Technician Certification

Concrete Field

MoDOT

Course Content
Concrete Field

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MoDOT TM 20

Measurement of Air, Surface Or Bituminous Mixture Temperature

MoDOT TM 20

Measurement of Air, Surface, or Bituminous Mixture Temperature

WHY IS TEMPERATURE IMPORTANT?

- To prevent early pavement deterioration.
- To provide quality assurance.
- To provide data to apply weather limitations for future construction.

MoDOT TM 20 2

EQUIPMENT CALIBRATION

- Thermometers used for testing should be calibrated annually.
- Calibration of a thermometer will establish a correction factor to use to correct the thermometer reading to the true temperature.
- Information on how MoDOT thermometers are calibrated can be obtained from the District Materials Staff or The Chemical Section of the Central Lab.

MoDOT TM 20 3

Equipment

Infrared
Thermometer

Surface or Loose Bituminous Mixture Temperature

Range 20° F to 400° F, max. increment 2° F

MoDOT TM 20 4

Equipment

Mercury
Thermometer

Air and Surface Temperature

Glass, range 20° F to 130° F, max. increment 2° F

MoDOT TM 20 5

Equipment

Max-Min
Thermometer

Air and Surface Temperature

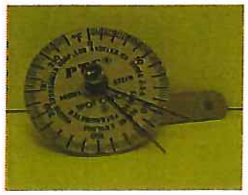
Range 20° F to 130° F, max. increment 2° F

MoDOT TM 20 6

Equipment

Spot Check Disc
Thermometer

Surface Temperature
Range 32° F to 250° F, max. increment 2° F

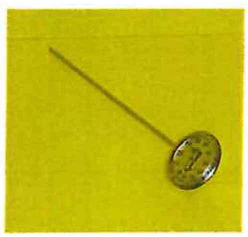


MoDOT TM 20 7

Equipment

BI-Therm Dial
Thermometer

Bituminous Mixture Temperature
Range 50° F to 400° F, max. increment 5° F

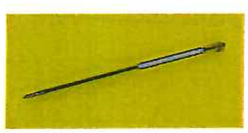


MoDOT TM 20 8

Equipment

Armored
Thermometer

Loose Bituminous Mixture Temperature
Range 50° F to 400° F, max. increment 5° F



MoDOT TM 20 9

Equipment

Wooden Box

Surface Temperature
See Test Method (TM 20) for dimensions and color requirements

MoDOT TM 20 10

PRECAUTIONS

- Do not use BI-Therm Dial thermometer (poker) for surface or air temperature.
- Infrared thermometer are for surface or bituminous mixture temperature only.
- Do not check surface temperature of asphalt immediately after roller has passed.
- Always check surface temperatures on stationary targets.

MoDOT TM 20 11

PROCEDURE

- Air Temperature (Mercury or Max-Min)
  - Location
    - Shaded area not exposed to direct sunlight
    - Safe area where it will not be damaged by moving equipment
    - Position 4.5 ft. above the surface level

MoDOT TM 20 12

PROCEDURE

- Surface Temperature
  - Infrared gun
    - Follow the manufacturer's recommendations (read your operators manual)
  - Spot Check disc-surface thermometer
    - Place on surface
    - Read when needle stops moving

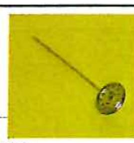
MoDOT TM 20 13

PROCEDURE

- Surface Temperature (continued)
  - Wooden box with Mercury or Max-Min
    - place box with the open side down and the thermometer underneath the box
    - leave thermometer under box for a minimum of 5 minutes
    - Lift the box enough to read the temperature

MoDOT TM 20 14

PROCEDURE



- Bituminous Mixture Temperature
  - Armored or BI-Therm Dial Thermometer
    - Place stem in loose bituminous mixture
    - Do not disturb until reading has stabilized
    - Read temperature

MoDOT TM 20 15

PROCEDURE

- Bituminous Mixture Temperature
  - Infrared Thermometer
    - Follow Manufactures Instructions
    - Direct reading at bituminous loose mix located in truck, a receiving hopper or material at the end of the paver augers
    - Read temperature

MoDOT TM 20 16

DOCUMENTATION

- Read and record the air, surface or bituminous mixture temperature to the accuracy listed below in a bound field book.
  - Air, nearest 2° F
  - Surface, nearest 2° F
  - Bituminous Mixture, nearest 5 ° F

END

8/31/2015 MoDOT TM 20 17

106.3.2.20 TM-20, Measurement of Air, Surface or Bituminous Mixture Temperature

From Engineering Policy Guide

This method describes the equipment and procedures required to determine air temperature, surface temperature of a base or pavement, and bituminous mixture temperature in the loose state.

106.3.2.20.1 Apparatus

Infrared Thermometer. Used for surface and loose bituminous mixture temperature determination. The thermometer should register in the range of 20° F to 400° F, with a maximum increment of 2 °F. Operation of this instrument should be based on the manufacturer's instructions.

Mercury Thermometer. Used for air or surface temperature determination. Typically a straight glass thermometer or a U-shaped glass thermometer in a plastic housing commonly referred to as a MAX-MIN thermometer. The thermometer should register in the range of 20° F to 130° F, with a maximum increment of 2 °F.

Armored Thermometer. Used for loose bituminous mixture temperature determination. The thermometer should register in the range of 50° F to 400° F, with a maximum increment of 5 °F.

Bi-Therm Dial Thermometer. Used for loose bituminous mixture temperature determination. The thermometer should register in the range of 50° F to 400° F, with a maximum increment of 5 °F.

Spot Check Disc Thermometer. Used for surface temperature determination. The thermometer should register in the range of 32° F to 250° F, with a maximum increment of 2 °F.

Digital Thermometer. Used for air surface or bituminous mixture temperature determination. Thermometer will measure temperature in the range of 0° F to 400° F as a minimum with a maximum increment of 1° F. Thermometer will have a remote probe and may have recording capabilities of maximum and minimum temperature reading. Thermometer, when purchased, shall have a record of calibration to NIST Traceable Standards provided.

Wooden Box. Used to cover a mercury thermometer when determining the temperature of a base or pavement. The box will be wooden with a material thickness of not less than 3/8 in. The minimum inside dimensions will be 2 in. tall, 3 in. wide and 14 in. long. The bottom side of the box is to be left open. The bottom edge of the sides and ends shall have attached a strip of foam rubber 3/16 in. thick and the same width as the thickness of the side and end boards. The outside of the box shall be painted with aluminum paint. See Fig. 106.3.2.1.20, below, for a pictorial description.

Calibration of Thermometers. Thermometers shall be calibrated annually against a known standard.

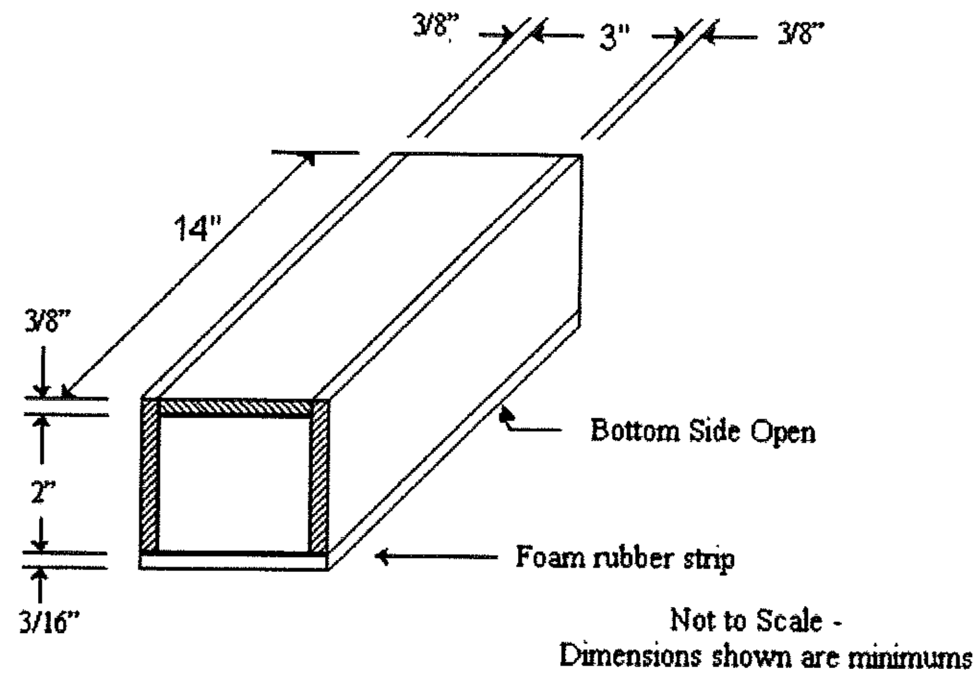


Fig. 106.3.2.1.20

106.3.2.20.2 Procedure

Air Temperature. The mercury thermometer or digital thermometer probe shall be positioned in a shaded area and shall not be exposed to direct sunlight. The thermometer shall be 4.5 ft. above surface level, measured from the surface to the bulb of the thermometer. Care should be taken to ensure no artificial heating or cooling occurs near the thermometer. The thermometer will be left in this location until the reading stabilizes. Air temperature shall be recorded to the nearest 2 °F.

Surface Temperature, mercury thermometer. The thermometer cannot be disturbed for at least 5 minutes while conducting this test, so select a location where this criteria can be met. Place the thermometer on the test surface and place the wooden box firmly over the thermometer ensuring the foam rubber strips are in contact with the test surface. The box should remain over the thermometer for a minimum of five minutes. After the 5 minutes, tip the box on edge only far enough to read the thermometer. The surface temperature shall be recorded to the nearest 2 °F.

Surface Temperature, infrared thermometer. When using an infrared thermometer, follow the manufacturer's recommended procedure. When obtaining the temperature of a surface, make sure air currents do not affect the reading. The surface temperature shall be recorded to the nearest 2 °F.

Surface Temperature, spot check disc thermometer. Place the thermometer on the surface and wait until the needle stops moving. Read the temperature. The surface temperature should be recorded to the nearest 2 °F.

Surface Temperature, digital thermometer. The thermometer probe cannot be disturbed for at least 5 minutes while conducting this test, so select a location where this criteria can be met. Place the thermometer probe on the test surface and place the wooden box firmly over the thermometer probe ensuring the foam rubber strips are in contact with the test surface. The box should remain over the thermometer probe for a minimum of five minutes. After the 5 minutes, read display of thermometer. The surface temperature shall be recorded to the nearest 2 °F.

Bituminous Mixture Temperature, armored or Bi-Therm Dial - The thermometer shall have the stem of the thermometer embedded in the loose bituminous mixture. The thermometer should not be disturbed until the thermometer reading has stabilized. When the thermometer has stabilized, read the thermometer. The bituminous mixture temperature shall be recorded to the nearest 5 °F. A digital thermometer that has a range capable of measuring the bituminous mixture temperature and a probe that can withstand the mixture temperature can be used in lieu of an armored or bi-therm dial thermometer.

Bituminous Mixture Temperature, infrared - The thermometer shall be used as recommended by the manufacturer. The location for determining the temperature of the loose bituminous material shall be either in the delivery truck bed, the receiving hopper of the paver or MTV, or at the material head at the end of the paver augers prior to entering the paver screed. The bituminous mixture temperature shall be recorded to the nearest 5 °F.

MoDOT TM 20: Measurement of Air, Surface and Bituminous Mixture Temperature
PROFICIENCY CHECKLIST

Applicant:______________________________________

Employer:______________________________________

Trial #	1	2
AIR		
1. Pick correct thermometer		
2. Location - Shade, no direct sunlight - position 4.5 feet above surface		
3. Document to nearest 2° F		
SURFACE		
4. Pick correct thermometer		
5. Procedure - spot check; place on surface until needle stops moving - infrared; point and shoot - mercury or Max-Min; place under wooden box wait 5 minutes		
6. Document to nearest 2° F		
BITUMINOUS MIXTURE		
7. Pick correct thermometer		
8. Procedure - infrared; point and shoot appropriate location - armored thermometer or BI-Therm Dial; place stem into mixture and wait until thermometer reading has stabilized		
9. Document to nearest 5° F		

Pass Pass

Fail Fail

Examiner:______________________________________ Date:____________________

AASHTO T 141

Sampling of Freshly Mixed Concrete

AASHTO T 141

Sampling of Freshly Mixed Concrete

Background and Overview

- Why do we sample freshly mixed concrete?
  - Sampling is the first step in finding out if the concrete meets the specifications
  - Sampling is the only way to obtain true test results

AASHTO T 141 2

Equipment

- Square nosed shovel
- Scoop
- Sample container

AASHTO T 141 3

Sampling Precautions and Procedures

- Check ticket for the correct information when the truck arrives on the job site
  - Name of concrete plant
  - Serial number of ticket
  - Truck number when a truck mixer is utilized
  - Name of contractor
  - Job Number, route and county designation
  - Specific class of concrete
  - Quantity of concrete in cubic yards
  - Date and time when batch was loaded or of first mixing of cement and aggregate
  - Number of revolutions when truck mixed

AASHTO T 141 4

Location

- Collect concrete sample in a safe location.
- Coordinate your sample taking with the contractor.
  - i.e. schedule, location, sample cure sites, etc.

Communication

AASHTO T 141 5

Sampling Precautions

- The entire sample for slump, air test and for molding test specimens such as cylinders and beams shall be taken at one time after about 1 cubic yard has been discharged from the mixer. (See EPG section 501.1.3 Sampling (Sec. 501.4)

Note: See Slide 10 for proper collection procedures.

AASHTO T 141 6

Sampling Precautions

- Avoid samples containing mud / debris / base rock / unmixed materials
- Use clean sample container and equipment
- Protect your sample from direct sunlight, wind, and moisture
- Complete all required test within 15 minutes from the time you gathered the sample

AASHTO T 141 7

Collection Procedures

- For Stationary Mixers (on job site mixers)
  - These instructions are for tilting and non-tilting mixers
  - Pass sample catcher completely through stream of concrete as it is leaving the mixer or divert concrete stream into your container about the middle of the batch
  - Don't restrict the flow of concrete as it will cause segregation of the mix

AASHTO T 141 8

Collection Procedures

- For Central Mixed concrete delivered to a paving operation
  - Obtain your sample from at least 5 different parts of the pile after the concrete is on sub-grade
  - Don't contaminate your sample with subgrade material
  - Mix your sample with a shovel to insure uniformity and eliminate segregation.

AASHTO T 141 9

Collection Procedures

- For Truck Mixed or Truck Delivered concrete
  - Move the concrete chute so concrete flows into your sample container or pass your sample catcher completely through the stream of concrete
  - Each time water or any admixture is added, the drum shall be turned an additional 30 revolutions, minimum, to mix water into concrete (Standard Specification Section 501.8.6)
  - Always take the sample after all water and add-mixtures have been added to concrete.

AASHTO T 141 10

Collection Procedures

- When a Concrete Pump Truck is being used
  - The designated location to obtain your concrete sample is at the point of truck discharge for quality control (see EPG Section 501.1.3 (Sec 501.4)).
  - Slump and Air Content will be checked when a pump is first used, at the truck discharge and pump discharge to compare properties.

AASHTO T 141 11

Collection Procedures

- When a Concrete Pump Truck is being used
  - Periodically the Slump and Air Content at the truck and pump discharge will be checked to compare property changes.

AASHTO T 141 12

Common Errors

- Sample taken before water added and all mixing is completed.
- Letting sample set too long before testing
- Not mixing composite sample
- Sample contains mud, debris, base rock, unmixed materials
- Unclean equipment

AASHTO T 141 13

Common Errors

- Not periodically checking the difference in properties between the truck discharge and the pump discharge.
- Not checking the difference in properties between the truck discharge and pump discharge when a pump is first used on the project.

AASHTO T 141 14

501.1.3 Sampling (Sec 501.4)

Sampling of fresh concrete by these instructions will meet the requirements of Section 501.4 of the Standard Specifications. Each sample should be large enough to permit completion of all necessary tests. Methods described should be tempered with judgment to assure that samples are as nearly as possible representative of the true nature and condition of the concrete sampled. For safety reasons, sampling should always be coordinated through contractor personnel.

501.1.3.1 Pumping Concrete

There has been discussion about the proper place to sample concrete when it is being pumped. The following guidelines will assure uniformity of contract enforcement statewide.

Ordinarily the most representative sample will be taken at the point of final discharge. For safety reasons, however, it is not always practical to do so. When concrete is being pumped our procedure has been to take samples at the truck chute. Usually there is no significant difference unless a new or reconditioned pump is being used, the concrete is being pumped a long distance or if there are high vertical drops in the line.

The first load should be checked at both points. The difference between the truck and the pump should be checked regularly, especially if there are significant changes in drop or distance, and certainly if a different pump is used.

Consider the change in air content when determining specification compliance. If you find that the air drops by 0.3%, subtract that from the reading at the truck. If you are on the low side at the truck the air should be adjusted accordingly. The correction factor from loss through pumping would also apply to the slump. The reported slump and air content should be what is at the point of placement.

The concrete truck boom shall be configured to minimize the free fall of concrete of the point of discharge. This is to minimize segregation, and loss of air and slump.

501.1.3.2 Sampling from Stationary Mixers Except Paving Mixers

The sample is to be obtained by passing a receptacle completely through the discharge stream of the mixer at about the middle of the batch, or by diverting the stream completely so that it discharges into a container. Do not restrict flow from the mixer in a way that can cause concrete to segregate. This method should be used for both tilting and non-tilting mixers.

501.1.3.3 Sampling Central or Truck Mixed Concrete

The entire sample for slump and air tests and for molding compressive strength specimens may be taken at one time, after approximately one cubic yard of concrete has been discharged. The sample shall be taken from at least 5 different parts of the pile. Acceptability of concrete for slump and air content and, when applicable, for strength requirements, will be determined by tests on these samples.

501.1.3.4 Protection of sample

After the sample has been obtained, it must be protected from direct sunlight and wind until it is used, which must not be more than 15 minutes after sampling. When the sample has been moved to the place where the test is to be made or specimens are to be molded it should be mixed with a shovel if necessary to assure uniformity of the mixed sample.

501.1.3.5 Compressive Strength

Compressive tests are performed both in the field and in the laboratory on cylindrical specimens of concrete, 6 in. diameter and 12 in. tall (6x12) or 4 in. diameter and 8 in. tall (4x8). The Standard Specifications require use of compressive specimens for job control of concrete production.

All concrete for air and slump tests as well as preparation of the specimens should be secured from a single batch of concrete. Air and slump tests should always be made on samples of concrete used for preparation of compressive specimens.

Cylinder forms shall be filled with fresh concrete in accordance with the instructions provided by AASHTO T 23 (ASTM C 31). Care should be taken when placing the caps on the molds to avoid damage to the surface of the concrete. The lids should be kept on tight to prevent moisture loss.

501.1.3.5.1 Curing

Curing of compressive specimens will depend on whether they are for standard cure or field cure.

Standard Cure is defined as 1) specified strength for 28-day testing; 2) Check of mixture proportions or design strength; 3) Quality control (i.e. monitoring mix variability) or 4) Maturity meter curve.

Standard curing involves two phases of curing: initial and final.

Each set of compressive test specimens for standard cure consists of two 6x12 cylinders or three 4x8 cylinders. Standard Cure specimens shall be cured in accordance with AASHTO T23 (ASTM C31) for initial and final curing.

Standard Cure – Initial

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. Recommended method for initial curing is keeping the specimen in the plastic mold covered with a plastic lid or place in a damp sand pit for a maximum of 48 hours in a temperature range from 60° F to 80° F and an environment preventing moisture loss.

AASHTO T 141 Sampling of Freshly Mixed Concrete
PROFICIENCY CHECKLIST

Applicant:____

Employer:____

Trial#	1	2
1. Check for required equipment - Square nose shovel - Scoop - Sample container		
2. Coordinate with contractor the collection of sample for safety purposes		
3. Central mix delivered to paving operation - Sample after contents of mixer have been discharged - 5 locations for composite sample - Avoid contamination from subgrade - mix to ensure uniformity		
4. Stationary Mixers, Truck Mixed, or Truck Delivered - take sample after all water is added and thoroughly mixed - move discharge chute or pass sample catcher completely through the stream of concrete - do not restrict the flow of concrete		
5. Quantity to sample - enough to perform all tests		

Pass Pass

Fail Fail

Examiner:____Date:____________________

ASTM C 1064

Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete

ASTM C 1064

Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete

Background and Overview

- Why check temperature of concrete?
- These problems can occur when concrete is placed at temperatures which are to high or low.
  - micro-cracking
  - false setting
  - uneven curing
  - other durability problems

ASTM C 1064 2

Specifications

The temperature for concrete placement is controlled in certain circumstances by the Standard Specifications or Job Special Provisions.

These should be consulted to determine the appropriate temperatures for the concrete being placed.

ASTM C 1064 3

Equipment and Apparatus

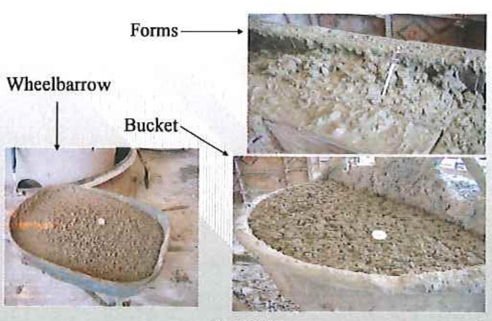
- Container
  - Large enough to provide at least 3” of concrete in all directions around the sensor of the thermometer.
  - 6” Cylinder mold, wheelbarrow, forms, drop bucket, non-mixing transport vehicle, etc.
  - Not a mixer truck, for safety concerns.
- Annually calibrated thermometer
  - range 30° F to 120° F
  - Increments of 1° F
  - Design allows 3” or more immersion during operation.

ASTM C 1064 4

Thermometer

ASTM C 1064 5

Containers



ASTM C 1064 6

Containers

- Note: A cylinder mold that is 6" in diameter will meet the required 3" coverage around the bulb of the thermometer. When taking the temperature of the concrete in a cylinder mold be sure the thermometer bulb is in the center.

ASTM C 1064 7

Procedures

- If temperature is not taken in forms, dampen container with water immediately prior to sampling concrete.
- Sample concrete in accordance with AASHTO T 141.
- Place the freshly mixed concrete into container.

ASTM C 1064 8

Procedures

- Insert the bulb of thermometer into concrete
  - must have minimum of 3" of concrete around bulb in all directions
  - pinch closed the hole around stem of thermometer
- Leave thermometer in place for a minimum of 2 minutes (or until the temperature stabilizes)
- Complete temperature measurement within 5 minutes of obtaining sample.
  - See test method for special instructions if aggregate size exceeds 3"

ASTM C 1064 9

Documentation

- Document the temperature in a bound field book to the nearest 1° F

ASTM C 1064 10

Common Errors

- Thermometer calibration not current
- Insufficient thermometer depth
- Waiting too long to collect sample for testing
- Using a thermometer without ± 1° F increments.

ASTM C 1064 11

Common Errors

- Not pinching the concrete around the thermometer stem after insertion into the concrete.
- Not waiting the proper minimum amount of time and making sure the thermometer has stabilized.

ASTM C 1064 12

703.3.8.6 Opening to Traffic. Traffic may be allowed on a deck when the material is tack free.

703.3.9 Hot Weather Concreting. The contractor shall schedule placing and finishing of bridge deck concrete during hours in which the ambient temperature will be lower than 85°F. The mixed concrete when placed in the deck forms shall have a temperature no higher than 85°F, however, if the contractor starts the concrete placement at least 30 minutes after sundown and covers the concrete with wet burlap when it will not mar the surface, but before morning solar radiation dries the surface and implements, to the extent possible, precautionary measures for hot weather concreting recommended in ACI 305R 'Hot Weather Concreting', then the concrete temperature can be increased to 90°F.

703.3.10 Cold Weather Concreting. Concrete work shall proceed on all structures, except bridge superstructures, whether or not heating will be required, unless it can be definitely established that the overall progress of the project will not be affected. Placing of concrete in the superstructure of a continuous or monolithic series of spans once begun shall be continued within the provisions of cold weather concreting procedures until all the concrete in that series is placed. Concrete placed in cold weather shall be protected from freezing during the curing period. Concrete shall not be placed on frozen ground, or against steel or concrete surfaces with temperatures lower than 35°F. Concrete shall not be placed where the ambient temperature is below 35°F without prior approval from the engineer. Concrete in bridge superstructures shall not be placed where the ambient temperature is below 40°F without prior approval from the engineer.

703.3.10.1 The aggregate, the water, or both, shall be heated during the season when the atmospheric temperature may drop below 40°F. Aggregate shall not be heated higher than 150°F. The temperature of the aggregate and water combined shall not be higher than 100°F when the cement is added. Any method of heating during the mixing of concrete may be used, provided the heating apparatus will heat the mass uniformly and avoid hot spots that will burn the material. The temperature of the concrete at the time of placing in the forms shall be no lower than 45°F for concrete in footings, massive piers and abutments, or less than 60 F for all other concrete.

703.3.10.2 When the ambient temperature is below 40°F, with the approval from the engineer, curing of superstructure concrete, substructure units above ground surface, retaining walls and box culverts of more than 15 square feet opening shall be accomplished by methods that will prevent concrete from freezing. The minimum compressive strength required for form removal and ending protection from freezing shall be in accordance with Sec 703.3.2.13. The contractor shall furnish temperature monitoring equipment and accessories that demonstrate to the engineer that concrete has been protected from freezing, with payment for such equipment and accessories included in the contract unit price for concrete. Exposed surfaces of the concrete shall be kept moist during the curing process. Substructure concrete below ground surface may be protected by submersion provided the temperature of the water is maintained between 40° and 80°F for seven days.

703.3.10.3 Concrete headwalls for pipe culverts, drop inlets and box culverts of 15 square feet or less openings, may be placed without air temperature limitations, but the contractor shall be responsible for proper protection from freezing during placing and curing of the concrete.

703.3.11 Extending and Widening Structures. Extending and widening of existing concrete structures shall be in accordance with the details shown on the plans. A continuous groove at least one inch deep shall be sawed in the faces of the existing concrete as a guide for the line of break to prevent spalling. Surfaces of existing concrete that are to come in contact with new concrete shall be thoroughly cleaned, saturated with water and painted with an epoxy mortar of paint consistency or other approved products. The new concrete shall be

ASTM C 1064 Measuring Temperature of Concrete
PROFICIENCY CHECKLIST

Applicant:______________________________________

Employer:______________________________________

Trial#	1	2
1. Sensing portion of thermometer submerged a minimum of 3 inches into concrete		
2. Concrete gently pressed around thermometer at surface of concrete		
3. Thermometer left in concrete for a minimum of 2 minutes or until stabilized		
4. Temperature recorded within 5 minutes of obtaining sample		
5. Temperature recorded to the nearest 1°		

Pass Pass

Fail Fail

Examiner:______________________________________Date:__________________

AASHTO T 119

Slump of Hydraulic Cement Concrete

AASHTO T 119

Slump of Hydraulic Cement Concrete

Background & Overview

- Slump test measures the consistency of fresh concrete. Increases in water content of the concrete result in increased slump.
- Increased slump relates to a decrease in compressive strength.
- The relationship in the field between slump and strength are not well defined but significant changes in slump indicates a change in the concrete strength.

AASHTO T 119 2

Equipment

- **Slump Cone or Mold** - formed #16 gage metal cone with top diameter of 4" ± ⅛ ", bottom diameter of 8" ± ⅛ "and height of 12" ± 1/8".
- **Tamping Rod** - a straight steel rod that has a circular x-section with ⅝ ± 1/16" diameter and 24 ± 4" in length and one end shall be rounded to a hemispherical shape ⅝" in diameter.
- **Measuring device** - having ¼" increments
- **Base Plate** - nonabsorbent surface
- **Scoop** - to collect sample

AASHTO T 119 3

Procedure

- Obtain a representative sample of the concrete as defined in the EPG 501.1.4.

AASHTO T 119 4

Procedure

- Dampen the mold and the surface you are going to place the mold on.
  - The surface is to be nonabsorbent, rigid, and level.
  - This surface is typically a base plate, but other surfaces which meet the requirements are acceptable.

AASHTO T 119 5

Procedure

- Place the mold on the surface. Ensure it is firmly secured during the filling process.

NOTE: Make sure that during the duration of this test the surface remains vibration free.

AASHTO T 119 6

Procedure

- Complete the entire test from start of filling through removal of the mold without interruption in an elapsed time of 2½ minutes or less.
- Fill the mold in layers of approximately ⅓ of the volume of the mold.
- One third of the volume of the slump cone fills it to a depth of 2 ⅝". Two thirds fills it to a depth of 6 ⅛".

AASHTO T 119 7

Procedure

- Fill the mold in three layers, each approximately one third the volume of the mold.
- Rod each layer 25 times with the rounded end. Uniformly distribute the strokes over the cross sectional area of the concrete.
- Be sure to clear concrete with each stroke of the rod so as not to create a stirring action.

AASHTO T 119 8

Procedure

- The bottom layer should be rodded completely through its depth, but not rapping the base.
  - For the bottom layer, you will have to angle the rod slightly to make about half of the strokes around the edge of the mold. The other half of the strokes should be made by working your way to the center of the area in a spiral motion.

AASHTO T 119 9

Procedure

- The second and third layers should be rodded approximately 1" into the underlying layer.
- Keep the rod clean between layers so that it does not contaminate the concrete.

AASHTO T 119 10

Procedure

- For the top layer, heap concrete above the top of the mold and be sure concrete remains above the top.
  - If the concrete level falls below the top of the mold, heap more concrete on top of the mold and continue rodding with the *total* stroke count equal to 25.

AASHTO T 119 11

Procedure

- Strike off the top of the mold using a rolling and screeding motion with the tamping rod.
- Remove any excess concrete from around the base of the mold.

AASHTO T 119 12

Procedure

- Immediately remove the mold from the concrete.
- Raise the mold 12" in 5 ± 2 seconds by a steady upward lift.
- Lift the mold straight up.
  - Do not lift sideways or twist the mold while lifting.
  - Do not jostle the base while removing the mold.

AASHTO T 119 13

Procedure

- As soon as the mold is removed, measure the slump. Turn the mold upside down and gently stand it next to the concrete and place the tamping rod across it.
- Measure the distance between the original center of the top of the concrete and the bottom of the rod.
- This measurement is the slump.
- Measure to the nearest ¼".

AASHTO T 119 14

Procedure

Note: If the concrete falls drastically away or shears off from one side, run the test again. If this happens a second time, the concrete lacks the necessary plasticity to run the test.

AASHTO T 119 15

Documentation

Record in a bound field book to the nearest 1/4". See EPG 501.5

AASHTO T 119 16

Common Testing Errors

- Using square end of tamping rod
- Filling mold in 3 layers equal in height
- Lifting mold sideways/twisting/jerking
- Contaminating rod by placing on ground between layers
- Exceeding time limit
- Rodding too deep/ not deep enough
- Using rebar as tamping rod

AASHTO T 119 17

Common Testing Errors

- Not rodding each layer 25 times
- Not lifting rod completely between strokes
- Tapping the sides of the mold with hammer or rod
- Using an absorbent base
- Not securing the mold to the base
- Not filling the mold full
- Standing water in bottom of secured slump cone

AASHTO T 119 18

501.1.4 Consistency (Sec 501.5)

Consistency (slump) of concrete should be determined each time an air-entrainment test is made. Other tests for consistency of concrete should be made as necessary to maintain proper control of the concrete. Placement of concrete should not be permitted until tests for both air entrainment and consistency have been made and results show that specification requirements have been met. When routine tests indicate a deviation from specifications for consistency, placementshould be suspended until adjustments have been made and additional tests completed which show concrete to be within specifications limits. Consistency tests are to be made according to the following instructions which will comply with the specification requirements pertaining to AASHTO designation T-119.

A considerable number of tests have been completed comparing results of testing air entrained concrete samples at the truck discharge point and the pump discharge point. The tests, with few exceptions, indicated that there are only minor variations in the results of the tests, with the tests from the pump discharge location usually slightly lower in air content and slump. If slump goes up drastically there probably would have to be a foreign liquid entering the system from somewhere. A high slump above the 6 to 7 in. range, according to AASHTO guidelines, normally indicates a risk of segregation. Timing in taking slump tests is important. The designated location for quality control sampling to determine air content and slump is the point of truck discharge. When any of the following conditions occur, it may be necessary to obtain a check sample at the point of pump discharge to assure that there is no significant variation in test results:

1. When a new or reconditioned concrete pump is placed into operation. 2. When there are any indications that a substantial change in air content or slump has occurred between the two points of discharge.

The mold for use in the performance of the slump test is available on requisition. It will be made of galvanized steel, not thinner than 16 gauge, and will have the shape of a frustum of a right circular cone with approximate inside diameters at the top of 4 in. and at the bottom of 8 in. Height will be approximately 12 in. The mold is satisfactory if the above dimensions are within 1/16 in. The mold will have foot pieces, and handles for moving mold at end of the test. A mold which clamps to a nonabsorbent base plate is acceptable.

The tamping rod which is used to consolidate the material in the cone shall be a round, straight, steel rod 5/8 inch in diameter, with one end rounded to a hemispherical tip. Length should be approximately 2 feet.

Sample of concrete from which consistency tests are to be made must be representative of the entire batch. Sample should be obtained in accordance with the method of sampling fresh concrete, Section 501.4 of the Standard Specifications.

The mold, which must be clean, should be dampened and placed on a flat, moist, nonabsorbent rigid surface. A sheet of 3/4 in. plywood is frequently used for this purpose. Hold the mold firmly in place during filling, by standing on the foot pieces.

From the sample of concrete, fill the mold in three layers, each layer being approximately 1/3 the volume of the mold. One-third of the volume fills it to a depth of about 2-5/8 in., 2/3 of the volume fills it to a depth of about 6-l/8 in.

Rod each layer with 25 strokes of the tamping rod. Distribute strokes uniformly over entire cross section of the layer. For the bottom layer this will necessitate inclining the rod slightly and making approximately one-half of the strokes near the perimeter and then progressing with vertical strokes spiraling toward the center. Rod the bottom layer throughout its depth. The other two layers are to be rodded throughout their depth so that strokes just penetrate into the underlying layer.

In filling and rodding the top layer, heap concrete above the mold before rodding is started. If, during the rodding operation, concrete subsides below top of the mold, add additional concrete to keep an excess of concrete above top of the mold. After rodding has been completed, strike off the surface of concrete by means of a screeding and rolling motion of the tamping rod.

Immediately remove the mold from the concrete by carefully raising it in a vertical direction. This should be done in approximately 5 seconds by a steady upward lift, with no sideways or twisting motion being imparted to the concrete. The entire operation from start of filling through removal of mold should be carried out without interruption. It should be completed within an elapsed time of approximately 2 1/2 minutes.

Immediately measure slump determining the difference between height of the mold and height over the displaced original center of the top surface of the specimen. Slump is measured to the nearest 1/4 inch of subsidence below top of the mold.

A record of each slump test performed should be entered in a bound field book by the inspector. The form of entry should be such as to provide date, time, mixing unit (such as truck mixer number, central mix unit number, etc.) and name of inspector.

AASHTO T 119 Standard Test Method for Slump of Hydraulic Cement Concrete
PROFICIENCY CHECKLIST

Applicant:____

Employer:____

Trial#	1	2
1. Cone clean and damp, and on damp, non-absorbing surface		
2. Cone filled in three layers of equal volume		
3. Each layer rodded 25 times		
4. Layers rodded properly a. Second and third layers rodded approximately 1" into underlying layer		
5. Last layer kept heaped above cone during rodding		
6. Cone struck off level with the top		
7. Cone filled and removed within 2 ½ minutes		
8. Time to lift cone (5 ± 2 sec)		
9. Slump measured to nearest ¼ inch		
10. Measuring procedure satisfactory		

Pass Pass

Fail Fail

Examiner:____ Date:____________________

AASHTO T 152

Air Content of Freshly Mixed Concrete by the Pressure Method

AASHTO T 152

Air Content of Freshly Mixed Concrete by the Pressure Method

Covered in this Module

- Background & Overview
- Equipment
- Air Meter Calibration
- Air Content
- Aggregate Correction
- Calculations

AASHTO T 152 2

Background & Overview

The air content test is used to determine the amount of air "entrapped" or entrained in the concrete mix. Having the correct amount of air in the mix makes the concrete more durable and more resistant to freezing and thawing. Too much air reduces the durability and compressive strength. Too little air reduces the durability.

AASHTO T 152 3

Background & Overview

- The designated quantity of air by volume shall be as specified for each type of concrete.
  - For concrete mechanically handled after sampling, the specified air will apply to the measurements taken, minus the established air loss. (paver, pump truck etc.)
- This method was designed to use with concrete with relatively dense aggregates. Concrete with lightweight aggregates or aggregates with high porosity can <u>NOT</u> be tested by this method.

AASHTO T 152 4

Equipment

- Air Meter (Type B)
- Tamping rod
  - $\frac{5}{8} \pm \frac{1}{16}$" x 20 ± 4"
- Mallet
- Water Supply
- Strike off bar
- Scoop or shovel
- Rubber syringe

AASHTO T 152 5

Equipment

- Note: Both are Type "B" air meters.

AASHTO T 152 6

Air Meter Calibration

The meter needs to be calibrated at least once a year by following the instructions that come with the meter. The Engineering Policy Guide (EPG) can also be consulted if necessary.

This device may not be compatible with all meters

AASHTO T 152 7

Air Meter Calibration

- Annual Calibration must be performed at 5% Air.
  - The quick field check using 1.2% air is not acceptable as calibration.

AASHTO T 152 8

Setting Initial Pressure
(Step 1 of Calibration Procedure)

- Fill the meter with water making certain all air is removed.
  - Skip to Step 2 if you are calibrating a meter without a zero indication.
- Pump air until hand is on the initial pressure line.
- Release air into measuring bowl.
- When initial pressure line is correctly positioned the gauge should read zero percent. (See Annex of T 152 for additional information

AASHTO T 152 9

Gauge Calibration

(Step 2 of the Calibration Procedure)

- Either remove or displace (using calibration devise) 5% air from measuring bowl.
- Set pressure to initial pressure line.
- Release into measuring bowl.
- Gauge should read 5% air.
- If not adjust gauge and repeat procedure.

AASHTO T 152 10

Procedure for Air Content

- Obtain a sample of freshly mixed concrete.

AASHTO T 152 11

Procedure for Air Content

- Dampen the interior of the bowl and place it on a flat surface.
- Concrete is to be placed in the bowl in equal layers and consolidated, by either rodding or vibration.

AASHTO T 152 12

Procedure for Air Content

- Rod concretes with a slump greater than 3". Rod or vibrate concrete with a slump of 1" to 3". Consolidate concrete with slump less than 1" by vibration.

AASHTO T 152 13

Procedure for Air Content (Rodding)

- When rodding the concrete, place the concrete in three equal layers. Rod each layer 25 times with the tamping rod. The strokes should be evenly dispersed across the area of the concrete.
  - Make sure rod clears the surface of the concrete with each stroke. Avoid stirring action.

AASHTO T 152 14

Procedure for Air Content (Rodding)

After each layer is rodded, sharply tap the side of the bowl with the mallet 10 to 15 times. This will close the voids left by the tamping rod and will release any entrapped air.

AASHTO T 152 15

Procedure for Air Content (Rodding)

- Rod the bottom layer throughout its depth, but do not forcibly strike the bottom of the bowl.
- When rodding the second and final layers only allow the rod to penetrate the previous layer about one inch.
- When the final layer of concrete is added, be careful to avoid excessive overfilling.

AASHTO T 152 16

Procedure for Air Content (Vibration)

- When vibrating the concrete, place the concrete in 2 equal layers. Vibrate each layer by inserting the vibrator in three places evenly dispersed across the area of the concrete. Avoid excessive overfilling with the final layer. When vibrating the bottom layer, do not let the vibrator touch the bottom or sides of the bowl.

AASHTO T 152 17

Procedure for Air Content (Vibration)

- Always be careful when removing the vibrator so that air voids are not left in the concrete.
- Do not over vibrate the concrete.
- Vibration should stop when the concrete becomes relatively smooth and has a glazed appearance.
  - If froth begins to form on top of the concrete, then the concrete has been vibrated too long.

AASHTO T 152 18

Procedure for Air Content

- Strike off the top surface with the strike off bar using a sawing motion until the bowl is just level full. A small quantity of concrete may be added to fill any voids in the surface. Large excesses of concrete should be removed with a scoop before the strike off bar is used.

AASHTO T 152 19

Procedure for Air Content

- Clean the rims of the bowl and cover. This will make sure a tight pressure seal is made when the cover is placed on the bowl.
- Moisten the bottom of the cover and secure the cover on the bowl.

AASHTO T 152 20

Procedure for Air Content

- Close the air valve between the air chamber and the measuring bowl and open both petcocks on the holes through the cover.
- Introduce water through one petcock until it comes out the opposite petcock.

AASHTO T 152 21

Procedure for Air Content

- Jar the pot gently until all air is expelled from this same petcock.
- Close the air bleeder valve on the air chamber and pump air into the air chamber until the gauge hand is on the initial pressure line.

AASHTO T 152 22

Procedure for Air Content

- Wait a few seconds and then stabilize the gauge hand at the initial pressure line by pumping air in or bleeding air out while you are tapping the gauge lightly by hand.
- Close both petcocks on the holes through the cover.

AASHTO T 152 23

Procedure for Air Content

- Open the air valve between the air chamber and the measuring bowl.
- Tap the sides of the measuring bowl sharply with the mallet to relieve local restraints.

AASHTO T 152 24

Procedure for Air Content

- Lightly tap the pressure gauge by hand and read the percentage of air on the dial of the pressure gauge.
- This reading minus the aggregate correction factor is the air content of the concrete mixture.

AASHTO T 152 25

Common Testing Errors (Air Content)

Not rodding or vibrating each layer

Not having equal height layers

Not tapping pot between layers

Not closing all petcocks allowing water to escape during test

Not tapping pot after reading gauge and releasing pressure

AASHTO T 152 26

Common Testing Errors (Air Content)

Not tapping sides of pot to make sure all excess air has been removed after starting to add water

Not having a tight pressure seal between the cover and the bowl due to not cleaning the rim of the pot or meter top

AASHTO T 152 27

Common Testing Errors (Air Content)

- Over vibration
- Incorrect number of insertions of the rod
- Incorrect vibrator

AASHTO T 152 28

Aggregate Correction Factor

The aggregate correction factor is determined on a combined sample of fine and coarse aggregate.

- Determine the weight of the coarse and fine aggregate that will be in the air meter when an air test is run. Use the following formulas to calculate the weights.

AASHTO T 152 29

Aggregate Correction Factor

$$F_s = \frac{S \times F_b}{B}$$

F_s = weight of the fine aggregate used in the aggregate correction factor test, in pounds.

S = volume of the air meter measuring bowl; for MoDOT gauges 0.25 cubic feet.

B = volume of concrete produced per batch, this should be 27 cubic feet (1 cubic yard).

F_b = total weight of fine aggregate used in one cubic yard of concrete. This will be the scale weight, in lbs., taken from the pouring report.

AASHTO T 152 30

Aggregate Correction Factor

$$C_s = \frac{S \times C_b}{B}$$

C_s = weight of the coarse aggregate used in the aggregate correction factor test, in pounds.

S = volume of the air meter measuring bowl; for MoDOT gauges 0.25 cubic feet.

B = volume of concrete produced per batch, this should be 27 cubic feet (1 cubic yard).

C_b = total weight of coarse aggregate used in one cubic yard of concrete. This will be the scale weight, in lbs., taken from the pouring report.

AASHTO T 152 31

Classroom Exercise

- Given Scale weights from Concrete Mix Design:
  - Fine Aggregate – 1281 lbs./yd.^{3}
  - Coarse Aggregate – 1843 lbs./yd.^{3}
- Calculate both the weight of Fine and Coarse Aggregate to the nearest 0.01 pound, used to determine Aggregate Correction.

AASHTO T 152 32

Classroom Exercise

$$F_s = \frac{S \times F_b}{B}$$

$$F_s = (S / B) x F_b$$

The above equations are the same only expressed differently.

AASHTO T 152 33

Aggregate Correction Factor

- Weigh out the amount of course aggregate (C_s), and fine aggregate (F_s), that was calculated.
- Thoroughly mix the two together.
- Fill the bowl one third full of water.
- Place the mixed aggregate in the bowl a small amount at a time. If necessary add more water to the bowl to make sure the aggregate stays covered with water.

AASHTO T 152 34

Aggregate Correction Factor

- Rod the top 1" of aggregate 8-12 times, tap the sides and stir after each addition of aggregate to eliminate any entrapped air.
- After each scoopful of aggregate is added to the bowl, remove accumulations of foam promptly.

AASHTO T 152 35

Aggregate Correction Factor

- Clean the rims of the bowl and cover. This will make sure a tight pressure seal is made when the cover is placed on the bowl.
- Follow the same operating procedure for determining air of concrete, with the following exception:

AASHTO T 152 36

Aggregate Correction Factor

- Follow Mfg. recommendations, remove a volume of water equal to the volume of air that would be contained in a typical concrete sample. (generally 5%)
  - Note: Annex A1.9 of the T152 gives instructions on this procedure.

AASHTO T152 37

Common Testing Error (Aggregate Correction Factor)

Not getting the sample weight of each aggregate

Not rodding or stirring the aggregates

Not tapping the bowl to eliminate excess air

Not cleaning bowl rim and cover

Not closing all petcocks

Not letting pressure stabilize before reading

AASHTO T152 38

Calculations

$$As = A1 - G$$

As - actual air content of sample tested, in percentage

A1 - gauge reading for air content of the sample tested, in percentage

G - aggregate correction factor, in percentage

AASHTO T152 39

Documentation

Record to the nearest whole or half division of the meter's scale in a bound field book. Example, to the nearest 0.10 or 0.05%.

(See EPG Section 501.1.8.2.)

AASHTO T 152 40

501.1.8 Air-Entrained Concrete (Sec 501.10)

Air entrainment tests by the pressure method

Test methods outlined in the following paragraphs were derived from AASHTO T-152 to provide a basis for determining air content of freshly mixed concrete. Principles involved are based on the fact that air is the only compressible component in freshly mixed concrete. Operation of testing equipment is to be in accordance with the manufacturer's instructions.

The pressure method of determining air entrainment is to be used for concrete intended for both structures and pavement, with the exception of lightweight concrete. Porosity of lightweight aggregates introduces errors into results which make other procedures necessary.

Air test are to be made at the beginning of each pour on structures and for each 100 cubic yards thereafter.

Equipment used to determine the air content of concrete shall meet the requirements of AASHTO T-152. All types of apparatus used for determining air content by the pressure method have several features in common:

(a) A measuring bowl which is sufficiently rigid to make a pressure tight container of accurate volume and which is suitable to hold a representative sample of the concrete to be tested. (b) A cover which is designed to be attached to the measuring bowl in a way which produces a rigid, pressure-tight assembly. (c) Means of applying a known pressure to the system, and for observing its effect on the volume of the sample. (d) Appropriate tools for placing and consolidating the sample and using the apparatus. A tampering rod 5/8 inch in diameter with a hemispherical tip is furnished for compacting concrete. This rod should be approximately 2 feet in length. A mallet with a rubber or rawhide head weighing approximately 1/2 lb. is furnished for tapping the measuring bowl during the testing process. Other accessories such as a trowel, strike-off bar, funnel, and water measure are part of the set.

The following procedures for calibration of the apparatus, determination of air content of concrete, and calculations of results will be given in general terms since minor changes are necessary for different types of apparatus. However, the intent will serve as a guide to exact procedures to be used if equipment furnished is slightly different.

Aggregate correction factors shall be made available by the district to the Central Laboratory when coarse aggregate samples are submitted for AASHTO T161 testing.

501.1.8.1 Calibration

Protex Meter. Calibration of pressure-type apparatus is affected by changes in barometric pressure such as those caused by changes of temperature and humidity, and by rough handling. Steps (a) through (e) normally need be made only at time of initial calibration, and occasionally there after to check the stability of volume for the calibration cylinder and measuring bowl. Step (f) must be made as frequently as necessary to insure that proper gauge pressure is being used in tests for air content of concrete.

(a) Calibration of the calibration cylinder. Accurately determine weight of water, w, in grams required to fill the calibration cylinder, using a scale sensitive to 0.5 gram. (b) Calibration of measuring bowl. Determine weight of water, W, (in pounds) required to fill the measuring bowl. Use a scale sensitive to 0.1 percent of the weight of the bowl filled with water. Slide a glass plate carefully over the flange of the bowl in a way to insure that the bowl is completely filled with water. A thin film of cup grease smeared on the flange of the bowl will make a water tight joint between the glass plate and top of the bowl. (c) Determination of Constant, R. The constant, R, represents the volume of the calibration cylinder expressed as a percentage of the volume of the measuring bowl. Calculate R by the following equation: R=\frac{0.2205w(grams)}{W(pounds)} If scales of adequate capacity are available and the inspector so desires, W may be determined in grams. If that is done the equation reduces to: R=\frac{w(grams)}{W(grams)} (d) Determination of expansion factor, D. Determine the expansion factor, D, for any given apparatus assembly by filling the apparatus with water only. Make certain that all entrapped air has been removed and the water level is exactly on the zero mark. Apply an air pressure approximately equal to the operating pressure, P, determined by the calibration test described in (f). The amount the water column lowers will be the equivalent expansion factor, D, for that particular apparatus and pressure. For this portion of the calibration, it will be satisfactory to use an approximate value for P. This is determined by making a preliminary calibration test as described in (f), except that an approximate value for calibration factor, K, will be used. For this test, K, will be approximate, because the factor, D, as yet unknown, is assumed to be zero. See (e). (e) Determination of calibration factor, K. The calibration factor, K, is the amount the water column must be depressed during the calibration procedure to obtain the gauge pressure required, so that graduations on the glass tube correspond directly to the percentage of air introduced into the measuring bowl by the calibration cylinder when the bowl is level full of water. Calculate K as follows: K = 0.98R + D (f) Calibration test to determine operating pressure, P, on pressure gauge. If the rim of the calibration cylinder contains no recesses or projections, fit it with three or more spacers equally spaced around the circumference. Invert cylinder and place it at the center of the dry bottom of the measuring bowl. The spacers provide opening for flow of water into the calibration cylinder when pressure is applied. Secure the inverted cylinder against displacement and carefully lower the conical cover into place and clamp. After cover is clamped in place, carefully adjust the apparatus assembly to a true vertical position. Add water at air temperature by means of the tube and funnel until water rises above the zero mark in the standpipe. Close vent and pump air into the apparatus to the approximate operating pressure. Incline the assembly about 30 degrees from vertical, and using bottom of the bowl as a pivot, describe several complete circles with the upper end of the standpipe. Simultaneously, tap over and sides of the bowl lightly to remove any entrapped air which might be adhering to inner surfaces of the apparatus. Return the apparatus to a vertical position, gradually release pressure to avoid loss of air (from the calibration cylinder), and open vent. Bring water level exactly to the zero mark by bleeding water through the petcock in the top of the conical cover. When the zero mark has been reached, close vent and then apply pressure until the water level has dropped an amount equivalent to about 0.1 to 0.2 percent of air more than the value of the calibration factor, K, determined as described in (e). To relieve local restraints lightly tap sides of the bowl. When the water level is exactly at the value of calibration factor, K, read the pressure, P, indicated by the gauge and record to the nearest 0.1 psi. Gradually release pressure and open vent to determine whether the water level returns to the zero mark when sides of the bowl are tapped lightly. Failure to do so indicates loss of air from the calibration cylinder or loss of water due to a leak in the assembly. If the water level fails to return to within 0.05% air of the zero mark and no leakage beyond a few drops of water is found, some air probably was lost from the calibration cylinder. In this case, repeat the entire calibration procedure, step by step. If leakage is more than a few drops of water, tighten the leaking joint before repeating the calibration procedure. Check the indicated pressure reading promptly by bringing the water level exactly to the zero mark, closing vent, and applying the pressure, P, just determined. Tap gauge lightly with a finger. When gauge indicates the exact pressure, P, water column should read the value of the calibration factor K, used in the first pressure application. The reading should be within about 0.5 percent of air.

Soiltest Meter The easiest method of calibrating the Soiltest Air Meter is by using the calibration block.

a. Fill the material container with water. b. Place the 5 percent calibration block in the material container. c. Place and clamp lid onto the container, run air test as you normally would for concrete. d. If the gauge hand indicates 5 percent air, the equipment is properly calibrated. e. If the gauge hand indicates air content other than 5 percent, adjust the initial starting point (the yellow needle) and run through the test again. This may be done a few times until the gauge is properly calibrated.

Determination of Aggregate Correction Factor. Determine the aggregate correction factor on a combined sample of fine and coarse aggregate by the methods outlined in the following paragraphs:

Calculate weights of fine and coarse aggregate present in the volume, S, of the sample of fresh concrete whose air content is to be determined as follows:

$F_s=\frac{S \times F_b}{B}$ $C_s=\frac{S \times C_b}{B}$ Where: Fs = weight of fine aggregate in concrete sample under test, in lbs. S = volume of concrete sample (Same as volume of measuring bowl of apparatus), in cubic feet. B = volume of concrete produced per batch, in cubic feet. Fb = total weight of fine aggregate in batch, in lbs. Cs = weight of coarse aggregate in concrete sample under test, in lbs., and Cb = total weight of coarse aggregate in batch, in lbs.

Mix representative samples of fine aggregate of weight, Fs, and coarse aggregate of weight, C, and place in the measuring bowl which has been previously filled 1/3 full of water. Add mixed aggregate a little at a time until all of the aggregate is inundated. Add each scoopful in a manner that will entrap as little air as possible. Promptly remove accumulations of foam. Tap sides of the bowl and lightly rod the upper inch of the aggregate about 10 times. Stir after each addition of mixed aggregate to eliminate entrapped air.

When all of the aggregate has been placed in the bowl and inundated for at least 5 minutes, strike off all foam and excess water, and thoroughly clean flanges of both the bowl and conical cover so that when the cover is clamped in place, a pressure tight seal will be obtained. Complete test as described below. The aggregate correction factor, G, is equal to h1-h2, as determined in the tests on the aggregate. The factor will normally remain fairly constant for any given aggregates but since different aggregates will have different factors, a new factor must be determined for each source.

501.1.8.2 Procedure for Determining Air Content of Concrete

With the Protex Meter, place a representative sample of concrete in the measuring bowl in three equal layers. Consolidate each layer by rodding, and by tapping the bowl. When concrete is placed, consolidate each layer of concrete with 25 strokes of the tamping rod, evenly distributed over the cross section. Follow the rodding of each layer by tapping sides of the bowl with the mallet, until cavities left by rodding are leveled out and no large bubbles of air appear on the surface of the rodded layer. When rodding the first layer, rod should not strike bottom of the bowl. In rodding the second and final layers, use only enough force to cause the rod to penetrate the surface of the previous layer. Slightly overfill the bowl with the third layer. After rodding, remove excess concrete by sliding the strike off bar across the top flange with a sawing motion, until the bowl is just level full.

Thoroughly clean flanges of the bowl and conical cover so that when the cover is clamped in place, a pressure-tight seal will be obtained. Assemble the apparatus and add water over the concrete by means of the tube. Water should be added until it rises to about the half way mark in the standpipe. Incline the apparatus assembly about 30 degrees from vertical, using bottom of the bowl as a pivot. Describe several complete circles with the upper end of the column, simultaneously tapping the conical cover lightly to remove any entrapped air bubbles above the concrete sample. Return the apparatus assembly to its vertical position. Fill the water column lightly above the zero mark, while lightly tapping sides of the bowl. Foam on the surface of the water column may be removed with a syringe or with spray of alcohol to provide a clear meniscus. Bring the water level to the zero mark of the graduated tube before closing vent at top of the water column.

Apply slightly more than the desired test pressure, P (about 0.2 psi more), to the concrete by means of the hand pump. To relieve local restraints, tap sides of the measure. When the pressure gauge indicates exact test pressure, P (as determined in accordance with instructions for the calibration test), read the water level, h1, and record to the nearest division or half division (0.10 or 0.05% air content) on the graduated bore tube or gauge glass of the standpipe. For extremely harsh mixes, it may be necessary to tap the bowl vigorously until further tapping produces no change in indicated air content. Gradually release air pressure to vent at the top of the water column, and tap sides of the bowl lightly for about 1 minute. Record the water level, h2, to the nearest division or half division. The apparent air content, A1, is equal to h1-h2.

Repeat the steps described in Section 501.16.4.3.3.2 without adding water to reestablish the water level at the zero mark. The two consecutive determinations of apparent air content should check within 0.2% of the air. Use the average to get the value, A1, to be used in calculating the air content, A, in accordance with Section 501.16.4.4.

CALCULATION. Calculate the air content of the concrete as follows:

A = A1 – G Where: A = Air content percentage, by volume of concrete. A1 = Apparent air content percentage, by volume of concrete. G = Aggregate correction factor percentage, by volume.

Concrete placement shall be halted if results of tests for entrained air indicate non-compliance with specification requirements.

Data for tests for air entrainment should be entered directly in a bound field book by the inspector. The aggregate correction factor should be determined at start of the work for each mix and complete data and calculations entered in the field book. Each test for determination of operating pressure, P, must also be entered.

In the record of test for air entrainment the aggregate correction factor and operating pressure used should be identified with the test from which they were determined. This can be done by reference to book and page number on which the test is recorded.

AASHTO T 152 Air Content of Freshly Mixed Concrete By Pressure Method
PROFICIENCY CHECKLIST

Applicant:____

Employer:____

Trial#	1	2
General		
1. Bowl dampened		
2. Bowl filled in three equal layers		
3. Each layer rodded 25 times		
4. After rodding each layer, bowl tapped 10 to 15 times with mallet		
5. Excess concrete removed with sawing motion of strike-off bar		
Type "B" Meter		
1. Flanges of bowl cleaned and unit assembled		
2. Air valve between air chamber and bowl closed		
3. Using rubber syringe water injected through one petcock until water emerges from opposite petcock		
4. Meter jarred gently until all air is expelled		
5. Air bleeder valve on air chamber closed and air pumped into chamber until gauge hand is on initial pressure line		
6. A few seconds allowed for compressed air to cool		
7. Initial pressure stabilized while tapping gauge lightly		
8. Petcocks closed. (Not before filling of air chamber, Step 5)		
9. Air valve between air chamber and measuring bowl opened		
10. Sides of measuring bowl tapped smartly		
11.Pressure gauge tapped lightly and percentage of air read		
12.Air content of sample calculated as follows: Air content (%) = Apparent Air Content – Aggregate Correction Factor		
13.Is aggregate correction factor determined for different aggregates		

Pass Pass

Fail Fail

Examiner:____Date:____________________

AASHTO T 23

Making and Curing of Concrete Test Specimens in the Field

MoDOT

AASHTO T 23

Making and Curing Concrete Test Specimens in the Field

Background & Overview

- The strength of concrete is determined for various reasons and as such specimens are treated differently depending on the intended use.
  - Standard Cure specimens are used to determine 28 day strength, the check of mix proportions, Quality Control (i.e. monitoring mix variability) and establishing strength for using a Maturity meter curve.
  - Field Cure specimens are used to control items such as form removal, staged construction, opening to traffic, or cold weather placement.

AASHTO T 23 2

Background & Overview

Standard Cure specimens made to verify the design strength of the concrete mixture are cured in an optimum condition to determine the 28 day strength.

The making and curing of these specimens cannot be performed without proper procedures or the results will not indicate the true condition of the concrete represented.

AASHTO T 23 3

Background & Overview

- EPG Section 501.1.3 Sampling (Sec. 501.4) contains specific information about curing procedures.

AASHTO T23 4

Background & Overview

There are two types of specimens made for field testing - cylinders and beams. Test specimens can be various sizes depending on the type of procedure used to test the specimens or the agency preference. The concrete used to make the specimens is obtained by AASHTO T 141, Sampling Freshly Mixed Concrete.

AASHTO T23 5

Background & Overview

- This certification will focus on cylinders which are typical to MoDOT and are molded in plastic single use cylinder molds. There are other types of specimens covered by AASHTO T 23.

AASHTO T23 6

Equipment

- Mold and cap
- Tamping Rod – Size determined by the size of specimen being made
- Scoop
- Marker
- Trowel or straight-edge
- Duct tape
- Tachometer
- Vibrator

AASHTO T 23 7

Precautions

Molding the specimens should be located as near the placement of the concrete as practical. The location should be a level, rigid, horizontal surface, free from vibration and other disturbances.

AASHTO T 23 8

Precautions

After molding, the specimens are immediately moved to a safe location for curing and are not moved again until hardened to prevent damage. When moved they are placed into the proper curing environment, dependent on their intended use.

AASHTO T 23 9

Cylinder Sizes

- There are two sizes of cylinders typically used for compressive strength tests.
- 4" x 8" and 6" x 12"
  - 4" x 8" may be used for aggregates 1" nominal or less.
  - 6" x 12" for aggregates 2" nominal or less.
    - Aggregates larger than 2" are to be removed from concrete prior to molding by sieving.

AASHTO T 23 — 10

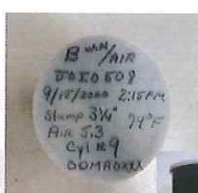
Preparation

- The tools needed to complete the molding should be made available prior to sampling.
  - Plastic molds with lids
  - Rod with a hemispherical (round) end
    - $\frac{3}{8} \pm \frac{1}{16}$" x 12 ± 4" for 4" diameter cylinders
    - $\frac{5}{8} \pm \frac{1}{16}$" x 20 ± 4" for 6" diameter cylinders
  - Duct tape, marker, scoop or shovel, and any covering similar to the placed concrete.

AASHTO T 23 — 11

Preparation

- Write the cylinder number, ID number, date of pour, project information, cement factor, and class of concrete on the cylinder mold and cap.



AASHTO T 23 — 12

Procedure for Consolidation

- The method of consolidation of the concrete is dependent on the slump determined by AASHTO T 119.
- Slump >1" - Rod or Vibrate
- Slump ≤1" – Vibrate

AASHTO T 23 13

Procedure for Rodding

- Consolidation procedures vary depending on the mold size.
- The concrete is placed into the mold by use of a scoop or shovel, in equal lifts.
  - 2 lifts for 4" x 8" cylinders
  - 3 lifts for 6" x 12" cylinders
- Consolidate with the round end of the rod by rodding into each layer 25 times.

AASHTO T 23 14

Procedure for Rodding

The rodding should be uniformly dispersed across the layer and should extend to the bottom of the mold for the first lift and approximately 1" into the lift below for the second and final lifts.

AASHTO T 23 15

Procedure for Rodding

After each layer is rodded, the mold is tapped lightly 10 – 15 times to release large air bubbles and close holes left by rodding.

Note: For light gauge single use molds, use open hand only, as these molds are susceptible to damage if a mallet is used.

AASHTO T 23 16

Procedure for Rodding

- When placing the final lift into the mold, the operator shall attempt to add an amount of concrete that will exactly fill the mold after compaction.
  - Underfilled molds shall be adjusted using representative concrete *during* consolidation.
  - Overfilled molds shall have excess concrete removed.

AASHTO T 23 17

Procedure for Vibrating

- The concrete is placed into the mold by use of a scoop or shovel, in 2 equal lifts.
- Consolidate the first lift by inserting the vibrator into the lift without touching the sides or bottom. For the second lift, extend the vibrator into the *lower* lift approximately 1".
- Insertions:
  - **1 location for 4" x 8" cylinders.**
  - **2 locations for 6" x 12" cylinders.**

AASHTO T 23 18

Procedure for Vibrating

- Place all the concrete for each layer in before commencing vibration of the layer.
- Avoid touching the sides or bottom of the mold.
- Slowly remove vibrator so that no large air pockets are left in the specimen.

AASHTO T23 19

Procedure for Vibrating

- Continue vibration only long enough to achieve proper consolidation.
  - Generally up to 5 seconds with slumps greater than 3" is sufficient.
  - Longer times may be necessary with lower slumps, however exceeding 10 seconds would be rare.

AASHTO T23 20

Procedure for Vibrating

- If necessary, after vibrating each lift, tap the outside of the mold 10 to 15 times to close any holes left by the vibrator.
- When placing the second lift into the mold be sure not to overfill by more than ¼".

AASHTO T23 21

Finishing Procedure

- After consolidation, strike off excess concrete from the surface and float or trowel as required.

The tamping rod may be used for striking off concrete where consistency allows.

AASHTO T23 22

Finishing Procedure

- Perform all finishing, with minimum manipulation, to produce a flat even surface, level with the rim or edge of the mold, having no depressions or projections more than 1/8".
- Wipe off the excess concrete and snap the cap onto the top of the mold.

AASHTO T23 23

Curing Procedures

Secure the cap to the mold. At this point the concrete cylinders should be moved to their initial curing position dependent on their ultimate use.

AASHTO T23 24

Field Cure Specimens

- Specimens made for form removal or opening to traffic should be stored and cured at a location near, and in the same environment as the placed concrete.
- Removal of the specimens from this environment and stripping of the mold should be done as close to the desired breaking time as possible.
  - If the structure forms are removed prior to breaking, specimen molds should also be removed.

AASHTO T23 25

Standard Cure Specimens

- Specimens made for 28 day testing, mixture proportions or design strength, quality control or maturity meter curve shall be cured in two phases.
  - Initial Curing
  - Final Curing

AASHTO T23 26

Standard Cure Specimens

- Initial Curing - 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. Recommended method for initial curing is keeping the specimen in the plastic mold covered with a plastic lid or place in a damp sand pit for a maximum of 48 hours in a temperature range from 60° F to 80° F and an environment preventing moisture loss.

AASHTO T23 27

Standard Cure Specimens

- Final Curing - Upon completion of initial curing and within 30 minutes of removing the molds, cure specimens with free water maintained on their surfaces at all times at a temperature of 70° F to 77° F using water storage tanks or moisture room per AASHTO M201 (ASTM C511).
  - Additional information is provided in the EPG section 501.1.3.

AASHTO T23 28

28 Day Specimens

- Specimens should not be transported to begin final cure until at least 8 hours after final set.
- Specimens may be transported to test location for final curing. To transport, after the initial cure period, the specimen shall be removed from the mold and placed in a plastic bag to maintain free moisture during shipping.
  - NOTE: A damp towel on each end of the cylinder in the bag will aid in maintaining moisture.

AASHTO T23 29

28 Day Specimens

- During transport, use suitable material to prevent damage from jarring and use suitable insulation material during cold weather.
- More detailed information is in the EPG 501.1.3 Sampling (Sec. 501.4)

AASHTO T23 30

Number of Specimens

- For Strength Acceptance (Standard Cure)
  - 2 specimens for 6”x12” cylinders
  - 3 specimens for 4”x8” cylinders
- Tests required to control construction operations (Field Cure) such as opening strength, form removal or discontinuance of heating or wet curing on basis of specified strength.
  - 1 per break, as needed.

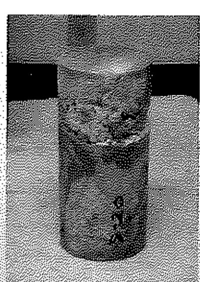
AASHTO T23 31

Common Testing Errors

- Unstable molding platform
- Unequal or wrong number of lifts
- Strokes of top two layers do not penetrate approximately 1” into the next lower layer
- Top of specimen not properly finished
- Foreign objects entered into specimen
- Cap not placed securely on mold

AASHTO T23 32

Common Testing Errors



- Not enough or too many strokes of rod per layer
- Uneven distribution of strokes around layer
- Mold not lightly tapped after rodding each layer
- Shipped without maintaining proper moisture

AASHTO T23 33

501.1.3.4 Protection of sample

After the sample has been obtained, it must be protected from direct sunlight and wind until it is used, which must not be more than 15 minutes after sampling. When the sample has been moved to the place where the test is to be made or specimens are to be molded it should be mixed with a shovel if necessary to assure uniformity of the mixed sample.

501.1.3.5 Compressive Strength

Compressive tests are performed both in the field and in the laboratory on cylindrical specimens of concrete, 6 in. diameter and 12 in. tall (6x12) or 4 in. diameter and 8 in. tall (4x8). The Standard Specifications require use of compressive specimens for job control of concrete production.

All concrete for air and slump tests as well as preparation of the specimens should be secured from a single batch of concrete. Air and slump tests should always be made on samples of concrete used for preparation of compressive specimens.

Cylinder forms shall be filled with fresh concrete in accordance with the instructions provided by AASHTO T 23 (ASTM C 31). Care should be taken when placing the caps on the molds to avoid damage to the surface of the concrete. The lids should be kept on tight to prevent moisture loss.

501.1.3.5.1 Curing

Curing of compressive specimens will depend on whether they are for standard cure or field cure.

Standard Cure is defined as 1) specified strength for 28-day testing; 2) Check of mixture proportions or design strength; 3) Quality control (i.e. monitoring mix variability) or 4) Maturity meter curve.

Standard curing involves two phases of curing: initial and final.

Each set of compressive test specimens for standard cure consists of two 6x12 cylinders or three 4x8 cylinders. Standard Cure specimens shall be cured in accordance with AASHTO T23 (ASTM C31) for initial and final curing.

Standard Cure – Initial

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. Recommended method for initial curing is keeping the specimen in the plastic mold covered with a plastic lid or place in a damp sand pit for a maximum of 48 hours in a temperature range from 60° F to 80° F and an environment preventing moisture loss.

Standard Cure - Final

Upon completion of initial curing and within 30 minutes of removing the molds, cure specimens with free water maintained on their surfaces at all times at a temperature of 70° F to 77° F using water storage tanks or moisture room per AASHTO M201 (ASTM C511).

Storage Tanks When water tanks are used for final curing the temperature shall be maintained at 70° F to 77° F. Method of recording temperature is required. Transportation of Specimens Specimens may be transported to the Central Laboratory for final curing. To transport, after the initial cure period, the specimen shall be removed from the mold and placed in a plastic bag to maintain free moisture during shipping. Specimens should not be transported to begin final cure until at least 8 hours after final set. During transporting, use suitable material to prevent damage from jarring and use suitable insulation material during cold weather. Show shipper's name and address on the outside of the box. The box comes with the address of Central Laboratory printed on the side and a preprinted form that provides basic information about the cylinders. If the box does not have the form preprinted, contact the Central Laboratory for copies of the self stick form. SiteManager Sample ID number should be written on the side of cylinders or cylinder molds. Necessary boxes, cardboard liners, polyethylene bags, wire ties and rolls of strapping tape are stock items available by requisition.

Field Curing

Field cure is defined as 1) Opening to traffic strength or staged construction; 2) Comparison with test results of standard cure to in place methods, such as maturity method verification; 3) Adequacy of curing and protection of concrete in the structure, such as cold weather placement or 4) Form removal.

Field curing shall be in accordance with AASHTO T23 (ASTM C 31). Store cylinders in or on the structure as near as practical to the represented concrete. Protect all surfaces of the cylinders from the elements, and ensure a temperature and moisture environment similar to the formed work. 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.

Compressive test specimens for field cures may consist of one or more for either 6x12 cylinders 4x8 cylinders. Specimens prepared to determine when forms may be removed will be cured as described in above except for bridge decks or heated concrete. Specimens representing bridge decks are to be cured on the deck under wet mats until the cylinders are to be broken or wet curing is discontinued. If cylinders remain after wet curing has ended, they shall be cured in plastic molds under field conditions until they are to be broken.

Specimens representing heated concrete are to be left in the enclosure subject to the same protection as concrete they represent until they are to be broken. Cylinders should be left in molds and covered with wet burlap for 48 hours. If cylinders remain after the heating period has ended they shall be cured in plastic molds under field conditions until they are to be broken.

Curing of bridge decks shall be in accordance with Standard Specification 704, wet curing shall be maintained for 7 days and until the concrete has reached a minimum of 3000 psi.

AASHTO T 23 Making and Curing of Concrete Specimens
In the Field
PROFICIENCY CHECKLIST

Applicant:____

Employer:____

Trial#	1	2
Preparation of 4 x 8 inch concrete cylinders		
1. Each layer properly consolidated per AASHTO T 119		
2. Mold filled in 3 approx. equal layers (Vibrated = 2)		
3. Rod each layer 25 times a. If using vibrator, one location per layer		
4. Is mold tapped lightly 10 to 15 times after each layer is rodded		
5. Is mold tapped with open hand for light gauge single use molds		
6. Cylinder mold struck off level with top		
7. Mold properly cleaned and sealed with cap		
Preparation of 6 x 12 inch concrete cylinders		
1. Each layer properly consolidated per AASHTO T 119		
2. Mold filled in 3 approx. equal layers (Vibrated = 2)		
3. Rod each layer 25 times a. If using vibrator, 2 locations per layer		
4. Is mold tapped lightly 10 to 15 times after each layer is rodded		
5. Is mold tapped with open hand for light gauge single use molds		
6. Cylinder mold struck off level with top		
7. Mold properly cleaned and sealed with cap		

Pass Pass

Fail Fail

Examiner:____Date:____________________

Glossary of Terms

AASHTO
American Association of State Highway and Transportation Officials

Aggregate Correction Factor
An easily run test that accounts for air in the aggregate structure which fills with water under pressure. It is determined on inundated fine and coarse aggregate in approximately the same moisture condition, amount and proportions occurring in the concrete sample under test.

Air Content
The amount of air in mortar or concrete, exclusive of pore space in the aggregate particles, usually expressed as a percentage of total volume of mortar or concrete.

Air Void
A space in cement paste, mortar, or concrete filled with air, and entrapped air void is characteristically 1mm (0.04 in.) or more in size and irregular in shape; an air entrained air void is typically between 10µm and 1mm in diameter and spherical (or nearly so).

Batch Weights
Quantity of concrete or mortar mixed at one time.

Central Mixed Concrete
A stationary concrete mixer from which the fresh concrete is transported to the work.

Compression Test
Test made on a specimen of mortar or concrete to determine the compressive strength; unless otherwise specified, compression tests of mortars are made on 50mm (2 in.) cubes, and compression tests of concrete are made on cylinders either 4 inches in diameter and 8 inches in height or 6 inches in diameter and 12 inches in height.

Compressive Strength
The measure resistance of a concrete or mortar specimen to axial loading; expressed as pounds per square inch (psi) of cross-sectional area.

Concrete
A composite material that consists essentially of a binding medium in which is embedded particles or fragments of relatively inert material filler. In Portland cement concrete, the binder is a mixture of Portland cement and water; the filler may be any of a wide variety of natural or artificial aggregates.

Consistency
The relative mobility or ability of fresh concrete or mortar to flow. The usual measures of consistency are slump or ball penetration for concrete and flow for mortar.

Consolidation
The process of inducing a closer arrangement of the solid particles in freshly mixed concrete or mortar during placement by the reduction of voids, usually by vibration, centrifugation, tamping, or some combination of these actions; also applicable to similar manipulation of other cementitious mixtures, soils, aggregates, or the like.

Core
A cylindrical specimen of standard diameter drilled from a structure or rock foundation to be bested compression or examined petrographically.

Entrained Air
Round, uniformly distributed, microscopic, non-coalescing air bubbles entrained by the use of air-entraining agents; usually less than 1mm (.04 in.) in size.

Entrapped Air
Air in concrete that is not purposely entrained. Entrapped air is generally considered to be large voids (larger than 1mm [.04 in.]).

Field Cured Cylinders
Test cylinders cured as nearly as practicable in the same manner as the concrete in the structure to indicate when supporting forms may be removed, additional loads may be imposed, or the structure may be placed in service.

Finishing
Leveling, smoothing, compacting, and otherwise treating surfaces of fresh or recently placed concrete or mortar to produce desired appearance and service.

Gradation
The distribution of particles of granular material among various sizes, usually expressed in terms of cumulative percentages larger or smaller than each of a series of sizes (sieve openings) or the percentages between certain ranges of sizes (sieve openings).

Length Measurement
The longitudinal measurement taken along the specimen axis.

Plasticity
The property of fresh concrete or mortar which determines its resistance to deformation or its ease of molding.

PSI
Pounds per square inch; a measurement of the compressive, tensile or flexural strength of concrete as determined by appropriate test.

Pumping
The forceful displacement of a mixture of soil and water that occurs under slab joints, cracks, cracks and pavement edges which are depressed and released quickly by high-speed heavy vehicle loads; occurs when concrete pavements are placed directly on fine-grained, plastic soils or erodible sub base materials.

Quality Assurance
Planned and systematic actions by an owner or his representative to provide confidence that a product or facility meet applicable standards of good practice. This involves continued evaluation of design, plan specification development, contract advertisement and award, construction, and maintenance, and the interactions of these activities.

Quality Control
Actions taken by a producer or contractor to provide control over what is being done and what is being provided so that the applicable standards of good practice for the work are followed.

Rebar
Abbreviation for "Reinforcing Bar." Bars, wires, strands, and other slender members embedded in concrete in such a manner that the reinforcement and the concrete act together in resisting forces.

Rod, Tamping
A straight steel rod of circular cross section having one or both ends rounded to a hemispherical tip.

Rodding
Compaction of concrete by means of a tamping rod.

Sample
A group of units, or portion of material, taken from a larger collection of units or quantity of material, which serves to provide information that can be used as a basis for action on the larger quantity or the production process; the term is also used in the sense of a sample of observations.

Slump
A measure of consistency of freshly mixed concrete, equal to the subsidence measured to the nearest 6mm (¼ in.) of the molded specimen immediately after removal of the slump cone.

Standard Cure
The curing method used when specimens are intended for acceptance testing for specified strength, checking the adequacy of mixture proportions for strength, quality control.

Strike off
To remove concrete in excess of that required to fill the form evenly or bring the surface to grade; performed with a straight edged piece of wood or metal by means of forward sawing movement or by a power operated tool appropriate for this purpose; also the name applied to the tool.

Tamping
The operation of compacting freshly placed concrete by repeated blows or penetrations with a tamping device.

Thickness Measurement
The length measurement of a core taken perpendicular to the driving surface of a pavement.

Three Point Caliper
A device used to determine the length of a cylindrical shaped specimen consisting of three resting points and a means of evenly measuring nine different points on the opposite end.

Truck-Mixed Concrete
Concrete, the mixing of which is accomplished in a truck mixer.

SAMPLING FRESHLY MIXED CONCRETE
AASHTO T 141
ASTM C 172

Developed by
Western Alliance for Quality
Transportation Construction (WAQTC)

Modified by
Multi-Regional Training & Certification Group
2006

NOTE

There are no prerequisites for AASHTO T 141.

SAMPLING FRESHLY MIXED CONCRETE

This method covers procedures for obtaining representative samples of fresh concrete delivered to the project site and on which tests are to be performed to determine compliance with quality requirements of the specifications under which concrete is furnished. The method includes sampling from stationary, paving and truck mixers, and from agitating and non-agitating equipment used to transport central mixed concrete. Sampling concrete 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 the user of this standard to establish appropriate safety and health practices.
This method also covers the procedure for preparing a sample of concrete for further testing where it is necessary to remove aggregate larger than the designated size for the test method being performed. The removal of large aggregate particles is accomplished by wet sieving.

Common Sampling Errors
- Sampling before enough concrete has been disbursed
- Not obtaining enough portions to make a representative sample
- Sampling from a revolving drum mixer before all water has been added

SUMMARY OF TESTING

Apparatus

- Wheelbarrow
- Cover for wheelbarrow (plastic, canvas, or burlap)
- Buckets
- Shovel
- Cleaning equipment: including scrub brush, rubber gloves, water
- Apparatus for wet sieving including a sieve or sieves conforming to AASHTO M92 of suitable size and conveniently arranged and supported so that the sieve can be shaken rapidly by hand.

Procedure

1. Use every precaution in order to obtain samples representative of the true nature and condition of the concrete being placed being careful not to obtain samples from the very first or very last portions of the batch. The size of the sample will be 1.5 times the volume of concrete required for the specified testing, but not less than 0.03 m^3 (1 ft^3).
   Note 1: Sampling should normally be performed as the concrete is delivered from the mixer to the conveying vehicle used to transport the concrete to the forms; however, specifications may require other points of sampling, such as at the discharge of a concrete pump.

- **Sampling from stationary mixers, except paving mixers**

  Sample the concrete by collecting two or more portions taken at regularly spaced intervals during discharge of the middle of the batch. Combine the portions into one sample for testing purposes. Do not obtain portions of the composite sample from the very first or last part of the batch discharge. Perform sampling by passing a receptacle completely through the discharge stream, or by completely diverting the discharge into a sample container. Take care not to restrict the flow of concrete from the mixer, container, or transportation unit so as to cause segregation. These requirements apply to both tilting and nontilting mixers.

- **Sampling from paving mixers**

  Sample after the contents of the paving mixer have been discharged. Obtain material from at least five different locations in the pile and combine into one test sample. Avoid contamination with subgrade material or prolonged contact with absorptive subgrade. To preclude contamination or absorption by the subgrade, the concrete may be sampled by placing a shallow container on the subgrade and discharging the concrete across the container.

- **Sampling from revolving drum truck mixers or agitators**

  Sample the concrete after a minimum of 1/2 m^3 (1/2 yd^3) of concrete has been discharged. Do not obtain samples until after all of the water has been added to the mixer. Do not obtain samples from the very first or last portions of the batch discharge. Sample by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container. Regulate the rate of discharge of the batch by the rate of revolution of the drum and not by the size of the gate opening.

- **Sampling from open-top truck mixers, agitators, non-agitating equipment or other types of open-top containers**

  Sample by whichever of the procedures described above is most applicable under the given conditions.

- **Sampling from pump or conveyor placement systems**

  Sample after a minimum of 1/2 m^3 (1/2 yd^3) of concrete has been discharged. Do not obtain samples until after all of the pump slurry has been eliminated. Sample by repeatedly passing a receptacle through the entire discharge system or by completely diverting the discharge into a sample container. Do not lower the pump arm from the placement position to ground level for ease of sampling, as it may modify the air content of the concrete being sampled. Do not obtain samples from the very first or last portions of the batch discharge.

2. Transport samples to the place where fresh concrete tests are to be performed and specimens are to be molded. They shall then be combined and remixed with a shovel the minimum amount necessary to ensure uniformity. Protect the sample from direct sunlight, wind, rain, and sources of contamination.
3. Complete test for temperature and start tests for slump and air content within 5 minutes of obtaining the sample. Complete tests as expeditiously as possible. Start molding specimens for strength tests within 15 minutes of obtaining the sample.

Wet Sieving

When required for slump testing, air content testing or molding test specimens the concrete sample shall be wet-sieved, after transporting but prior to remixing, by the following.

1. Place the sieve designated by the test procedure over dampened sample container.
2. Pass the concrete over the designated sieve. Do not overload the sieve (one particle thick).
3. Shake or vibrate the sieve until no more material passes the sieve. A horizontal back and forth motion is preferred.
4. Discard oversize material including all adherent mortar.
5. Repeat until sample of sufficient size is obtained. Mortar adhering to the wet-sieving equipment shall be included with the sample.
6. Remix the sample with a shovel the minimum amount necessary to ensure uniformity.

Note 2: Wet-sieving is not allowed for samples being utilized for density determinations according to the FOP for AASHTO T 121.

TESTING METHODOLOGY

SAMPLING FRESHLY MIXED CONCRETE
AASHTO T 141

Significance

Testing fresh concrete in the field begins with obtaining and preparing the sample to be tested. Standardized procedures for obtaining a representative sample from various types of mixing and/or agitating equipment have been established. Specific time limits regarding when tests for temperature, slump, and air content must be started and for when the molding of test specimens must begin are also established.

Technicians must be patient and refrain from obtaining the sample too quickly. Doing so would be a violation of the specifications under which the concrete is being supplied and it may result in a nonrepresentative sample of concrete. If one considers that the specifications may require strength tests to be made only once every 100 to 150 m^3 or 100 to 150 yd^3, the need for a truly representative sample is apparent. The minimum 0.03 m^3 (1 ft^3) sample from which the compressive strength test specimens will be made represents only 0.02 to 0.03 percent of the total quantity of concrete placed. For this reason, every precaution must be taken to obtain a sample that is truly representative of the entire batch and then to protect that sample from the effects of evaporation, contamination, and physical damage.

Scope

This method covers procedures for obtaining representative samples of fresh concrete delivered to the project site and on which tests are to be performed to determine compliance

with quality requirements of the specifications under which
concrete is furnished.
The method includes sampling from stationary, paving and truck mixers, and from agitating and non-agitating equipment used to transport central mixed concrete. Sampling concrete 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 the user of this standard to establish appropriate safety and health practices.

This method also covers the procedure for preparing a sample of concrete for further testing where it is necessary to remove aggregate larger than the designated size for the test method being performed. The removal of large aggregate particles is accomplished by wet sieving.

Sampling apparatus

Apparatus

- Wheelbarrow
- Cover for wheelbarrow (plastic, canvas, or burlap)
- Buckets
- Shovel
- Cleaning equipment: including scrub brush, rubber gloves, water
- Apparatus for wet sieving including a sieve or sieves conforming to AASHTO M92 of suitable size and conveniently arranged and supported so that the sieve can be shaken rapidly by hand.

Procedure

Use every precaution in order to obtain samples representative of the true nature and condition of the concrete being placed being careful not to obtain samples from the very first or very last portions of the batch. The size of the sample will be 1.5 times the volume of concrete required for the specified testing, but not less than 0.03 m^3 (1 ft^3).

Note 1: Sampling should normally be performed as the concrete is delivered from the mixer to the conveying vehicle used to transport the concrete to the forms; however, specifications may require other points of sampling, such as at the discharge of a concrete pump.

- **Sampling from stationary mixers, except paving mixers**

  Sample the concrete by collecting two or more portions taken at regularly spaced intervals during discharge of the middle of the batch. Perform sampling by passing a receptacle completely through the discharge stream, or by completely diverting the discharge into a sample container. Take care not to restrict the flow of concrete from the mixer, container, or transportation unit so as to cause segregation. These requirements apply to both tilting and nontilting mixers.

Open-top truck

- **Sampling from paving mixers**

  Sample after the contents of the paving mixer have been discharged. Obtain material from at least five different locations in the pile and combine into one test sample. Avoid contamination with subgrade material or prolonged contact with absorptive subgrade. To preclude contamination or absorption by the subgrade, the concrete may be sampled by placing a shallow container on the subgrade and discharging the concrete across the container.

- **Sampling from revolving drum truck mixers or agitators**

  Sample the concrete after a minimum of 1/2 m^3 (1/2 yd^3) of concrete has been discharged. Do not obtain samples until after all of the water has been added to the mixer. Do not obtain samples from the very first or last portions of the batch discharge. Sample by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container. Regulate the rate of discharge of the batch by the rate of revolution of the drum and not by the size of the gate opening.

Sampling from truck mixer

- **Sampling from open-top truck mixers, agitators, non-agitating equipment or other types of open-top containers**

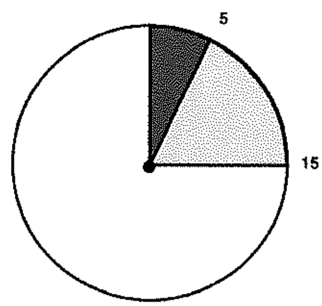
  Sample by whichever of the procedures described above is most applicable under the given conditions.

- **Sampling from pump or conveyor placement systems**

  Sample after a minimum of 1/2 m^3 (1/2 yd^3) of concrete has been discharged. Do not obtain samples until after all of the pump slurry has been eliminated. Sample by repeatedly passing a receptacle through the entire discharge system or by completely diverting the discharge into a sample container. Do not lower the pump arm from the placement position to ground level for ease of sampling, as it may modify the air content of the concrete being sampled. Do not obtain samples from the very first or last portions of the batch discharge.

Sampling at pump discharge

Transport samples to the place where fresh concrete tests are to be performed and specimens are to be molded. They shall then be combined and remixed with a shovel the minimum amount necessary to ensure uniformity. Protect the sample from direct sunlight, wind, rain, and sources of contamination.



Time from sampling to start of tests

Complete test for temperature and start tests for slump and air content within 5 minutes of obtaining the sample. Complete tests as expeditiously as possible. Start molding specimens for strength tests within 15 minutes of obtaining the sample.

Wet Sieving

When required for slump testing, air content testing or molding test specimens the concrete sample shall be wet-sieved, after transporting but prior to remixing, by the following.

1. Place the sieve designated by the test procedure over dampened sample container.
2. Pass the concrete over the designated sieve. Do not overload the sieve (one particle thick).
3. Shake or vibrate the sieve until no more material passes the sieve. A horizontal back and forth motion is preferred.
4. Discard oversize material including all adherent mortar.
5. Repeat until sample of sufficient size is obtained. Mortar adhering to the wet-sieving equipment shall be included with the sample.
6. Remix the sample with a shovel the minimum amount necessary to ensure uniformity.

   Note 2: Wet-sieving is not allowed for samples being utilized for density determinations according to the FOP for AASHTO T 121.

Tips!

- Read the specs.
- Start tests within the time specified.
- Organize all the equipment in advance.
- Do not to obtain samples from the very first or very last portions of the batch.

TEMPERATURE OF FRESHLY MIXED HYDRAULIC-CEMENT CONCRETE
AASHTO T 309
ASTM C 1064

FHWA SPONSORED

Developed by
Western Alliance for Quality
Transportation Construction (WAQTC)

Modified by
Multi-Regional Training & Certification Group
2006

NOTE

Successful completion of the following training materials, including examination and performance evaluation is a prerequisite for this training package.

- AASHTO T 141, Sampling Freshly Mixed Concrete

TEMPERATURE OF FRESHLY MIXED PORTLAND CEMENT CONCRETE

This procedure covers the determination of the temperature of freshly mixed Portland cement concrete in accordance with AASHTO T 309. It may be used to verify conformance to a specified requirement for temperature of concrete. Testing concrete 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 the user of this standard to establish appropriate safety and health practices.

COMMON TESTING ERRORS

- Not calibrating thermometer
- Not closing the void around the thermometer
- Not completing the test within 5 minutes after obtaining the sample
- Not leaving the thermometer in the concrete until the temperature stabilizes

SUMMARY OF TESTING

Apparatus

- Container — The container shall be made of nonabsorptive material and large enough to provide at least 75 mm (3 in.) of concrete in all directions around the sensor; concrete cover must also be a least three times the nominal maximum size of the coarse aggregate.
- Temperature Measuring Device — The temperature measuring device shall be calibrated and capable of measuring the temperature of the freshly mixed concrete to ±0.5°C (±1°F) throughout the temperature range likely to be encountered. Partial immersion liquid-in-glass thermometers (and possibly other types) shall have a permanent mark to which the device must be immersed without applying a correction factor.
- Reference Temperature Measuring Device — The reference temperature measuring device shall be a liquid-in-glass thermometer readable to 0.2°C (0.5°F) that has been verified and calibrated. The calibration certificate or report indicating conformance to the requirements of ASTM E 77 shall be available for inspection.

Calibration of Temperature Measuring Device

Each thermometer shall be verified for accuracy annually and whenever there is a question of accuracy. Calibration shall be performed by comparing readings on the temperature measuring device with another calibrated instrument at two temperatures at least 15°C or 27°F apart.

Sample Locations and Times

The temperature of freshly mixed concrete may be measured in the transporting equipment, in forms, or in sample containers, provided the sensor of the temperature measuring device has at least 75 mm (3 in.) of concrete cover in all direction around it.

Complete the temperature measurement of the freshly mixed concrete within 5 minutes of obtaining the sample.

Concrete containing aggregate of a nominal maximum size greater than 75 mm (3 in.) may require up to 20 minutes for the transfer of heat from the aggregate to the mortar after batching.

Procedure

1. Dampen the sample container.
2. Obtain the sample in accordance with AASHTO T 141.
3. Place sensor of the temperature measuring device in the freshly mixed concrete so that it has at least 75 mm (3 in.) of concrete cover in all directions around it.
4. Gently press the concrete in around the sensor of the temperature measuring device at the surface of the concrete so that air cannot reach the sensor.
5. Leave the sensor of the temperature measuring device in the freshly mixed concrete for a minimum of two minutes, or until the temperature reading stabilizes.
6. Complete the temperature measurement of the freshly mixed concrete within 5 minutes of obtaining the sample.
7. Read and record the temperature to the nearest 0.5°C (1°F).

Report

Results shall be reported on standard forms approved for use by the agency. Record the measured temperature of the freshly mixed concrete to the nearest 0.5°C (1°F).

TESTING METHODOLOGY

TEMPERATURE OF FRESHLY MIXED PORTLAND CEMENT CONCRETE

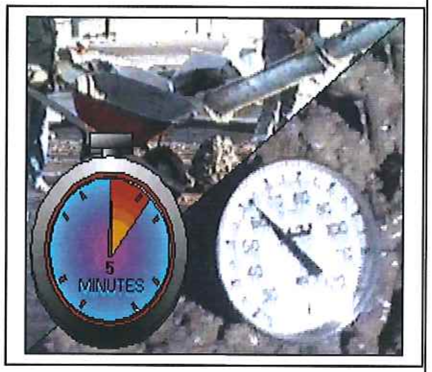
Significance

Concrete temperature is one of the most important factors influencing the quality, time of set and strength of concrete. Without control of concrete temperature, predicting the concrete's performance is very difficult, if not impossible. Concrete with a high initial temperature will probably have higher than normal early strength and lower than normal ultimate strength. Overall quality of the concrete will also probably be lowered. Conversely, concrete placed and cured at low temperatures will develop strength at a slower rate, but ultimately will have higher strength and be of a higher quality.

The temperatures of concrete and of the air are used to determine the type of curing and protection that will be needed, as well as the length of time curing and protection should be maintained. Ideally, concrete temperature will be between 16 and 27°C (60 and 80°F) during placement, and agency specifications may prohibit placement when air temperature is low, say below 2°C (36°F) or high, say above 32°C (90°F). Controlling concrete temperature and limiting placement to certain air temperatures will reduce or eliminate many problems, including those associated with strength development and durability.

Scope

This procedure covers the determination of the temperature of freshly mixed portland cement concrete in accordance with AASHTO T 309.



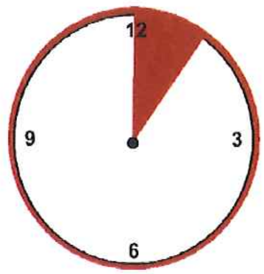
Temperature apparatus

Apparatus

- Container — The container shall be made of nonabsorptive material and large enough to provide at least 75 mm (3 in.) of concrete in all directions around the sensor; concrete cover must also be a least three times the nominal maximum size of the coarse aggregate.
- Temperature Measuring Device — The temperature measuring device shall be calibrated and capable of measuring the temperature of the freshly mixed concrete to ±0.5□C (±1□F) throughout the temperature range likely to be encountered. Partial immersion liquid-in-glass thermometers (and possibly other types) shall have a permanent mark to which the device must be immersed without applying a correction factor.
- Reference Temperature Measuring Device — The reference temperature measuring device shall be a liquid-in-glass thermometer readable to 0.2°C (0.5°F) that has been verified and calibrated. The calibration certificate or report indicating conformance to the requirements of ASTM E 77 shall be available for inspection.

Calibration of Temperature Measuring Device

Each thermometer shall be verified for accuracy annually and whenever there is a question of accuracy. Calibration shall be performed by comparing readings on the temperature measuring device with another calibrated instrument at two temperatures at least 15°C or 27°F apart.



5 Minutes!

Sample Locations and Times

The temperature of freshly mixed concrete may be measured in the transporting equipment, in forms, or in sample containers, provided the sensor of the temperature measuring device has at least 75 mm (3 in.) of concrete cover in all direction around it.

Complete the temperature measurement of the freshly mixed concrete within 5 minutes of obtaining the sample.

Concrete containing aggregate of a nominal maximum size greater than 75 mm (3 in.) may require up to 20 minutes for the transfer of heat from the aggregate to the mortar after batching.

Procedure

1. Dampen the sample container.
2. Obtain the sample in accordance with the FOP for WAQTC TM 2.
3. Place sensor of the temperature measuring device in the freshly mixed concrete so that it has at least 75 mm (3 in.) of concrete cover in all directions around it.
4. Gently press the concrete in around the sensor of the temperature measuring device at the surface of the concrete so that air cannot reach the sensor.

Pressing concrete around sensing device

5. Leave the sensor of the temperature measuring device in the freshly mixed concrete for a minimum of two minutes, or until the temperature reading stabilizes.
6. Complete the temperature measurement of the freshly mixed concrete within 5 minutes of obtaining the sample.
7. Read and record the temperature to the nearest 0.5°C (1°F).

Report

Results shall be reported on standard forms approved for use by the agency. Record the measured temperature of the freshly mixed concrete to the nearest 0.5□C (1□F).

Tips!

- Complete within 5 minutes of obtaining sample.
- Use calibrated thermometer.
- Ensure that the sensor is surrounded by concrete, not air.
- Allow time for temperature to stabilize.

SLUMP OF HYDRAULIC CEMENT CONCRETE
AASHTO T 119
ASTM C 143

Developed by
Western Alliance for Quality
Transportation Construction (WAQTC)

Modified by
Multi-Regional Training & Certification Group
2006

NOTE

Successful completion of the following training materials, including examination and performance evaluation is a prerequisite for this training package.

- AASHTO T 141, Sampling Freshly Mixed Concrete

SLUMP OF HYDRAULIC CEMENT CONCRETE

This procedure provides instructions for determining the slump of hydraulic cement concrete in accordance with AASHTO T 119. This test procedure takes a sample of fresh concrete, places it in a mold on a hard, non-porous surface, and after removing the mold and allowing the concrete to subside, a measurement can be taken to determine the slump. The measurement is the vertical distance between the original and displaced position of the center of the top surface of the concrete. It is not applicable to non-plastic and non-cohesive concrete. With concrete using 37.5mm (1½ in.) or larger aggregate, the +37.5mm (1½ in.) aggregate must be removed in accordance with the AASHTO T 141. Testing concrete 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 the user of this standard to establish appropriate safety and health practices.

COMMON TESTING ERRORS

- Not performing the test on a flat surface
- Removing the mold either too slowly or too quickly
- Using testing equipment that is dirty with built-up concrete
- Not measuring at the displaced center of the concrete

SUMMARY OF TESTING

Apparatus

- Mold: The metal mold shall be provided with foot pieces and handles. The mold must be constructed without a seam. The interior of the mold shall be relatively smooth and free from projections such as protruding rivets. The mold shall be free from dents. A mold that clamps to a rigid nonabsorbent base plate is acceptable provided the clamping arrangement is such that it can be fully released without movement of the mold.
- Mold: Other than metal must conform to AASHTO T 119 Sections 5.1.1.1 & 5.1.1.2.
- Tamping rod: 16 mm (5/8 in.) diameter and approximately 600 mm (24 in.) long, having a hemispherical tip. (Hemispherical means "half a sphere"; the tip is rounded like half of a ball.)
- Scoop
- Tape measure or ruler with at least 5 mm or 1/8 in. graduations
- Base: Flat, rigid, non-absorbent moistened surface on which to set the slump cone

Procedure

1. Obtain the sample in accordance with AASHTO T 141. If any aggregate 37.5mm (1½ in.) or larger aggregate is present, aggregate must be removed in accordance with the Wet Sieving portion of AASHTO T 141.

   Note 1: Testing shall begin within five minutes of obtaining the sample.

2. Dampen the inside of the cone and place it on a dampened, rigid, nonabsorbent surface that is level and firm.
3. Stand on both foot pieces in order to hold the mold firmly in place.
4. Fill the cone 1/3 full by volume, to a depth of approximately 67 mm (2 5/8 in.) by depth.
5. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. For this bottom layer, incline the rod slightly and make approximately half the strokes near the perimeter, and then progress with vertical strokes, spiraling toward the center.

6. Fill the cone 2/3 full by volume, to a depth of approximately 155 mm (6 1/8 in.) by depth.

7. Consolidate this layer with 25 strokes of the tamping rod, just penetrating into the bottom layer. Distribute the strokes evenly.

8. Fill the cone to overflowing.

9. Consolidate this layer with 25 strokes of the tamping rod, just penetrating into the second layer. Distribute the strokes evenly. If the concrete falls below the top of the cone, stop, add more concrete, and continue rodding for a total of 25 strokes. Keep an excess of concrete above the top of the mold at all times. Distribute strokes evenly as before.

10. Strike off the top surface of concrete with a screeding and rolling motion of the tamping rod.

11. Clean overflow concrete away from the base of the mold.

12. Remove the mold from the concrete by raising it carefully in a vertical direction. Raise the mold 300 mm (12 in.) in 5 ±2 seconds by a steady upward lift with no lateral or torsional motion being imparted to the concrete.

    The entire operation from the start of the filling through removal of the mold shall be carried out without interruption and shall be completed within an elapsed time of 2 1/2 minutes.

13. Invert the slump cone and set it next to the specimen.

14. Lay the tamping rod across the mold so that it is over the test specimen.

15. Measure the distance between the <u>bottom</u> of the rod and the displaced original center of the top of the specimen to the nearest 5 mm (1/4 in.).

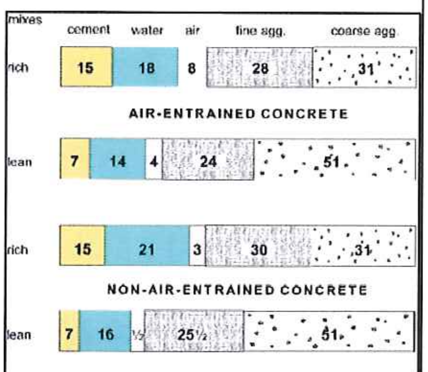
    Note 2: If a decided falling away or shearing off of concrete from one side or portion of the mass occurs, disregard the test and make a new test on another portion of the sample. If two consecutive tests on a sample of concrete show a falling away or shearing off of a portion of the concrete from the mass of the specimen, the concrete probably lacks the plasticity and cohesiveness necessary for the slump test to be applicable.

Report

Results shall be reported on standard forms approved for use by the agency. Record the slump to the nearest 5 mm (1/4 in.).

TESTING METHODOLOGY

SLUMP OF HYDRAULIC CEMENT CONCRETE



COMPONENTS OF CONCRETE IN PERCENT

Significance

The slump test is used to determine the consistency of concrete. Consistency is a measure of the relative fluidity or mobility of the mixture. Slump does not measure the water content of the concrete. While it is true that an increase or decrease in the water content will cause a corresponding increase or decrease in the slump of the concrete, many other factors can cause slump to change without any change in water content.

Also, water content may increase or decrease without any change in slump. Factors such as a change in aggregate properties, grading, mix proportions, air content, concrete temperature, or the use of special admixtures can influence the slump of the concrete. These can also result in a change in the water requirement for maintaining a given slump. For these reasons, one cannot assume that the water/cement ratio is being maintained simply because the slump is within the specification limits.

Scope

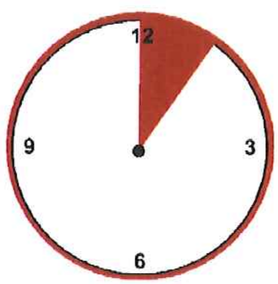
This procedure provides instructions for determining the slump of hydraulic cement concrete in accordance with AASHTO T 119. It is not applicable to non-plastic and non-cohesive concrete. With concrete using 37.5mm (1½ in.) or larger aggregate, the +37.5mm (1½ in.) aggregate must be removed in accordance with AASHTO T 141.

Apparatus

- Mold: The metal mold shall be provided with foot pieces and handles. The mold must be constructed without a seam. The interior of the mold shall be relatively smooth and free from projections such as protruding rivets. The mold shall be free from dents. A mold that clamps to a rigid nonabsorbent base plate is acceptable provided the clamping arrangement is such that it can be fully released without movement of the mold.
- Mold: Other than metal must conform to AASHTO T 119 Sections 5.1.1.1 & 5.1.1.2.

Apparatus

- Tamping rod: 16 mm (5/□in.) diameter and approximately 600 mm (24 in.) long, having a hemispherical tip. (Hemispherical means "half a sphere"; the tip is rounded like half of a ball.)
- Scoop
- Tape measure or ruler with at least 5 mm or 1/8 in. graduations
- Base: Flat, rigid, non-absorbent moistened surface on which to set the slump cone



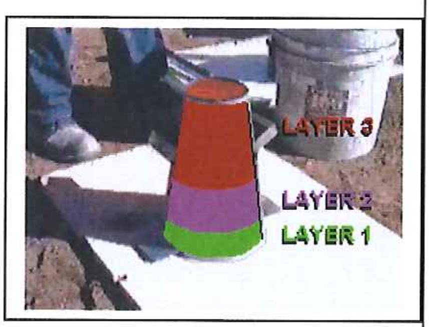
5 Minutes!

Procedure

1. Obtain the sample in accordance with AASHTO T 141. If any aggregate 37.5mm (1½ in.) or larger aggregate is present aggregate must be removed in accordance with the Wet Sieving portion of AASHTO T 141.

   Note 1: Testing shall begin within five minutes of obtaining the sample.

2. Dampen the inside of the cone and place it on a dampened, rigid, nonabsorbent surface that is level and firm.
3. Stand on both foot pieces in order to hold the mold firmly in place.
4. Fill the cone 1/3 full by volume, to a depth of approximately 67 mm (2 5/8 in.) by depth.



Three layers by volume

5. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. For this bottom layer, incline the rod slightly and make approximately half the strokes near the perimeter, and then progress with vertical strokes, spiraling toward the center.

Consolidating top layer

6. Fill the cone 2/3 full by volume, to a depth of approximately 155 mm (6 1/8 in.) by depth.
7. Consolidate this layer with 25 strokes of the tamping rod, just penetrating into the bottom layer. Distribute the strokes evenly.
8. Fill the cone to overflowing.
9. Consolidate this layer with 25 strokes of the tamping rod, just penetrating into the second layer. Distribute the strokes evenly. If the concrete falls below the top of the cone, stop, add more concrete, and continue rodding for a total of 25 strokes. Keep an excess of concrete above the top of the mold at all times. Distribute strokes evenly as before.

Striking off surface

10. Strike off the top surface of concrete with a screeding and rolling motion of the tamping rod.
11. Clean overflow concrete away from the base of the mold.
12. Remove the mold from the concrete by raising it carefully in a vertical direction. Raise the mold 300 mm (12 in.) in 5 □2 seconds by a steady upward lift with no lateral or torsional motion being imparted to the concrete.

    The entire operation from the start of the filling through removal of the mold shall be carried out without interruption and shall be completed within an elapsed time of 2 1/2 minutes.

Lifting slump cone

13. Invert the slump cone and set it next to the specimen.

14. Lay the tamping rod across the mold so that it is over the test specimen.

15. Measure the distance between the bottom of the rod and the displaced original center of the top of the specimen to the nearest 5 mm (1/4 in.).

    Note2: If a decided falling away or shearing off of concrete from one side or portion of the mass occurs, disregard the test and make a new test on another portion of the sample. If two consecutive tests on a sample of concrete show a falling away or shearing off of a portion of the concrete from the mass of the specimen, the concrete probably lacks the plasticity and cohesiveness necessary for the slump test to be applicable.

Measuring slump

Report

Results shall be reported on standard forms approved for use by the agency. Record the slump to the nearest 5 mm (1/4 in.).

Tips!

- Start within 5 minutes of obtaining sample.
- Avoid locations subject to vibration.
- Consolidation strokes in middle and top layers do not go through entire sample.
- Fill in thirds by volume, not height.

AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE PRESSURE METHOD

AASHTO T 152

ASTM C 231

FHWA SPONSORED

Developed by
Western Alliance for Quality
Transportation Construction (WAQTC)

Modified by
Multi-Regional Training & Certification Group
2006

NOTE

Successful completion of the following training materials, including examination and performance evaluation is a prerequisite for this training package.

- AASHTO T 141, Sampling Freshly Mixed Concrete

AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE PRESSURE METHOD

This procedure covers determination of the air content in freshly mixed Portland Cement Concrete containing dense aggregates in accordance with AASHTO T 152,Type B meter. It is not for use with lightweight or highly porous aggregates. This procedure includes calibration of the Type B air meter gauge, and two methods for calibrating the gauge are presented. Concrete containing aggregate that would be retained on the 50 mm (2 in) sieve must be wet sieved. Sieve a sufficient amount of the sample over the 37.5 mm (1 ½") sieve per the wet sieving portion of AASHTO T 141. Testing concrete 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 the user of this standard to establish appropriate safety and health practices.

COMMON TESTING ERRORS

- Using equipment that has hardened concrete left in the bowl
- Air meter not calibrated regularly
- Improper consolidation of fresh concrete
- Rim of the bowl not properly cleaned after being filled with concrete

SUMMARY OF TESTING

Apparatus

- Air meter: Type B, as described in AASHTO T 152
- Balance or scale: Accurate to 0.3 percent of the test load at any point within the range of use (for Method 1 calibration only)
- Tamping rod: 16 mm (5/8 in.) diameter and approximately 600 mm (24 in.) long, having a hemispherical tip. (Hemispherical means "half a sphere"; the tip is rounded like half of a ball.)
- Vibrator: 7000 vibrations per minute, 19 to 38 mm (0.75 to 1.50 in.) in diameter, at least 75 mm (3 in.) longer than the section being vibrated for use with low slump concrete
- Scoop
- Container for water: rubber syringe (may also be a squeeze bottle)
- Strike-off bar: Approximately 300 mm x 22 mm x 3 mm (12 in. x 3/4 in. x 1/8 in.)
- Strike-off Plate: A flat rectangular metal plate at least 6 mm (1/4 in.) thick or a glass or acrylic plate at least 12 mm (1/2 in.) thick, with a length and width at least 50 mm (2 in.) greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within tolerance of 1.5 mm (1/16 in.).

  Note 1: Use either the strike-off bar or strike-off plate; both are not required.
- Mallet: With a rubber or rawhide head having a mass of 0.57 ±0.23 kg (1.25 ±0.5 lb)

Calibration of Air Meter Gauge

Note 2: There are two methods for calibrating the air meter, mass or volume.

1. Screw the short piece of straight tubing into the threaded petcock hole on the underside of the cover. Determine the mass of the dry, empty air meter bowl and cover assembly (Mass Method only).
2. Fill the bowl nearly full with water.
3. Clamp the cover on the bowl with the tube extending down into the water. Mark the petcock with the tube attached for future reference.
4. Add water through the petcock having the pipe extension below until all air is forced out the other petcock. Rock the meter slightly until all air is expelled through the petcock.
5. Wipe off the air meter bowl and cover assembly, and determine the mass of the filled unit (Mass Method only).

6. Pump up the air pressure to a little beyond the predetermined initial pressure indicated on the gauge. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

7. Close both petcocks and immediately open the main air valve exhausting air into the bowl. Wait a few seconds until the meter needle stabilizes. The gauge should now read 0 percent. If two or more tests show a consistent variation from 0 percent in the result, change the initial pressure line to compensate for the variation, and use the newly established initial pressure line for subsequent tests.

8. Determine which petcock has the straight tube attached to it. Attach the curved tube to external portion of the same petcock.

9. Pump air into the air chamber. Open the petcock with the curved tube attached to it. Open the main air valve for short periods of time until 5 percent of water by mass or volume has been removed from the air meter. Remember to open both petcocks to release the pressure in the bowl and drain the water in the curved tube back into the bowl. To determine the mass of the water to be removed, subtract the mass found in Step 1 from the mass found in Step 5. Multiply this value by 0.05. This is the mass of the water that must be removed. To remove 5 percent by volume, remove water until the external calibrating vessel is level full.

   Note3: Many air meters are supplied with a calibration vessel(s) of known volume that are used for this purpose. Calibration vessel(s) should be brass, not plastic, and must be protected from crushing or denting.
   If an external calibration vessel is used, confirm what percentage volume it represents for the air meter being used. Vessels commonly represent 5 percent volume, but they are for specific size meters. This should be confirmed by mass.

10. Remove the curved tube. Pump up the air pressure to a little beyond the predetermined initial pressure indicated on the gauge. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

11. Close both petcocks and immediately open the main air valve exhausting air into the bowl. Wait a few seconds until the meter needle is stabilized. The gauge should now read 5.0 ±0.1 percent. If the gauge is outside that range, the meter needs adjustment. The adjustment could involve adjusting the starting point so that the gauge reads 5.0 ±0.1 percent when this calibration is run, or could involve moving the gauge needle to read 5.0 percent. Any adjustment should comply with the manufacturer's recommendations.
    Note 4: Calibration shall be performed at the frequency required by the agency. Record the date of the calibration, the calibration results, and the name of the technician performing the calibration in the log book kept with each air meter.

12. When the gauge hand reads correctly at 5.0 percent, additional water may be withdrawn in the same manner to check the results at other values such as 10 percent or 15 percent.

13. If an internal calibration vessel is used follow steps 1 thru 8 to set initial reading.

14. Release pressure from the bowl and remove cover. Place the internal calibration vessel into the bowl. This will displace 5 percent of the water in the bowl. (see AASHTO 152 for more information on internal calibration vessels)

15. Place the cover back on the bowl and add water through the petcock until all the air has been expelled.

16. Pump up the air pressure chamber to the initial pressure. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

17. Close both petcocks and immediately open the main air valve exhausting air into the bowl. Wait a few seconds until the meter needle stabilizes. The gauge should now read 5 percent.

Note 5: Remove the extension tubing from threaded petcock hole in the underside of the cover before starting the test procedure.

Procedure - General

Note 6: There are two methods of consolidating the concrete – rodding and internal vibration. If the slump is greater than 75 mm (3 in.), consolidation is by rodding. When the slump is 25 to 75 mm (1 to 3 in.), internal vibration or rodding can be used to consolidate the sample, but the method used must be that required by the agency in order to obtain consistent, comparable results. For slumps less than 25 mm (1 in.), consolidate the sample by internal vibration. The internal vibration procedure follows this general procedure.

1. Obtain the sample in accordance with AASHTO T 141. If any aggregate 37.5mm (1½ in.) or larger aggregate is present aggregate must be removed in accordance with the Wet Sieving portion of AASHTO T 141.
   Note 7: Testing shall begin within five minutes of obtaining the sample.
2. Dampen the inside of the air meter bowl and place on a firm level surface.

3. Fill the bowl approximately 1/3 full with concrete.

4. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. Rod throughout its depth without hitting the bottom too hard.

5. Tap the sides of the bowl smartly 10 to 15 times with the mallet to close voids and release trapped air.

6. Add the second layer, filling the bowl about 2/3 full.

7. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 25 mm (1 in.) into the bottom layer.

8. Tap the sides of the bowl 10 to 15 times with the mallet.

9. Add the final layer, slightly overfilling the bowl.

10. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 25 mm (1 in.) into the second layer.

11. Tap the sides of the bowl smartly 10 to 15 times with the mallet.
    Note 8: The bowl should be slightly over full, about 3 mm (1/8 in.) above the rim. If there is a great excess of concrete, remove a portion with the trowel or scoop. If the bowl is under full, add a small quantity. This adjustment may be done only after consolidating the final layer and before striking off the surface of the concrete.

12. Strike off the surface of the concrete and finish it smoothly with a sawing action of the strike-off bar or plate, using great care to leave the bowl just full. The surface should be smooth and free of voids.

13. Clean the top flange of the bowl to ensure a proper seal.

14. Moisten the inside of the cover and check to see that both petcocks are open and the main air valve is closed.

15. Clamp the cover on the bowl.

16. Inject water through a petcock on the cover until water emerges from the petcock on the other side.

17. Jar and or rock the air meter gently until no air bubbles appear to be coming out of the second petcock.

18. Close the air bleeder valve and pump air into the air chamber until the needle goes past the initial pressure determined for the gauge. Allow a few seconds for the compressed air to cool.

19. Tap the gauge gently with one hand while slowly opening the air bleeder valve until the needle rests on the initial pressure . Close the air bleeder valve.

20. Close both petcocks.

21. Open the main air valve.

22. Tap the sides of the bowl smartly with the mallet.

23. Lightly tap the gauge to settle the needle, and then read the air content to the nearest 0.1 percent.

24. Close the main air valve.

25. Open both petcocks to release pressure, remove the concrete, and thoroughly clean the cover and bowl with clean water.

26. Open the main air valve to relieve the pressure in the air chamber.

Procedure - Internal Vibration

1. Obtain the sample in accordance with the AASHTO T 141. If any aggregate 37.5mm (1½ in.) or larger aggregate is present aggregate must be removed in accordance with the Wet Sieving portion of AASHTO T 141.
2. Dampen the inside of the air meter bowl and place on a firm level surface.
3. Fill the bowl approximately half full.
4. Insert the vibrator at three different points. Do not let the vibrator touch the bottom or sides of the bowl.

   Note 9: Remove the vibrator slowly, so that no air pockets are left in the material.

   Note 10: Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation and loss of appreciable quantities of intentionally entrained air.
5. Fill the bowl a bit over full.
6. Insert the vibrator as in Step 3. Do not let the vibrator touch the sides of the bowl, and penetrate the first layer approximately 25 mm (1 in.).
7. Return to Step 12 of the general procedure and continue.

Report

- Results shall be reported on standard forms approved for use by the agency.
- Record the percent of air to the nearest 0.1 percent.
- Some agencies require an aggregate correction factor in order to determine total % entrained air.

Total % entrained air = Gauge reading – aggregate correction factor from mix design

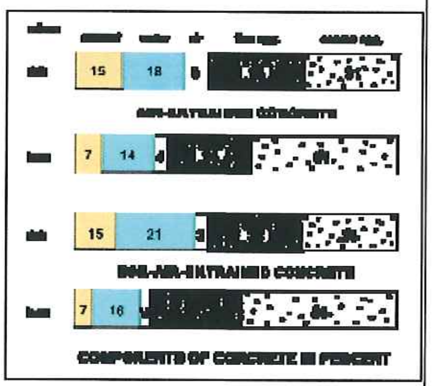
See AASHTO T 152 for more information.

TESTING METHODOLOGY

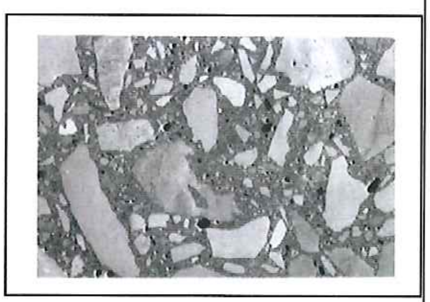
AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE PRESSURE METHOD

Significance

Concrete is not a solid, but rather a solid with void spaces. The voids may contain gas such as air, or liquid, such as water. All concrete contains air voids, and the amount can be increased by the addition of an air entraining agent to the mix. When such an agent is used, the size of the voids drastically decreases and the number of voids greatly increases, providing a much greater dispersal of voids.



Air entrainment is necessary in concrete that will be saturated and exposed to cycles of freezing and thawing, and to deicing chemicals. The microscopic entrained air voids provide a site for relief of internal pressure that develops as water freezes and thaws inside the concrete. Without the proper entrained-air content, normal concrete that is saturated and is exposed to cycles of freezing and thawing can fail prematurely by scaling, spalling, or cracking.

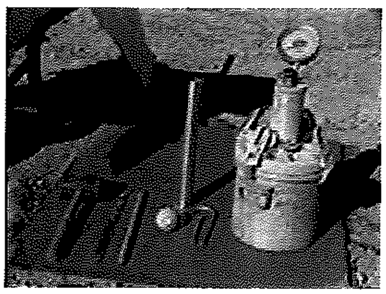


Air Voids

Care must be taken, however, not to have too much entrained air. As the air content increases, there will be a corresponding reduction in the strength and other desirable properties of the concrete. Typically, this strength reduction will be on the order of 3 to 5 percent for each 1 percent of air content. A concrete mix design proportioned for 5 percent air, for example, will be approximately 15 to 25 percent lower in strength if the air content were to double.

Scope

This procedure covers determination of the air content in freshly mixed Portland Cement Concrete containing dense aggregates in accordance with AASHTO T 152, Type B meter. It is not for use with lightweight or highly porous aggregates. This procedure includes calibration of the Type B air meter gauge, and two methods for calibrating the gauge are presented. Concrete containing aggregate that would be retained on the 50 mm (2 in) sieve must be wet sieved. Sieve a sufficient amount of the sample over the 37.5 mm (1 ½") sieve the wet sieving portion of AASHTO T 141.



Apparatus

Apparatus

- Air meter: Type B, as described in AASHTO T 152.
- Balance or scale: Accurate to 0.3 percent of the test load at any point within the range of use (for Method 1 calibration only).
- Tamping rod: 16 mm (5/8 in.) diameter and approximately 600 mm (24 in.) long, having a hemispherical tip. (Hemispherical means half a sphere; the tip is rounded like half of a ball).
- Vibrator: 7000 vibrations per minute, 19 to 38 mm (0.75 to 1.50 in.) in diameter, at least 75 mm (3 in.) longer than the section being vibrated for use with low slump concrete.
- Scoop
- Container for water: rubber syringe (may also be a squeeze bottle).
- Strike-off bar: Approximately 300 mm x 22 mm x 3 mm (12 in. x 3/4 in. x 1/8 in.).
- Strike-off Plate: A flat rectangular metal plate at least 6 mm (1/4 in.) thick or a glass or acrylic plate at least 12 mm (1/2 in.) thick, with a length and width at least 50 mm (2 in.) greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within tolerance of 1.5 mm (1/16 in.).

  Note 1: Use either the strike-off bar or strike-off plate; both are not required.

- Mallet: With a rubber or rawhide head having a mass of 0.57 ±0.23 kg (1.25 ±0.5 lb).

Calibration of Air Meter Gauge

Note 2: There are two methods for calibrating the air meter, mass or volume.

1. Screw the short piece of straight tubing into the threaded petcock hole on the underside of the cover. Determine the mass of the dry, empty air meter bowl and cover assembly. (Mass Method only)
2. Fill the bowl nearly full with water.
3. Clamp the cover on the bowl with the tube extending down into the water. Mark the petcock with the tube attached for future reference.
4. Add water through the petcock having the pipe extension below until all air is forced out the other petcock. Rock the meter slightly until all air is expelled through the petcock.
5. Wipe off the air meter bowl and cover assembly, and determine the mass of the filled unit (Mass Method only).
6. Pump up the air pressure to a little beyond the predetermined initial pressure indicated on the gauge. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.
7. Close both petcocks and immediately open the main air valve exhausting air into the bowl. Wait a few seconds until the meter needle stabilizes. The gauge should now read 0 percent. If two or more tests show a consistent variation from 0 percent in the result, change the initial pressure line to compensate for the variation, and use the newly established initial pressure line for subsequent tests.

Gauge reading zero

8. Determine which petcock has the straight tube attached to it. Attach the curved tube to external portion of the same petcock.

9. Pump air into the air chamber. Open the petcock with the curved tube attached to it. Open the main air valve for short periods of time until 5 percent of water by mass or volume has been removed from the air meter. Remember to open both petcocks to release the pressure in the bowl and drain the water in the curved tube back into the bowl. To determine the mass of the water to be removed, subtract the mass found in Step 1 from the mass found in Step 5. Multiply this value by 0.05. This is the mass of the water that must be removed. To remove 5 percent by volume, remove water until the external calibrating vessel is level full.

Note3: Many air meters are supplied with a calibration vessel(s) of known volume that are used for this purpose. Calibration vessel(s) should be brass, not plastic, and must be protected from crushing or denting.
If an external calibration vessel is used, confirm what percentage volume it represents for the air meter being used. Vessels commonly represent 5 percent volume, but they are for specific size meters. This should be confirmed by mass.

Air meter gauge

10. Remove the curved tube. Pump up the air pressure to a little beyond the predetermined initial pressure indicated on the gauge. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

11. Close both petcocks and immediately open the main air valve exhausting air into the bowl. Wait a few seconds until the meter needle is stabilized. The gauge should now read 5.0 ±0.1 percent. If the gauge is outside that range, the meter needs adjustment. The adjustment could involve adjusting the starting point so that the gauge reads 5.0 ±0.1 percent when this calibration is run, or could involve moving the gauge needle to read 5.0 percent. Any adjustment should comply with the manufacturer's recommendations.

    Note 4: Calibration shall be performed at the frequency required by the agency. Record the date of the calibration, the calibration results, and the name of the technician performing the calibration in the log book kept with each air meter.

12. When the gauge hand reads correctly at 5.0 percent, additional water may be withdrawn in the same manner to check the results at other values such as 10 percent or 15 percent.

13. If an internal calibration vessel is used follow steps 1 thru 8 to set initial reading.

14. Release pressure from the bowl and remove cover. Place the internal calibration vessel into the bowl. This will displace 5 percent of the water in the bowl. (see AASHTO 152 for more information on internal calibration vessels)

15. Place the cover back on the bowl and add water through the petcock until all the air has been expelled.

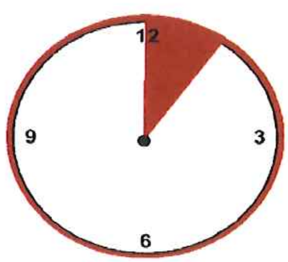
16. Pump up the air pressure chamber to the initial pressure. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

17. Close both petcocks and immediately open the main air valve exhausting air into the bowl. Wait a few seconds until the meter needle stabilizes. The gauge should now read 5 percent.

    Note 5: Remove the extension tubing from threaded petcock hole in the underside of the cover before starting the test procedure.

Procedure - General

Note 6: There are two methods of consolidating the concrete – rodding and internal vibration. If the slump is greater than 75 mm (3 in.), consolidation is by rodding. When the slump is 25 to 75 mm (1 to 3 in.), internal vibration or rodding can be used to consolidate the sample, but the method used must be that required by the agency in order to obtain consistent, comparable results. For slumps less than 25 mm (1 in.), consolidate the sample by internal vibration. The internal vibration procedure follows this general procedure.



5 Minutes!

1. Obtain the sample in accordance with AASHTO T 141. If any aggregate 37.5mm (1½ in.) or larger aggregate is present aggregate must be removed in accordance with the Wet Sieving portion of AASHTO T 141.

    Note 7: Testing shall begin within five minutes of obtaining the sample.

2. Dampen the inside of the air meter bowl and place on a firm level surface.

Consolidation

Tapping Measure

Strike Off

3. Fill the bowl approximately 1/3 full with concrete.
4. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. Rod throughout its depth without hitting the bottom too hard.
5. Tap the sides of the bowl smartly 10 to 15 times with the mallet to close voids and release trapped air.
6. Add the second layer, filling the bowl about 2/3 full.
7. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 25 mm (1 in.) into the bottom layer.
8. Tap the sides of the bowl 10 to 15 times with the mallet.
9. Add the final layer, slightly overfilling the bowl.
10. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 25 mm (1 in.) into the second layer.
11. Tap the sides of the bowl smartly 10 to 15 times with the mallet.

    Note 8: The bowl should be slightly over full, about 3 mm (1/8 in.) above the rim. If there is a great excess of concrete, remove a portion with the trowel or scoop. If the bowl is under full, add a small quantity. This adjustment may be done only after consolidating the final layer and before striking off the surface of the concrete.

12. Strike off the surface of the concrete and finish it smoothly with a sawing action of the strike-off bar or plate, using great care to leave the bowl just full. The surface should be smooth and free of voids.
13. Clean the top flange of the bowl to ensure a proper seal.

14. Moisten the inside of the cover and check to see that both petcocks are open and the main air valve is closed.
15. Clamp the cover on the bowl.
16. Inject water through a petcock on the cover until water emerges from the petcock on the other side.
17. Jar and or rock the air meter gently until no air bubbles appear to be coming out of the second petcock.
18. Close the air bleeder valve and pump air into the air chamber until the needle goes past the initial pressure determined for the gauge. Allow a few seconds for the compressed air to cool.

Tapping Air Meter Gauge

19. Tap the gauge gently with one hand while slowly opening the air bleeder valve until the needle rests on the initial pressure. Close the air bleeder valve.
20. Close both petcocks.
21. Open the main air valve.
22. Tap the sides of the bowl smartly with the mallet.
23. Lightly tap the gauge to settle the needle, and then read the air content to the nearest 0.1 percent.
24. Close the main air valve.
25. Open both petcocks to release pressure, remove the concrete, and thoroughly clean the cover and bowl with clean water.
26. Open the main air valve to relieve the pressure in the air chamber.

Procedure - Internal Vibration

1. Obtain the sample in accordance with AASHTO T 141. If any aggregate 37.5mm (1½ in.) or larger aggregate is present aggregate must be removed in accordance with the Wet Sieving portion of AASHTO T 141.
2. Dampen the inside of the air meter bowl and place on a firm level surface.
3. Fill the bowl approximately half full.
4. Insert the vibrator at three different points. Do not let the vibrator touch the bottom or sides of the bowl.

   Note 9: Remove the vibrator slowly, so that no air pockets are left in the material.

   Note 10: Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation and loss of appreciable quantities of intentionally entrained air.
5. Fill the bowl a bit over full.
6. Insert the vibrator as in Step 3. Do not let the vibrator touch the sides of the bowl, and penetrate the first layer approximately 25 mm (1 in.).
7. Return to Step 12 of the general procedure and continue.

Report

- Results shall be reported on standard forms approved for use by the agency.
- Record the percent of air to the nearest 0.1 percent.
- Some agencies require an aggregate correction factor in order to determine total percent entrained air.
  Total % entrained air =
  Gauge reading – aggregate correction factor from mix design
  (See AASHTO T 152 for more information)

MAKING AND CURING CONCRETE TEST SPECIMENS IN THE FIELD
AASHTO T 23
ASTM C 31

Developed by
Western Alliance for Quality
Transportation Construction (WAQTC)

Modified by
Multi-Regional Training & Certification Group
2006

NOTE

Successful completion of the following training materials, including examination and performance evaluation is a prerequisite for this training package.

- AASHTO T 141, Sampling Freshly Mixed Concrete
- AASHTO T 309, Temperature of Freshly Mixed Hydraulic-Cement Concrete
- AASHTO T 119, Slump of Hydraulic Cement Concrete
- AASHTO T 152, Air Content of Freshly Mixed Concrete by the Pressure Method
- AASHTO T 121, Density, Yield, and Air Content of Concrete

METHOD OF MAKING AND CURING CONCRETE TEST SPECIMENS IN THE FIELD

This procedure covers the method for making, initially curing, and transporting concrete test specimens in the field in accordance with AASHTO T 23. The concrete should be sampled after all the on-site adjustments have been made to the mix. This would include the addition of water, admixtures, etc. Testing concrete 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 the user of this standard to establish appropriate safety and health practices.

Common Testing Errors

- Improper consolidation of concrete in mold
- Specimens being jarred or moved while in the initial storage location
- Improper curing method used
- Not protecting the specimen while transporting

SUMMARY OF TESTING

Apparatus and Test Specimens

- Concrete cylinder molds: Conforming to AASHTO M 205 with a length equal to twice the diameter. Standard specimens shall be 150 mm (6 in.) by 300 mm (12 in.) cylinders. Mold diameter must be at least three times maximum aggregate size unless wet sieving is conducted according to the FOP for WAQTC TM 2. Agency specifications may allow cylinder molds of 100 mm (4 in.) by 200 mm (8 in.) size when the nominal maximum aggregate size does not exceed 25 mm (1 in.).
- Beam molds: Rectangular in shape with ends and sides at right angles to each other. Must be sufficiently rigid to resist warpage. Surfaces must be smooth. Molds shall produce length no more than 1.6 mm (1/16") shorter than that required (greater length is allowed). Maximum variation from nominal cross section shall not exceed 3.2 mm (1/8 in.). Ratio of width to depth may not exceed 1.5; the smaller dimension must be at least 3 times maximum aggregate size. Unless otherwise noted in specifications, beam molds for casting specimens in the field shall result in specimens having width and depth of not less than 150 mm (6 inches). Specimens shall be cast and hardened with the long axes horizontal.
- Standard tamping rod: 16 mm (5/8 in.) diameter and approximately 600 mm (24 in.) long, having a hemispherical tip for preparing 150mm (6 in.) x 300 mm (12 in.) cylinders.
- Small tamping rod: 10 mm (3/8 in.) diameter and approximately 305 mm (12 in.) long, having a hemispherical tip for preparing 100 mm (4 in.) x 200 mm (8 in.) cylinders.
- Vibrator: At least 7000 vibrations per minute, diameter no more than ¼ the diameter or width of the mold and at least 75 mm (3 in.) longer than the section being vibrated for use with low slump concrete.
- Scoop
- Trowel or Float
- Mallet: With a rubber or rawhide head having a mass of 0.57 ± 0.23 kg (1.25 ±0.5 lb.).
- Rigid base plates and cover plates: metal, glass, or plywood.
- Initial Curing Facilities: Temperature controlled curing box or enclosure capable of maintaining the required range of 16 to 27° C (60 to 80°F) during the entire initial curing period (for concrete with compressive strength of 40 Mpa (6000 psi) or more, the temperature shall be 20 to 26°C (68 to 78°F). As an alternative, sand or earth for initial cylinder protection may be used provided that the required temperature range is maintained and the specimens are not damaged.
- **Thermometer:** Capable of registering both maximum and minimum temperatures during the initial cure.

Procedure – Making Specimens – General

1. Obtain the sample according with AASHTO T 141. Wet Sieving per AASHTO T 141 is required when concrete contains aggregate with a nominal maximum size greater than 50 mm (2 in.) for specimen's with a 150 mm (6 in.) diameter, or greater than 25 mm (1 in.) for specimen's with a 100 mm (4 in.) diameter.
2. Remix the sample after transporting to testing location.
3. Begin making specimens within 15 minutes of obtaining the sample.
4. Set molds upright on a level rigid base in a location free from vibration and relatively close to where they will be stored.
5. Fill molds in the required number of layers attempting to exactly fill the mold on the final layer. Add or remove concrete prior to completion of consolidation to avoid a deficiency or excess of concrete.
6. There are two methods of consolidating the concrete – rodding and internal vibration. If the slump is greater than 25 mm (1 in.), consolidation may be by rodding or vibration. When the slump is 25 mm (1 in.) or less, consolidate the sample by internal vibration. Agency specifications may dictate when rodding or vibration will be used.

Procedure – Making Cylinders – Rodding

1. For the standard 150 mm (6 in.) by 300 mm (12 in.) specimen, fill each mold in three approximately equal layers, moving the scoop or trowel around the perimeter of the mold to evenly distribute the concrete. For the 100 mm (4 in.) by 200 mm (8 in.) specimen, fill the mold in two layers. When filling the final layer, slightly overfill the mold.
2. Consolidate each layer with 25 strokes of the appropriate tamping rod, using the rounded end. Distribute strokes evenly over the cross section of the concrete. Rod the first layer throughout its depth without forcibly hitting the bottom. For subsequent layers, rod the layer throughout its depth penetrating approximately 25 mm (1 in.) into the underlying layer.
3. After rodding each layer, tap the sides of each mold 10 to 15 times with the mallet (reusable steel molds) or lightly with the open hand (single-use light-gauge molds).
4. Strike off the surface of the molds with tamping rod, or straightedge and begin initial curing.

Note 1: Floating or troweling is permitted instead of striking off with rod or straightedge

Procedure – Making Cylinders – Internal Vibration

1. Fill the mold in two layers.
2. Insert the vibrator at the required number of different points for each layer (two points for 150 mm (6 in.) diameter cylinders; one point for 100 mm (4 in.)

diameter cylinders). When vibrating the bottom layer, do not let the vibrator touch the bottom or sides of the mold. When vibrating the top layer, the vibrator shall penetrate into the underlying layer approximately 25 mm (1 in.)

3. Remove the vibrator slowly, so that no air pockets are left in the material.

   Note 2: ***Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation and loss of appreciable quantities of intentionally entrained air.***

4. Strike off the surface of the molds with tamping rod, or straightedge and begin initial curing.

Procedure – Making Flexural Beams – Rodding

1. Fill the mold in two approximately equal layers with the second layer slightly overfilling the mold.

2. Consolidate each layer with the tamping rod once for every 1300 mm^2 (2 in^2) using the rounded end. Rod each layer throughout its depth taking care to not forcibly strike the bottom of the mold when compacting the first layer. Rod the second layer throughout its depth, penetrating approximately 25 mm (1") into the lower layer.

3. After rodding each layer, strike the mold 10 to 15 times with the mallet and spade along the sides and end using a trowel.

4. Strike off to a flat surface using a float or trowel and begin initial curing.

Procedure – Making Flexural Beams – Vibration

1. Fill the mold to overflowing in one layer.

2. Consolidate the concrete by inserting the vibrator vertically along the centerline at intervals not exceeding 150 mm (6 in.). Take care to not over vibrate, and withdraw the vibrator slowly to avoid large voids. Do not contact the bottom or sides of the mold with the vibrator.

3. After vibrating, strike the mold 10 to 15 times with the mallet.

4. Strike off to a flat surface using a float or trowel and begin initial curing.

Procedure – Initial Curing

- For initial curing of cylinders, there are two methods, use of which depends on the agency. In both methods, the curing place must be firm, within ¼ in. of a level surface, and free from vibrations or other disturbances.
- Maintain initial curing temperature of 16 to 27° C (60 to 80°F) or 20 to 26°C (68 to 78°F) for concrete with strength of 40 Mpa (6000 psi) or more.
- Prevent loss of moisture.

Method 1 – Initial cure in a temperature controlled chest-type curing box

1. Finish the cylinder using the tamping rod, straightedge, float or trowel. The finished surface shall be flat with no projections or depressions greater than 6.3 mm (1/8 in.).
2. Place the mold in the curing box. When lifting light-gauge molds be careful to avoid distortion (support the bottom, avoid squeezing the sides).
3. Place the lid on the mold to prevent moisture loss.
4. Mark the necessary identification data on the cylinder mold and lid.

Method 2 – Initial cure by burying in earth or by using a curing box over the cylinder

Note 3: This procedure may not be the preferred method of initial curing due to problems in maintaining the required range of temperature.

1. Move the cylinder with excess concrete to the initial curing location.
2. Mark the necessary identification data on the cylinder mold and lid.
3. Place the cylinder on level sand or earth, or on a board, and pile sand or earth around the cylinder to within 50 mm (2 in.) of the top.
4. Finish the cylinder using the tamping rod, straightedge, float or trowel. Use a sawing motion across the top of the mold. The finished surface shall be flat with no projections or depressions greater than 6.3 mm (1/8 in.).
5. If required by the agency, place a cover plate on top of the cylinder and leave it in place for the duration of the curing period or place the lid on the mold to prevent moisture loss.

Procedure – Transporting Specimens

- After 24 to 48 hours of initial curing, the specimens will be transported to the laboratory for storing under standard conditions. Specimen identity will be noted along with the date / time the specimen was made and the maximum and minimum temperatures registered during the initial cure.

Note 4: If a specimen does not attain initial set within 48 hours, it is to remain in place until initial set is reached. Concrete producer shall determine initial set according to AASHTO T 197.

- While in transport, specimens shall be protected from jarring, extreme changes in temperature, freezing, or moisture loss.
- Cylinders shall be secured so that the axis is vertical.
- Transportation time shall not exceed 4 hours.

Final Curing

- For all specimens (cylinders or beams) final curing must be started within 30 minutes of mold removal. Temperature shall be maintained at 23° ± 2° C (73 ±3° F) Free moisture must be present on the surfaces of the specimens during the entire curing period. Curing may be accomplished in a moist room or water tank conforming to M 201.
- For cylinders, during the final 3 hours prior to testing the temperature requirement may be waived, but free moisture must be maintained on specimen surfaces at all times until tested.
- Final curing of beams must include immersing in lime-saturated water for at least 20 hours prior to testing.

Report

- Report on standard agency forms.
- Pertinent placement information for identification of project, element(s) represented, etc.
- Date and Time molded.
- Test ages.
- Slump, Air Content, & Density
- Temperature (concrete, initial cure max. & min., and ambient).
- Method of initial curing.
- Other information as required by agency such as concrete supplier, truck number, invoice number, water added, etc.

TESTING METHODOLOGY

METHOD OF MAKING AND CURING CONCRETE TEST SPECIMENS IN THE FIELD

Significance

Concrete is specified primarily on the basis of strength. Standard specimens are made and subsequently tested to determine the acceptability of concrete. Concrete strength test specimens are made in accordance with a standard procedure to produce results that are reliable and tests that can be reproduced by someone else with the same concrete, following the same procedures.

Specimens are molded according to standard procedures and then cured under proper temperature and moisture conditions. Deviation from the standard procedures can cause significant differences in strength results. For example, specimens improperly cured between 32 and 38° C (90 and 100°F) will develop strength at a different rate than specimens cured at the specified temperature range of 16 to 27° C (60 to 80°F) required by this method. Ultimate strength is also affected.

Typical Strength Specimens

This test method pertains to specimens cast for the purpose of acceptance. Agencies sometimes specify curing practices other than those presented here. (To determine adequacy of protection or when a structure may be placed in service for example.)

Scope

This procedure covers the method for making, initially curing, and transporting concrete test specimens in the field in accordance with AASHTO T 23.

Apparatus and Test Specimens

- Concrete cylinder molds: Conforming to AASHTO M 205 with a length equal to twice the diameter. Standard specimens shall be 150 mm (6 in.) by 300 mm (12 in.) cylinders. Mold diameter must be at least three times maximum aggregate size unless wet sieving is conducted according to AASHTO T 141. Agency specifications may allow cylinder molds of 100 mm (4 in.) by 200 mm (8 in.) size when the nominal maximum aggregate size does not exceed 25 mm (1 in.).

Apparatus, Cylinders

- Beam molds: Rectangular in shape with ends and sides at right angles to each other. Must be sufficiently rigid to resist warpage. Surfaces must be smooth. Molds shall produce length no more than 1.6 mm (1/16") shorter than that required (greater length is allowed). Maximum variation from nominal cross section shall not exceed 3.2 mm (1/8 in.). Ratio of width to depth may not exceed 1.5; the smaller dimension must be at least 3 times maximum aggregate size. Unless otherwise noted in specifications, beam molds for casting specimens in the field shall result in specimens having width and depth of not less than 150 mm (6 inches). Specimens shall be cast and hardened with the long axes horizontal.
- Standard tamping rod: 16 mm (5/8 in.) diameter and approximately 600 mm (24 in.) long, having a hemispherical tip for preparing 150mm (6 in.) x 300 mm (12 in.) cylinders.
- Small tamping rod: 10 mm (3/8 in.) diameter and approximately 305 mm (12 in.) long, having a hemispherical tip for preparing 100 mm (4 in.) x 200 mm (8 in.) cylinders
- Vibrator: At least 7000 vibrations per minute, diameter no more than ¼ the diameter or width of the mold and at least 75 mm (3 in.) longer than the section being vibrated for use with low slump concrete.

- Scoop
- Trowel or Float
- Mallet: With a rubber or rawhide head having a mass of 0.57 ± 0.23 kg (1.25 ±0.5 lb.).
- Rigid base plates and cover plates: metal, glass, or plywood.
- Initial Curing Facilities: Temperature controlled curing box or enclosure capable of maintaining the required range of 16 to 27° C (60 to 80°F) during the entire initial curing period (for concrete with compressive strength of 40 Mpa (6000 psi) or more, the temperature shall be 20 to 26°C (68 to 78°F). As an alternative, sand or earth for initial cylinder protection may be used provided that the required temperature range is maintained and the specimens are not damaged.
- Thermometer: Capable of registering both maximum and minimum temperatures during the initial cure.

Procedure – Making Specimens – General

7. Obtain the sample according with the FOP for WAQTC TM 2. Wet Sieving per the FOP for WAQTC TM 2 is required when concrete contains aggregate with a nominal maximum size greater than 50 mm (2 in.) for specimen's with a 150 mm (6 in.) diameter, or greater than 25 mm (1 in.) for specimen's with a 100 mm (4 in.) diameter.
8. Remix the sample after transporting to testing location.
9. Begin making specimens within 15 minutes of obtaining the sample.
10. Set molds upright on a level rigid base in a location free from vibration and relatively close to where they will be stored.
11. Fill molds in the required number of layers attempting to exactly fill the mold on the final layer. Add or remove concrete prior to completion of consolidation to avoid a

deficiency or excess of concrete.

12. There are two methods of consolidating the concrete – rodding and internal vibration. If the slump is greater than 25 mm (1 in.), consolidation may be by rodding or vibration. When the slump is 25 mm (1 in.) or less, consolidate the sample by internal vibration. Agency specifications may dictate when rodding or vibration will be used.

Procedure – Making Cylinders – Rodding

5. For the standard 150 mm (6 in.) by 300 mm (12 in.) specimen, fill each mold in three approximately equal layers, moving the scoop or trowel around the perimeter of the mold to evenly distribute the concrete. For the 100 mm (4 in.) by 200 mm (8 in.) specimen, fill the mold in two layers. When filling the final layer, slightly overfill the mold.
6. Consolidate each layer with 25 strokes of the appropriate tamping rod, using the rounded end. Distribute strokes evenly over the cross section of the concrete. Rod the first layer throughout its depth without forcibly hitting the bottom. For subsequent layers, rod the layer throughout its depth penetrating approximately 25 mm (1 in.) into the underlying layer.
7. After rodding each layer, tap the sides of each mold 10 to 15 times with the mallet (reusable steel molds) or lightly with the open hand (single-use light-gauge molds).
8. Strike off the surface of the molds with tamping rod, or straightedge and begin initial curing.

   Note 1: Floating or troweling is permitted instead of striking off with rod or straightedge

Procedure – Making Cylinders – Internal Vibration

5. Fill the mold in two layers.
6. Insert the vibrator at the required number of

Consolidation of concrete in cylinder by rodding

Vibrating cylinder specimens

different points for each layer (two points for 150 mm (6 in.) diameter cylinders; one point for 100 mm (4 in.) diameter cylinders). When vibrating the bottom layer, do not let the vibrator touch the bottom or sides of the mold. When vibrating the top layer, the vibrator shall penetrate into the underlying layer approximately 25 mm (1 in.).

7. Remove the vibrator slowly, so that no air pockets are left in the material.

   Note 2: Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation and loss of appreciable quantities of intentionally entrained air.

8. Strike off the surface of the molds with tamping rod, or straightedge and begin initial curing.

Procedure – Making Flexural Beams – Rodding

Making a flexural beam, rodding

1. Fill the mold in two approximately equal layers with the second layer slightly overfilling the mold.
2. Consolidate each layer with the tamping rod once for every 1300 mm^2 (2 in^2) using the rounded end. Rod each layer throughout its depth taking care to not forcibly strike the bottom of the mold when compacting the first layer. Rod the second layer throughout its depth, penetrating approximately 25 mm (1") into the lower layer.
3. After rodding each layer, strike the mold 10 to 15 times with the mallet and spade along the sides and end using a trowel.
4. Strike off to a flat surface using a trowel and begin initial curing.

Making Beams
Internal Vibration

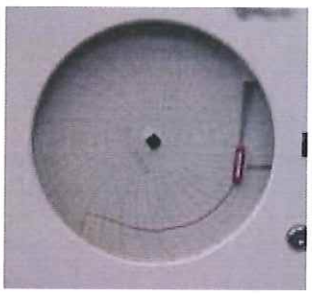
Procedure – Making Flexural Beams – Vibration

1. Fill the mold to overflowing in one layer.
2. Consolidate the concrete by inserting the

vibrator vertically along the centerline at intervals not exceeding 150 mm (6 in.). Take care to not over vibrate, and withdraw the vibrator slowly to avoid large voids. Do not contact the bottom or sides of the mold with the vibrator.

3. After vibrating, strike the mold 10 to 15 times with the mallet.
4. Strike off to a flat surface using a trowel and begin initial curing.

Procedure – Initial Curing



Recording Thermometer

- For initial curing of cylinders, there are two methods, use of which depends on the agency. In both methods, the curing place must be firm, within ¼ in. of a level surface, and free from vibrations or other disturbances.
- Maintain initial curing temperature of 16 to 27° C (60 to 80°F) or 20 to 26°C (68 to 78°F) for concrete with strength of 40 Mpa (6000 psi) or more.
- Prevent loss of moisture.

Temperature Controlled Curing Box

Method 1 – Initial cure in a temperature controlled chest-type curing box

5. Finish the cylinder using the tamping rod, straightedge, float or trowel. The finished surface shall be flat with no projections or depressions greater than 6.3 mm (1/8 in.).
6. Place the mold in the curing box. When lifting light-gauge molds be careful to avoid distortion (support the bottom, avoid squeezing the sides).
7. Place the lid on the mold to prevent moisture loss.
8. Mark the necessary identification data on the cylinder mold and lid.

Placing cover plate

Method 2 – Initial cure by burying in earth or by using a curing box over the cylinder

Note 3: This procedure may not be the preferred method of initial curing due to problems in maintaining the required range of temperature.

6. Move the cylinder with excess concrete to the initial curing location.
7. Mark the necessary identification data on the cylinder mold and lid.
3. Place the cylinder on level sand or earth, or on a board, and pile sand or earth around the cylinder to within 50 mm (2 in.) of the top.
4. Finish the cylinder using the tamping rod, straightedge, float or trowel. Use a sawing motion across the top of the mold. The finished surface shall be flat with no projections or depressions greater than 6.3 mm (1/8 in.).
5. If required by the agency, place a cover plate on top of the cylinder and leave it in place for the duration of the curing period or place the lid on the mold to prevent moisture loss.

Procedure – Transporting Specimens

Specimen identification

- After 24 to 48 hours of initial curing, the specimens will be transported to the laboratory for storing under standard conditions. Specimen identity will be noted along with the date / time the specimen was made and the maximum and minimum temperatures registered during the initial cure.

  Note 4: If a specimen does not attain initial set within 48 hours, it is to remain in place until initial set is reached. Concrete producer shall determine initial set according to AASHTO T 197

- While in transport, specimens shall be protected from jarring, extreme changes in temperature, freezing, or moisture loss.
- Cylinders shall be secured so that the axis is vertical.
- Transportation time shall not exceed 4 hours.

Final Curing

- For all specimens (cylinders or beams) final curing must be started within 30 minutes of mold removal. Temperature shall be maintained at 23° ± 2° C (73 ±3° F) Free moisture must be present on the surfaces of the specimens during the entire curing period. Curing may be accomplished in a moist room or water tank conforming to M 201.
- For cylinders, during the final 3 hours prior to testing the temperature requirement may be waived, but free moisture must be maintained on specimen surfaces at all times until tested.
- Final curing of beams must include immersing in lime-saturated water for at least 20 hours prior to testing.

Report

- Report on standard agency forms.
- Placement information for identification of project, element(s) represented, etc.
- Date molded & Time molded.
- Test ages.
- Slump, Air Content & density.
- Temperature (concrete, initial cure max. & min., and ambient).
- Method of initial curing.
- Other information as required by agency such as concrete supplier, truck number, invoice number, water added, etc.

Tips!

- Start within 15 minutes of obtaining sample.
- Use hand, for tapping single-use, light-gauge molds.
- Consolidation technique depends on the slump. Rodding and/or vibration may be appropriate for different slumps.
- Protect specimens from damage during transport and keep cylinders vertical.