METHOD OF TESTING COMPRESSIVE STRENGTH OF HIGH PERFORMANCE OR HIGH STRENGTH CONCRETE CYLINDERS

1. SCOPE

1.1 This method covers apparatus, materials and procedures for testing compressive strength of high performance or high strength concrete with 100 mm diameter and 200 mm long cylinders.

2. RELEVANT DOCUMENTS

2.1 ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

2.2 CSA A23.2-9C Compressive Strength of Cylindrical Concrete Specimens

3. PROCEDURE

3.1 Procedures of CSA A23.2-9C shall be followed, except as noted below.

4. EXCEPTIONS

4.1 APPA RATUS

4.1. The maximum calibrated and certified load of the compression testing machine shall not be less than 1300 kN.

4.1.1 Calibration of compression testing machine: The compression testing machine shall be calibrated, at 6-month intervals or more frequently, in accordance with ASTM E4.

4.1.2 The bearing faces of blocks used for compression testing of concrete must have a Rockwell hardness of not less than 55 HRC.

4.2 MATERIALS

4.2.1 Capping materials: The capping materials must have a compressive strength of not less than 70 MPa. Capping materials shall not be recycled for high performance concrete testing.

4.3 PROCEDURES

4.3.1 Receiving, De-molding, and Examination of Cylinders

4.3.1.1 Immediately after arrival at the laboratory, each concrete cylinder shall be demolded, laboratory identification number marked on it, and date and time of arrival noted. The type of mold used and the cylinder laboratory identification numbers shall be recorded.

Each cylinder shall be examined for its condition on arrival and its mass shall be determined to the nearest 0.05 kg with the results recorded. All cylinders having a condition on arrival of 2, 3, or 4 shall be immediately reported to the Owner.

Cylinders with a condition 2, 3, or 4 as detailed in Table 1, shall not be tested and shall be stored by the testing laboratory until advised otherwise by the Owner.

Table 1

Condition of Cylinder on Arrival	
1	Cylinder is acceptable for testing
2	Cylinder improperly made, testing not possible
3	Cylinder damaged, testing not possible
4	Concrete frozen

4.3.2. Curing of Cylinders

4.3.2.1 Cylinders for Determination of Early Age Compressive Strength

Cylinders for determination of early age compressive strength shall receive no curing and shall be tested immediately after receiving, de-molding, and examination.

4.3.2.2 All Other Contract Cylinders

All contract cylinders shall be placed in the moisture room or temperature-controlled water tank immediately after their arrival in the laboratory and de-molding. The cylinders shall be kept there until cylinder end preparation and testing in compression, except for referee cylinders as detailed below.

4.3.3 Procedure for Testing Cylinders

4.3.3.1 General

Each set of three acceptance cylinders shall be accompanied by a duplicate set of three referee cylinders. Acceptance cylinders shall be tested at 28 days of age. Cylinders for early strength determination shall be tested as indicated on Form PH-CC-322. Cylinders for information shall be tested at 28 days unless specified otherwise.

4.3.3.2. Specimen Diameter

The diameter of each cylinder shall be determined with two measurements at right angles to each other at about midheight of the cylinder and recorded to the nearest 0.1 mm. The two measurements shall then be averaged to the nearest 0.5 mm. The average diameter of each cylinder shall be recorded and used for calculating the cross-sectional area of the cylinder. If the two diameter measurements on a cylinder differ by more than 2 % of the smaller reading, the cylinder shall not be tested.

4.3.3.3 Cylinder End Preparation

Cylinder ends shall be prepared by either grinding or capping. The cylinders shall be kept moist after end preparation. If the cylinder ends are prepared more than 3 hours prior to the scheduled testing

time, the cylinders shall be kept in a curing facility after the completion of end preparation until the time of testing.

4.3.3.4 Specimen Tolerances

The planeness and perpendicularity of both prepared ends of every cylinder shall be measured and recorded.

Planeness: The surface of prepared ends of cylinders shall not depart from a plane by more than 0.025 mm.

Perpendicularity: Either prepared end of a cylinder shall not depart from the perpendicularity to the axis by more than 0.5° (approximately equivalent to 2 mm in 200 mm).

4.3.3.5 Prepare Cylinder Ends by Grinding

The grinding operation shall be carried out when the concrete has adequate strength to sustain the operation.

4.3.3.6 Prepare Cylinder Ends by Capping:

Each laboratory shall establish the time-strength development relation curve or table for its capping material up to 72 hours at least once every three months or once per batch of capping material whichever is more frequent.

Capping shall be done between 2 and 72 hours prior to testing, at such time that the capping material will have enough time to reach 70 MPa prior to testing cylinders according to the time-strength development curve or table for the material. (For example, if capping material ABC can reach 70 MPa at 24 hours, the cylinders must be capped at least 24 hours prior to testing.)

Each day that high performance concrete cylinders are capped, three 50 x 50 x 50 mm cubes of the capping material shall be made as per CSA A23.2-9C at the same time as the cylinders are capped.

Each day that high performance concrete cylinders are tested, the strength of capping material cubes shall be tested prior to the cylinder test.

4.3.3.7 Testing Compressive Strength

All cylinders shall be tested to complete failure. The type of failure shall be recorded according to ASTM C39 (Section 9.1.6 and Figure 2).

4.3.3.8 Calculation of Compressive Strength

4.3.3.8.1 Calculate the compressive strength of each cylinder and the mean compressive strength of the three cylinders

4.3.3.8.2 Calculate the difference in compressive strength between individual cylinders and the mean and record the difference in the form of percentage of the mean.

4.3.3.8.3 If none of the three results differs more than 15% (of the mean) from the mean, the mean is considered valid and shall be recorded as the compressive strength of this set.

4.3.3.8.4 If one or more of the three individual results differs more than 15% from the mean, the lowest result should be discarded. The mean of the remaining two cylinders shall be calculated

4.3.3.8.5 Examples of Calculation

Example A:

The results of the three cylinders are: 54.0, 60.0 and 63.0 MPa.

The mean of the three = (54.0+60.0+63.0) / 3 = 59.0.

The differences between each individual and the mean are:

(54.0 - 59.0) / 59.0 x 100% = -8%

(60.0 - 59.0) / 59.0 x 100% = 2%

(63.0 - 59.0) / 59.0 x 100% = 7%

None of the three is more than 15%, therefore, the result of this set should be 59.0 MPa.

Example B:

The results of the three cylinders are: 51.0, 70.0 and 80.0 MPa.

The mean of the three = (51.0 + 70.0 + 80.0) / 3 = 67.0.

The differences between each individual and the mean are:

(51.0 - 67.0) / 67.0 x 100% = -24%

(70.0 - 67.0) / 67.0 x 100% = 4%

(80.0 - 67.0) / 67.0 x 100% = 19%

The first and the third cylinders are more than 15% apart from the mean, therefore, the lowest result, 51.0 MPa, is discarded.

The mean of the remaining two is: (70.0 + 80.0) / 2 = 75.0 MPa.

4.3.4 Additional Requirements for Referee Cylinders

4.3.4.1 Curing

Cylinders for referee testing shall be removed from the moisture room or water bath at the age of 28 days. From 28 days of age until they are delivered to the designated referee laboratory or disposed of, the referee cylinders shall be protected from loss of moisture and kept at a temperature of 5^{o}C or higher.

4.3.4.2 Procedure on Arrival at the Designated Referee Laboratory

Immediately after arrival of referee cylinders at the designated referee laboratory, each cylinder shall be properly identified by a laboratory number, and date and time of arrival noted.

Each cylinder shall be examined for its condition on arrival and its mass shall be determined to the nearest 0.05 kg with the results recorded. All cylinders having a condition on arrival of 2, 3, or shall be immediately reported to the Owner.

Cylinders with a condition 2, 3, or 4 as detailed in Table 1, shall not be tested and shall be stored by the testing laboratory until advised otherwise by the Owner.

4.3.4.3 Testing

Testing of referee cylinders shall be carried out according to this test method. The testing shall be carried out 24 hours ± 3 hours after the samples arrive at the designated referee laboratory. At the

completion of testing, the referee laboratory shall document the form of breaking by taking photographs.

4.3.4.4 Storage of Broken Pieces of the Referee Cylinders

Broken pieces of the referee cylinders shall be identified and stored for one hundred and twenty days from the time of testing. After sixty days and at two month intervals, the referee laboratory may request, in writing, permission from the Regional Head of Quality Assurance to dispose of the broken pieces of the referee cylinders and upon written confirmation, these remnants shall be properly disposed of by the laboratory.

5. REPORTING OF RESULTS

The report shall include:

a. Diameter of each cylinder to the nearest 0.5 mm;
b. Cross-sectional area of each cylinder in square mm;
c. Mass of each cylinder, to the nearest 0.05 kilograms;
d. Maximum load in Newton;
e. Compressive strength of each cylinder calculated to the nearest 0.1 MPa;
f. Mean compressive strength of the set calculated according to the above instructions, to the nearest 0.1 MPa;
g. Deviation of result of each cylinder from the mean in percentage of the mean and identification of any discarded test results;
h. The type of fracture (according to ASTM C39 Section 9.1.6 and Figure 2);
i. Method of end preparation, i.e. capping or grinding;
j. If the cylinders are capped, the compressive strength of the capping material to the nearest 0.1 MPa and testing time in hours after casting;
k. The planeness and perpendicularity measurements of both ends of each cylinder;
l. For all cylinders, age at the time of testing;
m. Name and signature of laboratory staff who reviewed the test report; and
n. For referee cylinders, photographs of the type of failure.

Test results obtained on acceptance cylinders from MTO construction contracts shall be reported on Concrete Construction Report Form PH-CC-322.