Tex-418-A, Compressive Strength of Cylindrical Concrete Specimens

Overview


Part I of this method covers determining 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 800 kg/m$^3$ (50 lb/ft$^3$). Except for editorial differences, this test method is identical with ASTM C 39 and AASHTO T 22, Part II discusses the use of neoprene caps during this testing.

Part I, Determining Compressive Strength of Cylindrical Concrete Specimens

This part determines 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 800 kg/m$^3$ (50 lb/ft$^3$).

Significance and Use

Below is information regarding the significance and use of this test method.

Exercise care interpreting the significance of compressive strength determinations by this test method, since strength is not a fundamental or intrinsic property of concrete made from given materials. Values obtained will depend on the size and shape of the specimen, batching, mixing procedures, the methods of sampling, molding, fabrication, age, temperature, and the moisture conditions during curing.

Use this method to determine compressive strength of cylindrical specimens prepared and cured according to test methods “Tex-424-A, Obtaining and Testing Drilled Cores of Concrete, Tex-447-A, Making and Curing Concrete Test Specimens,” and/or “Tex-450-A, Capping Cylindrical Concrete Specimens.”

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

The following apparatus is required:

♦ Testing Machine, power operated, able to apply a load continuously rather than intermittently, without shock, having sufficient capacity, and capable of providing the rates of loading prescribed herein. If it has only one loading rate, it must be provided with a supplemental means for loading at a rate suitable for verification. This supplemental means of loading may be power or hand operated.

♦ Elastic calibration device, such as the circular proving ring, with sufficient capacity to cover the potential loading range of the testing machine and which complies with the requirements of ASTM E 74.

♦ Testing space, large enough to accommodate, in a readable position, an elastic calibration device

♦ Bearing Blocks, Upper and Lower, with bearing faces that have a Rockwell hardness not less than 55 HRC, and minimum dimensions at least 3% greater than the diameter of the test specimen. Except for the concentric circles described below, bearing faces shall not depart from a plane by more than 0.025 mm (0.001 in.) in any 152 mm (6 in.) in blocks 152 mm (6 in.) in diameter or larger, or by more than 0.025 mm (0.001 in.) in diameter of any smaller block. New blocks must be manufactured to one half this tolerance.

♦ Upper bearing block, a spherically seated block that will bear on the upper surface of the specimen. The maximum diameter of the bearing face of the suspended spherically seated block shall not exceed these values:

<table>
<thead>
<tr>
<th>Diameter of Test Specimens mm (in.)</th>
<th>Maximum Diameter of Bearing Face mm (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>51 (2)</td>
<td>102 (4)</td>
</tr>
<tr>
<td>76 (3)</td>
<td>127 (5)</td>
</tr>
<tr>
<td>102 (4)</td>
<td>165 (6½)</td>
</tr>
<tr>
<td>152 (6)</td>
<td>254 (10)</td>
</tr>
<tr>
<td>203 (8)</td>
<td>279 (11)</td>
</tr>
</tbody>
</table>

NOTE: Square bearing faces are permissible, provided the diameter of the largest possible inscribed circle does not exceed the above diameter.

The center of the sphere must coincide with the surface of the bearing face within a tolerance of ± 5% of the radius of the sphere. The diameter of the sphere must be at least 75% of the diameter of the specimen to be tested.

When the diameter of the bearing face of the spherically seated block exceeds the diameter of the specimen by more than 13 mm (½ in.), inscribe concentric circles not more than 0.8 mm (1/32 in.) deep and not more than 1.2 mm (3/64 in.) wide to facilitate proper centering.

(continued...)
Apparatus (continued)

The ball and the socket must be so designed by the manufacturer that the steel in the contact area does not permanently deform under repeated loads up to 82.7 MPa (12,000 psi) on the test specimen. The preferred contact area is in the form of a ring (described as “preferred bearing area”) as shown in ‘Schematic Sketch of a Typical Spherical Bearing Block.’

![Schematic Sketch of a Typical Spherical Bearing Block](image)

Figure 4-5. Schematic Sketch of a Typical Spherical Bearing Block.

The following text refers to the ‘Schematic Sketch of a Typical Spherical Bearing Block.’

The curved surfaces of the socket and of the spherical portion shall be kept clean and shall be lubricated with a petroleum-type oil such as conventional motor oil, not with a pressure type grease. After contacting the specimen and application of small initial load, further tilting of the spherically seated block is not intended and is undesirable.

If the radius of the sphere is smaller than the radius of the largest specimen to be tested, the portion of the bearing face extending beyond the sphere shall have a thickness not less than the difference between the radius of the sphere and radius of the specimen. The least dimension of the bearing face shall be at least as great as the diameter of the sphere.

The movable portion of the bearing block shall be held closely in the spherical seat, but the design shall be such that the bearing face can be rotated freely and tilt at least 4° in any direction.

(continued...)
Apparatus (continued)

Make final centering with reference to the upper spherical block. When the lower bearing block is used to assist in centering the specimen, the center of the concentric rings, when provided, or of the block itself, must be directly below the center of the spherical head. Make provisions on the platen to assure such a position.

♦ Lower bearing block, at least 25 mm (1 in.) thick when new, and at least 22.9 mm (9/10 in.) thick after any resurfacing operations, on which specimens will rest, which provides a machineable surface to maintain the specified surface conditions. Concentric circles, as described above, are optional. The block may be fastened to the platen of the testing machine. If the machine is so designed that the platen itself can be maintained in the specified surface condition, a bottom block is not required.

♦ Load Indicators

♦ Dial-type, with a graduated scale that can be read to at least the nearest 0.1% of the indicated load at any given level within the loading range. In no case shall the loading range of a dial be considered to include loads below the value that is 100 times the smallest change of load that can be read on the scale. The scale must be provided with a graduation line equal to zero and so numbered. The dial pointer shall be of sufficient length to reach the graduation marks; the width of the pointer tip must not exceed the clear distance between the smallest graduations. Each dial shall be equipped with a zero adjustment easily accessible from outside the case, with a suitable device that, at all times until reset, will indicate to within 1% accuracy the maximum load being applied.

NOTE: One half of a scale interval is about as close as can reasonably be read (0.50 mm [0.02 in.]) along the arc described by the end of the pointer) or when the spacing on the load indicating mechanism is between 1 mm and 1.6 mm (1/25 in. and 1/16 in). When spacing is between 1.6 mm (1/16 in.) and 3.2 mm (1/8 in), one third of an interval can be read with reasonable certainty. When the spacing is 3.2 mm (1/8 in.) or more, one fourth of a scale interval can be read with reasonable certainty.

♦ Digital load indicator, with a numerical display large enough to be easily read, and numerical increment equal to or less than 0.10% of the full scale load of a given loading range. In no case shall the verified loading range include loads less than the minimum numerical increment multiplied by 100. The accuracy of the indicated load must be within 1.0% for any value displayed within the verified loading range. Provision must be made for adjusting to indicate true zero at zero load. A maximum load indicator will indicate, within 1% system accuracy, the maximum load applied to the specimen at all times, until reset.
Calibration Requirements

Below are the requirements for verifying calibration of the testing machine:

- Verifying calibration of the testing machine according to ASTM E 4 is required:
  - After an elapsed interval since the previous verification of 18 months maximum, but preferably after an interval of 12 months
  - On original installation or relocation of the machine
  - Immediately after making repairs or adjustments which may in any way affect the operation of the weighing system or the values displayed, except for zero adjustments that compensate for the weight of tooling, or specimen, or both
  - Whenever there is reason to doubt the accuracy of the results, without regard to the time interval since the last verification.

- The accuracy of the testing machine should conform to these provisions:
  - The percentage of error for the loads within the proposed range of use of the testing machine must not exceed ± 1.0% of the indicated load.
  - The accuracy of the testing machine should be verified by applying five test loads in four approximately equal increments in ascending order. The difference between any two successive test loads should not exceed one third of the difference between the maximum and minimum test loads.
  - The test load as indicated by the testing machine, and the applied load computed from the readings of the verification device, will be recorded at each test point.
  - Calculate the error, $E$, and the percentage of error, $Ep$, for each point from these data:
    
    $E = A - B$
    
    $Ep = 100 \left( \frac{A - B}{B} \right)$

    Where:

    $A =$ load, N indicated by the machine being verified, and

    $B =$ applied load, N as determined by the calibrating device.

- The report on the verification of a testing machine should state within what loading range it was found to conform to specification requirements, rather than reporting a blanket acceptance or rejection. In no case shall the loading range be stated as including loads below the value which is 100 times the smallest change of load that can be estimated on the load-indicating mechanism of the testing machine or loads within that portion of the range below 10% of the maximum range capacity.

- In no case shall the loading range be stated as including loads outside the range of loads applied during the verification test.

- The indicated load of a testing machine should not be corrected either by calculation or by the use of a calibration diagram to obtain values within the required permissible variation.
Specimens

♦ Specimens shall not be tested if any diameter of a cylinder differs from any other diameter of the same cylinder by more than 2%.

NOTE: This may occur when single use molds are damaged or deformed during shipment, when flexible single use molds are deformed during molding, or when a core drill deflects or shifts during drilling.

♦ Neither end of compressive test specimens should depart from perpendicularity to the axis by more than 0.5° (3 mm in 300 mm [1/8 in. in 12 in.]).

♦ Cap the ends of compression test specimens according to Test Method “Tex-450-A, Capping Cylindrical Concrete Specimens.”

♦ Determine the diameter used for calculating the cross-sectional area of the test specimen to the nearest 0.25 mm (0.01 in.) by averaging two diameters measured at right angles to each other at about mid-height of the specimen.

♦ The number of individual cylinders measured for determining average diameter may be reduced to one for each ten specimens or three specimens per day, whichever is greater, if all cylinders are known to have been made from a single lot of reusable or single-use molds which consistently produce specimens with average diameters within a range of 0.51 mm (0.02 in).

♦ When the average diameters do not fall within the range of 0.51 mm (0.02 in.) or when the cylinders are not made from a single lot of molds, each cylinder tested must be measured and the value used to calculate the unit compressive strength of that specimen.

♦ When the diameters are measured at the reduced frequency, the cross-sectional areas of all cylinders tested on that day shall be computed from the average of the diameters of the three or more cylinders representing the group tested that day.

♦ The length shall be measured to the nearest 0.05\(D\) when the length to diameter ratio is less than 1.8, or more than 2.2, or when the volume of the cylinder is determined from measured dimensions.

Test Procedure

The following describes the procedure for compression testing of cylindrical concrete specimens:

♦ Test specimens in a moist condition.

♦ Perform compression tests of moist cured specimens as soon as practicable after removal from moist storage.

♦ Keep test specimens moist by any convenient method during the period between removal from moist storage and testing.

(continued...)
Chapter 4 – Concrete

Test Procedure (continued)

♦ Break all test specimens for a given test age within the permissible time tolerances prescribed:

| Time Tolerances |
|-----------------|-----------------|
| Test Age        | Permissible Tolerance |
| 24 h            | ±0.5 h or 2.1%    |
| 3 days          | 2 h or 2.8%       |
| 7 days          | 6 h or 3.6%       |
| 28 days         | 20 h or 3.0%      |
| 90 days         | 2 days 2.2%       |

The following table details compression testing cylindrical concrete specimens.

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
</table>
| 1    | ♦ Place the lower bearing block, with its hardened face up, on the table or platen of the testing machine directly under the spherically seated (upper) bearing block.  
♦ Clean the bearing faces of the upper and lower bearing blocks and the test specimen and place the test specimen on the lower bearing block.  
♦ Carefully align the axis of the specimen with the center of thrust of the spherically seated block.  
♦ As the spherically seated block is brought to bear on the specimen, rotate its movable portion gently by hand, so that uniform seating is obtained. |
| 2    | ♦ Apply the load continuously and without shock.  
• For testing machines of the screw type, the moving head shall travel at a rate of approximately 1.3 mm (0.05 in.)/minutes when the machine is running idle.  
• For hydraulically operated machines, the load shall be applied at a rate of movement (platen to cross-head measurement) corresponding to a loading rate on the specimen within the range of 0.14 to 0.34 MPa/s (20 to 50 psi/s). Maintain the designated rate of movement at least during the latter half of the anticipated loading phase of the testing cycle.  
♦ During the application of the first half of the anticipated loading phase a higher rate of loading shall be permitted.  
♦ Make no adjustment in the rate of movement of the platen at any time while a specimen is yielding rapidly immediately before failure.  
♦ Apply the load until the specimen fails, and record the maximum load carried by the specimen during the test.  
♦ Note the type of failure and the appearance of the concrete. |

Calculations

Use the following calculations to determine the compressive strength of the specimens:

Calculate the compressive strength of the specimen by dividing the maximum load carried by the specimen during the test by the average cross-sectional area determined as previously described and express the result to the nearest 50 kPa (10 psi).

If the specimen length to diameter ratio is less than 1.8, correct the result obtained by multiplying by the appropriate correction factor shown in the following table:
NOTE 8: These correction factors apply to light weight concrete weighing between 1600 and 1920 kg/m$^3$ (100 and 200 lb/ft$^3$) and to normal weight concrete. They are applicable to concrete dry or soaked at time of loading. Values not given in the table shall be determined by interpolation. The correction factors are applicable for nominal concrete strengths from 13.8 to 41.4 MPa (2000 to 6000 psi).

### Correction Factors

<table>
<thead>
<tr>
<th>L/D</th>
<th>1.75</th>
<th>1.50</th>
<th>1.25</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
<td>0.98</td>
<td>0.96</td>
<td>0.93</td>
<td>0.87</td>
</tr>
</tbody>
</table>

Report

Include the following in the report:

- Identification Number
- Diameter (and length, if outside the range of 1.8$D$ to 2.2$D$), in inches
- Cross-sectional area, in square millimeters (square inches)
- Maximum load, in Newtons (pounds-force)
- Compressive strength calculated to the nearest 50 kPa (10 psi)
- Type of fracture, if other than the usual cone (see ‘Sketches of Types of Fracture’)
- Defects in either specimen or caps
- Age of specimen.

![Sketches of Types of Fracture](Image)

*Figure 4-6. Sketches of Types of Fracture.*
Part II, Compressive Strength of Cylindrical Concrete

This part discusses the use of neoprene caps during this testing.

Specimens Using Neoprene Caps

‘Part II, Compressive Strength of Cylindrical Concrete’ discusses the use of neoprene caps with metal extrusion control retainers as a suitable alternate capping procedure to those identified in Test Method “Tex-450-A, Capping Cylindrical Concrete Specimens” to determine the compressive strength of molded cylindrical concrete specimens. Except for editorial differences, this procedure is the same as AASHTO T 22, ‘ANNEX’ section.

Apparatus

The following apparatus is required:

♦ Steel extrusion control retainers, with cavities which have a depth at least twice the thickness of the pad. The inside diameter of the retaining rings should not be less than 102% or greater than 104% of the diameter of the cylinder. The surfaces of the steel retainer which contact the bearing blocks of the testing machine must be plane to within 0.05 mm (1/500 in.). The bearing surfaces of the retainers should not have gouges, grooves, or indentations greater than 0.25 mm (1/100 in.) deep or 32 mm$^2$ (1/20 in.$^2$) in surface area.

♦ Caps, made from neoprene meeting the requirements of ASTM D 2000, line call-out M2BC514A14B14 (see ‘Line Call-Out Designation’), 13 ± 2 mm (1/2 ± 1/16 in.) thick, and fit snugly inside the retainer.
"Line Call-Out" Designation

Grade Class | Tensile Strength | Compression Set
---|---|---
M | 2 | B C 5 14 A14 B14

SI Units | Type | Hardness | Heat Resistance
---|---|---|---

**Type** - 100 °C Test Temperature  
**Class** - 120% Maximum Volume Swell  
**Hardness (Durometer)** - 50± 5 points (Duro)  
**Tensile Strength** - 14 Mpa  
**Heat Resistance** - Tested according to Test Method ASTM D 573  
**Compression Set** - Tested according to Test Method ASTM D 395

Figure 4-7. “Line Call-Out” Designation.
Precautions

The following precaution should be observed when testing cylinders with neoprene caps:

Concrete cylinders tested with neoprene caps rupture more intensely than comparable cylinders tested with sulfur mortar caps. As a safety precaution, the cylinder testing machine should be equipped with a protective cage.

Test Specimens

Test specimen as detailed in ‘Part I, Determining Compressive Strength of Cylindrical Concrete Specimens’ of this test method, modified as noted:

♦ Each end of the concrete cylinder must be plane within 3.2 mm (1/8 in.) across any diameter; i.e., there shall be no depressions in the concrete surface which are deeper than 3.2 mm (1/8 in.). Do not test cylinders that do not meet this tolerance, unless the surface irregularity is corrected.

♦ Neither end of the concrete cylinder should depart from perpendicularity to the axis by more than 2.0 degrees (approximately equal to a difference in height of 5 mm [3/16 in.] for a 152 mm [6 in.] diameter cylinder). Cylinders not meeting this tolerance shall not be tested unless this irregularity is corrected.

Test Procedure

Perform the compression test as detailed in ‘Part I, Determining Compressive Strength of Cylindrical Concrete Specimens’ of this test method, modified as follows:

♦ Place an extrusion controller, containing a neoprene cap, on the top and bottom surfaces of the concrete cylinder. With the neoprene caps in contact with the concrete cylinder, carefully align the axis of the specimen with the center of thrust of the spherically seated block. Bring the bearing blocks of the machine in contact with both of the extrusion controllers.

♦ No loose particles shall be trapped between the concrete cylinder and the neoprene caps or between the bearing surfaces of the extrusion controllers and the bearing blocks of the testing machine.

♦ The same surface of the neoprene cap shall bear on the concrete cylinder for all tests performed with that cap. Do not test more than 100 cylinders with one neoprene cap. Pads exhibiting cracks or splits, regardless of number of uses, must be replaced immediately.

NOTE 1: Deterioration of the pad at the perimeter is normal, however if the thickness is reduced by more than 4 mm (1/8 in.) the pad shall be replaced.

NOTE 2: When used, neoprene caps shall be considered as an acceptable substitute for sulfur-mortar caps without correction for apparent strength differences.