5.1 Construct prisms of units representative of those used in the construction. If units have flutes or ribs that project ½ in. (12.5 mm) or more from the surface of the unit, remove those flutes or ribs by saw cutting flush with the surface of the unit at the base of the flute or rib. When prisms are used for field quality control or assurance, record the location in the structure that corresponds to the set of prisms constructed.

Note 2—Building codes or project specifications may require a set of prisms for a given square footage of construction. Recording the location of the structure that corresponds to a set of prisms allows the test results to be attributed to a particular portion of the structure.

5.2 Construct a set of prisms for each combination of materials and each test age at which the compressive strength of masonry is to be determined.

5.3 Build each prism in an opened, moisture-tight bag large enough to enclose and seal the completed prism. Construct prisms on a flat, level base. Construct prisms in a location where they will remain undisturbed until transported for testing.

5.4 Construct prisms as shown in Fig. 1 with units laid in stack bond in stretcher position. Orient units in the prism as in the corresponding construction. At the time of prism construction, the surfaces of the units shall be free of moisture. Where the corresponding construction is of multi-wythe masonry having wythes composed of different units or mortar, build prisms representative of each different wythe and test separately.

5.5 Build prisms with full-size or reduced length units. Any required saw cutting shall be performed on units prior to prism construction. The moisture content(s) of units used to construct prisms shall be representative of those used in construction. Prisms composed of units that contain closed cells shall have at least one complete cell with one full-width cross web on either end (see Fig. 2). Prisms composed of units without closed cells shall have as symmetrical a cross section as possible. The minimum length of prisms shall be 4 in. (100 mm).
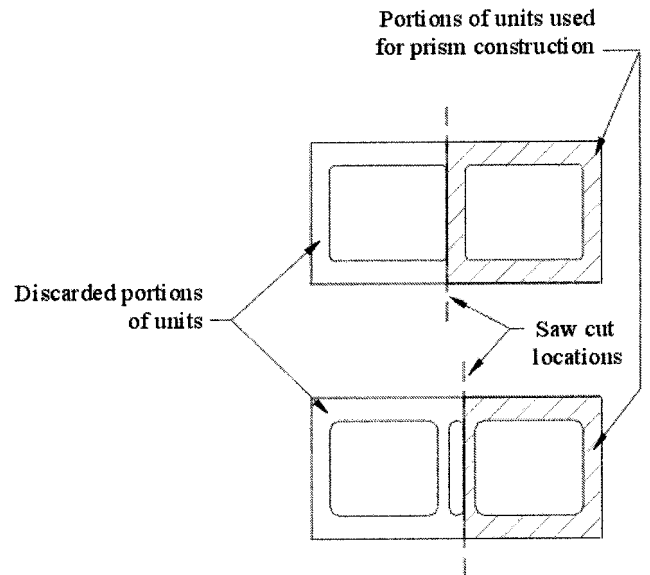

FIG. 2 Reduction of Hollow Units Prior to Prism Construction

Note 3—When using larger masonry units, experience has shown that reducing the length of these units prior to prism construction makes their handling and transportation easier. Thus, these reduced length unit prisms are less likely to be damaged and are more likely to be properly capped and tested. Also, the smaller prism will be less likely to be affected by plate bending effects during testing, as described in Note 8, and will therefore provide a more accurate assessment of the strength of the materials in the masonry prism. For these reasons, the use of reduced length prisms is encouraged.

5.6 Build masonry prisms with full mortar beds (mortar all webs and face shells of hollow units). Use mortar representative of that used in the corresponding construction. Use mortar joint thickness and a method of positioning and aligning units, that are representative of the corresponding construction. Use mortar joints that are cut flush. For prisms to be grouted, remove mortar "fins" that protrude into the grout space.

5.7 Build prisms a minimum of two units high with a height-to-thickness ratio, h_p/t_p, between 1.3 and 5.0.

5.8 Immediately following the construction of the prism, seal the moisture-tight bag around the prism.

5.9 *Grouted Prisms.*

5.9.1 When prisms are used for field quality control or assurance, construct prisms at the same time as the corresponding construction, and grout prisms when the corresponding construction is being grouted. When prisms are used for other
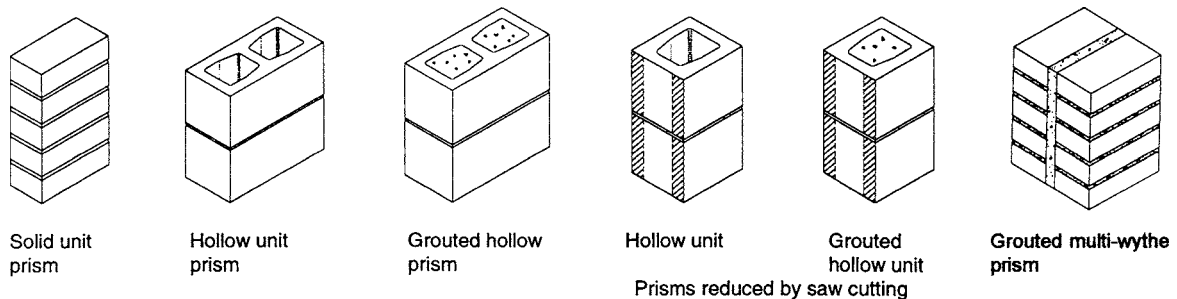

FIG. 1 Masonry Prism Construction

purposes, grout prisms not less than 4 h nor more than 48 h following the construction of the prisms.

5.9.2 Where the corresponding construction is to be solidly grouted, solidly grout the prisms. Use grout representative of that used in the corresponding construction. Before placing grout, remove mortar droppings from the grout space. Use grout consolidation and reconsolidation procedures representative of those used in the construction. Place additional grout into the prisms as necessary after each consolidation. Screed off excess and finish the grout so that it is level with the top of the prism and in contact with the units at the perimeter of the grout space. Grouted prisms shall contain no reinforcement.

5.9.3 Where the corresponding construction is to be partially grouted, construct two sets of prisms; grout one set solid as described in 5.9.2 and leave the other set ungrouted.

5.9.4 Where open-end units or prisms containing grout between similar wythes are to be grouted, use similar masonry units as forms to confine the grout during placement. Brace forms to prevent displacement during grouting. Grout as described in 5.9.2.

5.9.5 Immediately following the grouting operation, reseal the moisture-tight bag around the prism.

5.10 Keep all prisms from freezing. Do not disturb or move prisms for the first 48 h after construction and grouting. Keep prisms in the moisture-tight bags until 48 h prior to testing.

5.11 Store an indicating maximum-minimum thermometer with the sample and record the maximum and minimum temperatures experienced during the initial 48-h period.

6. Obtaining and Transporting Masonry Prisms

6.1 For field-removed masonry specimens, select and remove specimens in accordance with Practice C1532.

6.2 Prior to transporting constructed prisms and field-removed masonry specimens, strap or clamp each prism or specimen to prevent damage during handling and transportation. Secure prisms and specimens to prevent jarring, bouncing, or tipping over during transporting.

6.3 Transport prisms and masonry specimens in accordance with Practice C1532.

6.4 For field-removed masonry specimens, after the specimens have been transported to the laboratory, obtain prisms from the masonry specimens using procedures outlined in Practice C1587.

7. Curing

7.1 After the initial 48 h of curing for constructed prisms, maintain the bagged prisms in an area with a temperature of 75 ± 15°F (24 ± 8°C). Two days prior to testing, remove the moisture-tight bags and continue storing at a temperature of 75 ± 15°F (24 ± 8°C) and a relative humidity less than 80 %.

7.2 For prisms obtained from field-removed masonry, store within the laboratory at a temperature of 75 ± 15°F (24 ± 8°C) and a relative humidity less than 80 % for at least two days prior to testing.

7.3 Prisms shall not be oven-dried or otherwise exposed to temperatures exceeding storage temperature requirements at any time prior to testing.

7.4 Visible moisture shall not be present on the surface of the prisms at the time of testing. Extend storage time as needed to ensure dry surface conditions of the prisms at the time of testing.

7.5 Test prisms at an age of 28 days or at the designated test ages. Test a set of prisms at each age. Prism age shall be determined from the time of laying units for ungrouted prisms, and from the time of grouting for grouted prisms.

8. Measurements and Determination of Net Area

8.1 *Measuring Prisms*—As shown in Fig. 3, measure the length and width at the edges of the top and bottom faces of the prisms to the nearest 0.05 in. (1 mm). Determine the length and width by averaging the four measurements of each dimension. Measure the height of the prism at the center of each face to the nearest 0.05 in. (1 mm). Determine the height by averaging the four measurements.

8.1.1 For prisms obtained from field-removed masonry specimens, perform additional measurements as needed to document the condition and dimensions of the specimen.

NOTE 4—Prisms obtained from field-removed masonry specimens will have many different sizes, shapes, and configurations. These variations are a result of differing bonding arrangements, mortaring or joining practices, presence of reinforcement and other accessories in conjunction with the masonry in service, and of techniques used to remove the specimens from wall assemblies. These variations may create non-uniform prism dimensions along its length or in its cross-section. As such, additional measurements are often required to adequately document the condition of the prism and to communicate that condition to readers of the test report.

8.2 *Net Cross-Sectional Area*:

8.2.1 *Constructed Prisms*—Take the net cross-sectional area of ungrouted prisms as the net cross-sectional area of masonry units, determined by measurement or from a representative sample of units tested in accordance with Test Methods C140 for concrete masonry and with Test Methods C67 for clay masonry. If cut units are used for prism construction, determine the net cross-sectional area from additional units cut in a similar manner. Determine net cross-sectional area of fully grouted prisms by multiplying the length and width of the prism (see 8.1).
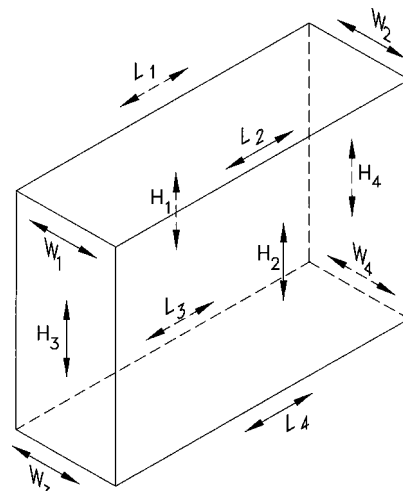

FIG. 3 Prism Measurement Location

Note 5—Net area determined by Test Methods C140 for hollow concrete units is usually slightly different from the minimum net cross-sectional area because unit face shells and webs are typically tapered.

8.2.1.1 Consider clay masonry units whose net cross-sectional area is at least 75 % of the gross cross-sectional area as 100 % solid.

8.2.2 *Prisms Obtained from Field-Removed Masonry Specimens*—Use methods identified above to determine net area if appropriate. Net area for prisms obtained from field-removed masonry specimens is considered to be minimum bearing area. If prisms are not of uniform length or width throughout the height of the specimen, or if mortared surfaces are not fully bedded, use professional judgment to determine the minimum bearing area that exists for the prism at whatever location that occurs.

Note 6—While constructed prisms are required to be fully-bedded with mortar, prisms obtained from field-removed masonry specimens, particularly for hollow masonry, will often have only the face shells of the hollow units mortared. For such prisms, if any mortar on the top and bottom bearing surfaces of the prisms are removed to result in full bearing across the unit cross-section, the minimum cross-section will typically occur at an intermediate mortar bed joint. For face shell bedded sections, multiplying the measured length of the prism at the bed joint location by the sum of the face shell thicknesses can be an effective method for determining minimum net bearing area. Because the face shells of hollow units are often tapered, the thickness of the face shell above the mortar bed joint and below the mortar bed joint may differ. In such a case, use the least face shell thickness of the two in the calculation. Obtaining access to measure face shell thickness is often difficult or impossible. Measurements of similar cross-sections from representative units or other parts of the prism is an option as is performing measurements after testing is performed. Refer to Test Methods C67 and C140 for recommended methods of measuring face shell thickness.

9. Capping

9.1 *Capping Prisms*—Cap prisms in accordance with Practice C1552.

10. Procedure

10.1 *Test Apparatus*—The test machine shall have an accuracy of plus or minus 1.0 % over the anticipated load range. The upper platen 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 lie at the center of the surface held in its spherical seat but shall be free to turn in any direction, and its perimeter shall have at least ¼ in. (6.3 mm) clearance from the head to accommodate specimens whose bearing surfaces are not parallel. The diameter of the upper platen (determined in accordance with A1.3) shall be at least 6 in. (150 mm). A hardened metal bearing plate used beneath the specimen is not required, but has been found to minimize wear of the lower platen of the machine.

10.1.1 When the bearing area of the upper platen or lower platen is not sufficient to cover the area of the specimen, a single steel bearing plate with a thickness equal to at least the distance from the edge of the platen to the most distant corner of the specimen shall be placed between the platen and the capped specimen. The length and width of the steel plate shall be at least ¼ in. (6 mm) greater than the length and width of the prisms.

10.1.2 The surfaces of the platen or plate intended for contact with the specimen shall have a hardness not less than HRC 60 (BHN 620). The surfaces of the platen and plate shall not depart from plane surfaces by more than 0.001 in. (0.03 mm) in any 6-in. (150-mm) dimension.

Note 7—Annex A1 includes guidance on determining the required plate thicknesses based on the configurations of the test specimen and the test machine.

Note 8—Research has shown that the thickness of bearing plates has a significant effect on the tested compressive strength of masonry prisms when the bearing area of the plate is not sufficient to cover the area of the specimen. Plate bending results in nonuniform stress distributions that can influence the failure mechanisms of the tested specimens. The magnitude of this effect is controlled by the stiffness of the plate, the size of the specimen tested, and the strength of the specimen. Tested compressive strengths will typically increase with increased plate thickness and with reduced distance to the furthest corner of the specimen. Some testing laboratories have machine size limitations that limit the practicality of eliminating plate bending entirely. Therefore, the plate thickness requirements in 10.1 are intended to provide an adequate level of accuracy in the compression test results so as to conform to the limits of practicality of the testing laboratory.

10.2 *Installing the Prism in the Test Machine*—Wipe clean the bearing faces of the platens, the bearing plates, and the test specimen. Place the test specimen on the lower platen or bearing plate. Align both centroidal axes of the specimen with the center of thrust of the machine. As the spherically seated upper platen or plate is brought to bear on the specimen, rotate the movable portion of the upper platen gently by hand so that uniform seating is obtained.

10.3 *Loading*:

10.3.1 For constructed prisms, apply an initial load to the prism up to one-half of the expected total load at any convenient rate. Apply the remaining load at a uniform rate in not less than 1 nor more than 2 min.

10.3.2 For prisms obtained from field-removed masonry specimens, apply an initial load to the prisms up to one-fourth of the expected load at any convenient rate. Apply the remaining load at a uniform rate in not less than 2 nor more than 4 min.

10.3.3 If the mode of failure cannot be determined once the maximum load is reached, continue loading the specimen until the mode of failure is identifiable. Record the maximum load and note the mode of failure.

10.4 *Observations*—Describe the mode of failure as fully as possible or illustrate, or both, crack patterns and spalling on a sketch or photograph. Note whether failure occurred on one side or one end of the prism prior to fracture of the opposing side or end of the prism. Identify mode of failure using Fig. 4.

11. Calculation

11.1 *Masonry Prism Strength*—Calculate each masonry prism strength by dividing each prism's maximum compressive load sustained by the net cross-sectional area of that prism, and express the result to the nearest 10 psi (69 kPa).

11.1.1 Where sets of grouted and ungrouted prisms are tested, calculate the masonry prism strength separately for the grouted set and the ungrouted set.
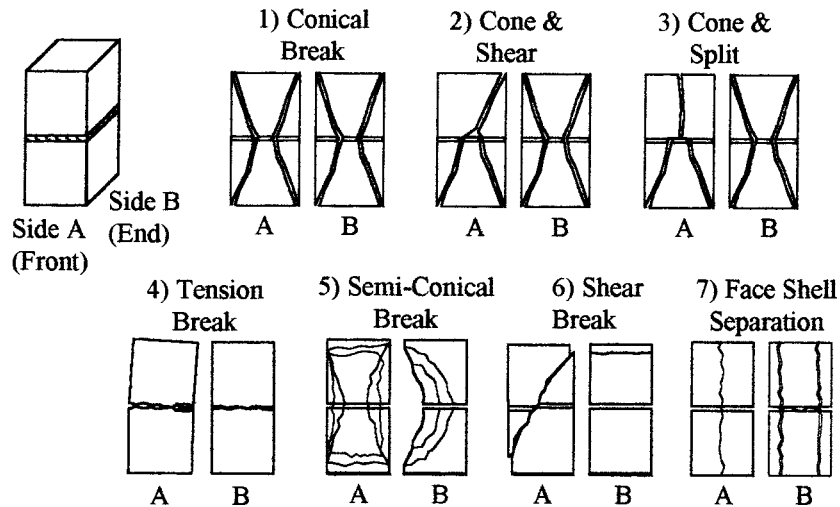
	1) Conical Break		2) Cone & Shear		3) Cone & Split	
	A	B	A	B	A	B

	4) Tension Break		5) Semi-Conical Break		6) Shear Break		7) Face Shell Separation	
	A	B	A	B	A	B	A	B

Side A (Front)   Side B (End)

FIG. 4 Sketches of Mode of Failure

11.1.2 Where a set of prisms is tested for each wythe of a multi-wythe wall, calculate the masonry prism strength for each wythe.

11.2 *Compressive Strength of Masonry*:

11.2.1 Calculate the h_p/t_p ratio for each prism using the height and the least lateral dimension of that prism. Determine the correction factor from Table 1. If a prism's height to thickness ratio lies between the h_p/t_p values of Table 1, determine the corresponding correction factor by linear interpolation between the given values.

11.2.2 Multiply the masonry prism strength by the correction factor for the respective prism.

11.2.3 Calculate the compressive strength of masonry, f_{mt}, for each set of prisms by averaging the values obtained.

12. Report

12.1 *For constructed prisms, report the following information*:

12.1.1 Name of parties responsible for prism construction, transport, and testing.

12.1.2 Designation of each prism tested and description of prism including width, height, and length dimensions; h_p/t_p ratio; mortar type; and grout and masonry unit used in the construction.

12.1.3 For field quality control or assurance, location of structure that corresponds to prisms as recorded in 5.1.

12.1.4 The maximum and minimum temperature experienced by the prisms during the first 48 h after construction and grouting.

12.1.5 Age of prism at time of test.

12.1.6 Maximum compressive load sustained by each prism in pounds force or newtons.

12.1.7 Net cross-sectional area of each prism in square inches or square millimetres, and method used to calculate area.

12.1.8 Test observations for each prism in accordance with 10.4.

12.1.9 Compression machine spherical head diameter (or projected diameter if applicable), upper bearing plate thickness requirement based on size of tested specimen, and thickness of upper bearing plate used.

12.1.10 Compression machine lower platen dimensions, lower bearing plate thickness requirement based on size of tested specimen, and thickness of lower bearing plate used.

12.1.11 Compressive strength of each prism calculated to the nearest 10 psi or 69 kPa (see 11.1).

12.1.12 Compressive strength of masonry, f_{mt}, for each set of prisms calculated to the nearest 10 psi or 69 kPa (see 11.2).

12.2 *For prisms obtained from field-removed masonry specimens, report the following*:

12.2.1 Name of the party conducting the testing.

12.2.2 Name of parties responsible for prism removal, transport and testing.

12.2.3 Designation, photograph, and detailed description of the condition of each specimen prior to capping. Condition descriptions shall address all details that would influence interpretation of results and shall include the following as a minimum:

12.2.4 Test observations for each prism in accordance with 10.4.

12.2.5 Compression machine spherical head diameter (or projected diameter if applicable), upper bearing plate thickness requirement based on size of tested specimen, and thickness of upper bearing plate used.

12.2.6 Compression machine lower platen dimensions, lower bearing plate thickness requirement based on size of tested specimen, and thickness of lower bearing plate used.

12.2.7 Compressive strength of each prism calculated to the nearest 10 psi or 69 kPa (see 11.1).

12.2.8 Compressive strength of masonry, f_{mt}, for each set of prisms calculated to the nearest 10 psi or 69 kPa (see 11.2).

TABLE 1 Height to Thickness Correction Factors for Masonry Prism Compressive Strength

h_p/t_p[A]	1.3	1.5	2.0	2.5	3.0	4.0	5.0
Correction Factor	0.75	0.86	1.0	1.04	1.07	1.15	1.22

[A] h_p/t_p—Ratio of prism height to least lateral dimension of prism.

5

Note 9—Practices C1532 and C1587 include required report items related to selection, removal, and shipment of masonry specimens from field construction as well as preparation of those specimens for compression testing. Consider referencing those reports or including that information on the C1314 report for field-removed masonry specimens.

13. Precision and Bias

13.1 Due to the variety of materials and combinations of materials involved, no statement is made concerning the precision or bias of this test method. Sufficient test data for all materials and combinations of materials are not available to permit the development of precision and bias statements.

14. Keywords

14.1 compressive strength of masonry (f_{mt}); masonry prism; masonry prism strength; masonry specimen; specified compressive strength of masonry (f'_m)

ANNEX

(Mandatory Information)

A1. DETERMINING PLATE THICKNESS REQUIREMENTS FOR COMPRESSION TESTING

A1.1 *Scope*—This annex provides additional information to assist in determining the plate thickness requirements for compression testing as written in 10.1.

A1.2 *Test Equipment*—Fig. A1.1 shows the location of the referenced test equipment as used in the compression testing of masonry prisms.

A1.3 *Determining the Diameter of the Upper Platen*—As shown in Fig. A1.2, the diameter of the upper platen is considered in this test method to be equal to the maximum horizontal dimension measured across the circle created by the spherical portion of the upper platen (this measured diameter will often differ from the actual geometric diameter of the sphere based on its curvature). If the upper platen includes a non-spherical section that was manufactured integrally with the spherical head from a single piece of steel, the diameter of the upper platen is considered to be the diameter of the spherical seat on the upper surface of the upper platen plus the thickness of the non-spherical section (t_{PL}). However, the diameter of the upper platen shall not be greater than the minimum horizontal dimension of the upper platen.

A1.4 *Distance from Edge of Platen to Furthermost Corner of Test Specimen*—Determine the distance from the edge of the platen to the furthermost corner of the specimen as follows:

A1.4.1 Locate the specimen's center of mass, and mark it on top of the specimen.

A1.4.2 Determine to the nearest 1/8 in. (3 mm) the distance from the center of mass of the specimen to the furthermost corner or edge of the test specimen. Record this distance as A.

A1.4.3 The distance from the platen to the furthermost corner of the test specimen is obtained by the following equation (see Fig. A1.3):

$$d = A - \frac{D_{PL}}{2} \quad (A1.1)$$

where:
d = distance from the platen to the furthermost corner of the test specimen, in. (mm), and
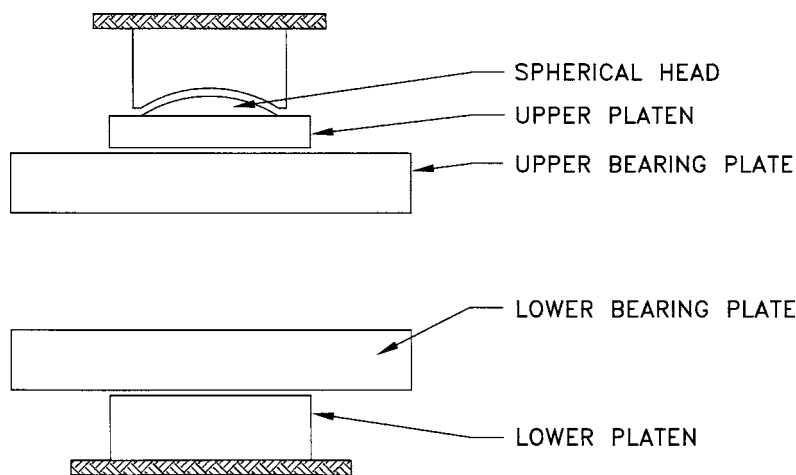A = distance from the center of mass of the specimen to the furthermost corner of the test specimen, in. (mm).

FIG. A1.1 Equipment Used for Compression Testing