CRD-C 164-92

Standard Test Method for Direct Tensile Strength of Cylindrical Concrete or Mortar Specimens

1. Scope

1.1 This test method covers the determination of the direct tensile strength of cylindrical specimens of concrete or mortar.

1.2 The values stated in non-SI units are to be regarded as the standard.

1.3 *This standard does not purport to address the safety problems 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

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens (CRD-C 14)

C 42 Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete (CRD-C 27)

C 192 Practice for Making and Curing concrete Test specimens in the Laboratory (CRD-C 10)

C 469 Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression (CRD-C 19)

D 2936 Method for Direct Tensile Strength of Intact Rock Core Specimens

E 4 Practices for Load Verification of Testing Machines (CRD-C 512)

E 122 Standard Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process (CRD-C 580)

3. Significance and Use

3.1 Concrete and mortar are much weaker in tension than in compression. Direct tensile stressing of concrete or mortar is the most basic test for determining the tensile strength of concrete or mortar.

4. Apparatus

4.1 **Testing Machine.** The testing machine shall conform to the applicable requirements of ASTM C 39 (CRD-C 14) and ASTM E 4 (CRD-C 512).

4.2 **Caps.** Cylindrical metal caps, cemented to the specimen ends, provide the means through which the direct tensile load can be applied. The diameter of the metal cap shall not be less than that of the test specimen, nor shall it exceed the test specimen diameter by more than 0.0625 in. (1.6 mm). Caps shall have a thickness of at least one-third the diameter of the specimen. Caps shall be provided with a suitable linkage system for load transfer from the testing machine to the test specimen. The linkage system shall be so designed that the load will be transmitted through the axis of the test specimen without the application of bending or torsional stresses. The length of the linkages at each end shall be at least two times the diameter of the caps. One such system is shown in Figure 1. Roller or link chain of suitable capacity has been found to perform quite well in this application. Because roller chain flexes in one plane only, the upper and lower segments should be positioned at right angles to each other to effectively reduce bending in the specimen. Ball-and-socket, cable, or similar arrangements have been found to be generally unsuitable as their tendency for bending and twisting makes the assembly unable to transmit a purely direct tensile stress to the test specimen.

5. Test Specimens

5.1 Test specimens shall be right circular cylinders molded or cored from larger masses.

5.1.1 The sides of the specimen shall be generally smooth and free of abrupt irregularities with all the elements straight to within 0.020 in. (0.50 mm) over the full length of the specimen. The deviation from straightness of the elements shall be determined by either Method A or Method B as follows:

5.1.1.1 Method A. Roll the cylindrical specimen on a smooth flat surface and measure the height of the maximum gap between the specimen and the flat surface with a feller gage. If the maximum gap exceeds 0.020 in. (0.50 mm), the specimen does not meet the required tolerance for straightness of the elements. The flat test surface on which the specimen is rolled shall not depart from a plane by more than 0.0005 in. (13 µm).

5.1.1.2 Method B:

5.1.1.2.1 Place the cylindrical surface of the specimen on a V-block that is laid flat on a surface. The smoothness of the surface shall not depart from a plane by more than 0.0005 in. (13 µm).

5.1.1.2.2 Place a dial indicator in contact with the top of the specimen as shown in Figure 2, and observe the dial reading as the specimen is moved from one end of the V-block to the other along a straight line.

5.1.1.2.3 Record the maximum and minimum readings on the dial gage and calculate the difference, Δ_0. Repeat the same operations by rotating the specimen for every 90°, and obtain the difference, Δ_{90}, Δ_{180}, Δ_{270}. The maximum value of these four differences shall be less than 0.020 in. (0.50 mm).

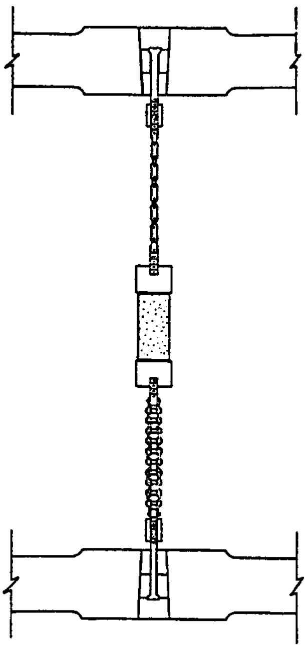

Figure 1. Direct Tensile-Strength Test Assembly

5.1.2 If necessary, cut the ends of the specimen parallel to each other, generally smooth, and at right angles to the longitudinal axis. The ends shall not depart from perpendicularity to the axis of the specimen by more than 0.25°, approximately 0.01 in. (0.3 mm) in 2 in. (50 mm). The perpendicularity of the end surfaces to the longitudinal axis shall be determined by the similar setup as for the cylindrical surface (Figure 3), except that the dial gage is mounted near the end of the V-block. Move the mounting pad horizontally so that the dial gage runs across the end surface of the specimen along a diametral direction. Take care to ensure that one end of the mounting pad maintains intimate contact with the end surface of the V-block during moving. Record the dial gage readings and calculate the difference between the maximum and the minimum values, Δ_1. Rotate the specimen 90° and repeat the same operations and calculate the difference, Δ_2. Turn the specimen around and repeat the same measurement procedures for the other end surface and obtain the difference values Δ'_1 and Δ'_2. The perpendicularity will be considered to have been met when:

$$\frac{\Delta_1}{D} \text{ and } \frac{\Delta'_1}{D} \leq 0.005$$

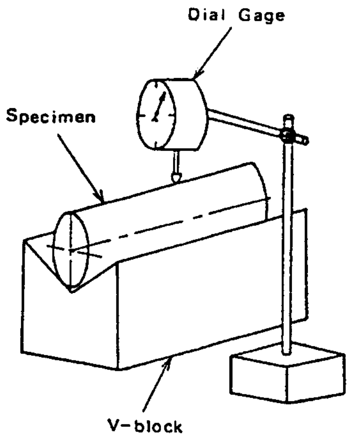

Figure 2. Assembly for Determining the Straightness of the Cylindrical Surface

where:

I = 1 or 2, and

D = diameter.

The smoothness of the end surfaces can be determined by taking dial gage readings for every 1/8 in. (3.2 mm) during the perpendicularity measurements. The closeness of the readings are expected to provide a smooth curve of the end surface along the specific diametral plane. The smoothness requirement is met when the slope along any part of the curve is less than 0.25°. In this test method, the condition of the specimen ends with regard to the degree of flatness and smoothness is not as critical as it is, for example, in compression tests where good bearing is a prerequisite. In direct-tension tests it is more important that the ends be parallel to each other and perpendicular to the longitudinal axis of the specimen in order to facilitate the application of a direct tensile load. End surfaces such as result from sawing with a diamond cut-off wheel, are entirely adequate. Grinding, lapping, or polishing beyond this point serves no useful purpose, and in fact, may adversely affect the adhesion of the cementing medium.

5.1.3 The specimen shall have a length-to-diameter ratio (L/D) of 2.0 to 2.5 and a diameter of not less than 2 in. (50-mm). The specimen should be free to select and fail on the weakest plane within its length. This degree of freedom becomes less as the specimen length diminishes. When cores of shorter than standard length must be tested, make suitable notation of this fact in the test report.

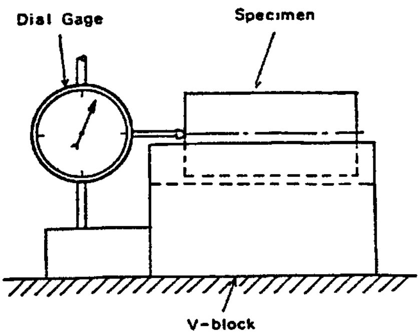

Figure 3. Assembly for Determining the Perpendicularity of End Surfaces to the Specimen Axis

5.1.4 It is desirable that the diameter of tension specimens be at least three times greater than the nominal maximum size of the aggregate. The specified minimum specimen diameter of approximately 2 in. (50 mm) will satisfy this criterion for mortar. It may be necessary in some instances to test specimens that do not comply with this criterion. In that case, and particularly when cores of diameter smaller than the specified minimum must be tested because of the unavailability of larger size specimens, make suitable notation of these facts in the test report and mention the nominal maximum size of the aggregate.

5.1.5 Determine the diameter of the test specimen to the nearest 0.01 in. (0.25 mm) by averaging two diameters measured at right angles to each other at about midlength of the specimen. Use this average diameter for calculating the cross-sectional area. Determine the length of the test specimen to the nearest 0.01 in. (0.25 mm) by averaging two height measurements along the diameter.

5.2 The moisture condition of the specimen at the time of test can have a significant effect upon the indicated strength of the mortar or concrete. Unless otherwise directed by the authority for which the tests are being performed, drilled specimens should be moisture conditioned as prescribed in C 42. Molded specimens should be moist cured as prescribed in C 192 and handled during testing as prescribed in C 39. If the concrete or mortar specimens are to be tested in a wet condition and the cement used to bond the specimen to the cap does not adhere satisfactorily to a moist specimen, the ends of the specimen may be dried sufficiently to overcome this problem by using a portable electric hair dryer.

5.3 The number of specimens tested will depend upon the availability of specimens and the purposes for which the testing is done. A minimum of ten specimens is preferred. The number of specimens tested should be indicated. The statistical basis for relating the required number of specimens to the variability of measurements is given in Practice E 122 (CRD-C 580).

6. Procedure

6.1 Cement the metal caps to the test specimen to ensure alignment of the cap axes with the longitudinal axis of the specimen. In cementing the metal caps to the test specimens, use jigs and fixtures of suitable design to hold the caps and specimens in proper alignment until the cement has hardened. The chucking arrangement of a machine lathe or drill press is also suitable. The cement used should be one that sets at mom temperature. Epoxy resin formulations of rather stiff consistency and similar to those used as a patching and filling compound in automobile body repair work have been found to be a suitable cementing medium. Some low viscosity epoxy resin formulations also have been found to be satisfactory.

6.2 Apply the tensile load continuously at an approximately constant rate and without shock to failure. Apply the load at a rate of 35 ± 5 psi (241 ± 34 kPa)/s unless otherwise directed (Note).

Note: The loading rate 35 ± 5 psi (241 ± 34 kPa)/s is that required in ASTM Method C 469 and is in essential agreement with that in ASTM Method C 39 ("20 to 50 psi (0.14 to 0.34 MPa)/s"). However, ASTM D 2936, from which this method is adapted, stipulates that the rate shall be such that failure will occur in not less than 5 nor more than 15 min. For a material with a tensile strength of 500 psi, and a time of 10 min. to failure this is 50 psi/min. or less than 1 psi/s. At 35 psi/s, for a tensile strength of 350 psi, the total time of loading will be only 10 seconds. When comparisons are made, specimens should have been loaded at similar loading rates. Note and record the maximum load carried by the specimen during the test. In this test arrangement failure often occurs near one of the capped ends. Discard the results for those tests in which failure occurs either partly or wholly within the cementing medium.

7. Calculation

7.1 Calculate the tensile strength of the specimen by dividing the maximum load carried by the specimen during test by the computed cross-sectional area and express the result to the nearest 5 psi (35.0 kPa).

8. Report

8.1 The report shall include the following:

8.1.1 Source of sample including project name and location,

8.1.2 Physical description of sample,

8.1.3 Date of sampling and testing,

8.1.4 Specimen length and diameter, also conformance with dimensional requirements,

8.1.5 Rate of loading or deformation rate,

8.1.6 General indication of moisture condition of sample at time of test, such as as-received, saturated, laboratory air dry, or oven dry,

8.1.7 Direct tensile strength for each specimen as calculated, average direct tensile strength of all specimens, standard deviation or coefficient of variation,

8.1.8 Type and location of failure (a sketch of the fractured sample is recommended), and

8.1.9 Other available physical data.

9. Precision and Bias

9.1 **Precision.** The precision of this test method has not been determined. Data are being sought to develop a precision statement.

9.2 **Bias.** Since them is no accepted reference material suitable for determining the bias for this procedure, bias has not been determined.