Designation: ~~E519/E519M – 21~~ E519/E519M – 22

Standard Test Method for Diagonal Tension (Shear) in Masonry Assemblages[1]

This standard is issued under the fixed designation E519/E519M; 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 determination of the diagonal tensile or shear strength of masonry assemblages by loading them in compression along one diagonal (see Fig. 1), thus causing a diagonal tension failure with the specimen splitting apart parallel to the direction of load.

1.2 Annex A1 provides requirements regarding the determination of the diagonal-tension strength of masonry under combined diagonal-tension and compressive loading.

1.3 The text of this standard refers to notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 These test methods cover the application of the tests 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.

1.5 *This standard may involve hazardous materials, operations, and equipment. 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

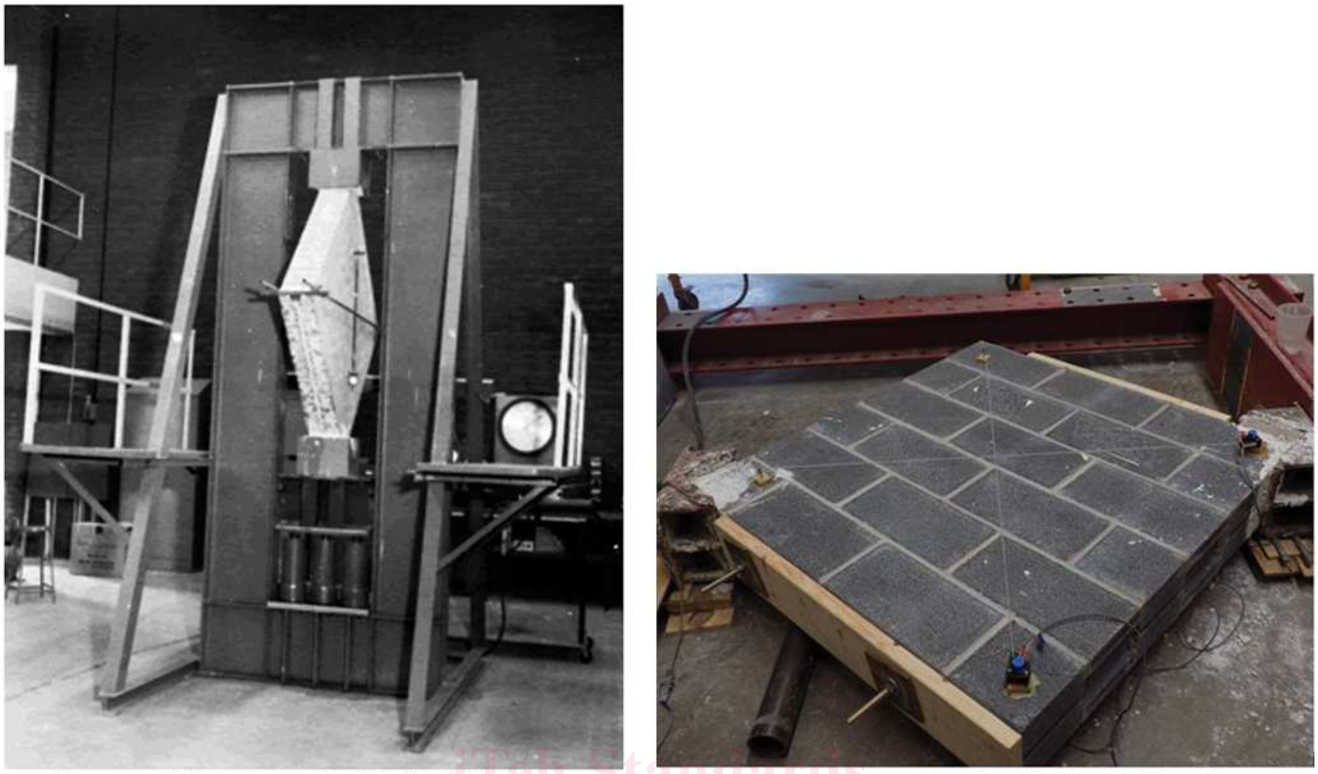
C67/C67M Test Methods for Sampling and Testing Brick and Structural Clay Tile
C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens)
C140/C140M Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
C1019 Test Method for Sampling and Testing Grout for Masonry
E4 Practices for Force Calibration and Verification of Testing Machines
E575 Practice for Reporting Data from Structural Tests of Building Constructions, Elements, Connections, and Assemblies

[1] This test method is under the jurisdiction of ASTM Committee C15 on Manufactured Masonry Units and is the direct responsibility of Subcommittee C15.04 on Research.

Current edition approved ~~June 1, 2021~~Dec. 1, 2022. Published ~~June 2021~~December 2022. Originally approved 1974. Last previous edition approved in ~~2020~~2021 as ~~E519/E519M – 20.~~E519/E519M – 21. DOI: ~~10.1520/E0519_E0519M-21.~~10.1520/E0519_E0519M-22.

[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.

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



Example of Apparatus for Vertical Specimen Example of Apparatus for Horizontal Specimen

FIG. 1 Apparatus for Determination of Diagonal Tensile or Shear Strength Masonry Assemblages

3. Significance and Use

3.1 This test method was developed to measure more accurately the diagonal tensile (shear) strength of masonry than was possible with other available methods. The specimen size was selected as being the smallest that would be reasonably representative of a full-size masonry assemblage and that would permit the use of testing machines such as are used by many laboratories.

NOTE 1—As a research test method used only for the purpose of evaluating the effects of variables such as type of masonry unit, mortar, workmanship, etc., a smaller size specimen could be used if the available testing equipment will not accommodate a 1.2-m [4-ft] square specimen. However, there is a lack of experimental data that would permit an evaluation of the effect of specimen size on the shear strength or to permit a correlation between the results of small-scale specimen tests and larger specimens.

4. Apparatus

4.1 *Testing Machine:*

4.1.1 The testing machine shall have sufficient compressive load capacity and provide the rate of loading prescribed in 6.4. The machine shall be power-operated and capable of applying the load continuously, rather than intermittently, and without shock. The machine shall conform to the requirements of the Calculation and Report sections of Practices E4.

4.1.2 Testing machines are permitted to accommodate the application of load in either a vertical or horizontal orientation. For horizontal test configurations, rigid steel rollers shall be provided at a spacing no greater than 400 mm [16 in.], allowing for unimpeded movement of test specimen under load in the plane of the direction of loading.

NOTE 2—In order to accommodate a 1.2-m [4-ft] square specimen placed in the machine so that the specimen diagonal is oriented parallel to the primary axis of the test machine and loading direction, the machine should have a clear opening height of at least 2.13 m [7 ft].

4.2 *Loading Shoes*—Two steel loading shoes (see Fig. 2 and Fig. 3) shall be used to apply the machine load to the specimen.

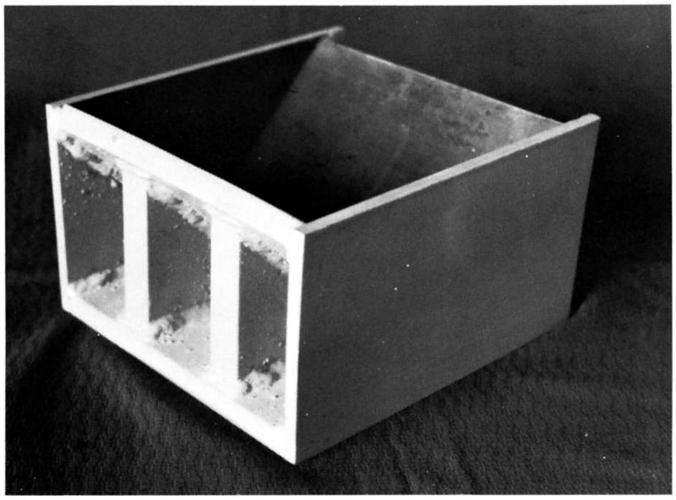


FIG. 2 Loading Shoe (Two Required)

NOTE 3—Experimental work has indicated that the length of bearing of the shoe should be approximately ⅛ the length of the edge of the specimen to avoid excessive bearing stress.

5. Test Specimens

5.1 *Size*—The nominal size of each specimen shall not be less than 1.2 by 1.2 m [4 by 4 ft] by the thickness of the wall type being tested. The height and length of each specimen shall be within 6 mm [0.25 in.] of each other.

5.2 *Number of Specimens*—Tests shall be made on at least three like specimens constructed with the same size and type of masonry units, mortar, and workmanship.

5.3 *Curing*—After construction, specimens shall not be moved for at least 7 days. They shall be stored in laboratory air for not less than 28 days. The laboratory shall be maintained at a temperature of 24 ± 8°C [75 ± 15°F] with relative humidities between 25 and 75 %, and shall be free of drafts.

5.4 *Mortar*—Three 50-mm [2-in.] compressive strength cubes shall be molded from a sample of each batch of mortar used to build the specimens and stored under the same conditions as the specimens with which they are associated. The tests shall be conducted in accordance with Test Method C109/C109M. The cubes shall be tested on the same day as the specimen.

5.5 *Masonry Units*—Masonry units shall be sampled and tested in accordance with the following applicable methods: Test Method C67/C67M for clay brick or tile or Method C140/C140M for concrete masonry units.

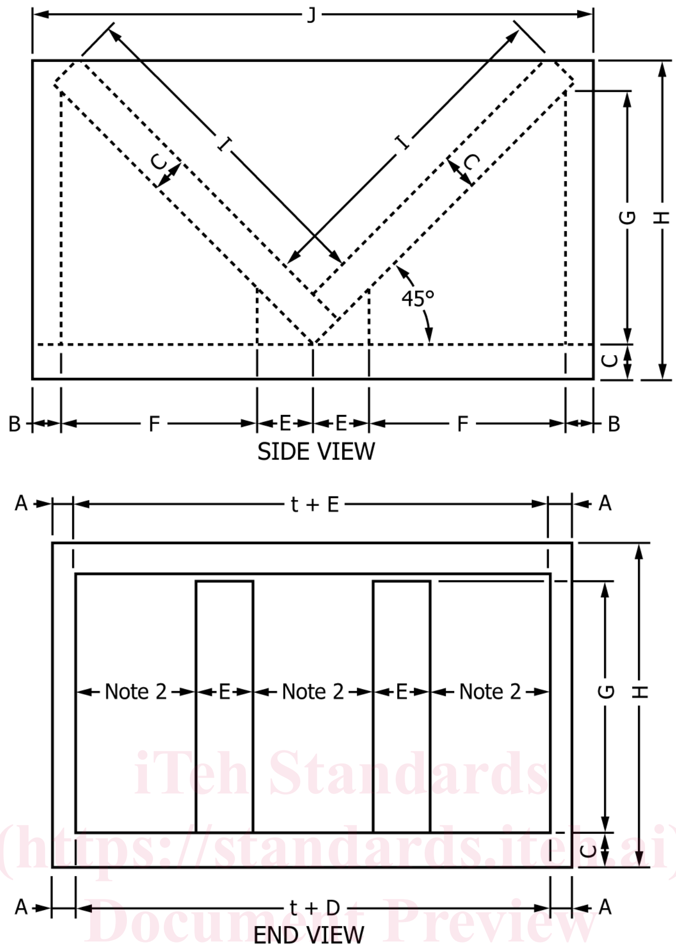
5.6 *Grout*—When specified, grout shall be sampled and tested in accordance with Test Method C1019.

6. Procedure

6.1 *Placement of Loading Shoes*—Position the upper and lower loading shoes so as to be centered on the upper and lower bearing surfaces of the testing machine.

6.2 *Specimen Placement*—Seat the specimen in a centered and plumb position in a bed of gypsum capping material placed in the lower loading shoe. When necessary (see A1.3), fill the spaces between the specimen and the side-confining plates with the capping material also. Age the caps for at least 2 h before testing. Neoprene pads are permitted to be used in lieu of capping if it can be shown that the tested strength and stiffness of the specimen is not affected (see Note 4 and Note 5).

NOTE 4—Some specimens, such as unreinforced masonry, typically do not resist sufficient load to cause crushing at the loaded corners of the panel. In these scenarios, the use of loading shoes filled with capping material is unnecessary and the use of neoprene pads is sufficient to obtain an accurate and



NOTE 1—Material = cold-rolled steel.

NOTE 2—Number and spacing of stiffeners will depend upon the thickness (*t*) of the wall specimen to be tested.

Table of Loading Shoe Minimum Dimensions, mm [in.]			
A	10 [⅜]	F	89 [3½]
B	13 [½]	G	114 [4½]
C	16 [⅝]	H	146 [5¾]
D	22 [⅞]	I	152 [6]
E	25 [1]	J	254 [10]

FIG. 3 Dimensions of Loading Shoe

repeatable assessment of the diagonal tensile strength of the specimen. If corner crushing is seen when neoprene pads are used, then standard capping should be used instead.

NOTE 5—When neoprene pads are used, experience has shown that pads with a Shore A durometer hardness of 50 to 60 are suitable for this application.

6.3 *Instrumentation*—When required, measure the shortening of the diagonal parallel to the direction of applied load and the lengthening of the diagonal perpendicular to the direction of applied load using a suitable linear displacement measuring instrument (see Note 6 and Note 7). Record the gage lengths. Gage lengths shall be at least eighty percent of the diagonal length of the specimen.

NOTE 6—Linear Variable Differential Transformers (LVDT), potentiometers, and dial micrometers are some examples of the linear displacement measuring instruments. Different assemblies will have different stiffness characteristics based upon the strength and properties of the masonry units, mortar, and presence of grout and reinforcement. The selection of the linear displacement measuring instrument and its measurement resolution will need to take into consideration the anticipated stiffness of the test panel to accurately calculate the shear strain during testing.

NOTE 7—In general, the resolution of the linear displacement measuring instrument should be such that the corresponding strain measurements are no greater than 10 % of the maximum expected elastic strain, although there are cases where this is not practical especially with non-linear response.

6.4 *Application of Load:*

6.4.1 For specimens without instrumentation, apply the load continuously to ultimate. Up to one half of the expected maximum load may be applied at any convenient rate, after which adjust the controls of the machine so that the remaining load is applied at a uniform rate so that the maximum load is reached in not less than 1 nor more than 2 min.

6.4.2 For specimens instrumented for measuring deformations or strains, apply the loads in suitable increments at rates comparable to 6.4.1. Choose the increments so that at least ten deformation or strain readings will be obtained to determine definitely the stress-strain curve. Such readings should be obtained for loads as close to the ultimate load as feasible. When the behavior of the specimen under load indicates that it might fail suddenly and damage the deformation-measuring instruments, remove the instrumentation and apply the load continuously until the maximum load that can be applied to the specimen is determined.

7. Calculation

7.1 *Shear Stress*—Calculate the shear stress for specimens on the basis of net area. Calculate the shear stress of the specimen as follows:

$$S_s = \frac{0.707P}{A_n} \quad (1)$$

where:

S_s = shear stress on net area, MPa [psi],
P = applied load, N [lbf], and
A_n = net area of the specimen, mm^2 [$in.^2$], calculated as follows:

$$A_n = \left(\frac{w+h}{2}\right)tn \quad (2)$$

where:

w = width of specimen, mm [in.],
h = height of specimen, mm [in.],
t = total thickness of specimen, mm [in.], and
n = percent of the gross area of the unit that is solid, expressed as a decimal.

NOTE 8—The determination of n is applicable to solid units and ungrouted hollow units. When test specimens are grouted, additional analysis or testing is necessary to determine the net cross-sectional area of the failure plane of the specimens and resulting shear stresses.

7.2 *Shear Strain*—When required, calculate the shear strain as follows:

$$\gamma = \frac{\Delta x + \Delta y}{g} \quad (3)$$

where:

γ = shearing strain, or mm/mm [in./in.],
Δx = shortening in the direction parallel to loading, mm [in.],
Δy = extension in the direction perpendicular to loading, mm [in.], and
g = gage length in the direction parallel to loading, mm [in.].

NOTE 9—Δy must be based on the same gage length as for Δx.

7.3 *Modulus of Rigidity*—Calculate the modulus of rigidity (modulus of elasticity in shear) as follows:

$$G = \frac{S_s}{\gamma} \quad (4)$$

where:

G = modulus of rigidity, MPa [psi].