WSDOT FOP for AASHTO T 23[1]

Making and Curing Concrete Test Specimens in the Field

1. Scope

   1.1 This method covers procedures for making and curing cylinder specimens from representative samples of fresh concrete for a construction project.

   1.2 The concrete used to make the molded specimens shall be sampled after all on-site adjustments have been made to the mixture proportions, including the addition of mix water and admixtures, except as modified in Section 5.1. This practice is not satisfactory for making specimens from concrete not having measurable slump or requiring other sizes or shapes of specimens.

   1.3 The values stated in English units are to be regarded as the standard.

   1.4 This standard does not purport to address the safety problems 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. (**Warning** – Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to exposed skin and tissue upon prolonged exposure.)

2. Referenced Documents

   2.1 AASHTO Standards

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

   M 201 – Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes

   M 205 – Molds for Forming Concrete Test Cylinders Vertically

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

   T 231 – Capping Cylindrical Concrete Specimens

   2.2 ASTM Standards

   C 125 – Terminology Related to Concrete and Concrete Aggregates

   2.3 ACI Standards

   309 R – Guide for Consolidation of Concrete

   2.4 WSDOT

   FOP for WAQTC TM 2 Sampling Freshly Mixed Concrete

3. Terminology

   For definitions of terms used in this practice, refer to Terminology ASTM C 125.

[1] This FOP is based on AASHTO T 23-08

4. Significance and Use

4.1 This practice provides standardized requirements for making, curing, protecting, and transporting concrete test specimens under field conditions.

4.2 If the specimens are made and standard cured, as stipulated herein, the resulting strength test data where the specimens are tested are able to be used for the following purposes:

4.2.1 Acceptance testing for specified strength,

4.2.2 Checking the adequacy of mixture proportions for strength,

4.2.3 Quality control.

4.3 If the specimens are made and field cured, as stipulated herein, the resulting strength test data when the specimens are tested are able to be used for the following purposes:

4.3.1 Determination of whether a structure is capable of being put in service.

4.3.2 Comparison with test results of standard cured specimens or with test results from various in-place test methods,

4.3.4 Adequacy of curing and protection of concrete in the structure.

4.3.5 Form or shoring removal time requirements.

5. Apparatus

5.1 Molds, General – Refer to AASHTO T 23.

5.2 Cylinder – Molds for casting concrete test specimens shall conform to the requirements of M 205, and shall come from an approved shipment as verified by the WSDOT Quality Systems Manual Verification Procedure No. 2.

5.3 Beam Molds – Refer to WSDOT Test Method T 808.

5.4 Tamping Rod – Two sizes are specified as indicated in Table 1. Each shall be a round, straight steel rod with at least the tamping end rounded to a hemispherical tip of the same diameter as the rod. Both ends may be rounded if preferred.

Diameter of Cylinder, in (mm)	Rod Dimensions	
	Diameter, in (mm)	Length of Rod, in (mm)
4 (100)	⅜ (10)	12 (300)
6 (150)	⅝ (16)	20 (500)

a. Rod tolerances length ± 4 in (100 mm) and diameter ± 1/16 in (2 mm).

Tamping Rod Requirements
Table 1

5.5 Vibrators – Internal vibrators shall be used. The vibrator frequency shall be at least 7,000 vibrations per minute at 150 Hz while the vibrator is operating in the concrete. The diameter of a round vibrator shall be no more than one-fourth the diameter of the

cylinder mold or one-fourth the width of the beam mold. Other shaped vibrators shall have a perimeter equivalent to the circumference of an appropriate round vibrator. The combined length of the vibrator shaft and vibrating element shall exceed the depth of the section being vibrated by at least 3 in (75 mm). The vibrator frequency shall be checked periodically.

Note 1: For information on size and frequency of various vibrators and a method to periodically check vibrator frequency, see ACI 309R.

5.6 Mallet – A mallet with a rubber or rawhide head weighing 1.25 ± 0.50 lb (0.57 ± 0.23 kg) shall be used.

5.7 Small Tools – Tools and items that may be required are shovels, pails, trowels, wood float, metal float, blunted trowels, straightedge, feeler gauge, scoops, and rules.

5.8 Sampling and Mixing Receptacle – The receptacle shall be a suitable heavy gage metal pan, wheelbarrow, or flat, clean non-absorbent mixing board of sufficient capacity to allow easy remixing of the entire sample with a shovel or trowel.

5.9 Cure Box – The cure box shall be capable of maintaining temperatures between 60°F and 80°F. The box shall also be capable of maintaining an environment that does not allow moisture loss from the concrete cylinders.

5.10 Temperature Measuring Device – The temperature measuring device shall be capable of recording the minimum and maximum temperature within a 24 hr period. The thermometer shall be capable of reading from 32°F to 150°F (0°C to 65°C) with an accuracy of 1.8°F (1.0°C).

6. Testing Requirements

Testing for determining the compressive strength at 28 days shall require a set of two specimens made from the same sample.

6.1 Compressive Strength Specimens – Compressive strength specimens shall be cylinders cast and allowed to set in an upright position. The length shall be twice the diameter. The cylinder diameter shall be at least three times the nominal maximum size of the coarse aggregate. The standard specimen shall be the 4 by 8 in (100 by 200 mm) cylinder when the nominal maximum size of the coarse aggregate does not exceed 1 in (25 mm). When the nominal maximum size of the coarse aggregate exceeds 1 in (25 mm) the specimens shall be made with 6 by 12 in (150 by 300 mm) cylinders. **Mixing of cylinder sizes for a particular concrete mix design is not permitted on a project.** When the nominal maximum size of the coarse aggregate exceeds 2 in (50 mm), the concrete sample shall be treated by wet sieving through a 2 in (50 mm) sieve as described in FOP for WAQTC TM 2. Contact the Materials Laboratory for directions.

Note 2: The nominal maximum size is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

Note 3: When molds in SI units are required and not available, equivalent inch-pound unit size molds should be permitted.

6.2 Flexural Strength Specimens

Refer to WSDOT Test Method T 808.

7. Sampling Concrete

7.1 The samples used to fabricate test specimens under this standard shall be obtained in accordance with FOP for WAQTC TM 2 unless an alternative procedure has been approved.

7.2 Record the identification of the sample with respect to the location of the concrete represented and the time of casting.

7.3 Cylinders shall be made using fresh concrete from the same sample as the slump, air content and temperature tests. Material from the slump, air content, and unit weight tests cannot be reused to construct cylinders.

8. Slump, Air Content, and Temperature

As required, perform the following tests prior to making cylinders:

8.1 Slump – FOP for AASHTO T 119

8.2 Air Content – FOP for WAQTC T 152 or FOP for AASHTO T 196

8.3 Temperature – FOP for AASHTO T 309

8.4 Unit Weight – AASHTO T 121

9. Molding Cylinders

9.1 Place of Molding – Mold cylinders on a level, rigid horizontal surface, free of vibration and other disturbances, at a place as near as practicable to the location where they are to be stored.

9.2 Casting the Concrete – Place the concrete in the mold using a scoop, blunted trowel, or shovel. Select each scoopful, trowelful, or shovelful of concrete from the mixing pan to ensure that it is representative of the batch. Remix the concrete in the mixing pan with a shovel or trowel to prevent segregation during the molding of specimens. Move the scoop, trowel, or shovel around the perimeter of the mold opening when adding concrete so the concrete is uniformly distributed within each layer with a minimum of segregation. Further distribute the concrete by use of the tamping rod prior to the start of consolidation. In placing the final layer, the operator shall attempt to add an amount of concrete that will exactly fill the mold after consolidation. Underfilled molds shall be adjusted with representative concrete during consolidation of the top layer. Overfilled molds shall have excess concrete removed.

9.2.1 Number of Layers – Make specimens in layers as indicated in Table 2 or 3.

Cylinders: Diameter, in (mm)	Number of Layers of Approximately Equal Depth	Number of Roddings per Layer
Cylinders: Diameter, in (mm)		
4 (100)	2	25
6 (150)	3	25

Molding Requirements by Rodding
Table 2

Cylinders: Diameter, in (mm)	Number of Layers	Number of Vibrator Insertions per Layer	Approximate Depth of Layer, in (mm)
Cylinders: Diameter, in (mm)			
4 (100)	2	1	one-half depth of specimen
6 (150)	2	2	one-half depth of specimen

Molding Requirements by Vibration
Table 3

9.2.2 Select the proper tamping rod from 5.4 and Table 1 or the proper vibrator from 5.5. If the method of consolidation is rodding, determine molding requirements from Table 2. If the method of consolidation is vibration, determine molding requirements from Table 3.

9.3 Consolidation

9.3.1 Method of Consolidation – Preparation of satisfactory cylinders require different methods of consolidation. The methods of consolidation are rodding and vibration. Base the selection of the method of consolidation on slump, unless the method is stated in the specifications under which the work is being performed. Rod or vibrate concretes with slumps greater than 1 in (25 mm). Vibrate concretes with slumps less than or equal to 1 in (25 mm). Concretes of such low water content that they cannot be properly consolidated by the method herein, or requiring other sizes and shapes of specimens to represent the product or structure, are not covered by this method. Specimens for such concretes shall be made in accordance with the requirements of R 39 with regards to specimen size and shape and method of consolidation.

9.3.2 Rodding – Place the concrete in the mold, in the required number of layers of approximately equal volume. Rod each layer with the rounded end of the rod using the required number of roddings specified in Table 2. Rod the bottom layer throughout its depth. Distribute the strokes uniformly over the cross section of the mold. For each layer, allow the rod to penetrate through the layer being rodded and into the layer below approximately 1 in (25 mm). After each layer is rodded, tap the outsides of the mold lightly 10 to 15 times with the open hand, mallet, or rod, to close any holes left by rodding and to release any large air bubbles that may have been trapped.

9.3.3 Vibration – Maintain a uniform time period for duration of vibration for the particular kind of concrete, vibrator, and specimen mold involved. The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator. Usually, sufficient vibration has been applied as soon as the surface of the concrete has become relatively flat and large air bubbles cease to break through the top surface. Continue vibration only long enough to achieve proper consolidation of the concrete. (See Note 4.) Fill the molds and vibrate in the required number of approximately equal layers. Place all the concrete for each layer in the mold before starting vibration of that layer. Compacting the specimen, insert the vibrator slowly and do not allow it to rest on the bottom or sides of the mold. Slowly withdraw the vibrator so that no large air pockets are left in the specimen. When placing the final layer, avoid overfilling by more than ¼ in (6 mm).

Note 4: Generally, no more than 5 s of vibration should be required for each insertion to adequately consolidate concrete with a slump greater than 3 in (75 mm). Longer times may be required for lower slump concrete, but the vibration time should rarely have to exceed 10 s per insertion.

9.3.3.1 Cylinders – The number of insertions of a vibrator per layer is given in Table 3. When more than one insertion per layer is required, distribute the insertion uniformly within each layer. Allow the vibration to penetrate through the layer being vibrated, and into the layer below, approximately 1 in (25 mm). After each layer is vibrated, tap the outsides of the mold lightly 10 to 15 times with the open hand, mallet, or rod, to close any holes left by rodding and to release any large air bubbles that may have been trapped.

9.3.3.2 Beam – Refer to WSDOT Test Method T 808.

9.4 Finishing – After consolidation, strike off excess concrete from the surface. Perform all finishing with the minimum manipulation necessary to produce a flat even surface that is level with the rim or edge of the mold and that has no depressions or projections larger than ⅛ in (3.2 mm). Place lid on cylinder.

10. Curing

10.1 Standard Curing – Standard curing is the curing method used when the specimens are made and cured for the purposes stated in 4.2.

10.1.1 Storage – If specimens cannot be molded at the place where they will receive initial curing, immediately after finishing, move the specimens to an initial curing place for storage. The supporting surface on which specimens are stored shall be level to within ¼ in per ft (20 mm per m). If cylinders in the single-use molds are moved, lift and support the cylinders from the bottom of the molds with a large trowel or similar device. If the top surface is marred during movement to place of initial storage, immediately refinish.

10.1.2 Initial Curing – Immediately after molding and finishing, the specimens shall be stored in a cure box for a period 24 ± 8 hours, unless Contractor provides initial curing information for final set.

For concrete with a specified strength less than 6,000 psi the cure temperature shall be between 60° F and 80° F and for concrete with specified strengths of 6,000 psi and higher the cure temperature shall be between 68°F and 78°F.

A minimum/maximum thermometer shall be mounted on the cure box such that the thermometer reads the internal temperature of the box but is visible from the outside. Keep a record of the minimum and maximum temperatures at intervals of 24 hours during the initial curing time.

Do not exceed the capacity of the cure box. When concrete is placed at more than one location simultaneously, each location must have its own cure box.

Once concrete cylinders are placed in the cure box, the cure box shall not be moved until the cylinders are ready to be transported to the final cure location (See 10.1.3).

10.1.3 Transportation of Specimens to Final Cure Location – Prior to transporting, cure and protect specimens as required in Section 10. Specimens shall not be transported until at least 8 h after final set. (See Note 5) During transporting, protect the specimen with suitable cushioning material to prevent damage from jarring and transport in an upright position. During cold weather, protect the specimens from freezing by transporting in an insulated container. Prevent moisture loss during transportation by use of tight-fitting plastic caps on plastic molds. Transportation time shall not exceed 4 h.

Note 5: If a specimen does not attain final set within 32 hours, it is to remain in place until final set is reached. The time of final set shall be provided by the concrete producer. After final set is reached, it can then be transported.

10.1.4 Final Curing

10.1.4.1 Cylinders – Upon completion of initial curing and within 30 minutes after removing the molds, cure specimens with free water maintained on their surfaces at all times at a temperature of 73 ± 3°F (23 ± 2°C) using water storage tanks or moist rooms complying with the requirements of Specification M 201, except when capping with sulfur mortar capping compound and immediately before testing. When capping with sulfur mortar capping compounds, the ends of the cylinder shall be dry enough to preclude the formation of steam or foam pockets under or in cap larger than ¼ in (6 mm) as described in T 231. For a period not to exceed 3 h immediately prior to test, standard curing temperature is not required provided free moisture is maintained on the cylinders and ambient temperature is between 68 to 80°F (20 and 30°C).

10.1.4.2 Beams – Refer to WSDOT Test Method T 808.

10.2 Field Curing – Field curing is the curing method used for the specimens made for the purposes stated in 4.3.

10.2.1 Cylinders – Store cylinders in or on the structure as near to the point of deposit of the concrete represented as possible. Protect all surfaces of the cylinders from the elements in as near as possible the same way as the formed work. Provide the cylinders with the same temperature and moisture environment as the structural work. Test the specimens in the moisture condition resulting from the specified curing treatment. To meet these conditions, specimens made for the purpose of determining when a structure is capable of being put in service shall be removed from the molds at the time of removal of form work.

10.2.2 Beams – Refer to WSDOT Test Method T 808.

11. Transportation of Specimens to Laboratory

See Section 10.1.3

12. Report

12.1 Report the following information to the laboratory that will test the specimens:

12.1.1 Identification number.

12.1.2 Location of concrete represented by the samples.

12.1.3 Date, time, and name of individual molding specimens.

12.1.4 Slump, air content, and concrete temperature, test results and results of any other tests on the fresh concrete and any deviations from referenced standard test methods.

12.1.5 Record all information required using the Materials Testing System (MATS) electronic Concrete Transmittal.

Note: Agencies that do not have access to MATS may use WSDOT Form 350-009 Concrete Cylinder Transmittal.

Performance Exam Checklist

Making and Curing Concrete Test Specimens in the Field
FOP for AASHTO T 23

Participant Name _____ Exam Date _____

	Procedure Element	Yes	No
1.	The tester has a copy of the current procedure on hand?	❒	❒
2.	Molds placed on a level, rigid, horizontal surface free of vibration?	❒	❒
3.	Making of specimens begun within 15 minutes of sampling?	❒	❒
4.	Concrete placed in the mold, moving a scoop or trowel around the perimeter of the mold to evenly distribute the concrete as discharged?	❒	❒
5.	Mold filled in correct number of layers, attempting to exactly fill the mold on the last layer?	❒	❒
6.	Each layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes?	❒	❒
7.	Bottom layer rodded throughout its depth?	❒	❒
8.	Middle and top layers rodded, each throughout their depths, and penetrate into the underlying layer?	❒	❒
9.	Sides of the mold tapped 10-15 times after rodding each layer?	❒	❒
10.	Strike off excess concrete, and finished the surface with a minimum of manipulation?	❒	❒
11.	Specimens covered with non-absorbent, nonreactive cap or plate?	❒	❒

First Attempt: Pass ❒ Fail ❒ Second Attempt: Pass ❒ Fail ❒

Signature of Examiner _____

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