T 22

COMPRESSIVE STRENGTH OF CYLINDRICAL CONCRETE SPECIMENS

FOP FOR AASHTO

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Scope

This test method covers the determination of compressive strength of cylindrical concrete specimens such as molded cylinders and drilled cores. It is limited to concrete having a unit weight in excess of 50 lb/ft^3.

This method consists of applying a compressive axial load to molded cylinders or cores at a rate that is within a prescribed range until failure occurs. The compressive strength of the specimens is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen.

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Significance

Compressive strength is not a fundamental or intrinsic property of concrete; therefore, care must be exercised in the interpretation of the significance of compressive strength determinations. Strength values obtained will depend on the size and shape of the specimen, batching and mixing procedures, methods of sampling and molding, and the age, temperature, and moisture conditions during curing.

This test method may be used to determine compressive strength of cylindrical specimens prepared and cured in accordance with AASHTO R 39, T 23, T 24, T 231 and ASTM C 873.

The results of this test may be used as a basis for quality control of concrete proportioning, mixing, and placing operations; determination of compliance with specification; and control for evaluating effectiveness of admixtures and similar uses.

04 **Apparatus**

- **Testing Machine:** Capacity sufficient to cause specimen failure at prescribed loading rates. The machine shall be power operated and must apply the load continuously without shock. The machine shall be accurate such that the percentage of error shall not exceed ±1.0 percent of the indicated load. See AASHTO T 22 for a detailed listing of the provisions under which the accuracy of a testing machine is to be determined.

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- **Bearing Blocks:** The machine shall be equipped with two bearing blocks. Bearing faces of both blocks shall have a least horizontal dimension at least 3 percent greater than the diameter of the specimen to be tested. The top bearing block shall be spherically seated. The top and bottom surfaces of the bottom bearing block shall be parallel to each other. See AASHTO T 22 for a more detailed listing of requirements for bearing blocks.

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- **Load Indication:** If the load of a compression machine is registered on a dial, the dial shall be graduated to at least the nearest 0.1 percent of the full-scale load. Each dial shall be equipped with a suitable device that at all times, until reset, will indicate to within 1 percent accuracy the maximum load applied to the specimen. If the load of the compression machine is indicated in digital form, the numerical increment must be equal to or less than 0.1 percent of the full-scale load of a given loading range.

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- **Safety:** A means to contain fragments in the case of an explosive rupture.
- **Neoprene Caps and Controllers:** Meeting the requirements of ASTM C 1231.

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Note 1: 0.5° is approximately equivalent to a difference of 0.12 in. in 12 inches.

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Table 1
Permissible Time Tolerances

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Specified Age	*Tolerance*
12 hrs	15 min (2.1%)
24 hrs	30 min (2.1%)
3 days	2 hrs (2.8%)
7 days	6 hrs (3.6%)
28 days	20 hrs (3.0%)
56 days	40 hrs (3.0%)
90 days	2 days (2.2%)

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Specimens

Specimens may be prepared for testing either by AASHTO T 231 "Capping Cylindrical Concrete Specimens" or by use of neoprene caps. When density of the test specimens is required, determine as described in AASHTO T 22, prior to capping.

- For either method, specimens shall not be tested if any individual diameter of a cylinder differs from any other diameter of the same cylinder by more than 2 percent.
- Neither end of compressive test specimen when tested shall depart from perpendicularity to the longitudinal axis by more than 0.5°.
- If the ends of the specimen are not plane within 0.002 in. the specimen shall be capped, sawed or ground according to AASHTO T 231, or prepared in accordance with ASTM C 1231.

Procedure

1. All test specimens for a given test age shall be broken within the permissible time tolerances prescribed in Table 1.
2. Compression tests of moisture-cured specimens shall be made as soon as practicable after removal from moist storage. Specimens shall be kept moist by any convenient method until tested.
3. Determine specimen diameter to the nearest 0.01 inch as the average of two measurements made at right angles to each other at mid-height of the specimen. If the specimens are known to have been made using reusable or single use molds from the same lot that consistently result in specimen diameters within a range of 0.02 inches, then diameter measurement for each days testing may be reduced to 1 for each 10 specimens or three specimens per day, whichever is greater. In this case, the average diameter of the specimens measured shall be used for calculation of the cross-sectional area.

16 4. Place the plain bearing block, with its hardened face up, on the table or platen of the testing machine directly under the spherically seated upper bearing block. Wipe clean the bearing faces of the upper and lower bearing blocks and the test specimen. Carefully align the axis of the specimen with the center of thrust of the spherically seated block.

5. Rotate the spherically seated block immediately prior to testing, to assure free movement.

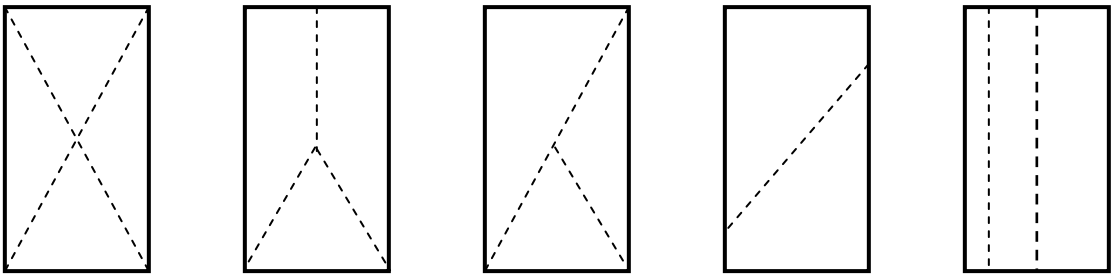
17 6. The speed of crosshead travel shall be controlled to result in a rate of loading within
18 the range of 35 ±7 psi/second.

19 7. The designated rate of movement shall be maintained at least during the latter half of the anticipated loading phase of the test cycle. During the application of the first half of the anticipated loading phase a higher rate of movement shall be permitted.

8. Make no adjustment in the rate of movement while the specimen is yielding rapidly immediately before failure.

20 9. At specimen failure record the maximum load
21 carried by the specimen during the test. Note the type of fracture and appearance of the concrete.

Types of Fracture 22



Cone (a) **Cone and Split (b)** **Cone and Shear (c)** **Shear (d)** **Columnar (e)**

23 **Calculation**

1. Calculate the compressive strength of the specimen by dividing the maximum load by the cross-sectional area.

Table 2				
Length/Diameter Correction				
L/D	1.75	1.50	1.25	1.00
Factor	0.98	0.96	0.93	0.87

24 2. If the specimen length-to-diameter is 1.75 or less, correct the result just obtained by multiplying that result by the appropriate correction factor shown in Table 2. Values not given shall be determined by interpolation. When correction is required, specimen length must be determined to the nearest 0.1 inch.

25 The correction factors apply to:

- Concrete with compressive strength ranging from 2000 to 6000 psi.
- Concrete in a dry or soaked state at time of testing.
- Normal weight concrete.
- Lightweight concrete weighing between 100 and 120 lb/ft^3.

26 **Report**

- Results shall be reported on standard forms approved for use by the agency.
- Identification number
- Diameter (and length if outside the range of 1.8D to 2.2D)
- Cross-sectional area
- Maximum load
- Compressive strength calculated to the nearest 10 psi.
- Type of fracture.
- Defects in specimen or caps.
- Age of specimen.

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Tips!

- Remember to rotate the spherically seated upper bearing block just prior to load application.
- Check agency specifications to determine if use of neoprene caps is allowed.
- Compressive strength is calculated and reported to the nearest 10 psi.

Calculation Examples

Calculate compressive strength according to the following formulas: 28

Cross-sectional Area (in^2): πr^2

where:

π = a transcendental number approximating 3.1416, representing the ratio of the circumference to the diameter of a circle (Used here as a constant).

r = radius of the specimen (1/2 the diameter)

Compressive Strength (psi): $\frac{\text{Total Load (lbs)}}{\text{Cross - sectional Area (in}^2\text{)}} * \text{Correction Factor}$

Example #1 (No correction for L/D required) 29

Specimen Diameter: 4.02”
Specimen Length: 7.9”
Maximum Load: 58,510 lbs.
L/D: 1.97 (No Correction Required)

Cross-sectional area = $3.1416 * 2.01^2 = 12.692$, say $12.69\ in^2$

Compressive Strength = $\frac{58{,}510\ lbs}{12.69\ in^2} = 4611$, say $4610\ psi$

Example #2 (Correction for L/D required) 30

Specimen Diameter: 3.78”
Specimen Length: 6.1”
Maximum Load: 63,460 lbs.
L/D: 1.61 (Correction Factor = 0.97)

Cross-sectional area = $3.1416 * 1.89^2 = 11.222$, say $11.22\ in^2$

Compressive Strength = $\frac{63{,}460\ lbs}{11.22\ in^2} = 5656 * 0.97 = 5486$, say $5490\ psi$

REVIEW QUESTIONS

1. Why is this test performed?

2. How many cylinders must be measured for determination of specimen diameter?

3. Describe the method of load application.

4. After specimen failure, what must be recorded?

5. Given the following, calculate the compressive strength:
   Maximum sustained load: 46,240 lbs.
   Average specimen diameter: 3.73 inches.
   Specimen length: 6.15 inches.

PERFORMANCE EXAM CHECKLIST

DETERMINATION OF COMPRESSIVE STRENGTH OF CYLINDRICAL CONCRETE SPECIMENS

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Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Participant Name:_____ Exam Date:_____

Specimens	Trial 1	Trial 2
1. Specimen verified that any diameter does not differ from any other diameter of the same cylinder by more than 2 percent?	_____	_____
2. Verified that neither end of the specimen when tested departs from perpendicularity to the axis by more than 0.5°?	_____	_____
3. Ends of the specimen capped, sawed or ground according to AASHTO T 231, or neoprene caps used according to ASTM C 1231?	_____	_____

Procedure		
1. Test specimens kept moist between removal from storage and testing?	_____	_____
2. Test conducted within the specified time limits for the test age?	_____	_____
3. Test specimen properly centered with thrust of spherically seated block?	_____	_____
4. Spherically seated block rotated immediately prior to testing?	_____	_____
5. Compression load applied continuously and without shock?	_____	_____
6. The designated rate of movement maintained during the latter half of the anticipated loading phase?	_____	_____
7. At specimen failure the maximum load carried by the specimen was recorded along with the type of failure?	_____	_____

Calculations		
1. Compressive strength properly determined?	_____	_____
2. Correction factor applied if length-to-diameter ratio is less than 1.8?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

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Signature of Examiner_____