CRD-C 166-92

Standard Test Method for Static Modulus of Elasticity of Concrete in Tension

1. Scope

1.1 This test method covers determination of chord modulus of elasticity (Young's) for molded concrete cylinders and diamond-drilled concrete cores when under axial tensile stress.

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

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of 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 31 Practice for Making and Curing Concrete Test Specimens in the Field (CRD-C 11)

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

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

C 125 Terminology Relating to Concrete and Concrete Aggregates (CRD-C 43)

C 174 Test Method for Measuring Length of Drilled Concrete Cores (CRD-C 28)

C 192 Method of 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)

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods (CRD-C 582)

2.2 **Corps of Engineers Standards**

CRD-C 164 Test Method for Direct Tensile Strength of Cylindrical Concrete or Mortar Specimens

3. Terminology

3.1 **Definitions:**

3.1.1 *chord modulus of elasticity* - The slope of the chord drawn between any two specified points on the stress-strain curve.

3.2 Other terms used in this method are defined in ASTM C 125.

4. Significance and Use

4.1 This method provides a stress to strain ratio value for concrete tested in direct tension at whatever age and curing conditions that may be designated from which modulus of elasticity can be calculated.

4.2 The modulus of elasticity values obtained will usually be less than moduli derived under rapid load application (dynamic or seismic rates, for example), and will usually be greater than values under slow load application or extended load duration, other test conditions being the same.

4.3 Limited data suggest that the modulus of elasticity in tension may not be significantly different from that in compression. The purpose of this method is to provide a standard test method for those who may desire to investigate this property of concrete or mortar.

5. Apparatus

5.1 The specimen caps and the load applying apparatus shall conform to the requirements of CRD-C 164.

5.2 **Strain Measuring System.** The strain shall be measured using devices recording to the nearest 5 millionths. Such systems may include electrical resistance gages (Note 1), tensiometers, or optical devices. The measuring device shall be such that the average of at least two axial strain measurements can be determined for each increment of load. Measuring positions shall be equally spaced around the circumference of the specimen close to midheight. The gage length over which the strains are determined shall be not less than three times the maximum size of the aggregate in the concrete nor more than three-fourths the height of the specimen. One suitable device is a tensiometer (such as shown in Figure 1) that consists of two independent yokes, each rigidly attached to the specimen. Support rods shall be used to maintain a constant distance between the two yokes until testing is initiated. During testing, the support rods shall be removed and the change in distance between the two yokes measured at two diametrically opposite gage lines. Deformation may be measured to the nearest 5 millionths by two linear variable differential transformers (LVDT).

Note 1. Although bonded strain gages are satisfactory on dry specimens, they may be difficult, if not impossible, to mount on specimens continually moist-cured until tested.

6. Test Specimens

6.1 Test specimens shall be right circular cylinders meeting the requirements of ASTM C 31, C 39, C 42, or C 192.

6.1.1 **Molded Cylindrical Specimens.** Test cylinders shall be molded in accordance with the requirements for test specimens in ASTM Method C 192 or in Method C 31. Specimens shall be subjected to the specified curing conditions and tested at the age for which the information is desired. Specimens removed from a moist room for test shall be kept moist by a wet cloth covering during the interval between removal and test.

6.1.2 **Drilled Core Specimens.** Cores shall comply with the requirements for drilling, and moisture conditioning applicable to specimens in ASTM Method C 42, except that only diamond-drilled cores having a length-to-diameter ratio of 2.0 to 2.5 shall be used. Requirements relative to storage and to ambient conditions immediately prior to test shall be the same as for molded cylindrical specimens.

6.2 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. by averaging two height measurements along the diameter.

6.3 The moisture condition of the specimen at the time of test can have a significant effect upon the indicated properties of the concrete or mortar. Good practice generally dictates that laboratory tests be made upon specimens representative of field conditions or conditions expected under the operating environment. However, consider also that there may be reasons for testing specimens at other moisture contents, or with none. In any case, relate the moisture content of the test specimen to the problem at hand and report the content in accordance with 9.1.2.

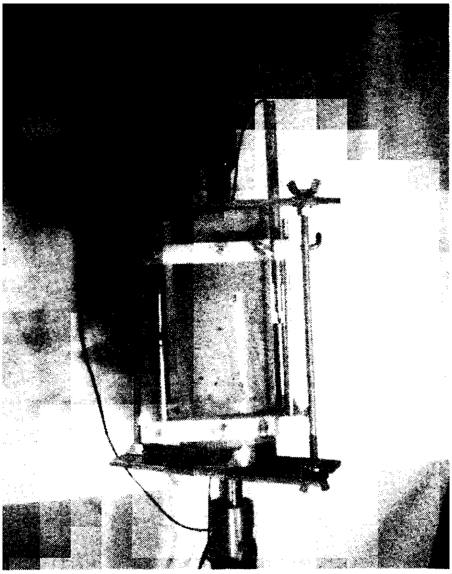

Figure 1. Suitable tensiometer

7. Procedure

7.1 Prepare the test specimens as described in CRD-C 164.

7.2 Place the specimen, with the strain-measuring system attached, in the testing machine making certain that the load transfer system is properly aligned. Zero the strain indicators.

7.3 Apply the tensile load continuously and without shock as prescribed in CRD-C 164. Record, without interruption of loading, the applied load and axial strain. Axial strain is defined as the total axial deformation divided by the effective gage length.

8. Calculation

8.1 Calculate the modulus of elasticity to the nearest 50,000 psi (345 MPa) as follows:

$$E = (S_2 - S_1)/(\varepsilon_2 - \varepsilon_1)$$

where:

E = chord modulus of elasticity, psi

S_2 = stress corresponding to 50 percent of ultimate load, psi

S_1 = stress corresponding to 10 percent of ultimate load, psi

ε_2 = longitudinal strain produced by S_2

ε_1 = longitudinal strain produced by S_1

8.2 The deformation shall be average measurement from the two axial strain measurements.

9. Report

9.1 The report shall include the following:

9.1.1 Specimen identification,

9.1.2 Physical description of specimen including type, dimension, moisture condition, and age,

9.1.3 Date of testing,

9.1.4 Type of strain measuring system used,

9.15 Location and type of failure.

9.1.6 Chord modulus of elasticity, and

9.1.7 Stress-strain curves.

10. Precision and Bias

10.1 **Precision.** The precision of this test method has not been determined.

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