Test method T308

Static chord modulus of elasticity of concrete specimens

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Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		Reformatted and Revision Summary Added	D.Dash	May 1999
		Date on Test Method Revised to Agree with Date on Revision Summary	D.Dash	Feb 2001
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Note that Roads and Maritime Services is hereafter referred to as 'RMS'.

The most recent revision to Test method T308 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T308

Static chord modulus of elasticity of concrete specimens

1. Scope

This test method sets out the procedure for determining the static chord modulus of elasticity of moulded cylinder specimens and of cores which have been taken from hardened concrete based on either the measured compressive strength of the concrete, the characteristic strength of the concrete, or the density of the concrete. The procedures conform to the methods described in Australian Standard 1012, Part 17 and Section 1.

Note: The static chord modulus of elasticity is defined as the gradient of the chord drawn between two specified points on a stress-strain curve.

2. Apparatus

(a) A testing machine, for the determination of compressive strength of concrete test specimens, conforming to the requirements of AS 1012, Part 9

(b) Deformation measuring apparatus, conforming to the requirements of AS 1012, Part 17

The deformation measuring apparatus may consist of either of the following:

(i) A compressometer consisting of two yokes and one or more gauges. Where two or more gauges are used, as in Fig 1.1 of the AS 1012, Part 17, both yokes shall be rigidly attached to the specimen, each by means of at least three symmetrically placed attached points. Where only one gauge is used, as in Fig 1.2 of AS 1012, Part 17, one yoke shall be rigidly attached to the specimen by means of at least three symmetrically placed attachment points. The other yoke shall be attached at two diametrically opposite points so that, within limits, it is free to rotate. The rotation yoke shall be connected to the fixed yoke by a pivot rod, located equidistant from the diametrically opposite attachment points, so as to maintain at this point a constant distance between the two yokes. A gauge shall be located on the point diametrically opposite to the pivot rod so as to measure the change in distance resulting from the rotation of the one yoke relative to the rigidly attached yoke. The measurement will be a function of the average deformation between the diametrically opposite attachment points of the rotating yoke and those of the fixed yoke, and the symmetry of the compressometer.

(ii) Demountable Gauges used independently. For this apparatus, the reference points shall be positively attached to, or embedded in the concrete specimen. Reference points relying on friction contact shall not be used.

3. Test Specimens

A minimum of three specimens is required for each determination of static chord modulus and not less than two specimens for the determination of average compressive strength, if the procedure in Method A below is to be adopted. All specimens shall be moulded from the same batch of concrete.

Concrete cylinders, 150 mm in diameter, shall be moulded, cured and prepared in accordance with Test Methods T304 and T305.

Cores shall be nominally 150 mm diameter, prepared and cured in accordance with Test Method T310.

Where independent demountable gauges are to be used, reference points are to be embedded or attached at a suitable time.

4. Procedure

Determine the static chord modulus according to **Method A**, **Method B** or **Method C** depending upon the number of specimens available for test and the available data.

Method A - Method Based on the Measured Compressive Strength of the Concrete

(a) Calculate the test load to be applied as follows:
The test load, F_t, to be applied in the determination of static chord modulus equals 40 per cent of the average compressive strength of the two test specimens referred to in *Test Specimens*, determined in accordance with Test Method T306 for moulded cylinders and Test Method T310 for cores.

(b) Carry out all measuring and testing operations as promptly as possible so that testing of each specimen will be completed within 30 minutes of removal from the curing environment. Record the temperature and relative humidity at the time of test.

(c) Test moulded specimens in a wet condition unless otherwise specified. Wipe away surplus water on specimens which have been cured by immersion before measuring and testing operations begin. Test cores in a dry condition unless otherwise specified.

(d) Inspect each specimen before placing in the machine, testing each cap by tapping with a suitable instrument. Remove and replace any hollow caps before the specimen is tested.

(e) Measure and record the diameter and height of each specimen, the diameter being the mean of two diameters at right angles to each other near the centre of the length of the specimen, the measurements being made to the nearest 0.5 mm. Measure the height over the full dimension, including the caps, to the nearest 2 mm.

(f) Clean the platens of the testing machine with clean rag whenever necessary, making sure that the surfaces are free from films of oil or other lubricating materials and particles of grit.

(g) Clean the bearing surfaces of the specimens, making sure that they are free from oil and particles of grit.

(h) If a compressometer is being used to measure strain, place it over the cylinder and secure in position, ensuring that the axis of the compressometer coincides with the axis of the cylinder and that the required gauge length is obtained.

(i) Place the specimen on the base plate of the testing machine and carefully align the axis of the specimen with the centre of thrust of the spherically-seated upper bearing block.

(j) Bring the spherically seated block slowly to bear upon the specimen and rotate the movable portions of the block gently by hand so that uniform seating is obtained.

(k) Adjust and note the reading on the dial gauges.

(l) Load the specimen to the test load, F_t, specified in (a) at least three times. During the first loading, which is primarily for seating the gauges, observe the performance of the gauges an correct any unusual behaviour prior to the second loading. No record of results need be kept for this loading. During each loading apply the force continuously and without shock as a rate of 260 ± 40 kN per minute. On reaching the test load, reduce the load to zero at approximately the same rate at which it was applied.

(m) During the second and successive loadings, record the following without interruption of loading:

  (i) The applied load, F, at the deformation equivalent to a longitudinal strain in the specimen of 50 microstrain

  (ii) the gauge reading or readings, depending whether one or more gauges or gauge lines are used to measure the deformation, at the test load, F_t.

Method B - Method Based on the Characteristic Strength of the Concrete

(a) Calculate the test load to be applied as follows:

The test load, F_t, shall be 40 percent of the design characteristic strength for the moulded concrete cylinder and core specimens. The characteristic strength is defined as that value of the strength, as assessed by standard tests, which is exceeded by the strength of at least 95 percent of the concrete (See AS 1480).

(b) Follow the procedure as set out in *Method A (b) to (m)* inclusive, applying the test load as calculated in *Method B (a)* above.

Method C - Method Based on the Density of the Concrete

(a) Determine the density of each of the test specimens in accordance with the Procedure set out in Test Method T316 - Mass/Unit Volume (Oven Dry Method).

Determine the average density of the concrete represented by the group of specimens to the nearest 20 kg/m^3.

(b) Determine the maximum strain to be applied, based on the average density of the concrete represented by the specimens, in accordance with the following table.

Table 1
Strain Limits

Density of test specimens at time of test kg/m^3	Maximum strain to be applied microstrain
3280 and over	300
2640 to 3260	380
2160 to 2620	450
1840 to 2140	520
1680 to 1820	600
1520 to 1660	680
1360 to 1500	750
1200 to 1340	820

Note: For most concretes the above strains will be produced by loads between 30 and 50 percent of the ultimate load.

(c) Follow the procedure as set out in *Method A (b) to (1)* inclusive applying the test load as calculated in *Method C (b)* above.

(d) During the second and successive loadings, record the following without interruption of loading:

(i) the applied load, F, at the deformation equivalent to a longitudinal strain in the specimen of 50 microstrain.

(ii) the applied load, F_t, at the deformation equivalent to a longitudinal strain, ε, as determined in accordance with *Method C (b)* above.

5. Calculations

(a) Where a single gauge type compressometer has been used, calculate the deformation from the following expression: $d = \dfrac{ge_r}{e_r + e_g}$

where $\dfrac{e_r}{e_r + e_g}$ = the compressometer factor

d = total deformation of the specimen throughout the effective gauge length (mm)

g = gauge reading (mm)

e_r = eccentricity of the load, measured in mm to the nearest .0025 mm from the axis of the specimen, and

e_g = eccentricity of the gauge, measured in mm to the nearest .0025 from the axis of the specimen.

(b) Where two or more gauges or gauge lines were used, the deformation, *d*, equals the mean of the gauge readings.

(c) For the second and successive loadings in **Method A** or **Method B** calculate the static chord modulus of elasticity to the nearest 1000 MPa as follows:

(i) Divide the applied load F (in Newtons) by the cross sectional area of the specimen (mm^2) to obtain the stress σ_1 (in MPa).

(ii) Divide the deformation, *d*, calculated in Calculations (a) or (b) by the gauge length used, to determine the longitudinal strain ε_2, at the test load F_t.

(iii) Divide the test load, F_t (in Newtons), by the cross sectional area (mm^2) of the specimen to obtain the stress ε_2 (in MPa) at the test load.

(iv) Calculate the static chord modulus of elasticity, E (in MPa), from that formula

$$E = \frac{\sigma_2 - \sigma_1}{\varepsilon_2 - 0.00005}$$

The static chord modulus of elasticity for each specimen equals the average of the moduli obtained from the second and successive loadings.

(d) For the second and successive loadings in **Method C** calculate the static chord modulus of elasticity to the nearest 500 MPa as follows:

(i) Divide the applied load F (in Newtons) by the cross sectional area of the specimen ($mm^{2)}$ to obtain the stress σ_1 (in MPa)

(ii) Divide the applied load F, (in Newtons) by the cross sectional areas of the specimen (mm^2) to obtain the stress σ_1 at longitudinal strain ε_2 .

(iii) Calculate the static chord modulus of elasticity, E, (in MPa) from the formula

$$E = \frac{\sigma_2 - \sigma_1}{\varepsilon_2 - 0.00005}$$

(iv) The static chord modulus of elasticity for each specimen equals the average of the moduli obtained from the second and successive loadings.

6. Records

Record the following information concerning each specimen.

(a) Identification marking

(b) Date of test

(c) Curing and environmental history

(d) Age of concrete at date of test

(e) Dimensions of the specimens

(f) Type of strain measuring device and gauge length

(g) End preparation

(h) Method of Test

(i) Measured average compressive strength and the test load (from Test Method T306 or T310); characteristic strength of the concrete and test load; or average density for the group of specimens and the specified strain limit (as appropriate)

(j) For cores, the size and position of any reinforcement, any defects in the cores before testing or found after testing and moisture condition at the time of testing

(k) Ambient temperature and relative humidity at time of test

(l) Load/stress and deformation/strain results for second and successive loadings and where required, a plot of stress-strain relationships

(m) Calculated static chord moduli of elasticity for each loading and the average of these

7. Reporting

Report the following:

(a) Identification and number of specimens

(b) Date of test

(c) Age of concrete in specimens

(d) Ambient temperature and relative humidity at time of test

(e) Method of test

(f) Average measured compressive strength of the concrete; characteristic strength of the concrete; or, average density of the group of specimens (as appropriate)

(g) Compressive stress at test load

(h) Average static chord modulus of elasticity determined from the average for each specimen, to the nearest 1000 MPa, and the range

(i) Such other information from the records as may have been requested

8. Techniques

(a) For compressometers as described in *Apparatus (b) (i)*, a jig and positioning rods such as illustrated in Fig 1.1 of AS 1012, Part 17, should be used to centre the compressometer around the specimen before clamping the compressometer in place. Remove the jig and positioning rods prior to commencement of loading

(b) When a compressometer with two gauges, or demountable gauges as described in *Apparatus (b) (ii)*, are used, two operators will be required to enable gauge readings to be taken simultaneously without interrupting the continuity of the application of the load

(c) If during a loading cycle, the reading at a required load value is not obtained, it is necessary to complete the loading cycle and then repeat the cycle recording the results obtained

(d) If a stress-strain curve is required, take readings at two or more intermediate points without interruption of loading