Standard Test Method for
Splitting Tensile Strength of Cylindrical Concrete Specimens[1]

1. Scope*

1.1 This test method covers the determination of the splitting tensile strength of cylindrical concrete specimens, such as molded cylinders and drilled cores.

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.

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.*

1.4 The text of this standard references notes that provide explanatory material. These notes shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

3. Summary of Test Method

3.1 This test method consists of applying a diametral compressive force along the length of a cylindrical concrete specimen at a rate that is within a prescribed range until failure occurs. This loading induces tensile stresses on the plane containing the applied load and relatively high compressive stresses in the area immediately around the applied load. Tensile failure occurs rather than compressive failure because the areas of load application are in a state of triaxial compression, thereby allowing them to withstand much higher compressive stresses than would be indicated by a uniaxial compressive strength test result.

3.2 Thin, plywood bearing strips are used to distribute the load applied along the length of the cylinder.

3.3 The maximum load sustained by the specimen is divided by appropriate geometrical factors to obtain the splitting tensile strength.

4. Significance and Use

4.1 Splitting tensile strength is generally greater than direct tensile strength and lower than flexural strength (modulus of rupture).

4.2 Splitting tensile strength is used in the design of structural lightweight concrete members to evaluate the shear resistance provided by concrete and to determine the development length of reinforcement.

5. Apparatus

5.1 *Testing Machine*—The testing machine shall conform to the requirements of Test Method C39/C39M and be of a type with sufficient capacity that will provide the rate of loading prescribed in 7.5.

5.2 *Supplementary Bearing Bar or Plate*—If the diameter or the largest dimension of the upper bearing face or the lower bearing block is less than the length of the cylinder to be tested, a supplementary bearing bar or plate of machined steel shall be used. The surfaces of the bar or plate shall be machined to within ± 0.025 mm [± 0.001 in.] of planeness, as measured on any line of contact of the bearing area. It shall have a width of at least 50 mm [2 in.], and a thickness not less than the distance from the edge of the spherical or rectangular bearing block to

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

the end of the cylinder. The bar or plate shall be used in such manner that the load will be applied over the entire length of the specimen.

5.3 *Bearing Strips*—Two bearing strips of nominal 3.0 mm [⅛ in.] thick plywood, free of imperfections, approximately 25 mm [1 in.] wide, and of a length equal to, or slightly longer than, that of the specimen shall be provided for each specimen. The bearing strips shall be placed between the specimen and both the upper and lower bearing blocks of the testing machine or between the specimen and supplemental bars or plates, when used (see 5.2). Bearing strips shall not be reused.

6. Test Specimens

6.1 The test specimens shall conform to the size, molding, and curing requirements set forth in either Practice C31/C31M (field specimens) or Practice C192/C192M (laboratory specimens). Drilled cores shall conform to the size and moisture-conditioning requirements set forth in Test Method C42/C42M. Moist-cured specimens, during the period between their removal from the curing environment and testing, shall be kept moist by a wet burlap or blanket covering, and shall be tested in a moist condition as soon as practicable.

6.2 The following curing procedure shall be used for evaluations of light-weight concrete: specimens tested at 28 days shall be in an air-dry condition after 7 days moist curing followed by 21 days drying at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 50 ± 5 % relative humidity.

7. Procedure

7.1 *Marking*—Draw diametral lines on each end of the specimen using a suitable device that will ensure that they are in the same axial plane (see Fig. 1, Fig. 2 and Note 1), or as an alternative, use the aligning jig shown in Fig. 3 (Note 2).

NOTE 1—Figs. 1 and 2 show a suitable device for drawing diametral lines on each end of a 150 mm × 300 mm [6 in. × 12 in.] cylinder in the same axial plane. The device consists of three parts as follows:
(1) A length of 100-mm [4-in.] steel channel, the flanges of which have been machined flat,
(2) A section, part a, that is grooved to fit smoothly over the flanges of the channel and that includes cap screws for positioning the vertical member of the assembly, and
(3) A vertical bar, part b, for guiding a pencil or marker,
The assembly (part a and part b) is not fastened to the channel and is positioned at either end of the cylinder without disturbing the position of the specimen when marking the diametral lines.

NOTE 2—Fig. 4 is a detailed drawing of the aligning jig shown in Fig. 3 for achieving the same purpose as marking the diametral lines. The device consists of:
*(1)* A base for holding the lower bearing strip and cylinder,
(2) A supplementary bearing bar conforming to the requirements in Section 5 as to critical dimensions and planeness, and
(3) Two uprights to serve for positioning the test cylinder, bearing strips, and supplementary bearing bar.

7.2 *Measurements*—Determine the diameter of the test specimen to the nearest 0.25 mm [0.01 in.] by averaging three diameters measured near the ends and the middle of the specimen and lying in the plane containing the lines marked on the two ends. Determine the length of the specimen to the nearest 2 mm [0.1 in.] by averaging at least two length measurements taken in the plane containing the lines marked on the two ends.

7.3 *Positioning Using Marked Diametral Lines*—Center one of the plywood strips along the center of the lower bearing block. Place the specimen on the plywood strip and align so that the lines marked on the ends of the specimen are vertical and centered over the plywood strip. Place a second plywood strip lengthwise on the cylinder, centered on the lines marked on the ends of the cylinder. Position the assembly to ensure the following conditions:

A	B	C	D	E	F
16 in.	8 ¼ in.	8 in.	4 in.	1 ¼ in.	1 in.
400 mm	205 mm	200 mm	100 mm	32 mm	25 mm
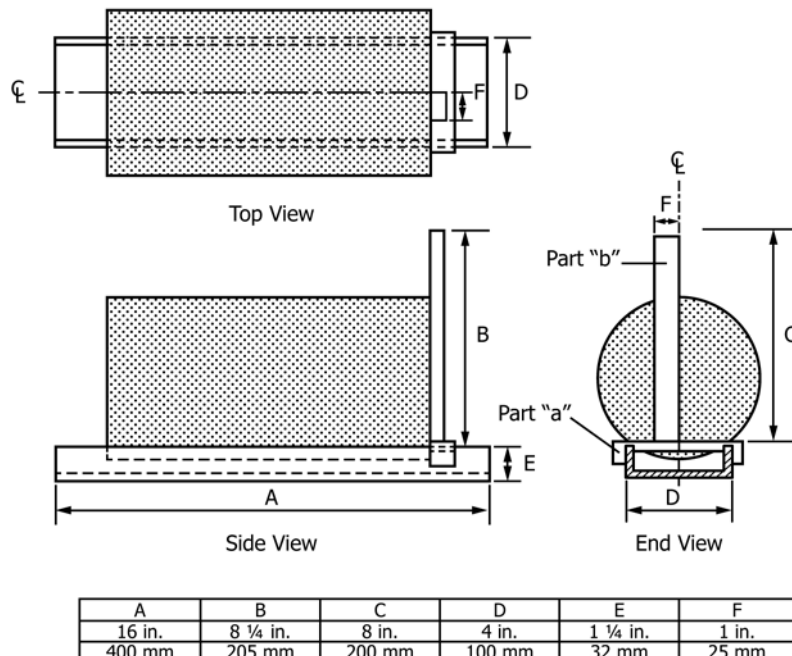
FIG. 1 General Views of a Suitable Apparatus for Marking End Diameters Used for Alignment of Specimen in Testing Machine

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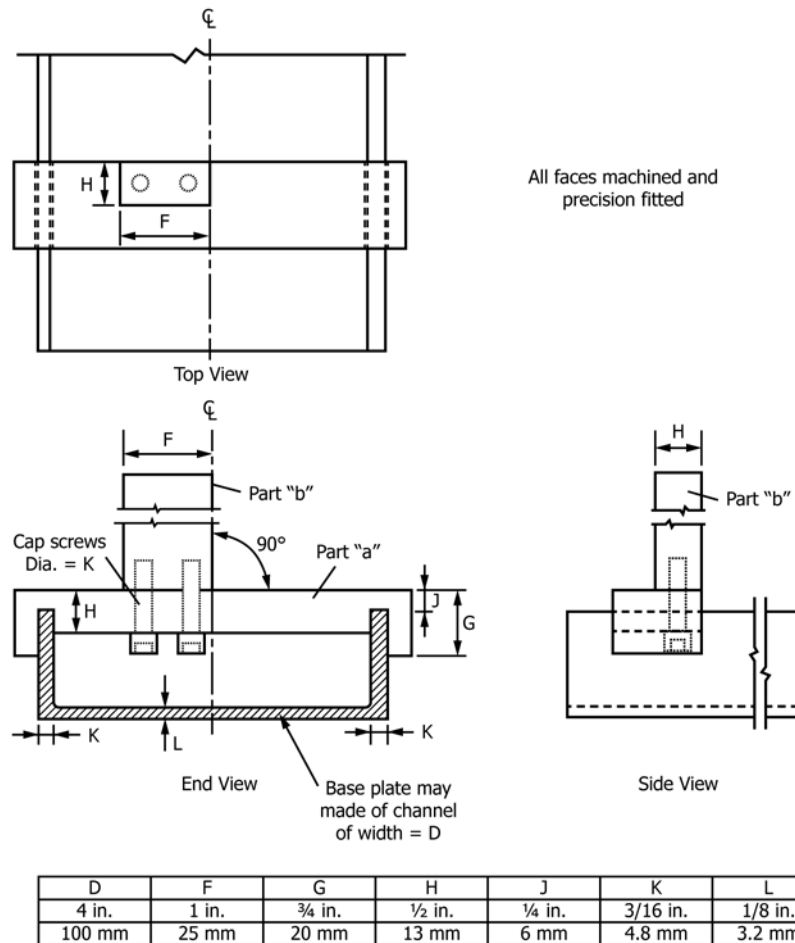| D	F	G	H	J	K	L
4 in.	1 in.	¾ in.	½ in.	¼ in.	3/16 in.	1/8 in.
100 mm	25 mm	20 mm	13 mm	6 mm	4.8 mm	3.2 mm

FIG. 2 Detailed Plans for a Suitable Apparatus for Marking End Diameters Used for Aligning the Specimen
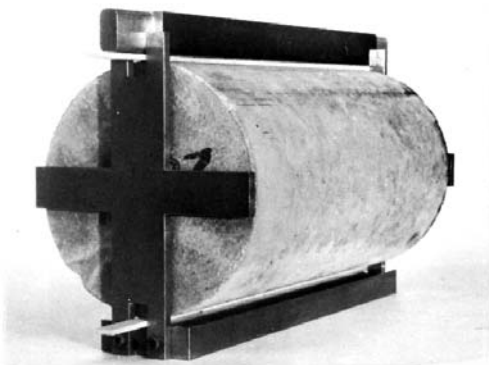

**FIG. 3 Jig for Aligning Concrete Cylinder and Bearing Strips**

7.3.1 The projection of the plane of the two lines marked on the ends of the specimen intersects the center of the upper bearing plate, and

7.3.2 The supplementary bearing bar or plate, when used, and the center of the specimen are directly beneath the center of thrust of the spherical bearing block (see Fig. 5).

7.4 *Positioning by Use of Aligning Jig*—Position the bearing strips, test cylinder, and supplementary bearing bar by means of the aligning jig as illustrated in Fig. 3 and center the jig so that the supplementary bearing bar and the center of the specimen are directly beneath the center of thrust of the spherical bearing block.

7.5 *Rate of Loading*—Apply the load continuously and without shock, at a constant rate within the range 0.7 to 1.4 MPa/min [100 to 200 psi/min] splitting tensile stress until failure of the specimen (Note 3). Record the maximum applied load indicated by the testing machine at failure. Note the type of failure and the appearance of the concrete.

NOTE 3—The relationship between splitting tensile stress and applied load is shown in Section 8. The required loading range in splitting tensile stress corresponds to applied total load in the range of 50 to 100 kN/min [11 300 to 22 600 lbf/min] for 150 by 300-mm [6 by 12-in.] cylinders.
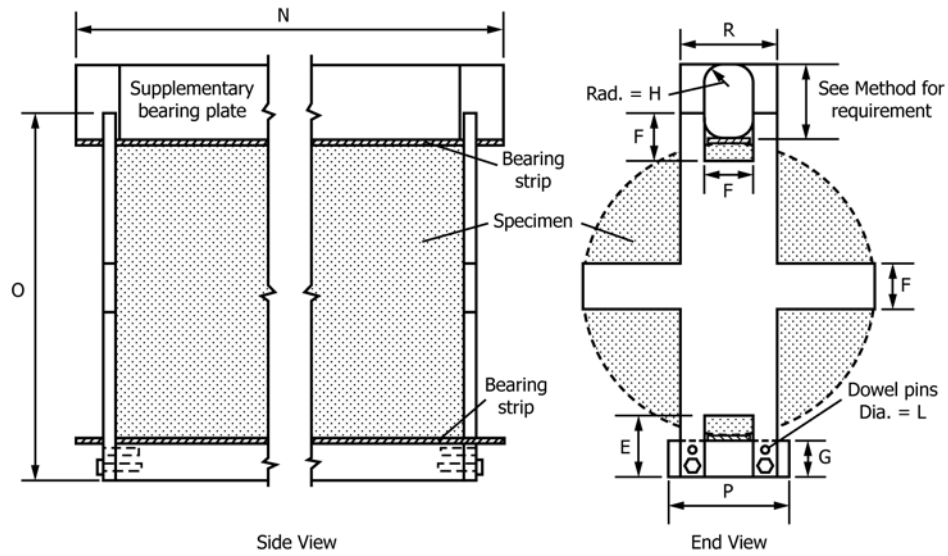
N	O	P	R	E	F	G	H	L
15 in.	7 ½ in.	2 ½ in.	2 in.	1 ¼ in.	1 in.	¾ in.	½ in.	1/8 in.
375 mm	190 mm	65 mm	50 mm	32 mm	25 mm	20 mm	13 mm	3 mm

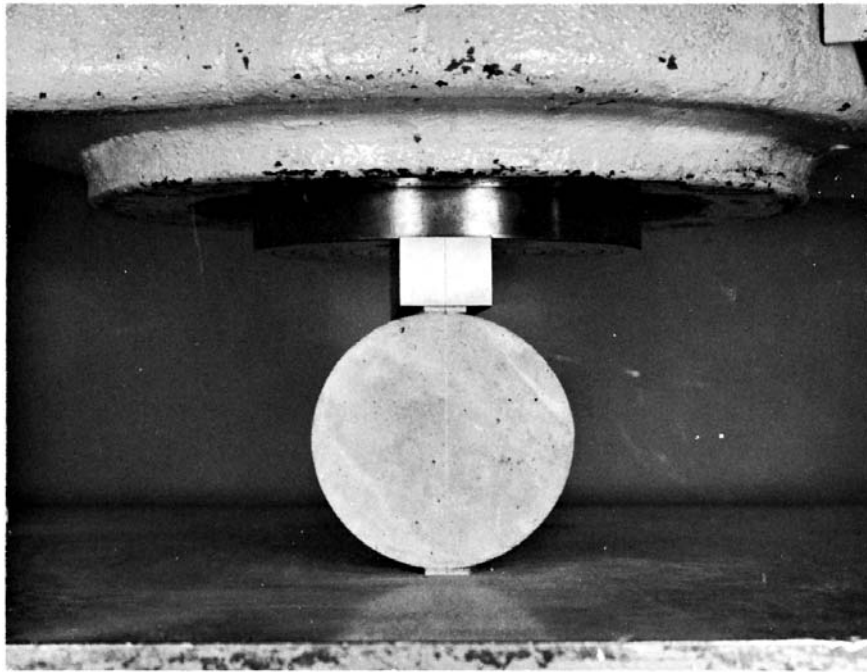**FIG. 4 Detailed Plans for a Suitable Aligning Jig for 150 × 300 mm [6 × 12 in.] Specimen**

FIG. 5 Specimen Positioned in a Testing Machine for Determination of Splitting Tensile Strength

8. Calculation

8.1 Calculate the splitting tensile strength of the specimen as follows:

$$T = 2P/\pi l d \qquad (1)$$

where:

T = splitting tensile strength, MPa [psi],
P = maximum applied load indicated by the testing machine, N [lbf],

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l = length, mm [in.], and
d = diameter, mm [in.].

9. Report

9.1 Report the following information:

9.1.1 Identification number,

9.1.2 Diameter and length, in. [mm],

9.1.3 Maximum load, lbf [N],

9.1.4 Splitting tensile strength calculated to the nearest 0.05 MPa [5 psi],

9.1.5 Estimated proportion of coarse aggregate fractured during test,

9.1.6 Age of specimen,

9.1.7 Curing history,

9.1.8 Defects in specimen,

9.1.9 Type of fracture, and

9.1.10 Type of specimen.

10. Precision and Bias

10.1 *Precision*—An interlaboratory study of this test method has not been performed. Available research data,[3] however, suggests that the within batch coefficient of variation is 5 % (see Note 4) for 150 × 300-mm [6 × 12-in.] cylindrical specimens with an average splitting tensile strength of 2.8 MPa [405 psi]. Results of two properly conducted tests on the same material, therefore, should not differ by more than 14 % (see Note 4) of their average for splitting tensile strengths of about 2.8 MPa [400 psi].

Note 4—These numbers represent, respectively, the (1s %) and (d2s %) limits as defined in Practice C670.

10.2 *Bias*—The test method has no bias because the splitting tensile strength can be defined only in terms of this test method.

11. Keywords

11.1 cylindrical concrete specimens; splitting tension; tensile strength

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[3] Wright, P. J. F., "Comments on an Indirect Tensile Test on Concrete Cylinders," *Magazine of Concrete Research*, Vol 7, No. 20, July 1955, pp. 87–95.

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this test method since the last issue, C496–04$^{\varepsilon1}$, that may impact the use of this test method. (Approved July 1, 2011)

(*1*) Reversed the order of units in the test method so that SI units appear first.