WSDOT FOP for AASHTO T 22[1]

Compressive Strength of Cylindrical Concrete Specimens

1. Scope

1.1 This test method covers 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 (800 kg/m^3).

1.2 The values stated in English units are 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 whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Warning: Means should be provided to contain concrete fragments during sudden rupture of specimens. Tendency for sudden rupture increases with increasing concrete strength (Note 1).

Note 1: The safety precautions given in the Manual of Aggregate and Concrete Testing, located in the Related Materials section of Volume 04.02 of the Annual Book of ASTM Standards, are recommended.

1.4 The text of this standard references notes which provide explanatory material. These notes shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 AASHTO Standards

R 39 – Making and Curing Concrete Test Specimens in the Laboratory

T 23 – Making and Curing Concrete Test Specimens in the Field

T 24 – Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

T 231 – Capping Cylindrical Concrete Specimens

2.2 ASTM Standards

C 873 – Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds

C 1231 – Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders

E 74 – Practice for Calibration of Force-Measuring Instruments for Verifying the Load Indication of Testing Machines

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[1]This FOP is based on AASHTO T 22-11 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.

3. Summary of Test Method

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

4. Significance and Use

4.1 Care must be exercised in the interpretation of 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, and fabrication and the age, temperature, and moisture conditions during curing.

4.2 This test method is used to determine compressive strength of cylindrical specimens prepared and cured in accordance with Methods T 23, T 24, T 231, and ASTM C873.

4.3 The results of this test method are 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.

5. Apparatus

5.1 Testing Machine – The testing machine shall be of a type having sufficient capacity and capable of providing the rates of loading prescribed in Section 7.5. As a minimum, the machine should be capable of achieving 170 percent of the design strength.

5.1.1 Verify calibration of the testing machines in accordance with Method T 67 except that the verified loading range shall be as required in Section 5.3.2. Verification is required under the following conditions:

5.1.1.1 At least annually, but not to exceed 13 months.

5.1.1.2 On original installation or immediately after relocation.

5.1.1.3 Immediately after making repairs or adjustments that affect the operation of the force applying system or the values displayed on the load indicating system, except for zero adjustments that compensate for the mass (weight) of tooling, or specimen, or both.

5.1.1.4 Whenever there is reason to suspect the accuracy of the indicated loads.

5.1.2. Design – The design of the machine must include the following features:

5.1.2.1 The machine must be power operated and must apply the load continuously rather than intermittently, and without shock. If it has only one loading rate (meeting the requirements of Section 7.5), 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.

5.1.2.2 The space provided for test specimens shall be large enough to accommodate, in a readable position, an elastic calibration device which is of sufficient capacity to cover the potential loading range of the testing machine and which complies with the requirements of Practice E 74.

Note 2: The types of elastic calibration devices most generally available and most commonly used for this purpose are the circular proving ring or load cell.

5.1.3 Accuracy – The accuracy of the testing machine shall be in accordance with the following provisions:

5.1.3.1 The percentage of error for the loads within the proposed range of use of the testing machine shall not exceed ± 1.0 percent of the indicated load.

5.1.3.2 The accuracy of the testing machine shall be verified by applying five test loads in four approximately equal increments in ascending order. The difference between any two successive test loads shall not exceed one third of the difference between the maximum and minimum test loads.

5.1.3.3 The test load as indicated by the testing machine and the applied load computed from the readings of the verification device shall be recorded at each test point. Calculate the error, E, and the percentage of error, Ep, for each point from these data as follows:

$$E = A - B$$
$$Ep = 100(A - B)/B$$

where:
A = load, lbf (kN) indicated by the machine being verified; and
B = applied load, lbf (kN) as determined by the calibrating device.

5.1.3.4 The report on the verification of a testing machine shall 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 percent of the maximum range capacity.

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

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

5.2 The testing machine shall be equipped with two steel bearing blocks with hardened faces (Note 3), one of which is a spherically seated block that will bear on the upper surface of the specimen, and the other a solid block on which the specimen shall rest. Bearing faces of the blocks shall have a minimum dimension at least 3 percent greater than the diameter of the specimen to be tested. Except for the concentric circles described below, the bearing faces shall not depart from a plane by more than 0.001 in (0.025 mm) in any 6 in (150 mm) of blocks 6 in (150 mm) in diameter or larger, or by more than 0.001 in (0.025 mm) in the diameter of any smaller block; and new blocks shall be manufactured within one half of this tolerance. When the diameter of the bearing face of the spherically seated block exceeds the diameter of the specimen by more than 0.5 in (13 mm), concentric circles not more than 0.031 in (0.8 mm) deep and not more than 0.047 in (1 mm) wide shall be inscribed to facilitate proper centering.

Note 3: It is desirable that the bearing faces of blocks used for compression testing of concrete have a Rockwell hardness of not less than 55 HRC.

5.2.1 Bottom bearing blocks shall conform to the following requirements:

5.2.1.1 The bottom bearing block is specified for the purpose of providing a readily machinable surface for maintenance of the specified surface conditions (Note 4). The top and bottom surfaces shall be parallel to each other. Its least horizontal dimension shall be at least 3 percent greater than the diameter of the specimen to be tested. Concentric circles as described in Section 5.2 are optional on the bottom block.

Note 4: The block may be fastened to the platen of the testing machine.

5.2.1.2 Final centering must be made 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 the center of the block itself must be directly below the center of the spherical head. Provision shall be made on the platen of the machine to assure such a position.

5.2.1.3 The bottom bearing block shall be at least 1 in (25 mm) thick when new, and at least 0.9 in (22.5 mm) thick after any resurfacing operations, except when the block is in full and intimate contact with the lower platen of the testing machine, the thickness may be reduced to 0.38 in (10 mm).

Note 5: If the testing machine is so designed that the platen itself can be readily maintained in the specified surface condition, a bottom block is not required.

5.2.2 The spherically seated bearing block shall conform to the following requirements:

5.2.2.1 The maximum diameter of the bearing face of the suspended spherically seated block shall not exceed the values given below:

Diameter of Test Specimens in (mm)	Maximum Diameter of Bearing Face in (mm)
2 (50)	4 (105)
3 (75)	5 (130)
4 (100)	6.5 (165)
6 (150)	10 (255)
8 (200)	11 (280)

Note 6: Square bearing faces are permissible, provided the diameter of the largest possible inscribed circle does not exceed the above diameter.

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

5.2.2.3 The ball and the socket shall be designed so that the steel in the contact area does not permanently deform when loaded to the capacity of the test machine. (Note 7).

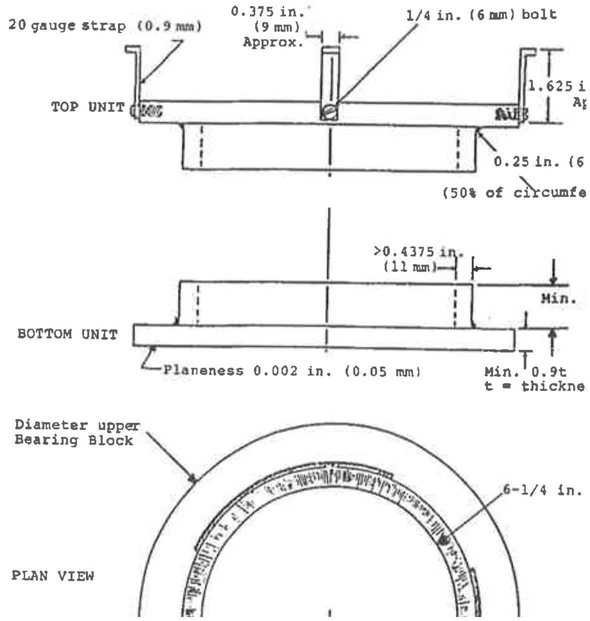
Note 7: The preferred contact area is in the form of a ring (described as preferred "bearing" area) as shown on Figure 1.

5.2.2.4 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.

5.2.2.5 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 (see Figure 1).

5.2.2.6 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 tilted at least 4 degrees in any direction.

5.2.2.7 If the ball portion of the upper bearing block is a two-piece design composed of a spherical portion and a bearing plate, a mechanical means shall be provided to ensure that the spherical portion is fixed and centered on the bearing plate.



Note: Provision shall be made for holding the ball in the socket and for holding the entire unit in the testing machine

Schematic Sketch of a Typical Spherical Bearing Block
Figure 1

5.3 Load Indication

5.3.1 If the load of a compression machine used in concrete testing is registered on a dial, the dial shall be provided with a graduated scale that is readable to at least the nearest 0.1 percent of the full scale load (Note 8). The dial shall be readable within 1 percent of the indicated load at any given load 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 shall 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 end of the pointer shall not exceed the clear distance between the smallest graduations. Each dial shall be equipped with a zero adjustment which is easily accessible from the outside of the dial case, while observing the zero mark and dial pointer, and with a *suitable device that at all times until reset will indicate to within one percent accuracy the maximum load applied to the specimen*.

Note 8: As close as can reasonably be read is considered to be 0.02 in (0.5 mm) along the arc described by the end of the pointer. Also, one half of a scale interval is close as can reasonably be read when the spacing on the load indicating mechanism is between 0.04 in (1 mm) and 0.06 in (2 mm). When the spacing is between 0.06 and 0.12 in (2 and 3 mm), one third of a scale interval can be read with reasonable certainty. When the spacing is 0.12 in (3 mm) or more, one fourth of a scale interval can be read with reasonable certainty.

5.3.2 If the testing machine load is indicated in digital form, the numerical display must be large enough to be easily read. The numerical increment must be equal to or less than 0.10 percent 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 percent for any value displayed within the verified loading range. Provision must be made for adjusting to indicate true zero at zero load. There shall be provided a maximum load indicator that at all times until reset will indicate within 1.0 percent system accuracy the maximum load applied to the specimen.

5.4 Provide a means for containing fragments in the event of explosive rupture of the cylinders during testing.

6. Specimens

6.1 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 (Note 9).

Note 9: 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.

6.2 Neither end of compressive test specimens when tested shall depart from perpendicularity to the axis by more than 0.5 degrees (approximately equivalent to 0.12 in in 12 in (3 mm in 300 mm). The ends of compression test specimens that are not plane within 0.002 in (0.050 mm) shall be sawed, ground, or capped in accordance with T 231 to meet that tolerance or if the ends meet the requirements of A6, then neoprene caps with steel controllers may be used instead of capping. The diameter used for calculating the cross-sectional area of the test specimen shall be determined to the nearest 0.01 in (0.25 mm) by averaging two diameters measured at right angles to each other at about mid-height of the specimen.

6.3 The height of the cylinder shall be determined to 0.01 in. The mass of the cylinder shall be determined to the nearest 0.1 lb or better.

7. Procedure

7.1 Compression tests of moist-cured specimens shall be made as soon as practicable after removal from moist storage.

7.2 Test specimens shall be kept moist by any convenient method during the period between removal from moist storage and testing. They shall be tested in the moist condition.

7.3 All test specimens for a given test age shall be broken within the permissible time tolerances prescribed as follows:

Test Age	Permissible Tolerance
12 h	± 0.25 h or 2.1%
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%
56 days	+ 40 h or 3.0%
90 days	+ 2 days 2.2%

Note: The 28-day compressive break may be extended by up to 48 hours if the scheduled 28-day break falls on a Saturday, Sunday, or Holiday. The Regional Materials Engineer must authorize the time extension in writing.

7.4 Placing the Specimen Place the plain (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. Wipe clean the bearing faces of the upper and lower bearing blocks and of the test specimen and place the test specimen on the lower bearing block.

7.4.1 Zero Verification and Block Seating – Prior to testing the specimen, verify that the load indicator is set to zero. In cases where the indicator is not properly set to zero, adjust the indicator (Note 10). Prior to the spherically-seated block is being brought to bear on the specimen, rotate its movable portion gently by hand so that uniform seating is obtained.

Note 10: The technique used to verify and adjust load indicator to zero will vary depending on the machine manufacturer. Consult your owner's manual or compression machine calibrator for the proper technique.

7.5 Rate of Loading – Apply the load continuously and without shock.

7.5.1 The load shall be applied at a rate of movement (platen to crosshead measurement) corresponding to a stress rate on the specimen of 35 ± 7 psi/s (0.25 ± 0.05 MPa/s) (Note 11). The designated rate of movement shall be maintained at least during the latter half of the anticipated loading phase.

Note 11: For a screw driven or displacement-controlled testing machine, preliminary testing will be necessary to establish the required rate of movement to achieve the specified stress rate. The required rate of movement will depend on the size of the test specimen, the elastic modulus of the concrete, and the stiffness of the testing machine.

7.5.2 During application of the first half of the anticipated loading phase, a higher rate of loading shall be permitted. The higher loading rate shall be applied in a controlled manner so that the specimen is not subjected to shock loading.

7.5.3 Make no adjustment in the rate of movement (platen to crosshead) as the ultimate load is being approached and the stress rate decreases due to cracking in the specimen.

7.6 Apply the compressive load until the load indicator shows that the load is decreasing steadily and the specimen displays a well-defined fracture pattern (Figure 2). For a testing machine equipped with a specimen break detector, automatic shut-off of the testing machine is prohibited until the load has dropped to a value that is less than 95 percent of the peak load. When testing with unbonded caps, a corner fracture may occur before the ultimate capacity of the specimen has been attained. Continue compressing the specimen until the user is certain that the ultimate capacity has been attained. Record the maximum load carried by the specimen during the test and note the type of fracture pattern according to Figure 2. If the fracture pattern is not one of the typical patterns shown in Figure 2, sketch and describe briefly the fracture pattern. If the measured strength is lower than expected, examine the fractured concrete and note the presence of large air voids, evidence of segregation, whether fractures pass predominantly around or through the coarse aggregate particles, and verify end preparations were in accordance with Practice T 231 or Practice C1231.

Note WSDOT 1: The test loading should be stopped when 80% of the loading capacity of the testing machine has been reached. Record the maximum load achieved and note that the sample was not taken to failure as it exceeded the safe working limits of the testing machine.

8. Calculation

8.1 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 described in Section 6 and express the result to the nearest 10 psi (0.1 MPa).

8.2 If the specimen length to diameter ratio is 1.75 or less, correct the result obtained in Section 8.1 by multiplying by the appropriate correction factor shown in the following table (Note 11):

L/D:	1.75	1.50	1.25	1.00	
Factor:	0.98	0.96	0.93	0.87	(Note 11)

Use interpolation to determine correction factors for L/D values between those given in the table.

Note 11: Correction factors depend on various conditions such as moisture condition, strength level, and elastic modulus. Average values are given in the table. These correction factors apply to lightweight concrete weighing between 100 and 120 lb/ft^3 (1,600 and 1,920 kg/m^3) and to normal weight concrete. They are applicable to concrete dry or soaked at the time of loading and for nominal concrete strengths from 2,000 to 6,000 psi(15 to 45 MPa). For strengths higher than 6,000 psi (45 MPa), correction factors may be larger than the values listed above x.

8.3 Calculate the average compressive strength of the set of specimens to the nearest 10 psi or 0.1MPa.

$$\text{Average Compressive Strength} = \frac{(CS_1 + CS_2)}{2}$$

Where:

CS_1 = Compressive Strength of Specimen 1
CS_2 = Compressive Strength of Specimen 2

Calculate the density of the specimen to the nearest 1 lb/ft^3 (10 kg/m^3) as follows:

$$\text{Density} = \frac{W}{V}$$

where:

W = mass of specimen, lb (kg)
V = volume of specimen computed from the average diameter and average length or from weighing the cylinder in air and submerged, ft^3 (m^3)

9. Report

9.1 Report the following information:

9.1.1 Identification number.

9.1.2 Diameter (and length, if outside the range of 1.8D to 2.2D), in inches or millimeters.

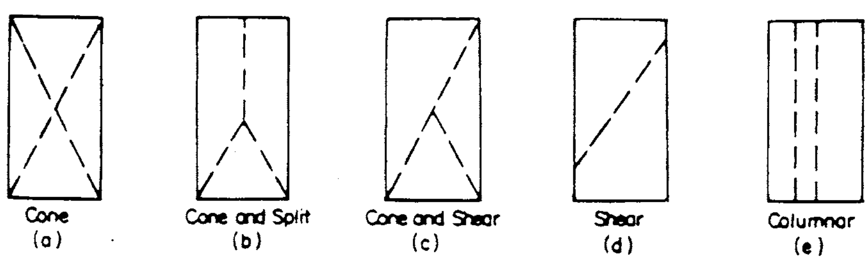
9.1.3 Cross-sectional area, in square inches or centimeters.

9.1.4 Maximum load, in pounds-force or Newton.

9.1.5 Compressive strength calculated to the nearest 10 psi or 0.1MPa.

9.1.6 Average compressive strength for the set of specimens calculated to the nearest 10 psi or 0.1 MPa.

9.1.7 Type of fracture, if other than the usual cone (see Figure 2).



Sketches of Types of Fracture
Figure 2

9.1.8 Defects in either specimen or caps.

9.1.9 Age of specimen.

9.1.10 Report the density to the nearest 10 kg/m^3 (1 lb/ft^3).

10. Precision and Bias

See AASHTO T 22 for precision and bias.

WSDOT has added Appendix A and it is an excerpt of ASTM C1231-00 sections 1 through 7.

Appendix A

A1. Scope

A1.1 This practice covers requirements for a capping system using unbonded caps for testing concrete cylinders molded in accordance with Practice C 31/C 31M or C 192/C 192M. Unbonded neoprene caps of a defined hardness are permitted to be used for testing for a specified maximum number of reuses without qualification testing up to a certain concrete compressive strength level. Above that strength, level neoprene caps will require qualification testing. Qualification testing is required for all elastomeric materials other than neoprene regardless of the concrete strength.

A1.2 Unbonded caps are not to be used for acceptance testing of concrete with compressive strength below 1500 psi (10 MPa) or above 12,000 psi (85 MPa).

A1.3 The values stated in either inch-pound or SI units shall be regarded as standard. SI units are shown in brackets. That values stated in each system may not be exact equivalents. Therefore, each system must be used independently of the other, without combining the values in any way.

A1.4 This standard does not purport to address all of the safety concerns, if any, 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. For a specific hazard statement, see Note 4.

A2. Referenced Documents

A2.1 ASTM Standards

C 31/C 31M – Practice for Making and Curing Concrete Test Specimens in the Field[2]

C 39 – Test Method for Compressive Strength of Cylindrical Concrete Specimens[2]

C 192/C 192M – Practice for Making and Curing Concrete Test Specimens in the Laboratory[2]

C 617 – Practice for Capping Cylindrical Concrete Specimens[2]

D 2000 – Classification System for Rubber Products in Automotive Applications[3]

D 2240 – Test Method for Rubber Property—Durometer Hardness[4]

A3. Terminology

A3.1 Definitions of Terms Specific to This Standard

A3.1.1 pad, n – An unbonded elastomeric pad.

A3.1.2 unbonded cap, n – A metal retainer and an elastomeric pad.

A4. Significance and Use

A4.1 This practice provides for using an unbonded capping system in testing hardened concrete cylinders made in accordance with Practices C 31/C 31M or C 192/C 192M in lieu of the capping systems described in Practice C 617.

A4.2 The elastomeric pads deform in initial loading to conform to the contour of the ends of the cylinder and are restrained from excessive lateral spreading by plates and metal rings to provide a uniform distribution of load from the bearing blocks of the testing machine to the ends of the concrete or mortar cylinders.

A5. Materials and Apparatus

A5.1 Materials and equipment necessary to produce ends of the reference cylinders that conform to planeness requirements of Test Method C 39 and the requirements of Practice C 617. This may include grinding equipment or capping materials and equipment to produce neat cement paste, high strength gypsum plaster, or sulfur mortar caps.

A5.2 Elastomeric Pads

A5.2.1 Pads shall be ½ ± 1⁄16 in (13 ± 2 mm) thick and the diameter shall not be more than 1⁄16 in (2 mm) smaller than the inside diameter of the retaining ring.

[1]This practice is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregate sand is the direct responsibility of Subcommittee C09.61 on Testing Concrete for Strength. Current edition approved January 2000. Published April 2000. Originally published as C 1231-93. Last previous edition C 1231-99.

[2]Annual Book of ASTM Standards, Volume 04.02.

[3]Annual Book of ASTM Standards, Volume 09.02.

[4]Annual Book of ASTM Standards, Volume 09.01.

A5.2.2 Pads shall be made from polychloroprene (neoprene) meeting the requirements of Classification D 2000 as follows:

Shore A Durometer	Classification D 2000 Line Call-Out
50	M2BC514
60	M2BC614
70	M2BC714

The tolerance on Shore A durometer hardness is ± 5. Table 1 provides requirements for use of caps made from material meeting the requirements of Classification D 2000, above.

A5.2.3 Other elastomeric materials that meet the performance requirements of qualification tests in Section 8 are permitted.

A5.2.4 Elastomeric pads shall be supplied with the following information:

A5.2.4.1 The manufacturer's or supplier's name.

A5.2.4.2 The Shore A hardness.

A5.2.4.3 The applicable range of concrete compressive strength from Table 1 or from qualification testing.

A5.2.5 The user shall maintain a record indicating the date the pads are placed in service, the pad durometer, and the number of uses to which they have been subjected.

A5.3 Retainers shall be made of metal that will prove durable in repeated use (Note 1). The cavity in the metal retainers shall have a depth at least twice the thickness of the pad. The inside diameter of the retaining rings shall not be less than 102 percent or greater than 107 percent of the diameter of the cylinder. The surfaces of the metal retainer which contact the bearing blocks of the testing machine shall be plane to within 0.002 in (0.05 mm).

The bearing surfaces of the retainers shall not have gouges, grooves, or indentations greater than 0.010 in (0.25 mm) deep or greater than 0.05 in^2 (32 $mm^{2)}$ in surface area.

Note 1: Retainers made from steel and some aluminum alloys have been found acceptable. Steel retaining rings that have been used successfully with ½ in (13 mm) neoprene pads are shown in Figure 1. Retainer design and metals used are subject to the performance and acceptance requirements of Section 8.

A6. Test Specimens

A6.1 The specimens shall be either 6 by 12 in (150 by 300 mm) or 4 by 8 in (100 by 200 mm) cylinders made in accordance with Practices C 31/C 31M or C 192/C 192M.

Neither end of a cylinder shall depart from perpendicularity to the axis by more than 0.5° (approximately equivalent to ⅛ in in 12 in (3 mm in 300 mm). No individual diameter of a cylinder may differ from any other diameter by more than 2 percent.

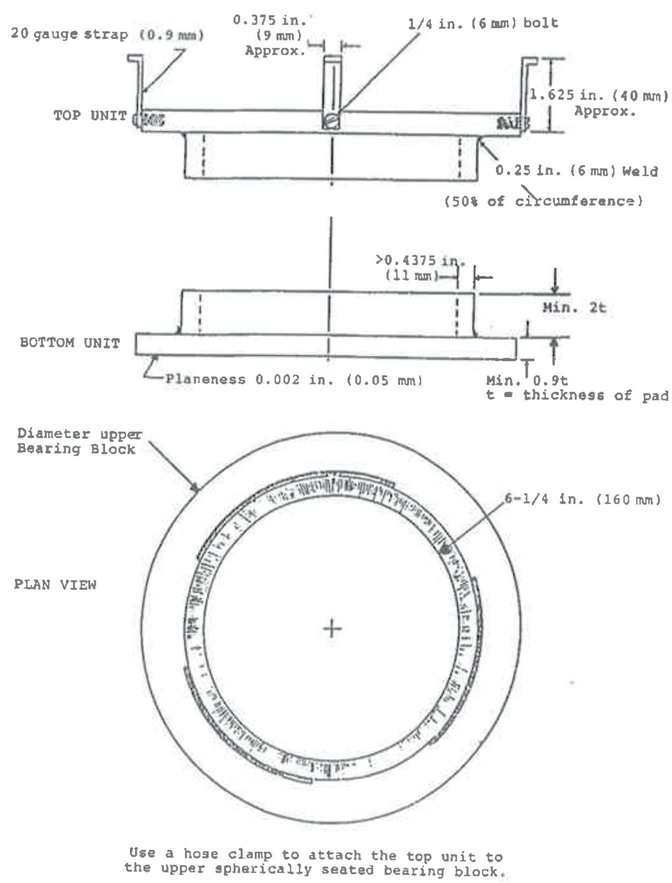
Note 2: One method of measuring the perpendicularly of ends of cylinders is to place a try square across any diameter and measure the departure of the longer blade from an element of the cylindrical surface. An alternative method is to place the end of the cylinder on a plane surface and support the try square on that surface.

A6.2 Depressions under a straight edge measured with a round wire gage across any diameter shall not exceed 0.20 in (5 mm). If cylinder ends do not meet this tolerance, the cylinder shall not be tested unless irregularities are corrected by sawing or grinding.

Cylinder Compressive Strength, psi (MPa)	Shore A Durometer Hardness	Qualification Tests Required	Maximum Reuses[A]
1500 to 6000 (10 to 40)	50	None	100
2500 to 7000 (17 to 50)	60	None	100
4000 to 7000 (28 to 50)	70	None	100
7000 to 12000 (50 to 80)	70	Required	50
Greater than 12000 (80)		Not Permitted	

[A]Maximum number of reuses. Will be less if pads wear, crack or split (Note 6).

Requirements for Use of Polychloroprene (Neoprene) Pads
Table 1



Example of Steel Retaining Rings for 6 by 12 in (150 by 300 mm) Cylinders (Nonmandatory)
Figure 1

A7 Procedure

A7.1 Unbonded caps are permitted to be used on one or both ends of a cylinder in lieu of a cap or caps meeting Practice C 617, provided they meet the requirements of Section 5.

A7.2 Examine the pads for excessive wear or damage (Note 6). Replace pads which have cracks or splits exceeding ⅜ in (10 mm) in length regardless of depth. Insert the pads in the retainers before they are placed on the cylinder (Note 3).

Note 3: Some manufacturers recommend dusting the pads and the ends of the cylinders with corn starch or talcum powder prior to testing.

Note 4: Caution: Concrete cylinders tested with unbonded caps rupture more violently than comparable cylinders tested with bonded caps. As a safety precaution, the cylinder testing machine must be equipped with a protective cage. In addition, some users have reported damage to testing machines from the sudden release of energy stored in the elastomeric pads.

A7.3 Center the unbonded cap or caps on the cylinder and place the cylinder on the lower bearing block of the testing machine. Carefully align the axis of the cylinder with the center of thrust of the testing machine by centering the upper retaining ring on the spherically seated bearing block. As the spherically seated block is brought to bear on the upper retaining ring, rotate its movable portion gently by hand so that uniform seating is obtained. After application of load, but before reaching 10 percent of the anticipated specimen strength, check to see that the axis of the cylinder is vertical within a tolerance of ⅛ in in 12 in (3.2 mm in 300 mm) and that the ends of the cylinder are centered within the retaining rings. If the cylinder alignment does not meet these requirements, release the load, check compliance with Section 6.1, and carefully recenter the specimen. Reapply load and recheck specimen centering and alignment. A pause in load application to check cylinder alignment is permissible.

A7.4 Complete the load application, testing, calculation, and reporting of results in accordance with Test Method C 39.

Note 5: Because of the violent release of energy stored in pads, the broken cylinder rarely exhibits conical fracture typical of capped cylinders and the sketches of types of fracture in Test Method C 39 are not descriptive. Occasionally, unbonded capped cylinders may develop early cracking, but continue to carry increasing load. For this reason, cylinders must be tested to complete failure.

Performance Exam Checklist

Compressive Strength of Cylindrical Concrete Specimens
FOP for AASHTO T 22

Participant Name ________________________ Exam Date ________________

Procedure Element	**Yes**	**No**
1. The tester has a copy of the current procedure on hand?	☐	☐
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?	☐	☐
3. Specimens kept moist between removal from moist storage and testing?	☐	☐
4. Is the diameter of the cylinder reported to the nearest 0.01 inch by averaging two diameters taken at about mid-height?	☐	☐
5. Is the length of the cylinder reported to the nearest 0.01 inches?	☐	☐
6. Is the mass of the cylinder reported to the nearest 0.1 lbs or better?	☐	☐
7. Ends of cylinders checked for perpendicularity to axis?	☐	☐
8. Ends of cylinders checked for depressions greater than 0.2 inch?	☐	☐
9. Ends of cylinders checked for plane?	☐	☐
10. If ends did not meet plane, was correct method chosen to correct plane?	☐	☐
11. Are lower and upper bearing surface wiped clean?	☐	☐
12. Is the axis of the cylinder aligned with center of the spherical block?	☐	☐
13. Is the spherical block rotated prior to it contacts with the cylinder?	☐	☐
14. Is the load applied continuously and without shock?	☐	☐
15. Is the load applied at the specified rate and maintain for the latter half of the anticipated load.	☐	☐
16. Is no rate adjustment made while the cylinder is yielding?	☐	☐
17. Is the maximum load recorded?	☐	☐
18. Are cylinders tested to failure and the type of fracture recorded?	☐	☐
19. Specimens broken within the permissible time tolerance?	☐	☐
20. All calculations performed correctly?	☐	☐
Unbonded Caps – AASHTO 22 Appendix A		
1. Pads examined for splits or cracks?	☐	☐
2. Cylinders centered in retaining rings?	☐	☐
3. Is cylinders checked for alignment with a small load applied?	☐	☐

First Attempt: Pass ☐ Fail ☐ Second Attempt: Pass ☐ Fail ☐

Signature of Examiner ____

Comments: