2027 Edition









CONCRETE FIELD

Includes Advanced Concrete





MoDOT

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Use For Notes If Needed

COURSE CONTENT

CONCRETE FIELD

MoDOT TM20	Measurement of Air, Surface, or Asphalt Mixture Temperature
AASHTO R60 ASTM C172	Sampling Freshly Mixed Concrete
AASHTO T309 ASTM C1064	Temperature of Freshly Mixed Hydraulic-Cement Concrete
AASHTO T119 ASTM C143	Test for Slump of Hydraulic Cement Concrete
AASHTO T152 ASTM C231	Test for Air Content of Freshly Mixed Concrete by the (Pressure) Method
AASHTO R100 ASTM C31	Making and Curing of Concrete Specimens in the Field
AASHTO T121M ASTM C138	Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
AASHTO T196M ASTM C173	Air content of Freshly Mixed Concrete by the (Volumetric) Method

APPENDIX

GLOSSARY

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Use For Notes If Needed

Concrete Field

Updates

2027 – Updates

- Enlarged slides.
- Added ASTM equivalents.
- **AASHTO R100**
    - Added language stating open hand shall be used for tapping single use molds.

2026 – Updates

- **AASHTO R100**
    - Final Standard Curing – cylinder temperature is now 73.5 ± 3.5°F.
    - Additional field testing information on the cylinders when reporting on.
- **AASHTO T309**
    - Calibration changed from annually to every 12 months.

2025 – Updates

- **AASHTO T152**
    - Equipment: For 14L measures the rubber or rawhide mallet head now weighs 0.60 ± 0.25kg, and for smaller measures the mallet now weighs 1.02 ± 0.23 kg.
    - Equipment: Meter Type B working pressures is now 50 to 205 Kpa.

2024 – Updates

- **MODOT TM20 –** No updates
- **AASHTO R60**
    - Added Continuous Mixer section.
- **AASHTO T119**
    - Equipment: Mold must be free from dents, deformations, or adhered mortar.
    - Procedure: 1st layer of rodding added: Rod the bottom layer through its depth.
- **AASHTO T152**
    - Equipment: Can use a plastic wash bottle to add water to the meter.
- **AASHTO T100**
    - Acceptance testing for strength, perform the following tests for each sample of concrete from which specimens are made. (Slump, Air Content, and Temperature).
- **AASHTO T121M**

Pints of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

- **New Table 1**:
- Calibrated Cup = Standardized Cup
- Bowl = Measuring Bowl
- Calculation section updated, and added a formula:

$$A = A_R - C + W$$

2023 – Updates

- **<u>AASHTO T196</u>:**
  - **Water for the meter**: The thermometer for measuring the temperature of the water for the meter shall meet the requirements of M 339M/M 339 with a temperature range of at least 19 to 23.5°C (66.4 to 74.6°F) and an accuracy of ±0.5°C (±0.9°F) (see note 3),
    - NOTE 3: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer that is submerged to its required immersion depth.
      - ASTM E2877 digital metal stem thermometer
      - ASTM E230/E 230M thermocouple thermometer, Type T, Special.

2022 – Updates

- **Removed Videos from most methods.**
- Added Advanced Concrete to the Manual, Exams, and Proficiency exam.
- One method update AASHTO T23 is now renamed to **AASHTO R100**
  - Changed under scope, the word “method” to “Practice”.
  - Changed Table for Tamping Rod Requirements for length of rod from 650 (26) to 600 (24).

2021 – Updates

- **Added Videos to all methods.**

- **Method updates for 2021:**
  - Method AASHTO T23: changed information on consolidation of cylindrical molds. When using reusable plastic molds, you can use a mallet to tap the outside, for one-time disposable molds that can be damaged with using a mallet, use an open hand to tap the outside of the mold.

- **AASHTO T 121**
    - One update on equipment: **Internal Vibrator**
        - Internal Vibrator: The vibrator frequency shall be at least 9000 vibrations per min (150HZ) while the vibrator is operating in concrete. The outside diameter of a round vibrator shall be at least 19mm (0.75in) and not greater than 38mm (1.50in). Other shaped vibrator shall have a perimeter equivalent to the circumference of an appropriate round vibrator. The combined length of the vibrator shaft and vibrating element shall exceed the depth of the section being vibrated by at least 75 mm (3in.). The vibrator frequency shall be checked periodically.

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Use For Notes If Needed

MoDOT TM20

Measurement of Air, Surface, or Asphalt Mixture Temperature

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Use For Notes If Needed

MoDOT TM 20

Measurement of Air, Surface or Asphalt Mixture Temperature

Slide 1

Notes

Why is Temperature Important?

- The temperature is required of many AASHTO specifications in testing of asphalt materials as well as concrete.
- Temperature is used to provide quality assurance and to prevent early pavement deterioration.

Slide 2

Notes

Equipment Calibration

- Calibrate thermometers **annually**.
- Calibration of a thermometer will establish a **correction factor** to adjust the thermometer reading to the true temperature.
- Information on how MoDOT owned thermometers are verified may be obtained from the District Materials Staff.
- Thermometers can be sent to the manufacturer on a yearly basis to be verified/calibrated.

Slide 3

Notes



National Institute of Standards And Technology

- A record of calibration/verification that is traceable to National Institute of Standards and Technology.
- (NIST) Traceable standards is needed for thermometers.
- Keep a Copy of this record in the Laboratory's Quality Control Manual.

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Notes

Infrared Thermometer

Surface, Asphalt Mixture

Range: 20° F to 400° F

Increment: 2° F



Slide 5

Notes

Mercury Thermometer

Air and Surface
Range: 20° F to 130° F
Increment: 2° F

Note: Mercury Thermometers are **rarely** used due to the potential of mercury contamination, if broken. Today technicians are using digital type thermometers with a metal probe.



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Notes

Digital Thermometer

Air, Surface, Asphalt Mixture
Range: 0°F to 400°F,
Increment: 1°F
NIST Traceable





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Notes

Max-Min Thermometer

Air, Surface
Range: 20° F to 130° F
Increment: 2° F



Slide 8

Notes

Spot Check Disc Thermometer

Surface
Range: 32° F to 250° F
Increment: 2° F



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Notes

BI-Therm Dial Thermometer

Asphalt Mixture
Range: 50° F to 400° F
Increment: 5° F





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Notes

Armored Thermometer

Asphalt Mixture
Range: 50° F to 400° F
Increment: 5° F

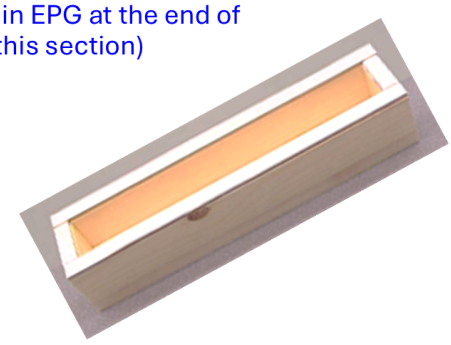


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Notes

Wooden Box

Surface
See EPG Test Method TM 20 for dimensions.
(included in EPG at the end of this section)



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Notes

Precautions

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



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Notes

Procedure Air Temperature

Thermometers
- Mercury
- Digital
- Max – Min

Location
- Shaded Area – Not exposed to direct sunlight.
- Safe Area

Position: 4.5 ft. above the surface

Report to nearest 2°F

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Notes

Surface Temperature

Infrared Thermometer
- Follow the manufacturer's recommendations.

Spot Check Disc Thermometer
- Place on surface
- Read when needle stops moving
- Report to nearest 2°F

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Notes

Surface Temperature (continued)

- Max-Min or Mercury Thermometer
  - Place thermometer on surface.
  - Place wooden box over top.
    - Open side covering thermometer.
  - Leave thermometer under box for a minimum of 5 minutes.
  - Lift the box enough to read the temperature
    - Report to the nearest 2°F



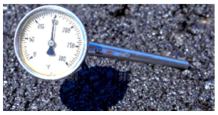


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Notes

Asphalt Mixture Temperature

- Digital, Armored or BI-Therm Dial Thermometer
  - Place stem in loose asphalt mixture.
  - Do not disturb until reading the stabilized.
  - Read Temperature.
  - Report to nearest 5°F





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Notes

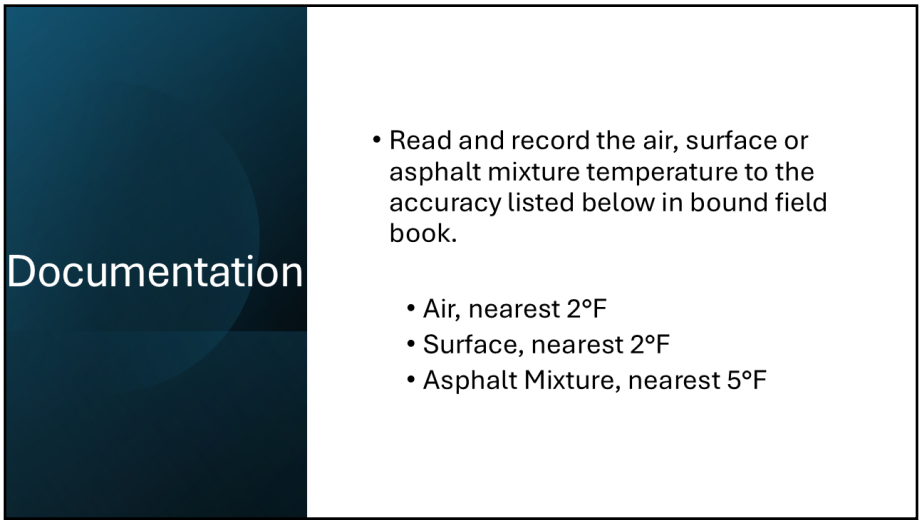
Asphalt Mixture Temperature (continued)

- Infrared Thermometer
  - Follow manufacturers instructions.
  - Direct reading of asphalt loose mix located in truck, a receiving hopper, or material at the end of paver augers.
  - Read Temperature.
  - Report to nearest 5°F



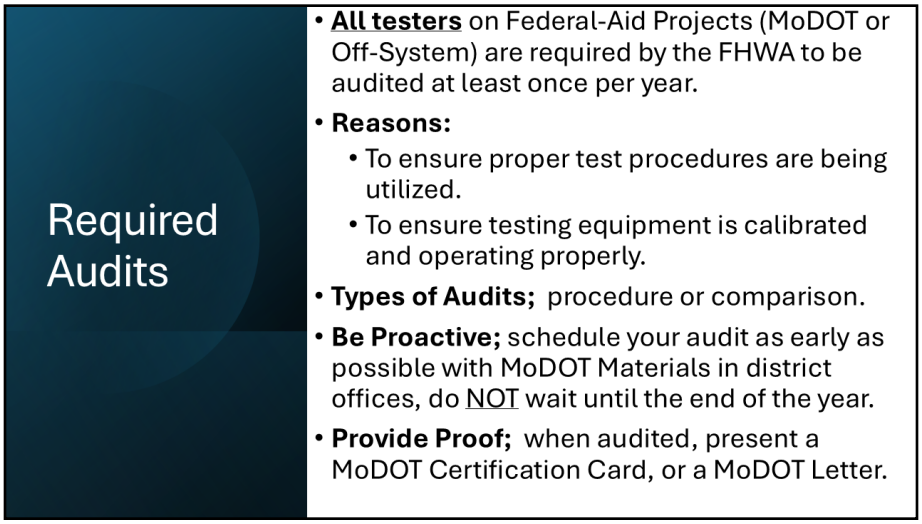
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Notes



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Notes



Slide 20

Notes

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Use For Notes If Needed

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

From Engineering Policy Guide
Jump to: navigation, search

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.

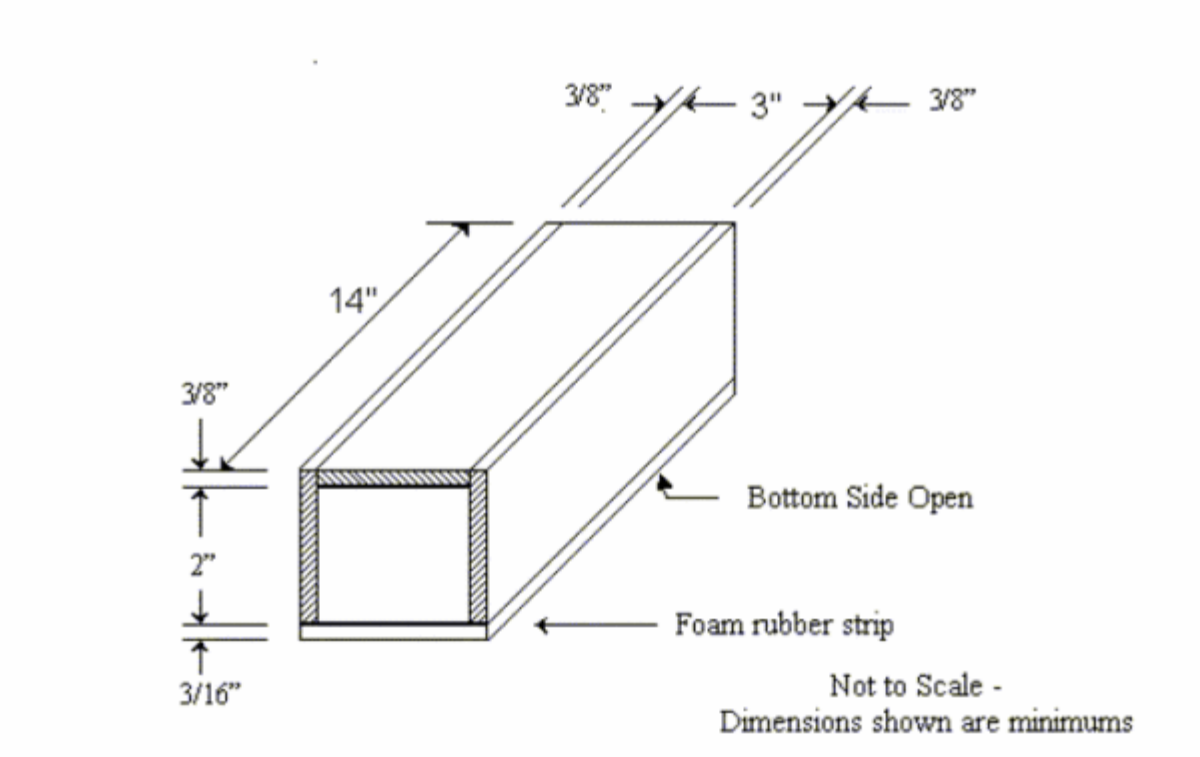


Fig. 106.3.2.1.20

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 criterion 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 criterion 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.

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Use For Notes If Needed

MoDOT TM20: Measurement of Air, Surface and Asphalt Mixture Temperature
PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

Trial #	1	2
Certificates or Report of Verification of Accuracy (Annual calibration) available?		
AIR		
1. Pick correct thermometer		
2. Location - *Mercury, Digital, Max-Min thermometers* - shade, no direct sunlight - position 4.5 feet above surface - safe location		
3. Document to nearest 2° F		
SURFACE		
4. Pick correct thermometer		
5. Procedure - *Spot Check Disc*; place on surface until needle stops moving - *Infrared*; follow manufacturer recommendations - *Mercury or Max-Min*; place under wooden box wait 5 minutes - *Digital* ; follow manufacturer recommendations		
6. Document to nearest 2° F		
ASPHALT MIXTURE		
7. Pick correct thermometer		
8. Procedure - *Infrared*; follow manufacturer recommendations - *Armored , BI-Therm Dial, or Digital*; place stem into mixture and wait until thermometer reading has stabilized		
9. Document to nearest 5° F		
	PASS	PASS
	FAIL	FAIL

Examiner:_____Date:_____

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Use For Notes If Needed

AASHTO R60

ASTM C172

Sampling of Freshly Mixed Concrete

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Use For Notes If Needed

AASHTO R60

Sampling Freshly Mixed Concrete



Slide 1

Notes

SCOPE

- This method covers the procedures for obtaining representative samples of fresh concrete as delivered to the project site and which tests are to be performed to determine compliance with quality requirements of the specifications under which the concrete is furnished.
- This method includes sampling from stationary, paving, and truck mixers and from agitating and non-agitating equipment used to transport central mixed concrete.

Slide 2

Notes

TERMINOLOGY

- Composite Sample - A sample which is made by combining samples from two or more locations/parts.

More definitions in the glossary.

Slide 3

Notes

SIGNIFICANCE AND USE

- This practice is intended to provide standard requirements and procedures for sampling freshly mixed concrete from different containers used in the production or transportation of concrete.



Slide 4

Notes

- The detailed requirements as to materials mixtures, air content, temperature, number of specimens, slump, Interpretation of results, precision and bias are described in specific test methods.

Significance and Use

Slide 5

Notes

Fresh concrete will be sampled from one of the mixers listed below;

- ***Stationary Mixers***
  (Except Paving Mixers)
- ***Paving Mixers***
- ***Revolving Drum Truck Mixers or Agitators***

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Notes

MoDOT – Sampling Note

- **EPG** = **E**ngineering **P**olicy **G**uide
- EPG, section **501.4** Sampling – Sampling of fresh concrete will be in accordance with AASHTO R60, except for central or truck mixed concrete.
- This will be discussed after AASHTO R60.

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Notes

EQUIPMENT

- Square nose shovel
- Scoop
- Testing equipment
- Sample container
- Tags, molds
- Safety equipment – Personal Protective Equipment (PPE)







Slide 8

Notes

Six things to take care of before sampling begins…



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Notes

1. Communicate with the contractor to coordinate sampling and to talk about SAFETY.



Before Sampling

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Notes

2. Set-up a testing area close to the site of sampling, with all testing equipment ready to go**.**



Before Sampling

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Notes

3. Check ticket information on the load when the truck arrives on the job site.

Take note of the following…

- 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

Before Sampling

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Notes

4. Wait until all additives and water have been added and mixed into the load.

5. Wait a minimum of 30 revolutions of the drum, after final change to mix, to make sure all is mixed well.. (MoDOT)

6. Discharge approximately 1 cubic yard before sampling. (MoDOT)

NOTES:

- Do not obtain the sample from the very first or last part of the batch discharge.
- Collect enough fresh concrete to complete all tests.

Before Sampling

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Notes

SAMPLING



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Notes

- Sample the concrete by passing the sample container through the entire concrete stream or move the shoot into the container.



AASHTO Sampling

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Notes

- The elapsed time shall not exceed **15min** between obtaining the first and final portions of obtaining the composite sample.



AASHTO Sampling

Slide 16

Notes

- Transport the samples to the place that was set-up earlier for testing fresh concrete and molding specimens.



AASHTO Sampling

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Notes

- The concrete sample portions shall be mixed with a shovel just enough to ensure uniformity.



AASHTO Sampling

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Notes

- Protect the sample from the **sun**, **wind**, **moisture,** and other sources of rapid evaporation and from contamination.



Moisture





AASHTO Sampling

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Notes

- After mixing with a shovel, start tests for temperature, slump and air content within **5 minutes**.
- **Complete these tests quickly!**

Temperature



Slump



Air Content





TESTING; SLUMP, TEMP, AIR

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Notes

- Start molding specimens for strength tests (cylinders and beams).
- Complete all required tests within **15 min** after fabricating the composite sample.



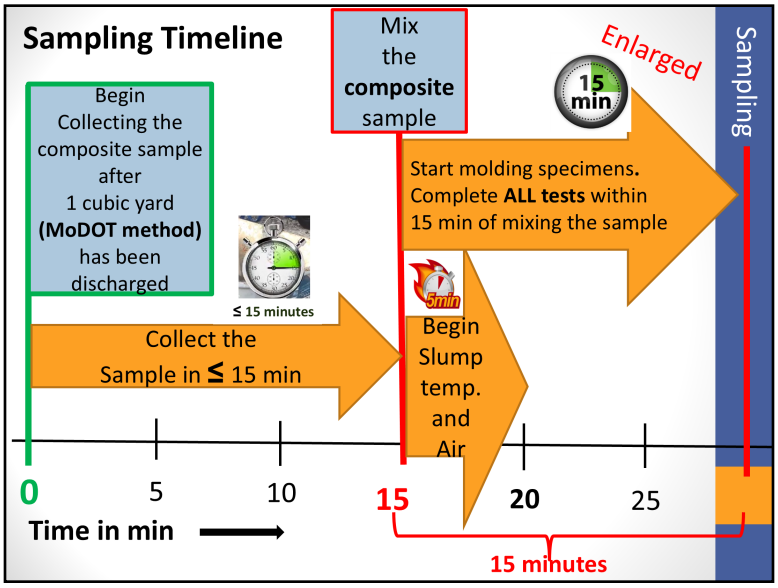
Complete everything within **30** minutes.



MOLDING SPECIMENS

Slide 21

Notes



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Notes

PROCEDURE

- Size of Sample – The sample to be used for strength tests, will need at least a minimum of 1 cubic foot. ($1ft^3$).

MODOT: Sample enough to do all tests.

- Exception: Smaller samples could be used if air content and slump tests are the only tests.

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Notes

MIXERS

- ***Stationary Mixers***
  (Except Paving Mixers)
- ***Paving Mixers***
- ***Revolving Drum Truck Mixers or Agitators***

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Notes

STATIONARY MIXERS



Notes

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Sampling from Stationary Mixers
(Except Paving Mixers)

Stationary Mixers

- Obtain two or more portions taken at regularly spaced intervals during discharge of the middle of the batch.
- Obtain these portions within the time limit of 15 min.
- Combine the portions into the composite sample for testing purposes.

Notes

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Stationary Mixers

- Perform sampling by passing a receptacle completely through the discharge stream or by completely diverting the discharge into a sample container.
- If the discharge of the concrete is too rapid to divert the complete discharge stream, discharge the concrete into a container or transportation unit sufficiently large enough to accommodate the entire batch and then accomplish the sampling.

Notes

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Stationary Mixers

- 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 non-tilting mixers.

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Notes

Stationary Mixers

- **NOTE**: No sample should be taken before 10 percent or after 90 percent of the batch has been discharged. Due to the difficulty of determining the actual quantity of concrete discharged, the intent is to provide samples that are representative of widely separated portions but not the beginning or end of the load.

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Notes

CONTINUOUS MIXERS



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Notes

Continuous Mixers

- Do not collect from very first or last portions of a mixer's continuous discharge.
- After all mixture adjustments have been made,
- Discharge 5 ft^3 of concrete.
- Obtain 2 or more portions at regularly spaced intervals during discharge of the concrete by passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container.
- Staying within the time limits.
- Combine into one composite sample for testing purposes.
- Then wait 2 to 5 min. before testing.
  - The waiting period is needed because the mix water was input only seconds before discharge.

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Notes

PAVING MIXERS



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Notes

Paving Mixers

- For Central Mixed concrete delivered to a paving operation:
  - Sample the concrete after the contents of the paving mixer have been discharged.
  - Obtain samples from at least **FIVE** different locations of the pile after the concrete is on the sub-grade and then combine them into one sample for testing purposes.

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Notes

Paving Mixers

- Avoid contamination with subgrade material or prolonged contact with an absorptive subgrade.
- To preclude contamination or absorption by the subgrade:
  - Sample the concrete by placing shallow containers on the subgrade and discharging concrete across the containers.

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Notes

Paving Mixers

- Combine the samples into one sample for test purposes.
- Mix your sample with a **square nose** shovel to ensure uniformity and eliminate segregation.
- The containers shall be of a size sufficient to provide a composite sample size that agrees with the maximum aggregate size.

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Notes

REVOLVING DRUM TRUCK MIXERS or AGITATORS



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Notes

Revolving Drum Truck Mixers

AASHTO R60 procedure . . .

- Sample the concrete by collecting two or more portions taken at regularly spaced intervals during discharge of the middle portion of the batch.
- Take the samples obtained within the time limit specified and combine them into one sample for test purposes.

NOTE: MODOT will release 1 Cubic Yard before sampling for truck mixed or truck delivered mixes. See MoDOT section.

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Notes

Revolving Drum Truck Mixers

- 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, **not** by the size of the gate opening.



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Notes

WET – SIEVING CONCRETE

(Only when necessary)
ASTM C172

- When the concrete contains aggregate larger than the appropriate size for the molds or equipment to be used, Wet-Sieve the sample.

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Notes

Wet-Sieving Video

https://youtu.be/oNH2VoiZH5k



NOTE: Use a square nose shovel

Wet-Sieving Concrete

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Notes

Additional Procedure for Large, Maximum-Size Aggregate Concrete

- If the sample consists of large maximum-sized aggregate, perform this procedure before running tests.
- Exception: Perform density (unit weight) tests for use in yield computations on the full mix (As received, large aggregate and all).

Wet-Sieving Concrete

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Notes

- **Sieve**; a sieve of suitable size and conveniently arranged and supported so that one can shake it rapidly by either hand or mechanical means. Generally, a horizontal back-and-forth motion is preferred.
- **Receptacle**; a container of suitable size having a nonabsorbent surface, like a wheelbarrow.
- **Hand Tools**; shovels, hand scoops, plastering tools, gloves



Wet-Sieving Concrete

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Notes

- **How to Perform Wet –Sieving**:
- After sampling the concrete and before remixing, pass the concrete over the designated sieve.
- Shake or vibrate the sieve by hand or mechanical means until no undersize material remains on the sieve.
- Remove and discard the aggregate retained.

NOTE: Do not wipe off the mortar on the retained aggregate.

Wet-Sieving Concrete

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Notes

- Place only enough concrete on the sieve at any one time so that, after sieving, the thickness of the layer of retained aggregate is not more than one particle thick.
- The concrete that passes the sieve shall fall into a batch pan of suitable size that has been dampened before use or onto a clean, moist, nonabsorbent surface.

Wet-Sieving Concrete

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Notes

- Scrape any mortar adhering to the sides of the wet-sieving equipment into the batch.
- After removing the larger aggregate particles by wet-sieving, remix the batch with a shovel in the minimum amount necessary to ensure uniformity and proceed testing immediately.

Wet-Sieving Concrete

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Notes

MoDOT Sampling Category 501 - Concrete Engineering Policy Guide

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Notes

MoDOT - Collection for Truck Mixed or Truck Delivered – Concrete Sampling

- EPG, section 501.4 ***Fresh Concrete Sampling*** – Sampling of fresh concrete shall be in accordance with AASHTO R60, except for central or truck mixed concrete.
- For central or truck mixed concrete the entire sample for temperature, slump, air-content and for molding compressive strength specimens may be taken at one time after all additives and water have been mixed and approximately **one cubic yard** of concrete has been discharged.

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Notes

MoDOT - Collection for Truck Mixed or Truck Delivered – Concrete Sampling

- 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)
- Move the concrete chute so concrete flows into your sample container or passes your sample catcher completely through the stream of concrete.

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Notes

- 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.

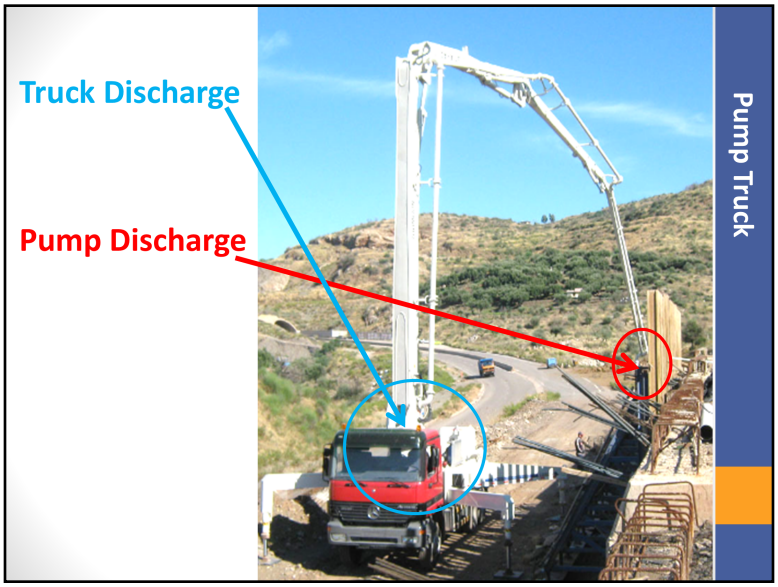
(see EPG section501.1.3, section 501.4).

  - Slump and Air Content will be checked when a pump is first used and periodically, at the truck discharge as well as the pump discharge to compare properties.

Pump Truck

Slide 49

Notes



Slide 50

Notes

Common Errors

- Sample taken before water is added and all mixing is completed.
- Letting sample set too long before testing.
- Sample contains mud, debris, base rock, unmixed materials.
- Unclean equipment.
- Not periodically checking the difference in properties between the truck discharge and the pump discharge.

Slide 51

Notes

Sampling Time Line

Begin Collecting the composite sample after 1 cubic yard (MoDOT method) has been discharged



≤ 15 minutes

Collect the Sample in ≤ 15 min

Mix the composite sample

Enlarged



Start molding specimens. Complete ALL tests within 15 min of mixing the sample



Begin Slump temp. and Air

Sampling

0 5 10 15 20 25 30

Time in min

15 minutes

501.1.3 Sampling (Sec 501.4 Standard Specifications)

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 R60/ASTM C172: Sampling Freshly Mixed Concrete
PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

	Trial# 1	2
Checked for required equipment: square nose shovel, scoop, sample container, testing equipment for Slump, Air-Content, Temperature, Strength tests, safety equipment, PPE, tags, molds.		
1. Communicate with the contractor to coordinate sampling and for safety purposes.		
2. Set-up a testing area with all testing equipment		
3. Collected ticket information on the load, name of concrete plant, job#, etc.		
4. Waited until all additives and water were added and mixed into the load		
5. After final additions, wait a minimum of 30 revolutions		
5. Collected the fresh sample(s) within 15 minutes from one of the following sources: -**Truck Mixed- Revolving Drum per MoDOT Method** *Discharged a minimum of 1 cubic yard *Passed a receptacle completely through the discharge stream or by diverting the discharge chute into a sample container *Collected enough fresh concrete to do all tests *Did not restrict the flow of concrete **-Stationary Mixers** *Sampled at the middle of the batch *Obtained 2 or more portions at regular spaced intervals (combined to make composite sample) *Did not restrict flow *Collected enough fresh concrete to do all tests -**Continuous Mixers** *Sampled middle portion of the batch *Discharge $5ft^3$ of concrete *Obtain 2 or more portions regularly spaced intervals during discharge *Combine into one composite sample to do all tests *Wait 2 to 5 min. before testing -**Paving Mixers** at a paving operation *After the contents of the mixer have been discharged *Obtained samples from at least 5 locations (combined to make composite sample) *Collected enough fresh concrete to do all tests *Avoided contamination from subgrade		
7. Performed Wet-Sieving as needed (Except for concrete used for unit weight)		
8. Transported the composite sample to the testing area and remixed with a square nose shovel		
9. Within 5 minutes of mixing the composite sample started tests for Temperature, Air-Content, and Slump		
10. Started molding specimens for strength tests and completed all tests within 15 minutes of mixing the composite sample.		
	PASS	PASS
Examiner: _____ Date: _____	Fail	Fail

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Use For Notes If Needed

AASHTO T309
ASTM C1064

Temperature of Freshly Mixed Hydraulic-Cement Concrete



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Use For Notes If Needed

AASHTO T309

ASTM C1064

Temperature of Freshly Mixed Hydraulic-Cement Concrete



Slide 1

Notes

SCOPE

- This test method covers the determination of temperature of freshly mixed hydraulic-cement concrete.

Slide 2

Notes

TERMINOLOGY

- **NIST** - **National Institute of Standards and Technology**, is a laboratory, of the United States Department of Commerce.
- **Thermometer** – For this method; refers to any of the devices listed below that are used to measure the temperature of concrete. (Unless the method calls for a specific type of thermometer).
  - Liquid-in-Glass Thermometer (mercury, alcohol, etc.)
  - Electronic Thermometer with probe
  - Dial Thermometer

  See the glossary for more definitions.

Slide 3

Notes

SIGNIFICANCE AND USE

- This test method provides a means for measuring the temperature of freshly mixed concrete. The measured temperature represents the temperature at the time of testing and may not be an indication of the temperature of the freshly mixed concrete at a later time. It may be used to verify conformance to a specified requirement for temperature of concrete.

Slide 4

Notes

Temperature

- Concrete containing aggregate of a nominal maximum size greater than **3 inches**, may require up to **20 min**. for the transfer of heat from aggregate to mortar.

Slide 5

Notes

EQUIPMENT

- **Container**
  - Will be large enough to provide at least **3”** of concrete in all directions around the sensor of the thermometer; concrete cover must also be at least **three** times the nominal maximum size of the coarse aggregate.
  - **Container examples**: 6” cylinder mold, wheelbarrow, forms, drop bucket, non-mixing transport vehicle etc.
  - **Do not** check temperature inside of a mixer truck, for safety concerns.

Slide 6

Notes

Container: 6" Cylinder Mold



A cylinder mold that is **6**" in diameter is acceptable for the required **3**" coverage around the probe or a bulb of the thermometer or as long as the thermometer bulb is in the center.

Slide 7

Notes

Thermometer

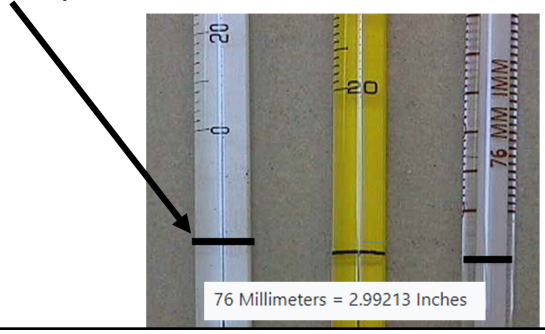
- Capable of accurately measuring the temperature of the freshly mixed concrete to **±1°F** (± 0.5°C) throughout a range of 30° to 120°F (0° to 50°C).
- Allows **3"** or more immersion during operation.
- Verified every 12 months, or whenever there is a question of accuracy.

Slide 8

Notes

- **Partial immersion liquid-in-glass thermometers:**

  - The partial immersion thermometer is not to be immersed past the permanent black line.
  - Many immersion lines are 76mm = 2.99 inches.



Slide 9

Notes

Reference Thermometers; These thermometers are mainly used for verifying other thermometers and are NIST traceable. Keep all certificates in the lab for viewing.



Slide 10

Notes

Verification of the Accuracy of Thermometers

Thermometers used in testing Concrete must be verified against an NIST traceable Reference Thermometer **every year** or whenever there is a question of accuracy.



Slide 11

Notes

- A company may send the thermometers off to another company to be verified.

OR

- A company may verify the thermometers in house, **see appendix** for more information on verifying the accuracy of thermometers.

- **MoDOT personnel**: **Check with your supervisor for information on verifying thermometers.**

Slide 12

Notes

SAMPLING

- It is acceptable to measure the temperature of freshly mixed concrete in either the transporting equipment or the forms after discharge provided the sensor of the temperature measuring device has at least **3**″ of concrete cover in all directions.
- If the transporting equipment or placement forms are not used as the container, a sample shall be prepared as follows:

Slide 13

Notes

- Immediately, prior to sampling the freshly mixed concrete, dampen the container with water.
- Sample the freshly mixed concrete in accordance with ASSHTO R 60. The composite sample is not required if the only purpose for obtaining the sample is to determine temperature.
- Place the freshly mixed concrete into the container.

Slide 14

Notes

PROCEDURE

- Position the thermometer so that the end of the temperature sensing portion is submerged a minimum of **3”** into the freshly mixed concrete.
- Close the void around the thermometer by gently pressing the concrete against the thermometer at the surface of the concrete to prevent ambient air temperature from affecting the reading.

Slide 15

Notes

TESTING - Temperature of Concrete



Slide 16

Notes

- Leave the temperature measuring device in the freshly mixed concrete from **2 to 5 min**.
- Read and record the temperature to the nearest **1°F (0.5°C)**.

NOTE: Do not remove the device from the concrete when reading the temperature.

Slide 17

Notes

REPORT

- Report the measured temperature of the freshly mixed concrete to the nearest **1°F (0.5°C)**.

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Notes

I. The contractor should provide a sufficient number of thermometer wells to provide a check on the concrete surface temperatures.
2. Concrete poured in moderately cool weather can develop excessive temperatures, and it is occasionally necessary to loosen the insulation to balance the temperature rise.
3. In severely cold weather, to prevent the conduction of cold by the protruding reinforcing steel, it may be necessary to provide supplemental heat at critical points.
4. Care should be taken to check the temperature periodically at critical points until the concrete has reached its required strength.

703.2.11 Hot Weather Concreting

Placement of superstructure concrete shall not be done when the ambient temperature is above 85°F. The internal temperature of the concrete shall not be greater than 85°F at the time of placement in the forms, regardless of ambient temperature.

Procedures For Checking Surface And Ambient Temperatures - MoDOT Test Method TM-20 Measurement of Air, Surface or Bituminous Mixture Temperature describes the methods for checking surface temperatures and air temperatures in the immediate vicinity of the work.

703.2.12 Checklist

The PODI Bridge Deck Pour Checklist (https://epg.modot.org/forms/CM/PODI_Bridge_Deck_Pour_Checklist.pdf) is a guide to the inspector during the sequence of operations associated with a deck pour.



703.2.13 Form Removal

Forms and falsework must be left in place until strength specified in the table in Sec 703.3.2.13 (http:/ /www.modot.org/business/standards_and_specs/SpecbookEPG.pdf#page=n) has been attained. Removal of falsework requires care to prevent damage to the concrete. Requirements in Sec 703 of the Standard Specifications must be carefully followed.

Honeycomb and indentations left by form hardware such as snap ties must be carefully repaired by filling with mortar as specified in the Standard Specifications. Particular attention must be given to color of the mortar. It may be necessary to add a small amount of white cement to match the color of the concrete to be repaired. Such patches must be carefully cured.

703.2.14 Surface Sealing

The principal problems with surface sealing are failure to clean the surface properly and non-uniformity of application. Any dirt left on the surface will absorb sealing material and prevent its penetration into the surface. Non-uniform application results in streaking and mottled surface

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Use For Notes If Needed

AASHTO T309/ASTM C1064: Temperature of Freshly Mixed Hydraulic-Cement Concrete
PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

	Trial#	1	2
1.	Thermometer verified annually to an NIST traceable thermometer		
2.	Sensing portion of thermometer submerged a minimum of 3 inches into concrete		
3.	Concrete gently pressed around thermometer at surface of concrete		
4.	Thermometer left in concrete for at least 2 minutes but not more than 5 minutes		
5.	Read and reported the temperature to the nearest 1°F (0.5°C)		

PASS PASS

FAIL FAIL

Examiner: _____Date:_____

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Use For Notes If Needed

AASHTO T119

ASTM C143

Test for Slump of Hydraulic Cement Concrete



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Use For Notes If Needed

AASHTO T119

ASTM C143

Test for Slump Of Hydraulic Cement Concrete



Slide 1

Notes

SCOPE

- This test method covers determination of slump of concrete, both in the laboratory and in the field.
- **NOTE:** Concretes having slumps less than 0.5 inches may not be adequately plastic and concretes having slumps greater than about 9 inches may not be adequately cohesive for this test to have significance.

Slide 2

Notes

SUMMARY

- A sample of freshly mixed concrete is placed and compacted by rodding in a mold in the shape of a cone in 3 layers, each approximately ⅓ of the volume of the mold.
- The mold is raised, and the concrete allowed to subside.
- The vertical distance between the original and the displaced position of the center of the top surface of the concrete is measured and reported as the slump of the concrete.

Slide 3

Notes

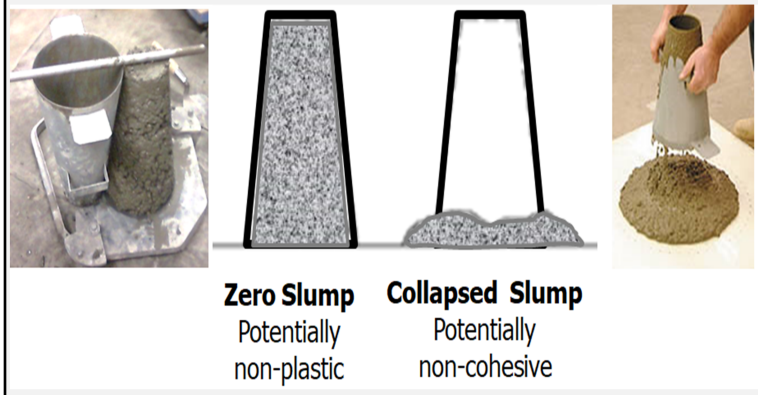
SIGNIFICANCE & USE

- This test method is intended to provide the user with a procedure to determine the slump of plastic hydraulic cement concretes.
- This test method is considered applicable to plastic concrete having coarse aggregate passing the 1½ (37.5mm) inch sieve.
- If the plastic concrete includes aggregate larger than 1½ inch (37.5mm), the larger aggregate particles are to be removed using **wet-sieving** as explained in R60.

Slide 4

Notes

- This test method is not considered applicable to non-plastic and non-cohesive concrete.



Zero Slump
Potentially non-plastic

Collapsed Slump
Potentially non-cohesive

Slide 5

Notes

EQUIPMENT

Mold – "Slump Cone"
The mold must be free from dents, deformations, or adhered mortar.



- #16 gage metal
- Top diameter of 4±⅛"
- Bottom diameter of 8±⅛"
- Height of 12±⅛"
- Foot pieces & Handles
- Clamps to nonabsorbent base plate
- Large enough to contain all the slumped concrete

NOTE: Information on Cone molds made from material other than metal see AASHTO T119.

Slide 6

Notes

- **Tamping Rod –**
  - straight steel rod
  - circular x-section
  - 5/8 ± 1/16" diameter
  - 24 ± 4" in length
  - one end shall be rounded to a Hemispherical shape 5/8" in diameter
- **Measuring Device**–
  - – Rigid Ruler
  - – Metal roll-up tape
  - – Marked in ¼" increments
- **Scoop**–
  - – Large enough to obtain a sample but small enough not to spill during testing
- **Base Plate**–
  - – Flat, level, rigid, and nonabsorbent

Notes

Slide 7

SAMPLE

- Obtain a representative sample of cement concrete according to AASHTO R60.

NOTE:

- Particles larger than 37.5mm (1½ in.), removed according to Section 6 of AASHTO R60.
- Slump testing shall begin within 5 minutes of obtaining the sample.

Notes

Slide 8

PROCEDURE

- **MoDOT:** Concrete slump is to be determined prior to each air-entrainment test taken, and as necessary to maintain proper control of the concrete consistency. See EPG sec 501.
- Dampen the inside of the mold and place it on a dampened, rigid, nonabsorbent surface that is level and firm.

NOTE: <u>During the test prevent movement of the cone until the lift is performed</u>.

Notes

Slide 9

Hold the mold firmly in place during filling and perimeter cleaning by standing on the two-foot pieces or by clamping the foot pieces to a base plate.



Slide 10

Notes

(1st Layer) Using the scoop, fill the mold **one-third full** by volume, to a depth of approximately **2.75 in. (**70mm**)**.

- Consolidate, with **25 strokes** of the tamping rod, using the rounded end, being careful to completely remove rod from concrete between strokes.
- Distribute the strokes evenly over the entire cross section of the concrete.
- For the bottom layer, incline the rod slightly and make approximately half the stokes near the perimeter, then progress with vertical strokes, spiraling toward the center. Rod the bottom layer through its depth.

Slide 11

Notes

(2nd Layer) Use the scoop to fill the mold **two-thirds full** by volume, to a depth of approximately **6.5 in.** (160mm).

- Consolidate, with **25 strokes** of the tamping rod; penetrate approximately **1 inch** into the bottom layer.
- Distribute the strokes evenly.

Slide 12

Notes

(3rd Layer) Fill the mold to overflowing. Consolidate with **25 strokes** of the tamping rod; penetrate approximately **1 inch** into the 2nd layer.

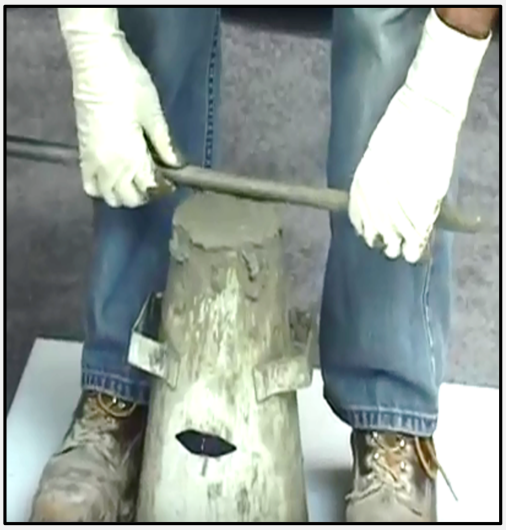
- If the concrete falls below the top of the mold, stop, add more concrete, and continue rodding for a **total** of 25 strokes.
- Keep an excess of concrete above the top of the mold at all times.
- Distribute the strokes evenly.



Slide 13

Notes

After the top layer has been rodded, strike off the top using a screeding and rolling motion of the tamping rod.



Slide 14

Notes

Clean around the base of the mold; carefully raise the mold vertically 12 inches in **5 ± 2 seconds** by a steady upward lift with no lateral or twisting motion.



Complete the test from filling to mold removal in **≤ 2 ½ minutes**.

Slide 15

Notes

- Immediately turn the mold upside down next to the specimen.
- Place the tamping rod across the mold so that it is over the test specimen.
- Measure the distance between the bottom of the rod and the displaced original center of the top of the specimen to the nearest ¼" (5mm).



Note: Do Not reuse the tested specimen for project related materials.

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Notes

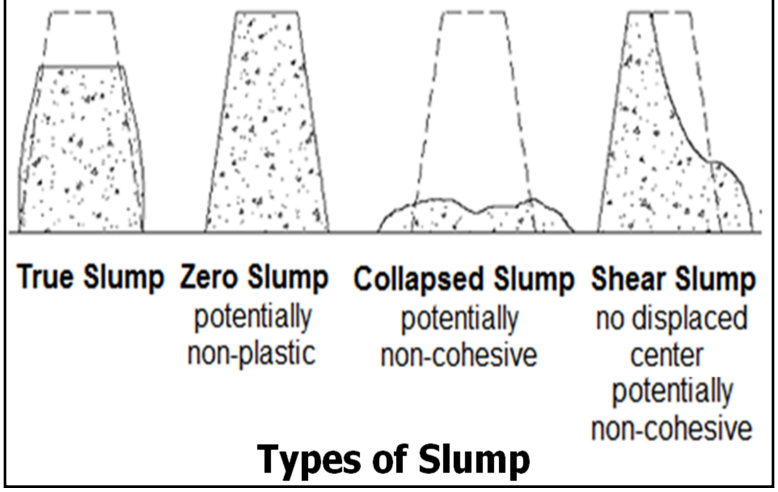
- If a decided falling away or shearing off of concrete from one side or portion of the mass occurs, disregard the test and make a new test on another portion of the sample.

NOTE: If two consecutive tests on a sample of concrete show a falling away or shearing off, the concrete probably lacks necessary plasticity and cohesiveness for the slump test to be applicable.



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Notes



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Notes

ZERO-SLUMP



This concrete is a bit too stiff it will be difficult to pour and vibrate properly, raising the risk of voids.

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Notes

TRUE-SLUMP



This concrete has about a 3.5-inch Slump. It's wet enough to be poured and vibrated properly yet dry enough that, as it cures, it will reach maximum strength.

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Notes

COLLAPSED-SLUMP



Excessive slump means the concrete has too much water. It's likely to shrink excessively and crack. It will be significantly weaker than properly hydrated concrete.

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Notes

REPORT

- Record the slump in terms of inches to the **nearest ¼ inch** (5mm) of subsidence of the off-set center of the specimen during the test.

See MoDOT EPG sec 501 for additional information.

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Notes

WHAT'S WRONG WITH THESE TESTS?



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Notes



Slide 24

Notes



Slide 25

Notes



Slide 26

Notes



Slide 27

Notes

Enlarged



This concrete is a bit too stiff it will be difficult to pour and vibrate properly, raising the risk of voids.

ZERO-SLUMP



This concrete has about a 3.5 inch Slump. It's wet enough to be poured and vibrated properly yet dry enough that, as it cures, it will reach maximum strength.

TRUE-SLUMP



Excessive slump means the concrete has too much water. it's likely to shrink excessively and crack. It will be significantly weaker than properly hydrated concrete.

COLAPSED-SLUMP

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, placement should 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 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.

A sample of concrete from which consistency tests are to be made must be representative of the entire batch. Sample**s** 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. 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 **approximately 1 inch.**

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 ½ minutes.

Immediately measure the 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 ¼ inch of subsidence below top of the mold.

A record of each slump test performed should be recorded in Site Manger.

AASHTO T119/ASTM C143: Slump of Hydraulic Cement Concrete

PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

Trial#	1	2
1. A Clean Slump Cone damped and placed on a moist, flat, level, nonabsorbent rigid surface		
2. Cone secured by clamps or by standing on foot pieces while filling the cone in three equal layers and while rodding		
3. Each layer approximately ⅓ the volume of the mold		
4. Each layer rodded 25 times		
5. Layers rodded properly a. First layer rodded through entire depth while inclining the rod & spiraling toward center b. Second layer rodded approximately 1" into underlying layer c. Third layer was kept heaped above the cone while rodding approximately 1" into the underlying layer		
6. Used a tamping rod to strike off level with the top of the mold		
7. Cone filled and removed within 2 ½ minutes		
8. Excess concrete cleaned away from the bottom of the mold and plate		
9. Movement/vibration of cone restricted until lift was performed		
10. Cone was lifted vertically without twisting, within 5 ± 2 seconds		
11. Immediately placed the mold upside-down next to the slumped concrete		
12. Placed the tamping rod on top of the cone, measured the vertical distance of the displaced original center of the slump to the rod		
13. Slump measured and recorded to the nearest ¼ inch		
	PASS	PASS
	FAIL	FAIL

Examiner: _____Date:_____

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Use For Notes If Needed

AASHTO T152

ASTM C231

Air Content of Freshly-Mixed Concrete by the Pressure Method

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Use For Notes If Needed



Slide 1

Notes

SCOPE

This method covers determination of the air content of freshly mixed concrete from observation of the change in volume of concrete with a change in pressure.

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.

Slide 2

Notes

SIGNIFICANCE & USE

- This test determines the air content of freshly mixed concrete exclusive of any air that exist inside voids within aggregate particles. It is applicable to concrete made with relatively dense aggregate particles and requires determination of the aggregate correction factor.
- The pressure procedure (AASHTO T152) gives substantially the same air content as the gravimetric and volumetric methods for concrete made with dense aggregates.
- The air content of hardened concrete may be either higher or lower than that determined by this test method. This depends on the methods and amount of consolidation effort applied to the concrete from which the hardened concrete specimen is taken.

Other methods T121 & T196

Slide 3

Notes

- **NOTE:** Concrete with light weight aggregates or aggregates with high porosity must be tested using the volumetric method - AASHTO T196.

The three AASHTO methods that provide **gravimetric**, **volumetric**, and **pressure** procedures, respectively, for determining the air content of freshly mixed concrete are:

1. **AASHTO T152**
   Air Content by ***pressure*** testing
   - Uses an Air Meter Type A or B
   - For Dense aggregate
   - Uses a correction factor for the air inside of aggregates

Slide 4

Notes

2. **AASHTO T121M**
   Air Content by ***gravimetric*** testing
   - Uses a Unit Measure for density
   - For "Yield" and "Air" content of concrete

3. **AASHTO T196M**
   Air Content by ***volumetric*** testing
   - Uses a Volumetric Air Meter (Roll-a-Meter)
   - For all types of aggregate
   - Is not affected by air inside of aggregates

Slide 5

Notes

Items that affect the air content in hardened concrete:

A. Uniformity and stability of the air bubbles in the fresh and hardened concrete.
B. Time of comparison
C. Environmental exposure
D. The stage in delivery
E. Placement
F. Consolidation processes at which the air is determined, that is, before or after the concrete goes through a pump; and other factors.

Slide 6

Notes

- Air Meter Type A or B (Typical vol. is 0.25 ft^3)
- Tamping rod
  5/8" ± 1/16" x 20 ± 4"
- Vibrator
- Scoop or shovel
- Mallet

Rubber or Rawhide head.
Wt. ~1.25 ±0.50lb.
For measures of 0.5ft^3 or smaller

Wt. ~2.25 ± 0.50lb.
For measures larger than 0.5ft^3

EQUIPMENT

Notes

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- Water Supply
- Strike off steel bar
  - 1/8" thick
  - ¾" wide
  - 12" long
- Rubber syringe, Plastic wash bottle
- Strike off plate

Flat rectangular
- Metal ¼" thick
- Glass or acrylic ≥ ½" thick
- Length ≥ 2" of the diameter of the measure
- Edges straight and smooth

EQUIPMENT

Notes

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INTERNAL VIBRATORS

- Minimum 9000 vpm (150hz) while in operation.
- Check periodically with a vibrating – reed tachometer.
- Vibrator element must be ≤ ¼ of the diameter of the cylinder mold or beam width.
- Combined length of vibrator element and shaft ≥ 3" longer than depth of section being vibrated.



Notes

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TYPE A AIR-METERS





More information can be found in the Appendix.

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Notes

TYPE "B" AIR-METERS

Covered in this certification



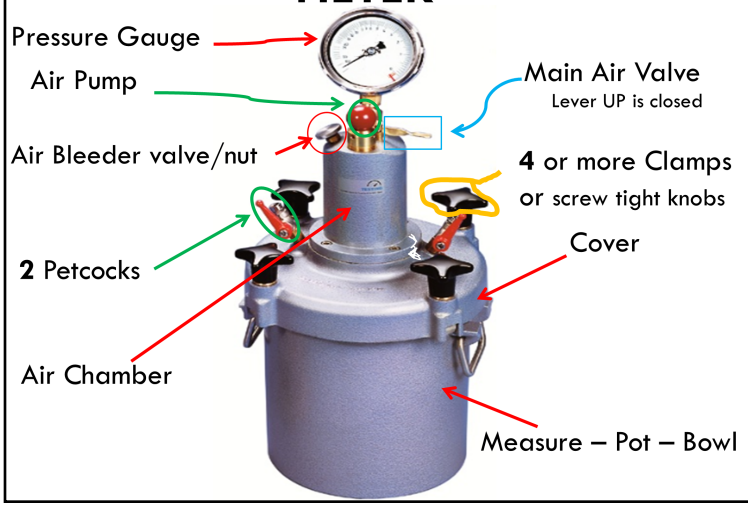


More information on equipment can be found in the Appendix.

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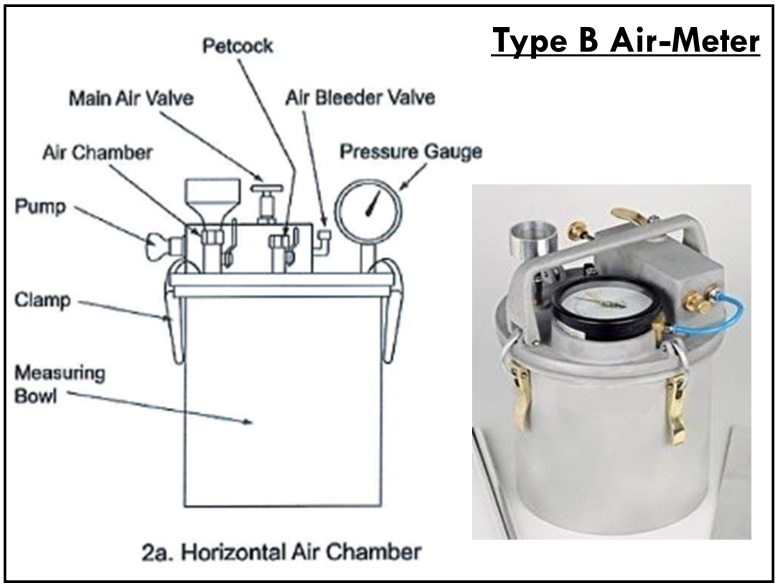
Notes

DIAGRAM OF A TYPE "B" AIR-METER



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Notes



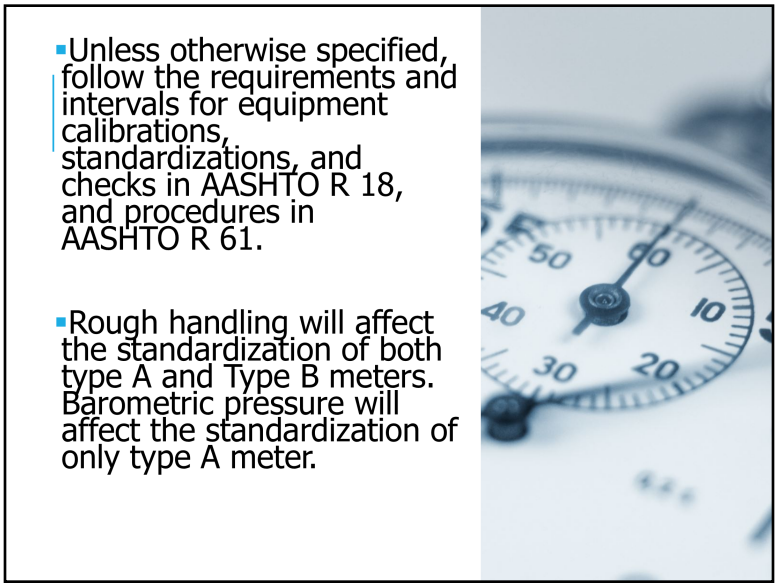
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Notes



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Notes



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Notes

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

*****See Annex and MoDOT EPG for more information on Calibration and Standardization.**



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Notes

AIR METER CHECK

If needed for a spot check in-between the annual calibration, use one of the "Air Meter Calibrators (5%)" below.

Verify the calibrator with the calibration of the Air Meter. In comparing results, note if there is a small off-set to apply to the calibrator.



Follow manufacturers instructions on how to use these devices.



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Notes

CALIBRATION OF APPARATUS

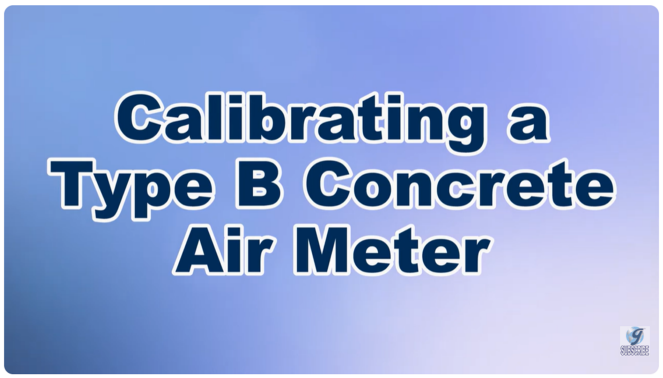
Information to be maintained in the records shall include determination of expansion factor, size of the standardization vessel used, and the reading of the meter at the standardization test point(s).

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Notes

CALIBRATION OF AIR METER

CALIBRATING A TYPE B AIR METER VIDEO



Calibrating a Type B Concrete Pressure Meter (HM-30, HM-30S)

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Notes

DETERMINATION OF THE AGGREGATE CORRECTION FACTOR



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Notes

AGGREGATE CORRECTION FACTOR: FINE AGGREGATE

$$F_S = \frac{S \ x \ F_b}{B}$$

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

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Notes

AGGREGATE CORRECTION FACTOR: COARSE AGGREGATE

$$C_S = \frac{S \ x \ C_b}{B}$$

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

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

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Notes

PLACEMENT OF AGGREGATE IN THE MEASURING BOWL

- Mix representative samples of fine aggregate (Fs) & Coarse aggregate (Cs), and place in the measuring bowl filled 1/3 full of water.
- Place mixed aggregate (small amount at a time) into the measuring bowl. If necessary, add additional water to submerge all the aggregates.
- Add each scoopful in a manner that will entrap as little air as possible and remove the accumulations of foam promptly.
- Tap the perimeter of the measuring bowl & lightly rod the upper 1" of the aggregate about 8-12 times. Stir after each addition of aggregate to eliminate the entrapped air.

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Notes

Initial Procedure for Type A & Type B Meters

- After aggregate is placed; Remove excess foam & keep the aggregate covered in water for a period of time approximately equal to the time between the introduction of water into the mixer and the time performing the test for air content.
- Remove a volume of water from the assembled & filled apparatus approximately equivalent to the volume of air that would be contained in a typical concrete sample (generally 5%) See Annex A1.9

Type A Meter: Complete the test for the determination of aggregate correction factor as described in the Appendix.

Type B Meter: Perform the procedure for determining air content as seen in Annex A1.9.

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Notes

AGGREGATE CORRECTION FACTOR: CLASSROOM EXERCISE



Given Scale weights from Concrete Mix Design:

Fine Aggregate – 1281 lbs./yd.^{3}
Coarse Aggregate – 1843 lbs./yd.^{3}

Report both the weight of Fine and Coarse aggregate to the nearest **0.01 pound**, used to determine Aggregate Correction Factor.

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Notes

Classroom Exercise

Determine the weight of the coarse and fine aggregate that will be in the air meter for testing using the following formulas to calculate the weights.

Fine Agg. $F_S = \frac{S \ x \ F_b}{B}$ **OR** Fs = (S/B) x Fb

Coarse Agg. $C_S = \frac{S \ x \ C_b}{B}$ **OR** Cs = (S/B) x Cb

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Notes

Classroom Exercise

ANSWER

F_b = 1281 lb. yd^3
C_b = 1843 lb. yd^3
S = 0.25
B = 27

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).

Fs = $\frac{0.25 \times 1281}{27}$ = 11.861 = **11.86 lb.**

Cs = $\frac{0.25 \times 1843}{27}$ = 17.064 = **17.06 lb.**

Report the answer to nearest **0.01 lb**.

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Notes

MODOT: EPG SECTION 501

- Air tests are to be made at the beginning of each pour on structures and for each 100 cubic yards there after.
- Aggregate correction factors shall be made available by the district to the Central Laboratory when coarse aggregate samples are submitted for AASHTO T161 testing. (Resistance of Concrete to Rapid Freezing and Thawing).

NOTE: See the EPG for additional information on MoDOT practices for testing Air Content of Concrete.

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Notes

PREPARATION AND PROCEDURE FOR DETERMINING AIR CONTENT OF CONCRETE



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Notes

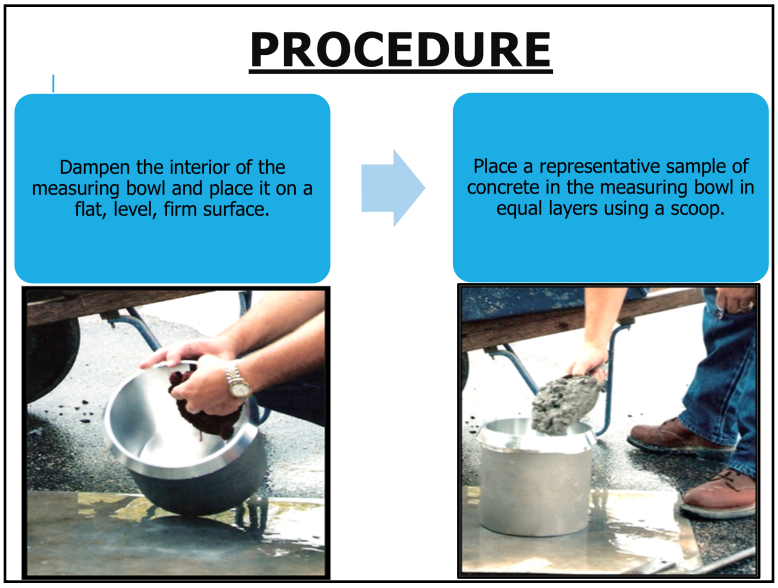
PREPARATION

- Obtain a sample of freshly mixed concrete in accordance with applicable procedures of AASHTO R 60.
- Make sure to follow AASHTO R60 for the coarse aggerate particle size to yield more than enough material to fill the measuring bowl that has been selected.
- Take caution to minimize disturbing the mortar when wet sieving.



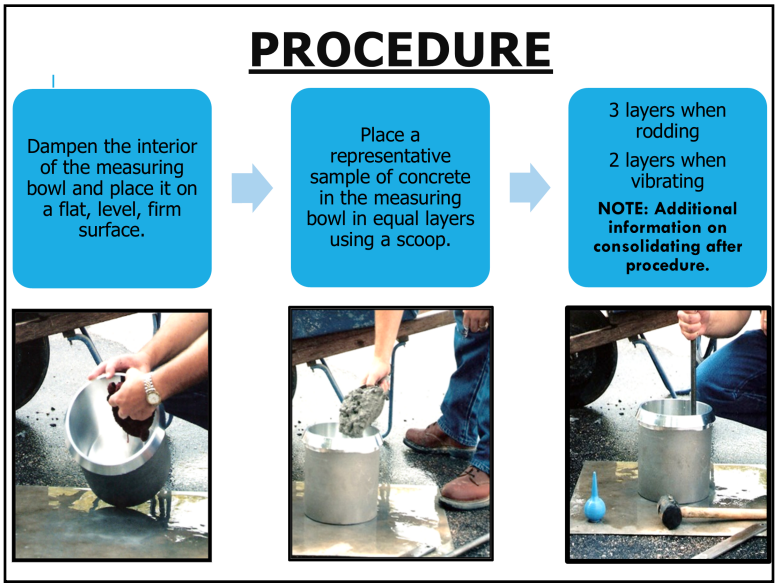
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Notes



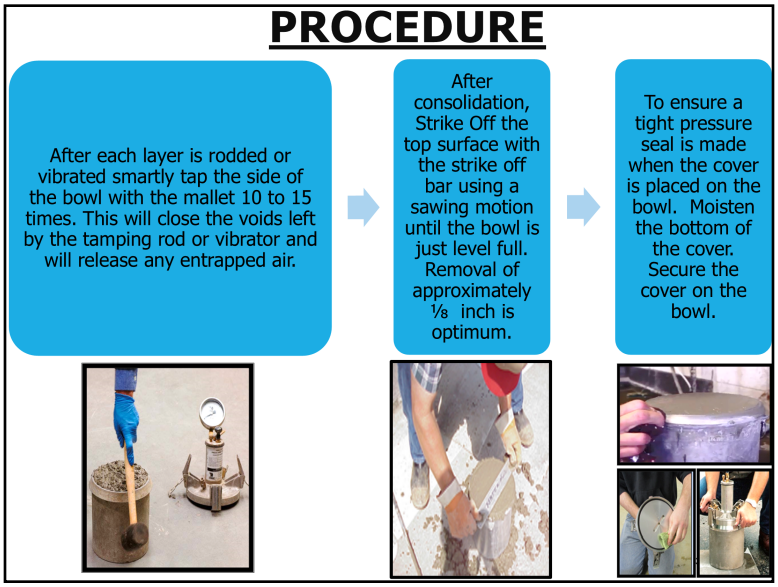
Slide 31

Notes



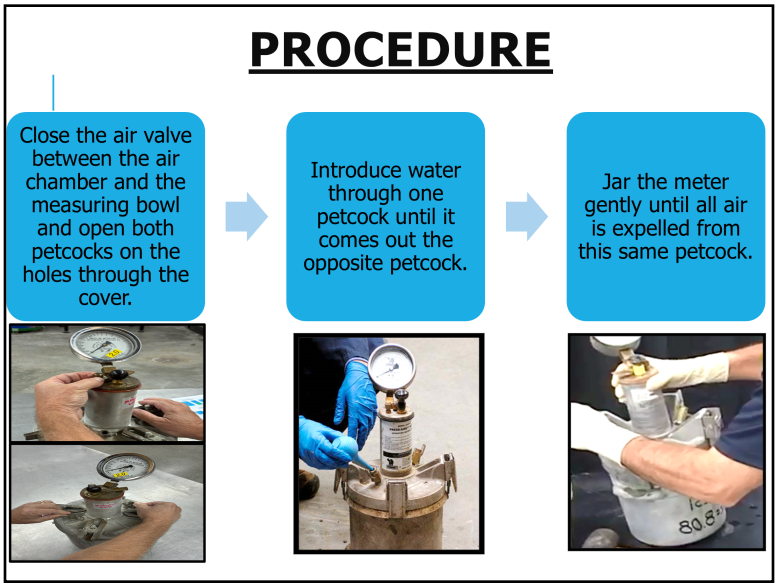
Slide 32

Notes



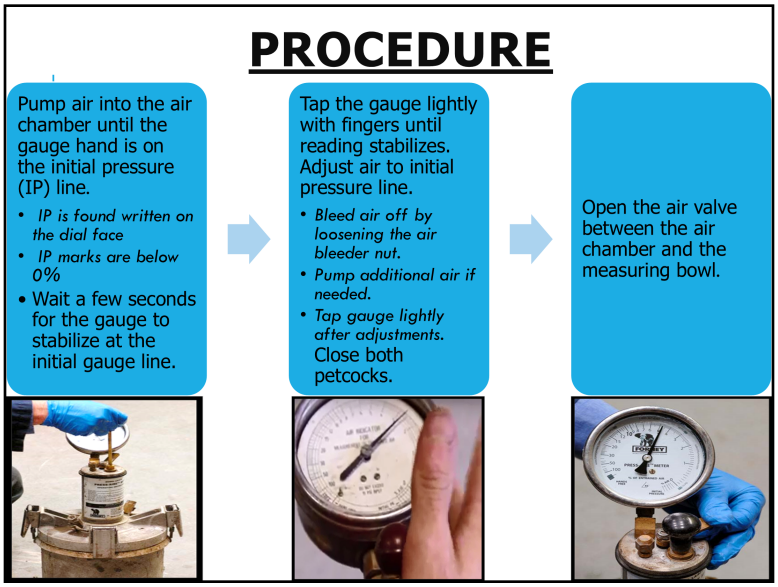
Slide 33

Notes



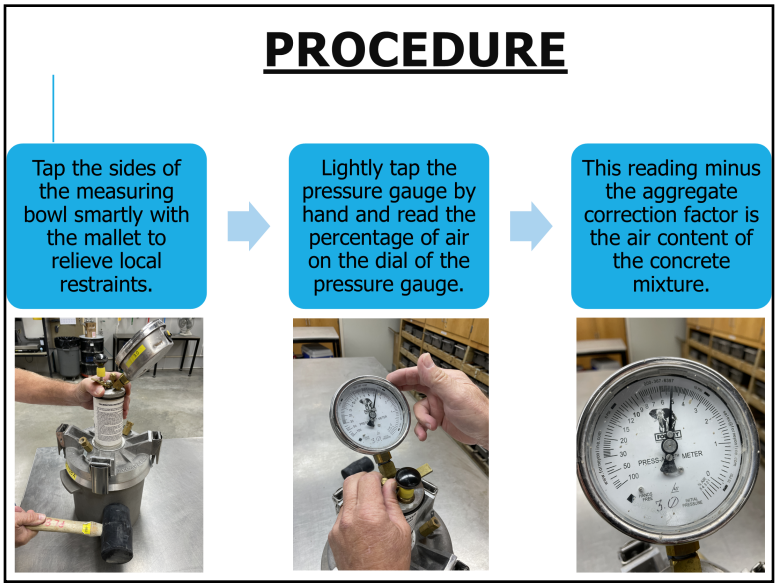
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Notes



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Notes



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Notes

Consolidate each layer by rodding or by vibration

A slump greater than **3** inches = **ROD**

A slump of **1** to **3** inches = **ROD or VIBRATE**

A slump less than **1** inch = **VIBRATE**

NOTE: Self-Consolidating Concrete (SCC) prohibits rodding and internal vibration, so slightly overfill the measure with SCC in one continuous lift.

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Notes

CONSOLIDATION BY 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. Rod the bottom layer throughout its depth, but **DO NOT** forcibly strike the bottom of the bowl.

-When rodding the second and final layer only allow the rod to penetrate the previous layer about 1 inch.

-When the final layer of concrete is added, be careful to avoid excessive overfilling.

(⅛ inch is optimum)

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Notes

CONSOLIDATION BY VIBRATING

When vibrating the concrete, place the concrete in **2** approximately equal layers.

Vibrate each layer by inserting the vibrator in **3 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.

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.

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Notes

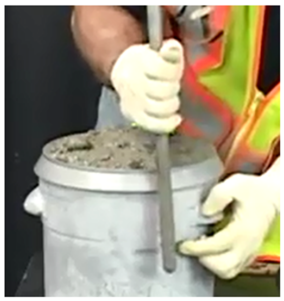
CONSOLIDATION SUMMARY

Rodding

3 layers

25 strokes/layer

10–15 sharp taps/layer



Vibration

2 layers

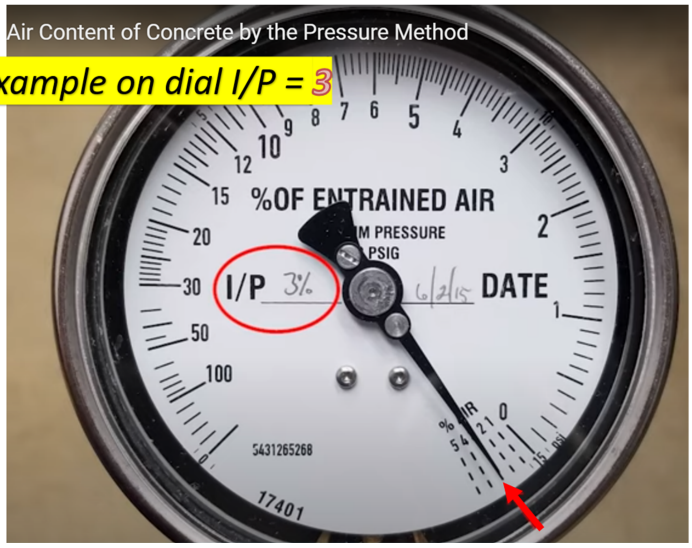
3 insertions per layer

Evenly distributed over cross section



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Notes



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Notes

CALCULATION – AIR CONTENT

$$A_s = A_1 - G$$

Calculate the air content of the concrete in the measuring bowl

A_s = Air content of sample tested, percent

A_1 = Apparent Air content of the sample tested, percent

G = Aggregate correction factor, percent

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Notes

REPORT

Report the air content of the concrete sample to the **nearest 0.1 percent** after subtracting the aggregate correction factor, unless the gauge reading of the meter **exceeds 8 percent**, in this case the corrected reading shall be reported to the **nearest ½ scale division on the dial.**

Example, to the nearest 0.1% or 0.5%.

Report the date and time of the test.

(For MoDOT See EPG Section 501.1.8.2.)

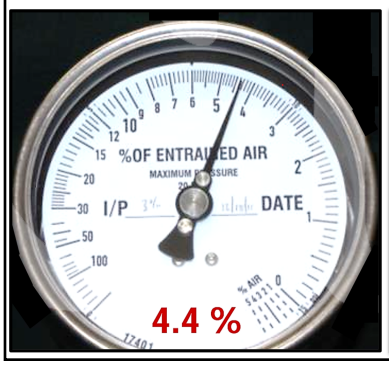
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Notes

READING THE % AIR

Air Content ≤ 8.0%

- Report to nearest 0.1%



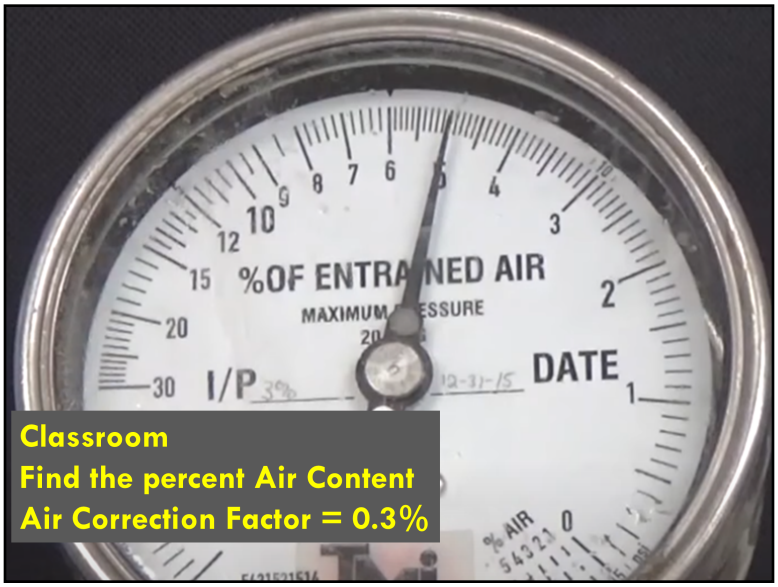
Air Content > 8.0%

- Report to nearest half-scale division



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Notes



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Notes

Air Content Calculation

Air% = Gauge Reading – Aggregate Correction Factor

Example:

ACF = 0.3%

Gauge Reading = 5.0%

Air% = 5.0% – 0.3

Air% = 4.7%

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Notes

ON YOUR OWN

Using the following information, what three items would be reported for air content per AASHTO T152? Report air to the correct decimal place.

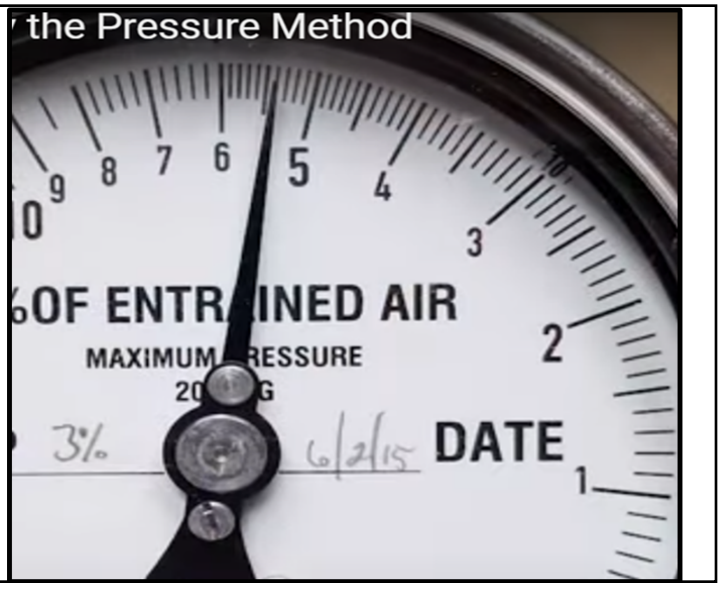
Air Content Reading, job information:

Taken on: *05/24/2024 at 10 AM*,
Producer/Supplier: *ABC Concrete Producers LLC*
Job#: *Jen8675309*
Location: *830 MoDOT Drive, Jefferson City MO. 65102*
Slump: *4.00 inches*
Air-Content pressure gauge reading: *gauge on next slide*
Aggregate Correction Factor: *0.3%*

1. _____
2. _____
3. _____

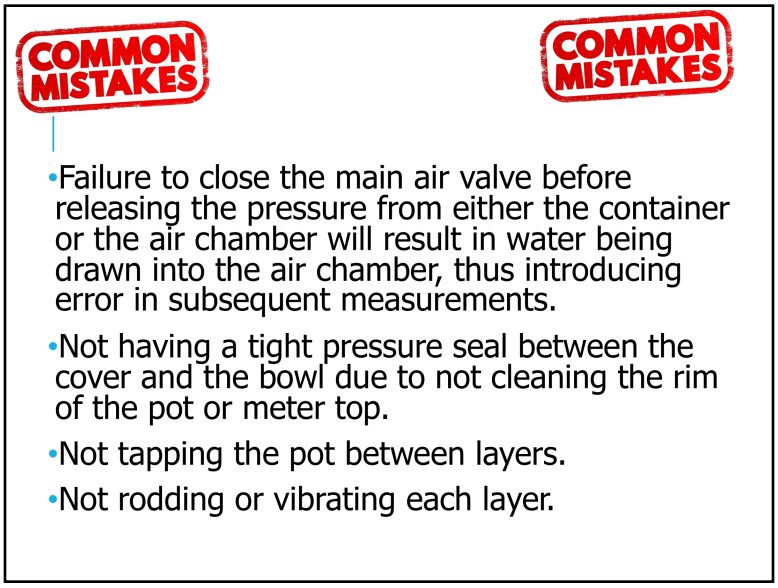
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Notes



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Notes



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Notes

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Use For Notes If Needed

501.1.8 Volumetric Batched and Continuous Mixed Concrete (Sec 501.9)

Upon written request by the contractor, the engineer may approve the use of concrete proportioned by volume. If concrete is proportioned by volume, all requirements of the Standard Specifications shall apply. The resident engineer and inspector should thoroughly familiarize themselves with the specification requirements of volumetric batched and continuous mixed concrete.

501.1.8.1 Calibration (Sec 501.9.3)

The following is to establish a procedure for calibrating units used for volumetric proportioning of low slump concrete, latex modified concrete and other concrete pours, except bridge decks, when approved by the Engineer.

Equipment:

a. Stop watch reading to 0.1 second.
b. Scales, minimum capacity of 200 lbs. and accurate to within 0.5% of the test load.
c. A suitable container for test sample. (The bottom 1/4 of a 55 gallon barrel is satisfactory).
d. 250 and 1000 milliliter graduated cylinders.

Before calibrating the unit, the inspector should become familiar with the general operation, controls, storage compartments, etc. of the volumetric proportioning unit. Proportioning tolerances and proportioning devices such as counter, flow meter, and calibrated gate openings shall be in accordance with Job Special Provision "Portland Cement Concrete Volumetric Batching and Continuous Mixing". The cement discharge rate for any unit is constant when operated in a given gear. For those units equipped with a range of gears on the cement feeder, the operator should be consulted as to what gear the unit will be operated in during the pour. Calibration shall be in that gear in which the concrete mix is to be produced. Mechanically driven units are equipped with tachometers and these units must be calibrated and operated under load at the RPM reading specified by the manufacturer within a tolerance of 50 RPM. On the all hydraulic proportioning units, it is only necessary to advance the throttle until it is against the preset stop. It is important to remember that calibration data obtained for one unit cannot be used on any other unit.

Calibration of all proportioning devices shall be on a weight basis with the exception of the admixture flow meters which may be calibrated on either a weight or a volume basis.

The first step in calibrating a volumetric proportioning unit is to determine the exact cement meter count and the corresponding time in seconds, to 0.1 second, for the discharge of one sack or 94 lbs. of cement. Both aggregate bins should be empty and the main conveyor belt should be clean. Check to ensure that all bin vibrators and the cement bin aeration system are functioning properly. Set throttle to hold the specified RPM reading on mechanical drive units or advance throttle to the preset stop on hydraulic drive units. Discharge enough cement to ensure that the main conveyor belt is fully primed and then reset the cement meter so it reads zero. Discharge approximately 100 pounds of cement into a clean, tared container. Carefully time the run by starting and stopping the stop watch at exactly the same time that the main clutch is engaged and disengaged. Record the actual weight of cement discharged, the cement meter count and the time to the nearest 0.1 second. A minimum of six test runs shall be made. Divide the total meter counts for the six test runs by the total weight of cement discharged and multiply this factor by 94 (the weight of one sack of cement) to determine the meter count to discharge one sack of cement. Likewise, divide the total number of

seconds for the six test runs by the total weight of cement discharged and multiply this factor by 94 to determine the time, to the nearest 0.1 second, to discharge one sack of cement.

Calibration procedures and calculations for both fine and coarse aggregate are the same. Because the gates on the fine and coarse aggregate bins of a volumetric proportioning unit do not completely close, only one of these materials can be charged into the mixer at any one time during calibration. Assuming that fine aggregate bin is to be calibrated first, fill it at least two-thirds full with sand and make sure the coarse aggregate bin is empty. Check to ensure that all bin vibrators are functioning properly and that the Cement Meter-Feeder clutch is disengaged to prevent cement discharge while calibrating the aggregate bins. The operator should set the sand gate control at the approximate setting for the weight desired based on previous experience. Set the throttle as noted above. Discharge and waste enough fine aggregate to ensure that the main conveyor belt is fully primed. Discharge approximately 150 to 200 pounds of fine aggregate into a clean, tared container. Carefully time the run by starting and stopping the stop watch exactly when the main clutch is engaged and disengaged. Record the weight of fine aggregate and the actual time to the nearest 0.1 second. Using these two figures and the time determined above, set up a direct proportion to calculate the amount of fine aggregate delivered in the exact length of time it takes to deliver 94 pounds of cement. If the actual quantity delivered is not within the allowable tolerance of the quantity required, adjust the gate control as needed and repeat the above procedure. Several trial runs may be necessary to obtain the correct gate setting. Once this gate setting has been established, at least three runs should be made to verify that it is correct. Empty the fine aggregate bin, charge the coarse aggregate bin and follow the same procedure as above to determine the coarse aggregate gate setting. If several mixes will be used from the same proportioning unit, coarse and fine aggregate bin curves may be plotted using three or more gate settings. The curves should cover the full range of aggregate flow rates anticipated and should be verified within the appropriate tolerances.

When admixtures are used the dispensers on the volumetric proportioning unit shall be calibrated. Calibration may be on either a weight or a volume basis. Dilution of admixtures is usually necessary in order that accurately measurable quantities can be dispensed through the flow meters. Set the throttle as noted above. Set the flow meter at a given point and discharge a sufficient amount of solution into a clean container to obtain an accurate measurement or weight. Carefully time the run to the nearest 0.1 second. Record the quantity of solution delivered and the time. Using these two figures and the time determined above, set up a direct proportion to calculate the amount of solution delivered in the exact length of time it takes to deliver 94 pounds of cement. Repeat the above procedure at least two more times at the same setting and average the results. In the same manner, determine the flow rate at two more points and plot a curve of meter setting vs. flow rate. Verify the curve at a point near where it is anticipated the flow meter will be set during mix production.

The rate of flow through the water flow meter should be determined and a calibration curve plotted as follows: Set the throttle as above. Set the flow meter at a given point and discharge a sufficient quantity of water into a clean, tared container to obtain an accurate weight. Carefully time the run to the nearest 0.1 second. Record the quantity of water delivered and the time. Using these two figures and the time determined above, set up a direct proportion to calculate the amount of water delivered in the exact length of time it takes to deliver 94 pounds of cement. Repeat the above procedure at least two more times at the same setting and average the results. In the same manner determine the flow rate at two more points and plot a curve of meter setting vs. flow rate. Verify the curve at a point near where it is anticipated the flow meter will be set during mix production. When determining the meter setting for actual mix production, the amount of

water in the admixture solutions as well as moisture in the aggregates must be taken into consideration and subtracted from the design gallons of water per sack of cement.

501.1.8.2 Verification (Sec 501.9.4)
Proportioning devices shall be verified by running the one-quarter cubic yard test in accordance with the Job Special provisions. Adjust the mix conveyor so that it is at an angle of about 20 degrees. Set the throttle as noted in Calibration. With all controls set for the designated mix, discharge enough mixed material to ensure that the entire length of the mix conveyor contains properly proportioned concrete and then stop the mixing action. Immediately reset the cement meter to zero and swing end of the mix conveyor over the one-quarter cubic yard container (36 in. x 36 in. x 9 in.). Activate the mixer and discharge mixed material into the container until the cement meter count shown that the quantity of cement for one-quarter cubic yard of concrete has been dispensed. Screed the concrete level. Mixes with very low slumps may require vibration. A tolerance of +1/8 inch from the top of the container will be permitted.

501.1.9 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.

501.1.9.1 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 ensure 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 ensure 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:

$$R = \frac{0.2205w(grams)}{W(grams)}$$

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).

$$K = 0.98R + D$$

(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:
(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.

Note: Use the 5% block only for checking in-between annual calibrations. The 5% block must be calibrated alongside the yearly calibration of the air-pot to note any offsets.

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 (± any calibrated offset), 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.

501.1.9.2 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.

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Use For Notes If Needed

AASHTO T152/ASTM C231: 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 a 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 emerged from opposite petcock		
4. Meter jarred gently until all air was expelled		
5. Air pumped into chamber until gauge hand is on initial pressure line		
6. Waited a few seconds to allow for the gauge to stabilize at the initial pressure line.		
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 sharply		
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. Aggregate correction factor determined for different aggregates		

PASS PASS

FAIL FAIL

Examiner: _____Date:_____

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Use For Notes If Needed

AASHTO R100

ASTM C31

Making and Curing
Of
Concrete Beam Specimens
in the Field



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Use For Notes If Needed

MAKING AND CURING CONCRETE TEST SPECIMENS IN THE FIELD

AASHTO R100

ASTM C31

Revised 12/1/2025

Slide 1

Notes





Cylinders **Beams**

Slide 2

Notes

SCOPE

- This practice covers procedures for casting and curing cylinder and beam specimens from representative samples of fresh concrete for a construction project.
- The concrete used to make the molded specimens shall be sampled after all on-site adjustments have been made to the mixture proportions, including the addition of mix water and admixtures.
- This is intented for concrete with measurable slump

Slide 3

Notes

SIGNIFICANCE AND USE

- This practice provides standardized requirements for casting, curing, protecting, and transporting concrete test specimens under field conditions.
- For acceptance testing for strength, perform the following 3 tests for each sample of concrete from which the specimens are made.
  1. Slump
  2. Air Content
  3. And Temperature

Notes

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SIGNIFICANCE AND USE

Cast & Standard Cured (Section 9.1)- Use Data for:

- Acceptance testing for specified strength
- Checking for adequacy of mixture proportions
- Quality control

Cast & Field Cured (Section 9.2)- Use Data for:

- Determination of whether a structure is capable of being put in service
- Adequacy of curing & protection of concrete in the structure
- Form or shoring removal time requirements
- Comparison with test results of standard cured specimens

Notes

Slide 5

EQUIPMENT

- Tamping Rod- (Size determined by the size of specimen)
- Cylinder Mold and Cap
- Beam Mold- (See appendix for specifics)
- Scoop
- Marker
- Trowel or Straight-Edge
- Mallet- (Rubber or Rawhide weighing 0.75-1.75lb)
- PPE
- Sampling Receptacle
- Max-Min Thermometer
- Wet-Sieving Equipment
- Vibrator
  - The diameter of a round vibrator shall be no more than 1/4th diameter of cylinder or width of mold. Other shaped vibrators shall have a perimeter equivalent to circumference of the round vibrator.

See Appendix for Additional Equipment Information

Notes

Slide 6

TESTING REQUIREMENTS

Min. Cross-Sectional Dimensions of Beams	AASHTO Table 2
NMAS	Min. Cross-Sectional Dimensions
≤ 1 Inch	4" x 4"
1" < NMAS ≤ 2"	6" x 6"

Method of Consolidation	AASHTO Table 3
Slump	Consolidation Method
≥ 1 Inch	Rod or Vibrate
≤ 1 Inch	Vibrate

Notes

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Notes

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TESTING REQUIREMENTS - CYLINDERS



- **Diameter**
  ≥ 3 x NMAS
- **Length**
  2 x Diameter
- **Acceptance Testing**
  6" x 12 " cylinder
  or
  4" x 8" cylinder

**NMAS = Nominal Maximum Aggregate Size

Notes

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6 X 12" CYLINDERS

- **Rodding**
  - 5/8" Rod
  - 3 Lifts
  - 25 Rods per Lift

(Penetrate previous lift by 1")

Tap 10-15 times with a mallet after each lift is consolidated on reusable molds.

Use open hand on single use molds that could be damaged from using a mallet.

- **Vibration**
  - Internal Vibrator
  - 2 Lifts
  - 2 Insertion per Lift

(Penetrate previous lift by 1")

Tap 10-15 times with a mallet after each lift is consolidated on reuseable molds.

Use open hand on single use molds that could be damaged from using a mallet.

Slide 10

Notes

4 X 8" CYLINDERS

- **Rodding**
  - 3/8" Rod
  - 2 Lifts
  - 25 Rods per Lift

(Penetrate previous lift by 1")

Tap 10-15 times with a mallet after each lift is consolidated on reusable molds.

Use open hand on single use molds that could be damaged from using a mallet.

- **Vibration**
  - Internal Vibrator
  - 2 Lifts
  - 1 Insertion per Lift

(Penetrate previous lift by 1")

Tap 10-15 times with a mallet after each lift is consolidated on reusable molds.

Use open hand on single use molds that could be damaged from using a mallet.

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Notes

MOLDING SPECIMEN LOCATION



- Cast Cylinders and Beams as close as possible to the place where they are to be stored.
- Cast specimens on a level, horizontal, and rigid surface.
- Surface should be free of vibration and other disturbances.

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Notes

SELF-CONSOLIDATING CONCRETE

- Cast Specimens should be filling procedure in ASTM C1758
- After Filling the container, finish the specimens with Section 8.6 without further consolidation

Notes

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SUMMARY FOR CASTING CYLINDERS AND BEAMS

- Sample concrete per AASHTO R60.
- Test Temperature, Slump, and Air.
- Determine method of consolidation from slump result (see Table 3).
- Select proper size mold, scoop, tamping rod or vibrator.
- Consolidate each layer according to size of the sample.
- Vibrate or rod into previous layers by 1 inch
- Final layer, add enough concrete to over-fill the mold after consolidation.
- Finish by striking off the excess concrete using a tamping rod, float, or trowel.
- Prepare specimens for initial curing.

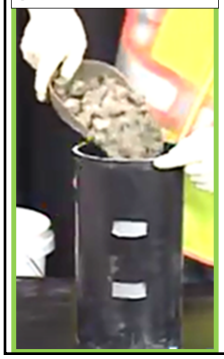
Notes

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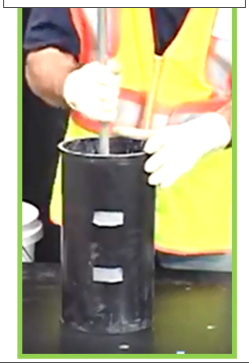
6"X 12" Cylinders

1ST LAYER

Filling 1st Layer 1/3 of Volume, Move scoop around the perimeter.



Rodding 25 times do not forcibly strike the bottom.

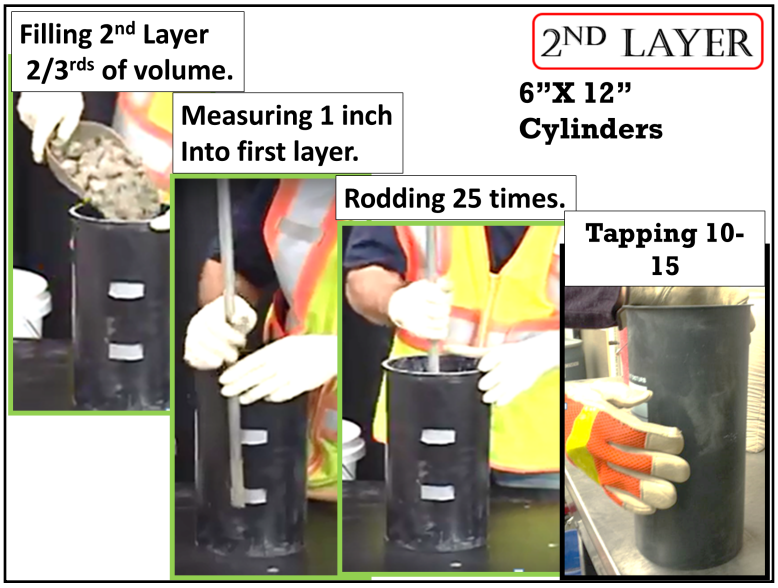


Tapping 10-15 times with a mallet. ***Use palm of hand for single use molds susceptible to damage.***



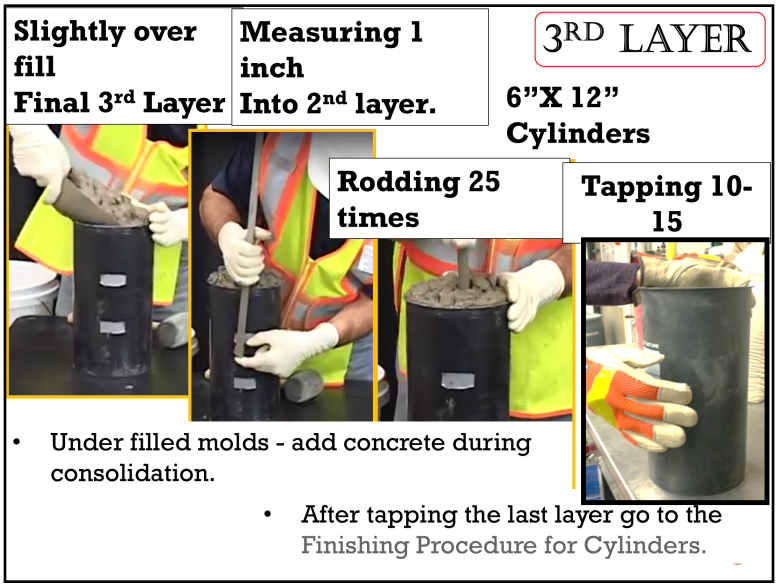
Notes

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Notes



Slide 17

Notes



Slide 18

Notes

Vibrating 6 x 12" Cylinder:

- Complete 2 equal lifts/layers.
- Move the scoop around the perimeter when filling.
- Vibrate after each layer with 2 insertions per layer.
- Avoid touching the sides or bottom of the mold.
- Tap the sides 10-15 times.
  - For light gauge molds **susceptible to damage** use an open hand to tap the sides.
- On the last layer, do not overfill by more than **¼"**.
- Number of Insertions per lift:
  - **1 location** for 4" x 8" cylinders.
  - **2 locations** for 6" x 12" cylinders

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Notes

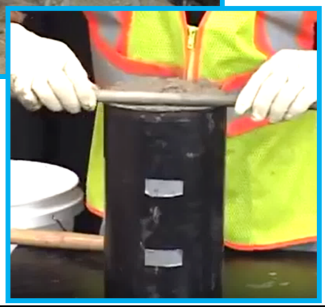
- Vibrate into the *lower* layer approximately **1"**
- Slowly remove the vibrator to avoid air pockets.
- Continue vibration only long enough to achieve proper consolidation.
  - Up to 5 seconds for slumps > 3"
  - Up to 10 seconds for slumps ≤ 3"
  - Exceeding 10 seconds is rare.
- After tapping the last layer go to the Finishing Procedure for Cylinders.

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Notes

FINISHING PROCEDURE CYLINDERS





- Strike-off excess concrete using a tamping rod (if concrete consistency permits) or float or trowel.
  - Use the minimum manipulation necessary to produce a flat, even surface level with the rim of the mold.
  - No depressions or projections greater than **⅛"**

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Notes

IDENTIFICATION - CYLINDERS

- Wipe off excess concrete.
- Put the cap on.
- Write the ID and other information on the mold, not the cap.
- Secure the lid with duct tape.

To Be On Label:

- Specimen Identification
- Serial Number of delivery ticket
- Location of concrete
- Date, Time and name of individual specimens
- Results from Slump, Air, and Temp testing



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Notes

- Within 15 minutes of molding, move to cylinders to initial place of curing.
- Maintain cylinders in upright position.
- Protect specimen from moisture loss, direct sunlight, and radiant heating devices.
- Initial Curing begins.

- Store for a period of 48 hours at 60 to 80° F
- Specimens that are ≥6,000 PSI store at 68 to 78° F
- Record temperature with a min/max thermometer.



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Notes

TRANSPORTATION

- Transport Specimens
  - Specimens shall not be transported until at least 8 hours after final set.
  - MoDOT Cylinders; after the initial cure period, the specimen shall be removed from the mold and placed in a sealed plastic bag to maintain free moisture during shipping.
- Protect specimens during transport from:
  - Jarring
  - Freezing
  - Moisture loss
- Transportation
  - Time allowed ≤ 4 hours

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Notes

BEAMS

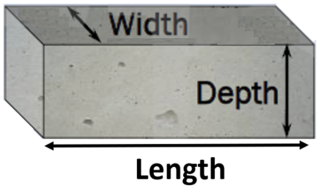
Note: All tables are at the end of this presentation.



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Notes

TESTING REQUIREMENTS - BEAMS



Standard Beam
6" x 6" x 20"

- **Beams**
  - **Ratio of Width to Depth**
    - $\frac{\text{Width}}{\text{Depth}} \leq 1.5$
  - **Length**
    - 2" > 3 x depth
  - Standard beam shall be 6 x 6 unless otherwise specified.

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Notes

PROCEDURE – MOLDED BEAMS

6" X 6" X 20" Beam

- Fill the beam in the correct number of lifts
  - Rodding – 2 lifts
  - Vibration – 1 lift
- When filling the final layer, avoid overfilling by more than ¼".

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Notes





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Notes

PROCEDURE – RODDING BEAMS

6" x 6" x 20 " Beam

- Use a ⅝" Rod
- Each layer , 1 rod every 2 in.^{2} of surface area.
  - 60 rods/lift.
  - Penetrate previous lifts about 1".
- Tap mold 10 – 15 times with a mallet after each lift has been consolidated.
- When placing the final layer, avoid overfilling by more than ¼ ".
- Spade each layer with a trowel.
  - Spade sides and ends.

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Notes











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Notes





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Notes

PROCEDURE – VIBRATING BEAMS

- Insert vibrator full depth.
  - Don't touch mold with vibrator.
  - Vibrate about 10 sec. per insertion or less.



- Insert at Intervals ≤ 6″ along centerline.
  - 3 - 4 insertions for a standard beam (6″x 6″x 20″)

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Notes

PROCEDURE –VIBRATING BEAMS

- For beams wider than 6″ use alternating insertions along two lines.



- Tap mold sharply 10 – 15 times with a mallet after each lift has been consolidated.
- Do not spade.

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Notes

FINISHING – BEAMS

- Finish beams using a float or trowel.
  - Use minimum manipulation necessary.
    - Strike off the top surface.
    - Work for a flat even surface that is level with the rim or edge of the mold.
  - No depressions or projections greater than ⅛".

Notes

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FINISHING – BEAMS

- Within 15 minutes of molding, move to initial place of curing.
- Refinish surface if needed.
- Protect from moisture loss.
  - ✓Use plastic sheeting.

Notes

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Consolidation Quick Chart for:	
Rodding ⅜ " Rod (4 inch in width) ⅝ " Rod (6-8 inch in width)	**Vibratior** Do not to Vibrator
2 Lifts	**1** Lift (avoic
Rod once every 2-inch² of surface area. Penetrate previous layer by 1 inch.	**1** insertion Insert full c along cent 4 insertion Beams wid alternating
Tap 10-15 times with a mallet per lift	**Tap 10-1** with a ma
Spade each layer with trowel on sides and ends	Do not sp

Notes

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CURING

- **Curing** is the process of maintaining moisture and temperature conditions for proper hydration of concrete mixtures.

Notes

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- **Standard Curing**
  - Acceptance testing for specified strength
  - Checking adequacy of mixture proportions
  - Quality control

- **Field Curing**
  - Determining when a structure may be put into service
  - Form removal time
  - Checking adequacy of curing and protection of structure
  - Comparison tests

Notes

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STANDARD CURING - CYLINDERS

- Includes two parts:

1. Initial Curing: Is the time in which the fresh concrete "sets" and becomes rigid.
2. Final Curing: Is the time in which the fresh concrete begins to harden and gain strength.

Notes

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STANDARD CURING-CYLINDERS

- Initial Curing Conditions:
  - Time Period
    - Up to 48 hours after molding.
  - Temperature
- Record temp. using a Max-Min Thermometer
  - For specimens < 6000 psi
    - 60 to 80 °F
  - For specimens ≥ 6000 psi
    - 68 to 78 °F



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Notes

STANDARD CURING CYLINDERS

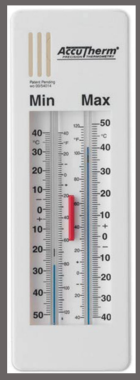


- Choose one or more of the following to control moisture environment of the specimen:
- Cover with containers with removable plastic lids.
  - Store in properly constructed boxes.
  - Damp sand pits.
  - Place inside plastic bags.
  - Immediately immerse in water saturated with calcium hydroxide.

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Notes

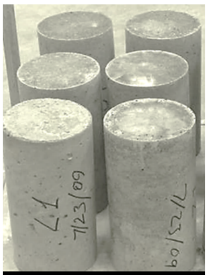
STANDARD CURING-CYLINDERS



- Controlling Temperature
  - Thermostatically controlled heating and cooling devices.
    - Light bulbs
    - Fans
    - Water baths
    - Ice
  - Record minimum and maximum temperatures for each set.
  - Shield specimens form direct sunlight, heat or loss of moisture.

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Notes



- Remove Molds
  - Copy identification markings on to specimen.
  - Final curing must begin within 30 minutes of mold removal.
- Final Curing
  - Always maintain free water on surfaces using;
    - Moist rooms
    - Storage tanks
- Temperature
  - 73.5 ± 3.5 °F

FINAL STANDARD CURING - CYLINDERS

At the end of curing, test the specimen.

Notes

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STANDARD CURING – BEAMS





- **Beams** are cured same as cylinders, except beams are stored in water saturated with calcium hydroxide at 73.5 ± 3.5°F for at least 20 hours prior to testing.
- Guard against drying between time of removal from curing to testing.

Notes

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FIELD CURING - CYLINDERS

Field Curing Conditions	Testing

• Store near the point of deposit.
• Protect like the formed concrete.
  • Provide like temperature and moisture conditions.
  • Including during transport.
• Remove cylinders from molds when formwork is removed.
	• Remove from field
	  • Maintain moisture and test in "as is" condition.

Notes

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FIELD CURING - BEAMS

- Cure in the same manner as concrete in the structure.
  At the end of 48 ± 4 hours, take the molded beams to the storage location and remove the molds.
- Slabs
  - Store on ground as molded, with top surfaces up.
  - Bank sides and ends with damp earth or sand leaving top surface exposed.

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Notes

FIELD CURING - BEAMS

- Structures
  - Store beams near the structure they represent.
  - Provide same temperature protection and moisture environment as structure.
- Testing
  - Remove from field and store in water saturated with calcium hydroxide @ 73.5 ± 3.5°F for 24 ± 4 hours prior to testing.

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Notes

REPORTING

- Identification number
- Location of concrete represented by the samples
- Date, Time, and Name of individual molding specimens
- Test Results
  - Slump, air content, and temperature: Method Deviations
- Curing Method –
  - **For Standard Curing**: Report the initial with Max and Min Temperatures and final curing method.
  - **For Field Curing:** Report the location where stored, manner of protection from the elements, temperature, and moisture environment, and time of removal from molds.

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Notes

COMMON 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.



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Notes

APPENDIX &TABLES

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Notes

CASTING - Cylinders

- Select tamping rod or vibrator from Table 1.
- Determine method of consolidation Table 3.
- Rodding, molding requirements on Table 4.
- Vibrating, molding requirements on Table 5.
- Select the right size scoop.
- While placing the sample in the mold, move the scoop around the perimeter of the mold.
- Consolidate each layer as required.
- Self-Consolidating Concrete – cast specimens without layers or consolidation.

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Notes

CYLINDERS

Tamping Rod Requirements	AASHTO Table 1	
	Rod Dimensions	
Diameter of cylinder or Width of Beam mm (inch)	Diameter mm (inch)	Length of rod mm (inch)
< 150 (6)	10 (3/8)	300 (12)
150 (6)	16 (5/8)	500 (20)
225 (9)	16 (5/8)	600 (24)

[a]Rod tolerances length ± 100mm (4 inches) and diameter ±2mm (1/16 inch).

Notes

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AASHTO TABLE 3 - CYLINDERS

Method of Consolidation Requirements	
Slump, mm (in)	Method of Consolidation
≥25mm (≥ 1 inch)	Rodding or Vibration
≤25mm (≤1 inch)	Vibration

NOTE: 1" you can Rod or Vibrate

Notes

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AASHTO TABLE 4 - CYLINDERS

Molding Requirements	By Rodding	
Specimen Type and Size Cylinders:	Number of Layers of Approximately Equal Depth	Number of Roddings per Layer
Diameter, mm (inch)		
100 (4 inch)	2	25
150 (6 inch)	3	25
225 (9 inch)	4	50

Notes

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AASHTO Table 1 - Beams	Tamping Rod Requirements	
	Rod Dimensions[a]	
Diameter of cylinder or Width of Beam mm (inch)	Diameter mm (inch)	Length of rod mm (inch)
< 150 (6)	10 (3/8)	300 (12)
150 (6)	16 (5/8)	500 (20)
225 (9)	16 (5/8)	600 (24)

[a]Rod tolerances length ± 100mm (4 inches) and diameter ±2mm (1/16 inch).

Notes

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Minimum cross-Sectional Dimensions of Beams	AASHTO Table 2 - Beams
Nominal Maximum Aggregate Size (NMAS)	Minimum Cross-Sectional Dimension
≤ 25mm (≤ 1 inch)	100 by 100mm (4 x 4 inches)
25mm (1 inch) < NMAS ≤ 50mm (2inch)	152 by 152 mm (6 by 6 inches)

Notes

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AASHTO TABLE 3 - BEAMS	
Method of Consolidation Requirements	
Slump, mm (in)	Method of Consolidation
≥25mm (≥ 1 inch)	Rodding or Vibration
≤25mm (≤1 inch)	Vibration

Notes

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Molding Requirements by Rodding	AASHTO Table 4- Beams	
Specimen Type and Size Beams:	**Layers of Approx. Equal Depth**	**Roddings per Layer**
Width, mm (inch)		**Once every 2 inch² of surface area**
100 (4 inch) to 200 (8 inch)	**2**	
Over 200 (8 inch)	**3 or more equal depths, each not to exceed (6 inch)**	**Once every 2 inch² of surface area**

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Notes

Molding Requirements by Vibration		AASHTO Table 5 - Beams	
Beam Width	**Layers**	**Vibrator Insertions per Layer**	**Approximate Depth of Layer**
4 to 8 inches	**1**	*	Depth of specimen as near as practicable
> 8 inches	**2 or more**	*	Depth of specimen as near as practicable

*Vibrator inserted at intervals not exceeding 6 inches, use alternating insertions along two lines.

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Notes

501.1.4.4 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.



501.1.4.5 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.

When cylinders are being submitted to the Central Laboratory for testing, the following information should be written on the side of the cylinder mold:

(a) AASHTOware Project (AWP) Identification No.
(b) Date of Pour
(c) Testing Age
(d) Cement Factor (sacks/cubic yard)
(e) Project Information (Job No., Route, and County)

501.1.4.5.1 Curing

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

Standard Cure is used for the following purposes:

1) Specified strength for 28-day testing
2) Check of mixture proportions or design strength
3) Quality control (i.e. monitoring mix variability)
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 R100 (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. AASHTOWare Project 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 used for the following purposes:

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
4) Form removal.

Field curing shall be in accordance with AASHTO R100 (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 sets for either 6x12 cylinders or 4x8 cylinders.

Specimens prepared to determine when forms may be removed will be cured as described above except for bridge decks or heated concrete.

- Specimens representing bridge decks are to be cured in plastic molds 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 remain 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 in plastic molds and covered with wet burlap for 48 hours. Cylinders left after the heating period has ended shall remain 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.

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Use For Notes If Needed

AASHTO R100/ ASTM C31: Making and Curing of Concrete Cylinder Specimens in the Field PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

Trial#	1	2
Sampled concrete per AASHTO R60		
Conducted Slump, Air Content, and Temperature Tests a. Reported results.		
Molding Cylinders		
1. Each layer properly consolidated per results of Slump, AASHTO T119		
2. 4" x 8" Mold filled in 2 approx. equal layers (Vibrated = 2 layers)		
6" x 12" Mold filled in 3 approx. equal layers (Vibrated = 2 layers)		
3. Rod each layer 25 times a. 4" x 8", vibrator, one location per layer b. 6" x 12", vibrator, two locations per layer		
4. Mold tapped lightly 10 to 15 times after each layer		
5. Mold tapped with **open hand** for light gauge single use molds		
6. Cylinder finished using either a tamping rod (if consistency of concrete permits) or with a handheld float, or a trowel so that the specimen is level with the rim of the mold.		
7. Mold properly cleaned and sealed with cap		
8. Identification information written on the container side and duct tape closed		
9. Set up initial cure per AASHTO R100 at 60-80°F		
10. Reported all core information, temperatures, and curing information		
	PASS	PASS
	FAIL	FAIL

Examiner: _____Date:_____

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Use For Notes If Needed

AASHTO R100/ ASTM C31: Making and Curing of Concrete BEAM Specimens In the Field PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

Trial#	1	2
Sample concrete per AASHTO R60		
Conducted Slump, Air Content, and Temperature Procedures a. Reported all results of these tests		
Molding Beams – 6" x 6" Standard Size		
1. Each layer properly consolidated per results of slump, AASHTO T 119		
2. Mold filled in 2 approximately equal layers (Vibrated = 1 layer)		
3. Rodded each layer every 2 square inches of surface area, into 1 inch of the layer below it. Spade each layer on the ends and sides. a. If vibrator used, 1 insertion per layer, insert full depth at intervals of approximately 6 inches along the center line of the length of the mold alternating insertions between 2 lines. Do not spade when consolidating by vibration.		
4. Mold tapped lightly 10 to 15 times after each layer was rodded		
5. Beam finished using either a tamping rod if consistency of concrete permits) or handheld float, or a trowel so that the specimen was level with the rim of the mold		
6. Identification, information written on the mold		
7. Beams cured the same as cylinders, except they are stored in water saturated with calcium hydroxide at 73.5±3.5°F at least 20 hours prior to testing		
8. Reported all beam information, temperatures, and curing information		
Transportation		
1. Waited at least 8 hours after final set to transport, protected specimens from the cold, moisture maintained, and did not exceed 4 hours of transport time		
	PASS	PASS
	FAIL	FAIL

Examiner: _____Date:_____

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Use For Notes If Needed

AASHTO T121M

ASTM C138

Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete Method



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Use For Notes If Needed

AASHTO T121M

ASTM 138

Density (Unit Weight), Yield & Air Content (Gravimetric) of Concrete

Slide 1

Notes

Scope

- This method covers determination of the density of freshly mixed concrete and gives formulas for calculating the yield, cement content and the air content of the concrete.
- Nonplastic concrete is not covered with this test method.



Slide 2

Notes

Abbreviations/Symbols

A = air content (percentage of voids) in the concrete;
C = actual cement content, kg/m^3 [lb/yd^3];
C_b = mass of cement in the batch, kg [lb];
M = total mass of all materials batched, kg [lb] (Section 3.1.4);
M_c = mass of the measure filled with concrete, kg [lb];
M_m = mass of the measure, kg [lb];
R_y = relative yield;
V = total absolute volume of the component ingredients in the batch, m^3 [ft^3] (Note 2);
V_m = volume of the measure, m^3[ft^3];
Y = yield, volume of concrete produced per batch, m^3 or [yd^3];
Y_d = yield, volume of concrete that the batch was designed to produce, m^3 [yd^3];
Y_f = yield, volume of concrete produced per batch, ft^3;
ρ = density (unit weight) of concrete, kg/m^3 [lb/ft^3]; and
ρ_T = theoretical density of the concrete computed on an airfree basis, kg/m^3 [lb/ft^3]

Slide 3

Notes

Terminology

- Absolute Volume (V): the absolute volume of each ingredient in cubic feet is equal to the mass of the ingredient divided by the project of its specific gravity times 62.4.
- Total Mass (M): The total mass of all materials batched is the sum of the masses of the cement, the fine aggregate in the condition used, the coarse aggregate in the condition used, the mixing water added to the batch, and any other solid or liquid materials used.

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Notes

Terminology

- Bulk Specific Gravity and Mass:
  - Aggregates: should be based on the saturated surface-dry condition.
  - Cement: the actual specific gravity should be determined by T133; a value of 3.15 maybe used for cements manufactured to meet the requirements in M85.
- Yield: is defined as the volume of concrete produced from a mixture of known quantities of the component materials.

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Notes

Equipment

Scale



- Accurate to 0.1 lb. or 0.3% of test load whichever is greater

Tamping Rod



- $\frac{5}{8} \pm \frac{1}{16}$ in diameter
- Smooth, round, straight rod
- Length @ least 4" longer than depth of measure but not greater than 24"
- Hemispherical Tip

Internal Vibrator



- 9000 vibrations per minute is the frequency when in operating
- Outside diameter: 0.75"-1.50"
- Verified every 2 years

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Notes

Equipment

Mallet



- Mass:
  - ➢ 1.25 ± 0.50lb when measure $\leq 0.5 ft^3$
  - ➢ $2.25 \pm 0.50 lb$ when measure $> 0.5 ft^3$
  - ➢ Rubber or Rawhide

Scoop



- Large enough so each amount of concrete to obtained from sampling is representative and not spilled during placement

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Notes

Equipment

Measure



- Steel or suitable material
- Capacity of measure is based on table 1
- Top rim of air meter bowls must be smooth and plane withing 0.01"

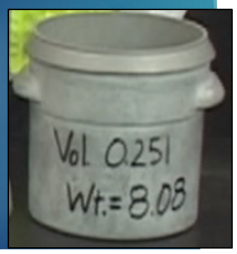
Table 1: Required Measure Capacity

Nominal Maximum Size of coarse Aggregate		Capacity of Measure	
mm	Inch	Liter	ft³
25.0	**1**	6	**0.2**
37.5	**1.5**	11	**0.4**
50	**2**	14	**0.5**
75	**3**	28	**1.0**
112	**4.5**	70	**2.5**
150	**6**	100	**3.5**

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Notes

Standardization



- AASHTO R18: Gives all intervals for equipment calibrations & standardizations
  - The Measure should be standardized every 12 months
    - Mark the measure with an ID
    - Volume of measure in 0.001 ft3

See the Appendix for more information on how to standardize a measure.

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Notes

Sampling

Obtain the sample of freshly mixed concrete in accordance with AASHTO R60.

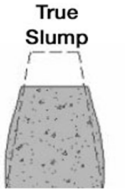


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Notes

Consolidation

Use the slump result and the chart below to determine to vibrate or rod the sample:



Slump	Consolidation Method:
Less than 1"	Vibrate
1" to 3"	Rod or Vibrate
Greater than 3"	Rod

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Notes

Procedure

Rodding

Dampen the interior of the measure & remove any standing water.

Determine the mass of the empty measure using the balance in equipment requirements.

Place the measure on a flat, level, firm surface.

Using the scoop described in equipment requirements. Place a representative sample of concrete in the measure in 3 equal layers.

Slide 12

Notes

Procedure
Rodding

Moving the scoop around the perimeter of measure place the concrete with minimal segregation.

Rod each layer 25 strokes with the tamping rod ($.5ft^3$) or smaller measures, 50 strokes when (1 ft^3), and one stroke per (3 in^2) of surface for larger measures.

Rod the bottom layer throughout its depth but the rod should not forcibly strike the bottom of measure. Make sure to distribute the strokes uniformly across the entire cross section while penetrating the previous layer approximately 1".

After each layer is rodded, tap around the perimeter of the measure 10-15 times with the mallet. Use the amount of force to close any voids left by tamping rod to release air bubbles

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Notes

Procedure
Rodding

After consolidation, there should be about 1/8" excess concrete above the top of the measure. Adjust the top level if needed by adding or removing a representative portion of concrete.

Strike off the concrete by pressing the strike off plate on the top surface of the measure to cover about 2/3 of the surface and withdraw the plate in a sawing motion to finish the only area originally covered.

Finally hold the plate at an incline and apply the final strokes to produce a smooth finished surface. Clean all excess concrete from the exterior of the measure.

Record Weight. Determine the net mass of the concrete in the measure with a scale (This is M_C). Record the weight to the nearest 0.1lb.

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Notes

PROCEDURE
Self-Consolidating Concrete

Dampen the measure, weight, Record the weight to the nearest 0.1lb

Slightly overfill the measure in one continuous lift

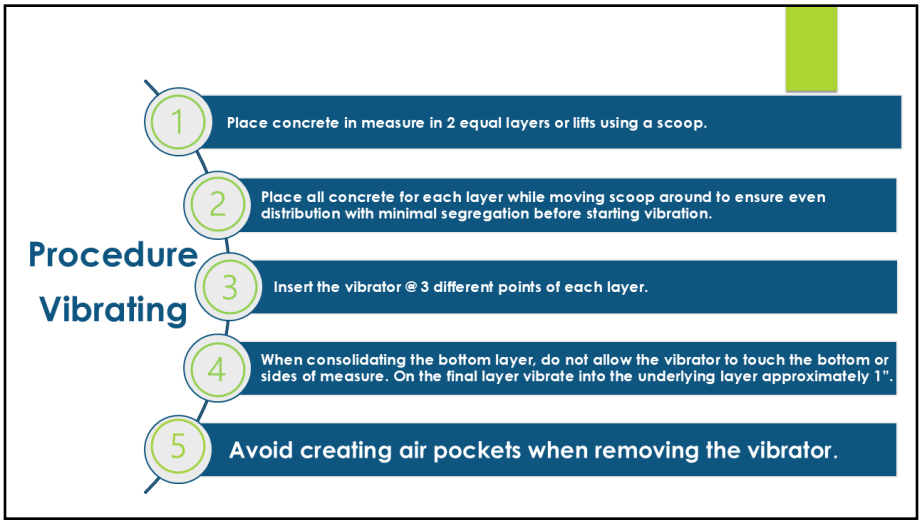
Drop height of the self-consolidating concrete shall be ≤ 5" when filling measure

DO NOT ROD, TAP or VIBRATE

Strike off, clean, weigh, Record to the nearest 0.1lb

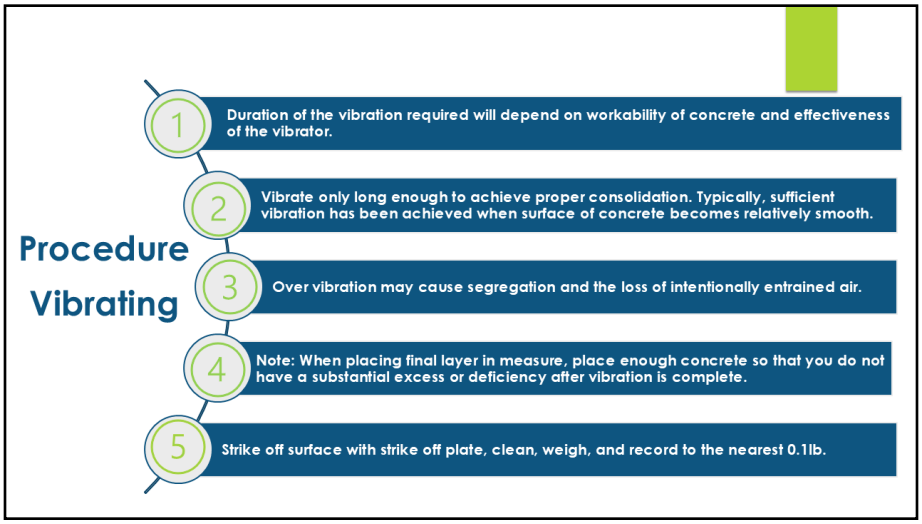
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Notes



Slide 16

Notes



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Notes

Symbols for Calculations

- **A** = air content, %
- **C** = actual cement content lb./yd^3 (kg/m^3)
- **C_b**= mass of cement in the batch, lb. (kg)
- **D** = density (unit weight) of concrete, lb./ft^3 (kg/m^3)
- **M** = total mass of all materials batched, lb. (kg)
- **M_c**= mass of the measure filled with concrete, lb. (kg)
- **M_m**= mass of the measure, lb. (kg)
- **Ry** = relative yield

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Notes

Symbols for Calculations

- **T** = Theoretical density of the concrete computed on an air free basis, lb./ft^3 (kg/m^3)
- **V** = Total absolute volume of the component ingredients in the batch, ft^3 (m^3)
- $\mathbf{V_m}$ = Volume of the measure, ft^3 (m^3)
- **Y** = Yield, volume of concrete produced per batch, yd^3 or (m^3)
- $\mathbf{Y_d}$ = Yield, volume of concrete that the batch was designed to produce, yd^3 or (m^3)
- $\mathbf{Y_f}$ = Yield, volume of concrete produced per batch, ft.^{3} (m^3)

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Notes

Calculations
Theoretical Density

The theoretical density is a laboratory determination. The value for the theoretical density is assumed to remain constant for all batches made using identical component ingredients and proportions.

$$T = \frac{M}{V}$$

Report to the nearest 0.1 lb./ft^3

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Notes

Calculations
Density (Unit Mass)

- Calculate the net mass of the concrete in pounds by subtracting the mass of the measure ($\mathbf{M_m}$) from the gross mass ($\mathbf{M_c}$).
- Calculate the *density*, (**D**), by dividing the net mass of the concrete by the volume of the measure ($\mathbf{V_m}$) as follows:

$$D = \frac{(M_C - M_m)}{V_m}$$

Report to the nearest 0.1 lb/ft^3

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Notes

Calculations Yield

- volume of concrete produced per batch yd^3 or ft^3

D = Density (unit weight) of concrete kg/m^3 (lb/ft^3)

M = total mass of all materials batched, kg (lb)

27 = The amount of cubic feet in yd^3

$$Y\ (ft^3) = \frac{M}{D}$$

$$Y\ (yd^3) = \frac{M}{(D \times 27)}$$

Report to the nearest 0.1 yd^3, 0.1 ft^3

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Notes

Calculations Relative Yield

Relative yield is the ratio of the actual volume of concrete obtained to the volume as designed for the batch calculated as follows.

$$R_y = \frac{Y}{Y_d}$$

Report to the nearest 0.1 ft^3/yd^3

NOTE: A value for Ry greater than **1.00** indicates an excess of concrete being produced, whereas a value less than this indicates the batch to be "short' of its designed volume. In practice, a ratio of yield in cubic feet per cubic yard of design concrete mixture is frequently used, for example, 27.3 ft^3/yd^3

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Notes

Calculations Cement Content

$$C = \frac{C_b}{Y}$$

C = actual cement content kg/m^3 (lb/yd^3)

C_b = mass of cement in the batch, kg (lb)

Y = yield, volume of concrete produced per batch, m^3 or (yd^3)

Report to the nearest whole 1 lbs/yd^3

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Notes

Calculations Air Content

T = theoretical density of the concrete computed on an air free basis, kg/m³ (lb./ft³)

D = density (unit weight) of concrete, kg/m³ (lb/ft³)

$$A = \frac{(T - D)}{T} \times 100$$

$\frac{lb}{ft^3}$ = **pcf** = pounds per cubic foot

Report to the nearest 0.1%.

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Notes

Reporting

- **Identification of concrete** represented by the sample
- **Date of Test**
- **Volume of density measure** to the nearest **0.001 ft³**
- **Density** (Unit Weight) to the nearest **0.1 lb./ft³**
- **Yield**, when requested, to the nearest **0.1 yd³**
- **Relative Yield**, when requested to the nearest **0.01**
- **Cement Content**, when requested to the nearest **lb./yd³**
- **Air Content**, when requested, to the nearest **0.1 %**

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Notes

Classroom: Exercise

A batch design of **9.0 yd³**, with a total of **34,850 lbs**. of materials, with a theoretical density of **142.5 lb./ft³**, using a **0.500 ft³** measure weighing **19.8 lbs.**, when filled with concrete the measure weighs **90.7 lbs**.

Calculate the following:

1. **Density**
2. **Yield per batch in yd³**
3. **Yield per batch in ft³**
4. **Yield per batch ft³/ yd³**
5. **All Relative Yield calculations**
6. **Air Content**

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Notes

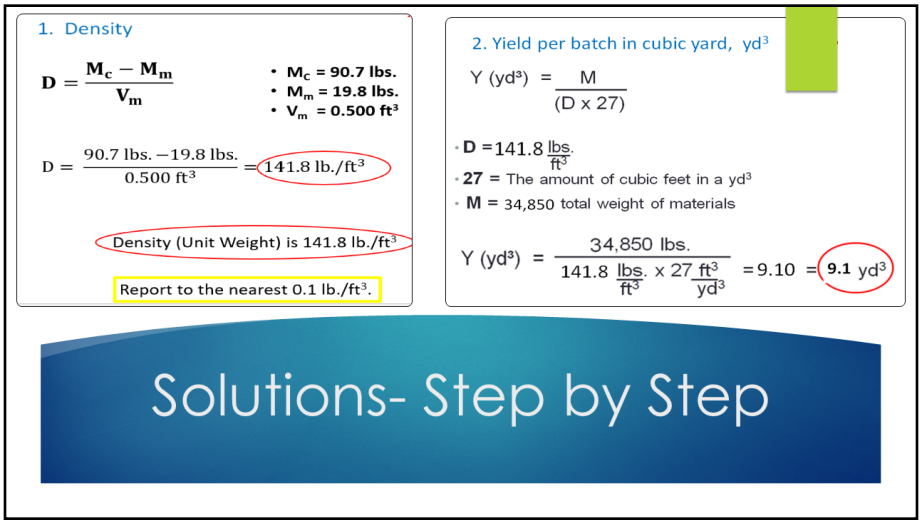
Classroom: Exercise Answers

Calculate the following:

1. **Density=141.8 lb/ft^3**
2. **Yield per batch= 9.1 yd^3**
3. **Yield per batch in ft^3= 245.8 ft^3**
4. **Yield per batch ft^3/yd^3 =27.3 ft^3/yd^3**
5. **All Relative Yield calculations= 1.01 yd^3**
6. **Air Content= 0.5%**

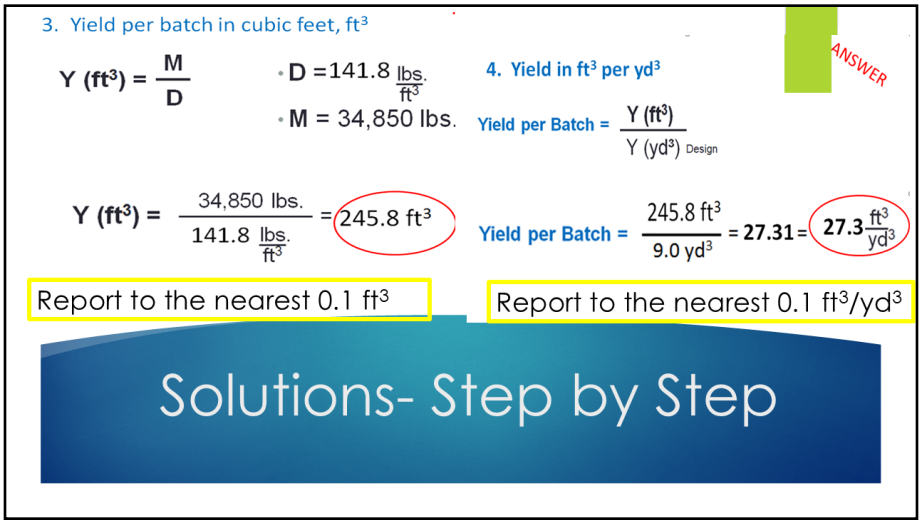
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Notes



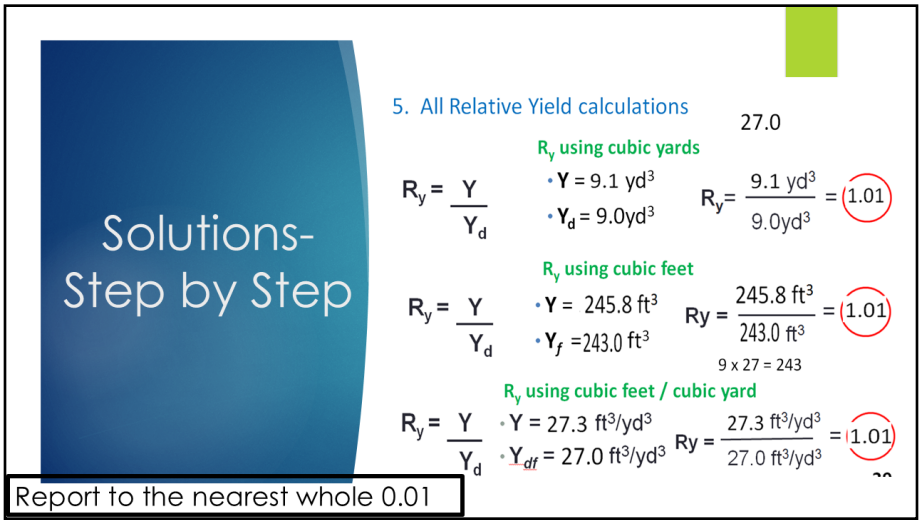
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Notes



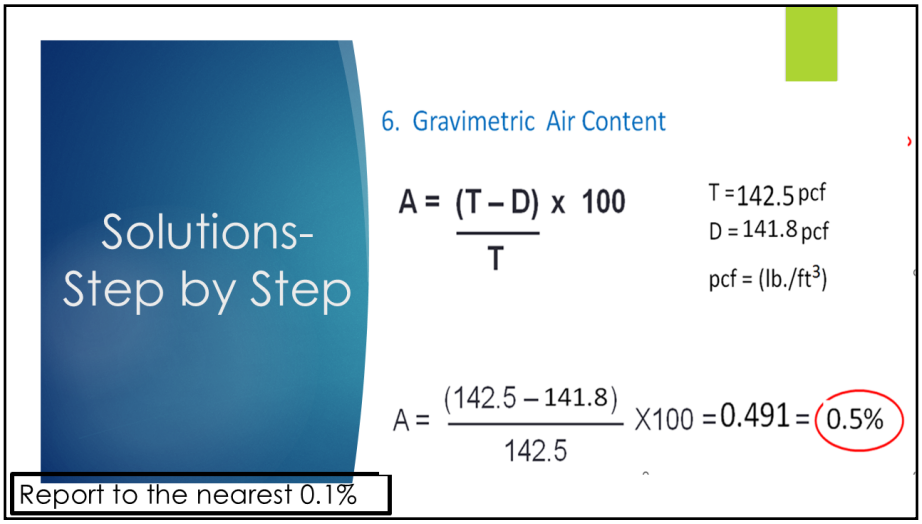
Slide 30

Notes



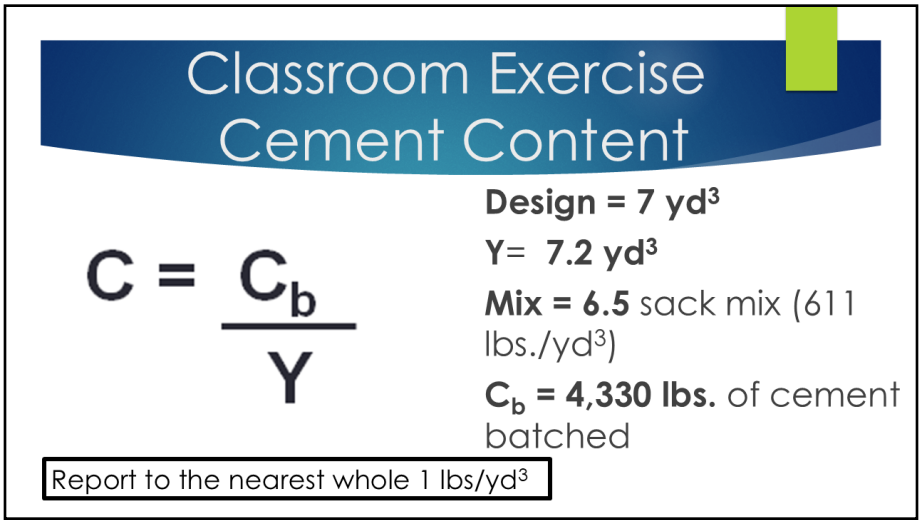
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Notes



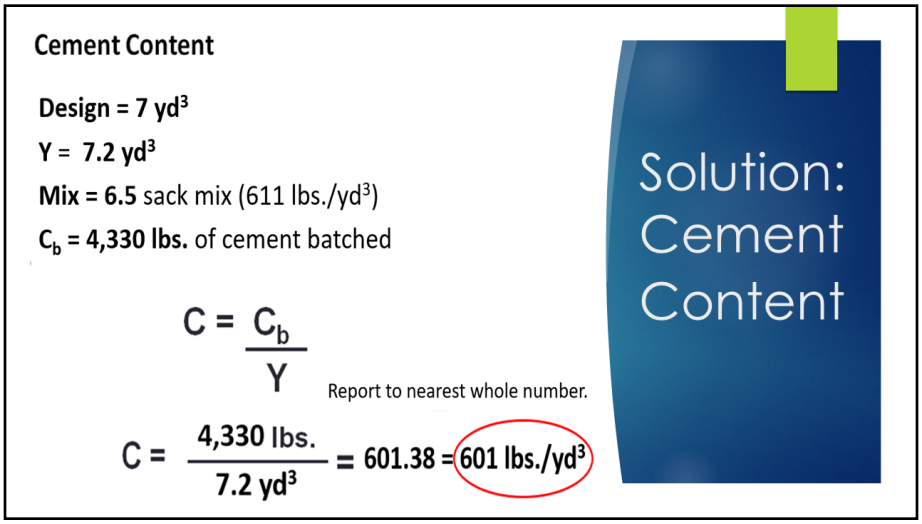
Slide 32

Notes



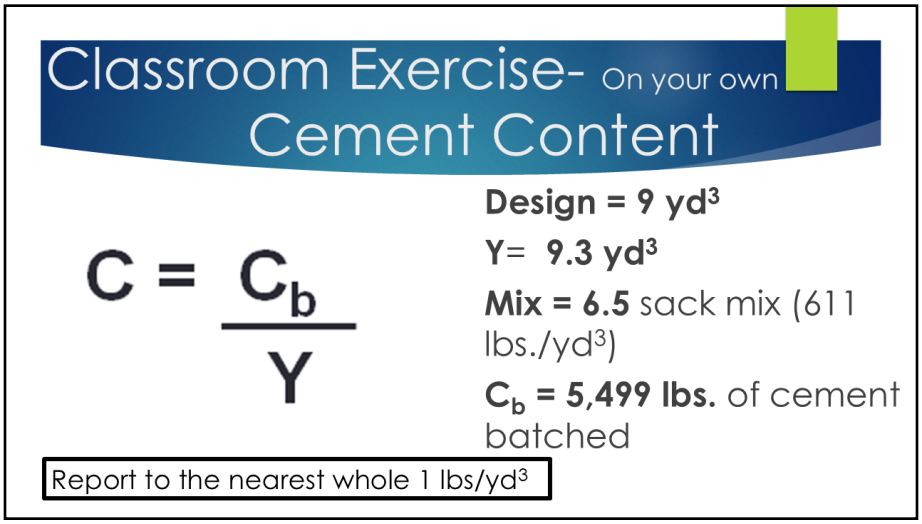
Slide 33

Notes



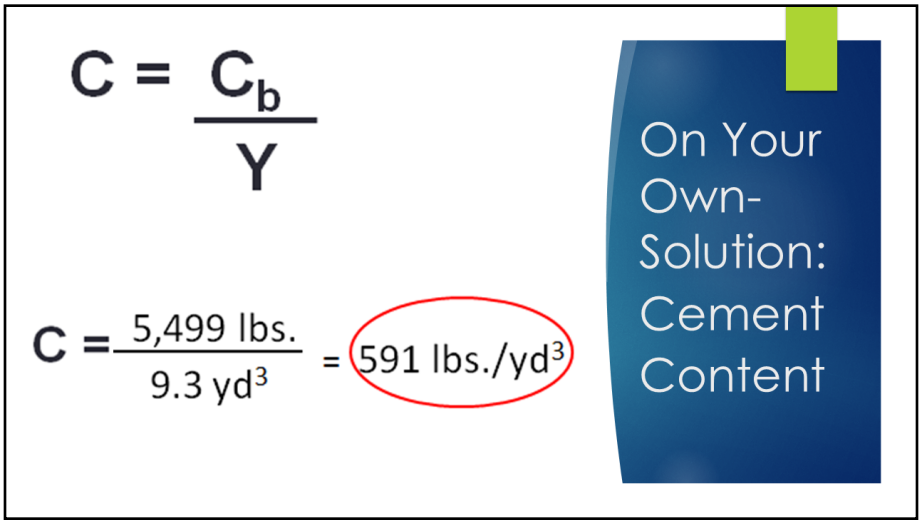
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Notes



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Notes



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Notes

Classroom: Exercise

A batch design of **7.0 yd³**, with a total of **27,878 lbs**. of materials, with a theoretical density of **146.4 lb./ft³**, using a **0.500 ft³** measure weighing **19.5 lbs.**, when filled with concrete the measure weighs **91.2 lbs**.

Calculate the following:

1. **Density**
2. **Yield per batch in yd³**
3. **Yield per batch in ft³**
4. **Yield per batch ft³/ yd³**
5. **All Relative Yield calculations**
6. **Air Content**

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Notes

Classroom: Exercise Answers

Calculate the following:

1. **Density=143.4 lb/ft^3**
2. **Yield per batch= 7.2 yd^3**
3. **Yield per batch in ft³= 194.4 ft^3**
4. **Yield per batch ft³/yd^3 = 27.8 ft³/yd^3**
5. **All Relative Yield calculations= 1.03**
6. **Air Content= 2.0%**

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Notes

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Use For Notes If Needed

CONCRETE – UNIT WEIGHT – **WORKSHEET** – AASHTO T121M

Y_d = Batch Design: _____ yd^3

M = Total Mass of weighed materials: _____ lbs.

T = Theoretical Density: _____ $lbs./ft^3$

Vm = __0.500 ft^3__ measure

Mm = Measure weighs: _____ lbs.

Mc = Measure filled with concrete: _____ lbs.

---

1. **Density** **D** = $\frac{Mc - Mm}{Vm}$

   (Report to **0.1** $lbs./ft^3$)

---

2. Yield per batch in cubic yards **Y (yd^3)** = $\frac{M}{(D \times 27)}$

   (Report to **0.1** yd^3)

---

3. Yield per batch in cubic feet **Y (ft^3)** = $\frac{M}{D}$

   (Report to **0.1** ft^3)

---

4. Yield per batch cubic foot per cubic yard $Y = \frac{Y(ft^3)}{Y_d\ (Yd^3)\ design}$

   (Report to **0.1** ft^3/yd^3)

---

5. Relative Yield in cubic yards $R_y = \frac{Y\ (yd^3)}{Y_d\ (yd^3)\ design}$

   (Report to **0.01**)

---

6. Air content $A = \frac{(T - D)}{T} \times 100$

   (Report to **0.1**%)

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Use For Notes If Needed

CONCRETE – UNIT WEIGHT – **WORKSHEET** – AASHTO T121M

Y_d = Batch Design: _____ yd^3

M = Total Mass of weighed materials: _____ lbs.

T = Theoretical Density: _____ $lbs./ft^3$

Vm = __0.500 ft^3__ measure

Mm = Measure weighs: _____ lbs.

Mc = Measure filled with concrete: _____ lbs.

---

1. **Density** **D** = $\frac{Mc - Mm}{Vm}$

   (Report to **0.1** $lbs./ft^3$)

---

2. Yield per batch in cubic yards **Y (yd^3)** = $\frac{M}{(D \times 27)}$

   (Report to **0.1** yd^3)

---

3. Yield per batch in cubic feet **Y (ft^3)** = $\frac{M}{D}$

   (Report to **0.1** ft^3)

---

4. Yield per batch cubic foot per cubic yard $Y = \frac{Y(ft^3)}{Y_d\ (Yd^3)\ design}$

   (Report to **0.1** ft^3/yd^3)

---

5. Relative Yield in cubic yards $R_y = \frac{Y\ (yd^3)}{Y_d\ (yd^3)\ design}$

   (Report to **0.01**)

---

6. Air content $A = \frac{(T - D)}{T} \times 100$

   (Report to **0.1**%)

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Use For Notes If Needed

CONCRETE – UNIT WEIGHT – **WORKSHEET** – AASHTO T121M

Y_d = Batch Design: _____ yd^3

M = Total Mass of weighed materials: _____ lbs.

T = Theoretical Density: _____ $lbs./ft^3$

Vm = __0.500 ft^3__ measure

Mm = Measure weighs: _____ lbs.

Mc = Measure filled with concrete: _____ lbs.

---

1. **Density** **D** = $\frac{Mc - Mm}{Vm}$

   (Report to **0.1** $lbs./ft^3$)

---

2. Yield per batch in cubic yards **Y (yd^3)** = $\frac{M}{(D \times 27)}$

   (Report to **0.1** yd^3)

---

3. Yield per batch in cubic feet **Y (ft^3)** = $\frac{M}{D}$

   (Report to **0.1** ft^3)

---

4. Yield per batch cubic foot per cubic yard $Y = \frac{Y(ft^3)}{Y_d\ (Yd^3)\ design}$

   (Report to **0.1** ft^3/yd^3)

---

5. Relative Yield in cubic yards $R_y = \frac{Y\ (yd^3)}{Y_d\ (yd^3)\ design}$

   (Report to **0.01**)

---

6. Air content $A = \frac{(T - D)}{T} \times 100$

   (Report to **0.1**%)

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Use For Notes If Needed

CONCRETE – UNIT WEIGHT – **WORKSHEET** – AASHTO T121M

Y_d = Batch Design: _____ yd^3

M = Total Mass of weighed materials: _____ lbs.

T = Theoretical Density: _____ $lbs./ft^3$

Vm = __0.500 ft^3__ measure

Mm = Measure weighs: _____ lbs.

Mc = Measure filled with concrete: _____ lbs.

---

1. **Density** **D** = $\frac{Mc - Mm}{Vm}$

   (Report to **0.1** $lbs./ft^3$)

---

2. Yield per batch in cubic yards **Y (yd^3)** = $\frac{M}{(D \times 27)}$

   (Report to **0.1** yd^3)

---

3. Yield per batch in cubic feet **Y (ft^3)** = $\frac{M}{D}$

   (Report to **0.1** ft^3)

---

4. Yield per batch cubic foot per cubic yard $Y = \frac{Y(ft^3)}{Y_d\ (Yd^3)\ design}$

   (Report to **0.1** ft^3/yd^3)

---

5. Relative Yield in cubic yards $R_y = \frac{Y\ (yd^3)}{Y_d\ (yd^3)\ design}$

   (Report to **0.01**)

---

6. Air content $A = \frac{(T - D)}{T} \times 100$

   (Report to **0.1**%)

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Use For Notes If Needed

AASHTO T121M/ASTM C138: Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

PROFICIENCY CHECKLIST

Applicant_____

Employer_____

Trial #	1	2
Standardize		
Mass and volume of empty measure determined in yearly standardization.		
Sample		
Obtained sample in accordance with AASHTO R60.		
Procedure – Rodding – Rod 25 or (50) times according to size of the measure		
1. Determined which consolidation method to use from the slump. 2. Determine which size measure and size mallet to use from the nominal maximum size of the aggregate. (Use chart)		
3. Dampened the measure, weigh to 0.1 lbs., and place on a flat, level, firm surface.		
4. Weigh and record empty measure to nearest 0.1 lbs.		
5. Scooped representative sample of concrete into the measure, moving the scoop around the perimeter to fill the measure in 3 equal layers.		
6. - **Bottom layer,** fill 1/3 full, rod 25 (50) times through without striking the bottom of the measure, tap 10-15 times with a mallet. - **2nd layer**, fill 2/3 full, rod 25 (50) times 1 inch into the bottom layer, tap 10-15 times with a mallet. - **3rd layer**, overfill by ⅛ inch and rod 25 (50) times 1 inch into the 2nd layer, tap 10-15 times with a mallet.		
7. Ensure proper consolidation has been achieved.		
8. If needed adjust the concrete by adding or removing concrete to be ⅛ inch overfill.		
9. Ensure proper consolidation has been achieved.		
Procedure - Vibration		
10. **For internal vibration**, measure filled in **2** equal layers.		
11. Vibrated each layer at **3** different points.		
12. Ensured proper consolidation has been achieved.		
Finishing		
13. Use a glass plate for strike off method, ending with a smooth finish.		
14. Clean the outside of the measure and the rim		
15. Weigh and record the full measure to the nearest 0.1 lbs.		
16. Calculate Density (unit weight), report to nearest 0.1 lb./ft^3		
17. When requested, report: Yield, Relative Yield, Cement Content, and Gravimetric Air Content.		
	PASS	PASS
	FAIL	FAIL

Examiner: _____ Date: _____

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Use For Notes If Needed

AASHTO T196M

ASTM C173

Air Content of Freshly Mixed Concrete by the Volumetric Method

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Use For Notes If Needed

AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE VOLUMETRIC METHOD

AASHTO T196M



Slide 1

Notes





SCOPE

This test method covers determination of the air content of freshly mixed concrete of freshly mixed concrete containing any type of aggregate:

- ❑ Dense
- ❑ Lightweight
- ❑ Cellular

Slide 2

Notes

SIGNIFICANCE & USE

This test method is the appropriate test to determine the air content of concretes containing lightweight aggregates, air-cooled slag, and highly porous or vascular natural aggregates.

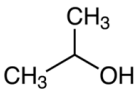
The air content of hardened concrete maybe either higher or lower than that determined by this test method. This will depend on the methods and amounts of consolidation effort applied to the concrete from which the hardened concrete has taken.

Slide 3

Notes

SIGNIFICANCE & USE

This test method requires the addition of sufficient isopropyl alcohol, when the meter is initially being filled with water, so that after the first or subsequent rolling, little or no foam collects in the neck of the top section of the meter. If more foam is present then that equivalent to two percent air above the water level, the test is declared invalid and must be repeated using a larger quantity of alcohol. The additional alcohol to dispel foam any time after the initial filling of the meter to the zero mark is not permitted.



Slide 4

Notes



EQUIPMENT

- ❑Air Meter (Roll-a-Meter)
- ❑Funnel
- ❑Tamping Rod
- ❑Strike off bar
- ❑ Standardized Cup
- ❑Measuring Vessel for isopropyl alcohol
- ❑Syringe
- ❑Pouring vessel for water
- ❑Scoop
- ❑Isopropyl Alcohol

** Note: See the appendix for additional information on apparatus

Slide 5

Notes

Numbers get larger
As you go down the tube.

Graduations at least 0.5% increments that cover a range of 0 to 9% of bowl Volume.



Watertight Cap

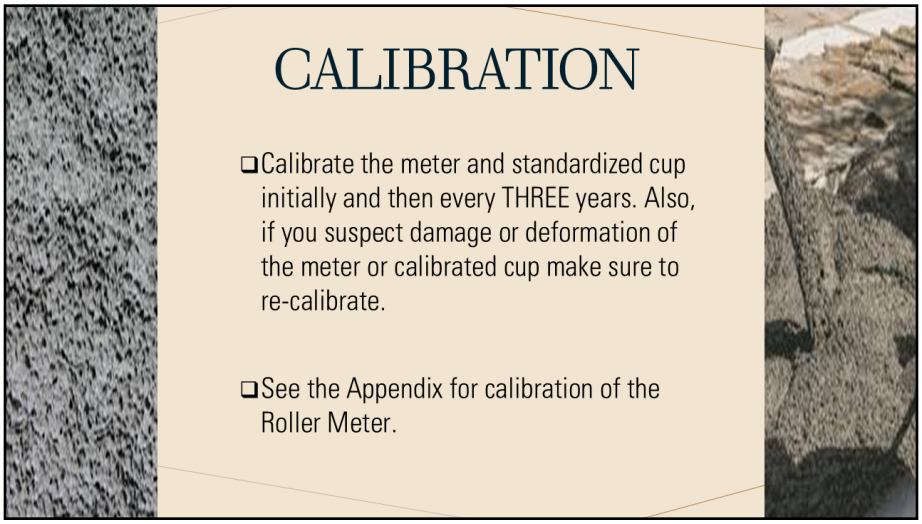
Rubber gasket For a watertight seal.

Measuring bowl or bowl



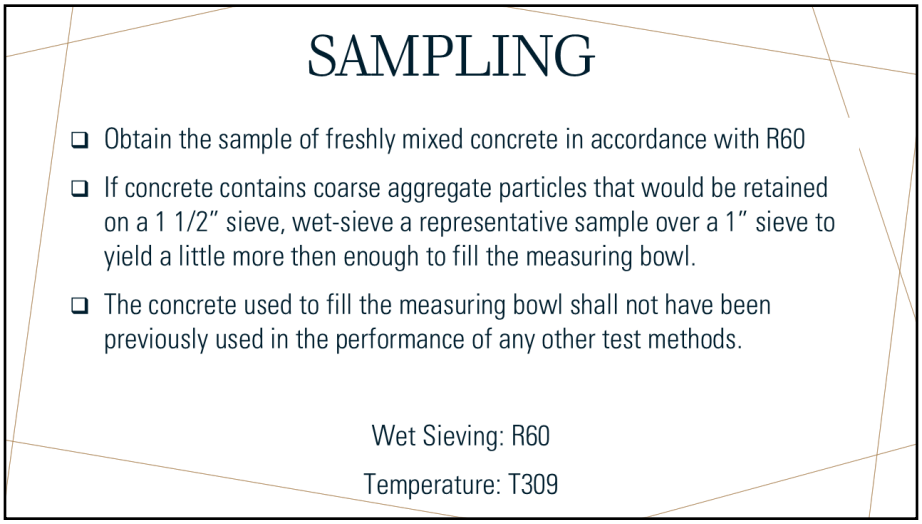
Slide 6

Notes



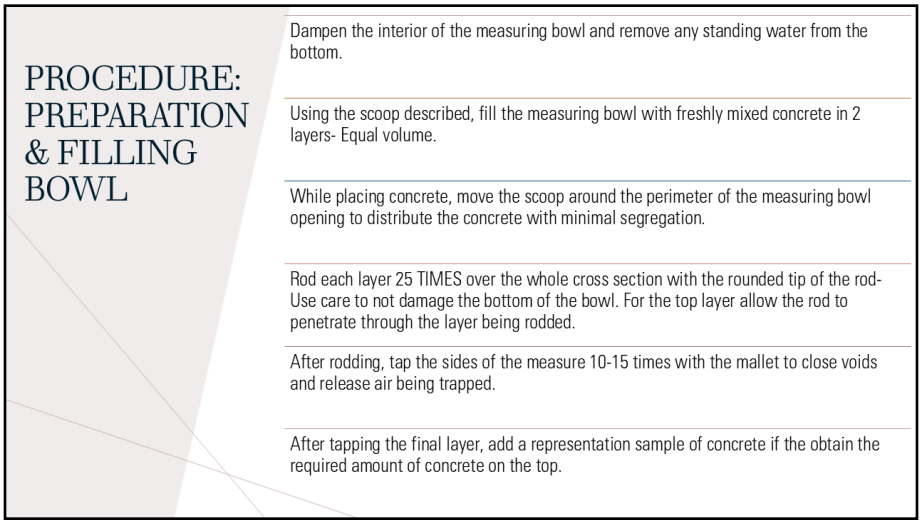
Slide 7

Notes



Slide 8

Notes



Slide 9

Notes

PROCEDURE: STRIKE OFF & ADDING WATER

After rodding and tapping the 2nd layer, strike off the excess concrete with the bar until the concrete is flush with the top of the bowl. Wipe the flange of the bowl clean.

Wet the inside of the top section of the meter including the gasket.

Attach the top section into the position on the bowl and insert the funnel.

Add at least 0.5L of water followed by selected amount of isopropyl alcohol. Record the amount of alcohol added.

Continue adding water at least until it appears in the graduated neck of the top section.

Remove the funnel. Adjust the liquid level until the bottom of the meniscus is level with the 0 mark on the graduated scale.

A rubber syringe is useful for this purpose. Attach and tighten the watertight cap.

Slide 10

Notes

PROCEDURE: FREE THE CONCRETE FROM MEASURING BOWL

Quickly invert the meter, shake the measuring bowl horizontally and return the meter to the upright position.

To prevent the aggregate from lodging int the neck of the unit. Do not invert longer then 5 SECONDS @ a time.

Repeat the inversion and shaking process for a minimum of 45 seconds and until the concrete has broken free and the aggregate can be heard.

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Notes

PROCEDURE: ROLLING

Place one hand on the next of the meter and the other on the flange

Using the hand on the neck tilt the top of the meter approximately 45 degrees from the vertical position with the bottom edge of the bowl on the floor

Using the hand on the flange rotate the meter, vigorously roll the meter ¼ - ½ turn forward and back several times. Quickly starting and stopping the roll

Turn the measuring bowl about 1/3 turn and repeat the rolling procedure as stated previously

Continue the turning & rolling procedures for approximately one minute. The aggregate must be heard sliding in the meter during this process

Slide 12

Notes

PROCEDURE: KEY NOTES

- If there is anytime during the inversion and rolling procedures liquid is found to be leaking from the meter, the test is invalid.
- Set the unit upright and loosen the top to allow any pressure to stabilize. Allow the meter to stand while the air rises to the top and Liquid Limit (LL) stabilizes. The ll is considered stable when the change is 0.25% or less in 2 MINITUTES.
- If it takes more then 6 MINITUTES for the LL to stabilize or more foam than that to 2 full percent air content divisions on the meter scale- discard the trial and start a new test.

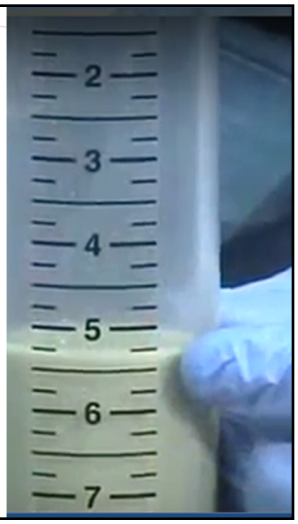


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Notes

PROCEDURE: KEY NOTES

- If the level is stable without excess foam, read the bottom of the meniscus to the nearest .25% and record the initial meter reading.
- If the air content is greater then the 9% rand of the meter, add a sufficient number of standardized cups of water to bring the ll within the graduate range. Read the bottom of the meniscus to the nearest .25%.



Slide 14

Notes

PROCEDURE: CONFIRMATION OF INITIAL METER READING

When the initial meter reading is obtained; retighten the top and repeat the one-Minute rolling.

When the LL is stable and the requirements are met make a direct reading to the bottom of the meniscus and est. to the 0.25% air. IF this reading has not changed more then 0.25% from the initial reading record it as FINAL reading

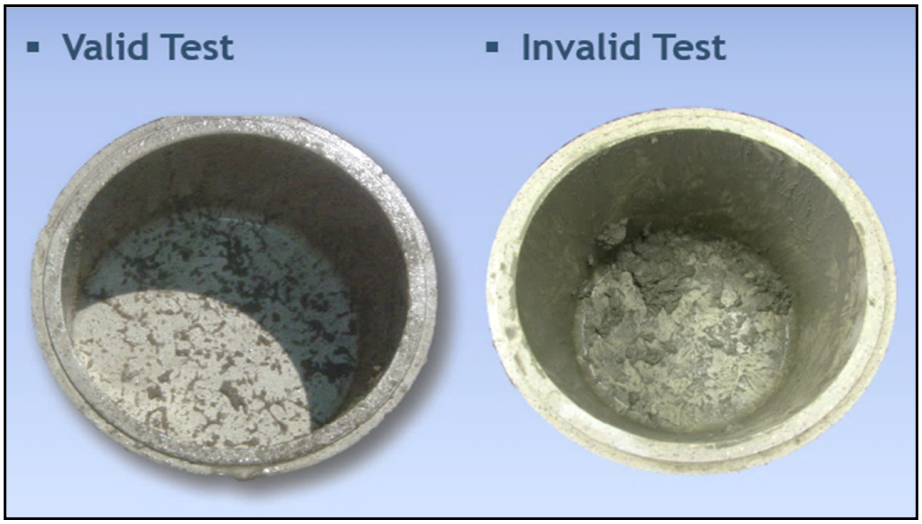
- If the reading has changed from the initial meter reading more then 0.25% this will be the new initial reading and repeat rolling.

If the reading changes more then the 0.25% after the third roll then discard the test and start a new one using more alcohol.

Disassemble the air meter by detaching the top section from the measuring bowl. Allow the liquid to discharge from the air meter. Dump the contents, examine the interior of the measuring bowl, tightly packed concrete present. If portions of undisturbed concrete are found the test is invalid.

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Notes



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Notes

CALCULATIONS & REPORTING NOTES

If more than 1.25 L of alcohol is used, a correction to the final meter reading is required. Round the volume of alcohol used to the nearest 0.5 L and select the correction factor from Table 1.

Table 1—Correction for the Effect of Isopropyl Alcohol on Air Meter Reading

70% Isopropyl Alcohol Used			Correction (Subtract)[a]
pt	oz	L	
≤2.0	≤32	≤1.0	0.0[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

[a] Subtract from final meter reading.

[b] Corrections less than 0.125 are not significant and are to be applied only when 1.25 L [2.5 pt] or more alcohol is used. The effect occurs when the meter is inverted after being filled with an alcohol-water solution, which then becomes further diluted when it is mixed with the water in the concrete. The values given are for air meters that have a bowl volume of 2.1 L [0.075 ft³] and a top section that is 1.2 times the volume of the bowl.

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Notes

CALCULATIONS & REPORTING

Calculate the air content of the concrete in the measuring bowl as follows:

$$A = A_R - C + W$$

A= Air Content, %
A_R= Final Meter Reading, %
C= Correction Factor from Table 1, %
W= Number of standardized cups of water added to the meter

Report the air content to the nearest 0.25%

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Notes

Practice #1

INTRODUCING A NEW FORMAT FOR CALCULATING AIR CONTENT

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Enlarged

Initial meter reading	6.50	
Final meter reading	6.75	
Pints of alcohol used	1.5	
Alcohol content correction		SUBTRACT
Calibrated cups of water added	0	ADD
Reported air content		%



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Notes

Practice #1

ANSWER

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Calculations

6.75
- 0
6.75
+ 0.
6.75

Initial meter reading	6.50	
Final meter reading	6.75	
Pints of alcohol used	1.5	
Alcohol content correction	- 0	SUBTRACT
Calibrated cups of water added	0	ADD
Reported air content	6.75	%



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Notes

Practice #2

Enlarged

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Initial meter reading	6.00	
Final meter reading	6.00	
Pints of alcohol used	3	
Alcohol content correction		SUBTRACT
Calibrated cups of water added	0	ADD
Reported air content		%

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Notes

Practice #2

ANSWER

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Initial meter reading	6.00	
Final meter reading	6.00	
Pints of alcohol used	3	
Alcohol content correction	-0.25	SUBTRACT
Calibrated cups of water added	0	ADD
Reported air content	5.75	%

Calculations

6.00
- 0.25
5.75
+ 0
5.75



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Notes

actice #3

Enlarged

Calculate the reported air content (volumeter) of the concrete.

S ol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
0	≤ 32	≤ 1.0	0.00[b]
	48	1.5	0.25
	64	2.0	0.50
	80	2.5	0.75

Initial meter reading	7.75	
Final meter reading	8.00	
Pints of alcohol used	4	
Alcohol content correction		SUBTRACT
Calibrated cups of water added	3	ADD
Reported air content		%

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Notes

Practice #3

ANSWER

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Initial meter reading	7.75	
Final meter reading	8.00	
Pints of alcohol used	4	
Alcohol content correction	-0.50	SUBTRACT
Calibrated cups of water added	3	ADD
Reported air content	10.50	%

Calculations

8.00
- .50
7.50
+3.00
10.50

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Notes

Practice #1

INTRODUCING A NEW FORMAT FOR CALCULATING AIR CONTENT

Enlarged

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Initial meter reading	6.50	
Final meter reading	6.75	
Pints of alcohol used	1.5	
Alcohol content correction		SUBTRACT
Calibrated cups of water added	0	ADD
Reported air content		%



NOTE: Report air to the nearest **0.25%**

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Practice #1

ANSWER

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Initial meter reading	6.50	
Final meter reading	6.75	
Pints of alcohol used	1.5	
Alcohol content correction	- 0	SUBTRACT
Calibrated cups of water added	0	ADD
Reported air content	6.75	%

Calculations

6.75
- 0
6.75
+ 0.
6.75



37

Practice #2

Enlarged

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Initial meter reading 6.00

Final meter reading 6.00

Pints of alcohol used 3

Alcohol content correction _____ SUBTRACT

Calibrated cups of water added 0 ADD

Reported air content _____ %

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Practice #2

ANSWER

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Initial meter reading 6.00

Final meter reading 6.00

Pints of alcohol used 3

Alcohol content correction -0.25 SUBTRACT

Calibrated cups of water added 0 ADD

Reported air content 5.75 %

Calculations

6.00
- 0.25
5.75
+ 0
5.75



39

Practice #3

Enlarged

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Initial meter reading: 7.75

Final meter reading: 8.00

Pints of alcohol used: 4

Alcohol content correction: _____ SUBTRACT

Calibrated cups of water added: 3 ADD

Reported air content: _____ %

40

Practice #3

ANSWER

Calculate the reported air content (volumeter) of the concrete.

PINTS of Alcohol	Ounces of Alcohol	Liters of Alcohol	Correction (subtract)[a]
≤ 2.0	≤ 32	≤ 1.0	0.00[b]
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Initial meter reading: 7.75

Final meter reading: 8.00

Pints of alcohol used: 4

Alcohol content correction: -0.50 SUBTRACT

Calibrated cups of water added: 3 ADD

Reported air content: 10.50 %

Calculations

8.00
- .50
7.50
+3.00
10.50

41

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Use For Notes If Needed

AASHTO T196M/ASTM C173: Air Content of Freshly Mixed Concrete by the Volumetric Method

PROFICIENCY CHECKLIST

Applicant_____

Employer_____

Trial #	1	2
Sample		
1. Obtained sample in accordance with AASHTO R60		
Procedure		
2. Bowl filled in 2 layers		
3. Each layer rodded 25 times		
4. Bowl tapped (sharply) 10-15 times after rodding each layer		
5. Used funnel, water added, then alcohol added, then final water added until liquid level close to zero		
6. Funnel removed, adjusted the water to where the bottom of the meniscus is on zero		
7. Screw cap attached and tightened		
Initial Reading		
1. Unit inverted and agitated at 5 second intervals for a minimum of 45 seconds and until concrete is free from the base		
2. Unit vigorously rolled ¼ to ½ turn forward and back several times with base at a 45° angle, then turn base about ⅓ turn and rolling process resumed		
3. Meter checked for leaks; if leaking, test started over with a new sample		
4. Apparatus placed upright, cap loosened and allowed to stand until air rises to the top a. Less than 0.25% change in 2 minutes (without excessive foam), initial reading recorded to the nearest 0.25% b. More than 6 minutes to stabilize or observed excessive foam, test discarded and new test ran		
Confirmation of Initial Meter Reading		
1. One-minute rolling repeated, and liquid level checked		
2. Confirmation reading is greater than 0.25% of initial, new meter reading recorded as new initial reading, repeat 1-minute rolling		
3. Level of liquid read less than 0.25% change, final meter reading recorded to nearest 0.25%		
4. Apparatus disassembled and checked for undisturbed concrete		
Calculations		
1. Correction factor from Table 1 subtracted for use of 2.5 pints or more of alcohol		
2. If required, number of calibration cups of water added to air content		
3. Air content reported to the nearest 0.25% air		
	PASS	PASS
	FAIL	FAIL

Examiner: _____Date:_____

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Use For Notes If Needed

APPENDIX



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Use For Notes If Needed

Standardization of AASHTO T121M/ASTM C138 Measure

Measure the inside diameter, the inside height, and the minimum thicknesses for the measure, see Table 1 below. Record these measurements in a lab quality manual.

Table 1
Dimensions of Measures

Capacity m^3 (ft^3)	Inside Diameter mm (in.)	Inside Height mm (in.)	Minimum Thicknesses mm (in.)		Nominal Maximum Size of Coarse Aggregate** mm (in.)
			Bottom	Wall	
0.0071	203 ±2.54	213 ±2.54	5.1	3.0	25
(1/4)*	(8.0 ±0.1)	(8.4 ±0.1)	(0.20)	(0.12)	(1)
0.0142	254 ±2.54	279 ±2.54	5.1	3.0	50
(1/2)	(10.0 ±0.1)	(11.0 ±0.1)	(0.20)	(0.12)	(2)
0.0283	356 ±2.54	284 ±2.54	5.1	3.0	76
(1)	(14.0 ±0.1)	(11.2 ±0.1)	(0.20)	(0.12)	(3)

* ***Note:*** Measure may be the base of the air meter used in the FOP for AASHTO T 152.
** Nominal maximum size: One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

Standardization of Measure

Standardization is a critical step to ensure accurate test results when using this apparatus. Failure to perform the standardization procedures as described herein will produce inaccurate or unreliable test results.

1. Determine the mass of the dry measure and strike-off plate.
2. Fill the measure with water at a temperature between 16°C and 29°C (60°F and 85°F) and cover with the strike-off plate in such a way as to eliminate bubbles and excess water.
3. Wipe the outside of the measure and cover plate dry, being careful not to lose any water from the measure.
4. Determine the mass of the measure, strike-off plate, and water in the measure.
5. Determine the mass of the water in the measure by subtracting the mass in Step 1 from the mass in Step 4.
6. Measure the temperature of the water and determine its density from Table 2, interpolating as necessary.
7. Calculate the volume of the measure, V_m, by dividing the mass of the water in the measure by the density of the water at the measured temperature, from Table 2.

$$V_m = \frac{Mass\ of\ Water}{Density\ of\ Water}$$

See **table 2** on the next page

Example: at 23°C (73.4°F)

$$V_m = \frac{7.062\ kg}{997.54\ kg/m^3} = 0.007079 m^3 \qquad V_m = \frac{15.53 lb}{62.274\ lb/ft^3} = 0.2494 ft^3$$

Table 2
Unit Mass of Water
15°C to 30°C

°C	(°F)	kg/m³	(lb/ft³)	°C	(°F)	kg/m³	(lb/ft³)
15	(59.0)	999.10	(62.372)	23	(73.4)	997.54	(62.274)
15.6	(60.0)	999.01	(62.366)	23.9	(75.0)	997.32	(62.261)
16	(60.8)	998.94	(62.361)	24	(75.2)	997.29	(62.259)
17	(62.6)	998.77	(62.350)	25	(77.0)	997.03	(62.243)
18	(64.4)	998.60	(62.340)	26	(78.8)	996.77	(62.227)
18.3	(65.0)	998.54	(62.336)	26.7	(80.0)	996.59	(62.216)
19	(66.2)	998.40	(62.328)	27	(80.6)	996.50	(62.209)
20	(68.0)	998.20	(62.315)	28	(82.4)	996.23	(62.192)
21	(69.8)	997.99	(62.302)	29	(84.2)	995.95	(62.175)
21.1	(70.0)	997.97	(62.301)	29.4	(85.0)	995.83	(62.166)
22	(71.6)	997.77	(62.288)	30	(86.0)	995.65	(62.156)

Calculation Example: Standardizing a Measure

$$Vm = \frac{Wmgw - Wmg}{Ws}$$

Vm = Volume of the measure = _____?

Wmgw = weight of the plate, glass, and water = 32.78 lbs.

Wmg = weight of the measure and glass plate = 17.17 lbs.

Ws = from the chart, density of water at _ 75 ___ °F

from the chart = 62.26 ft³

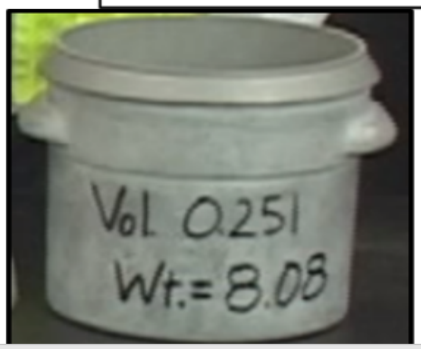
Empty measure = 8.08 lbs.

$$Vm = \frac{32.78\ lb. - 17.17\ lb.}{62.26\ ft^3}$$

Ans: Volume of the measure = 0.2507 = 0.251 ft³

Report to nearest 0.001 ft³

Temperature ° F	Pounds Pe Cubic Foo
60	62.37
65	62.34
70	62.30
73.4	62.27
75	62.26
80	62.22
85	62.17



Apparatus for Air Meter – Volumetric

Air Meter – The air meter consists of a bowl and a top section (See Figure 1) conforming to the following requirements:

The bowl and the top sections shall be of sufficient thickness and rigid enough to withstand rough field use. The material shall not be marked by high pH cement paste, deformed from high temperatures or brittle or cracked from low temperatures. The apparatus must have a watertight seal when assembled.

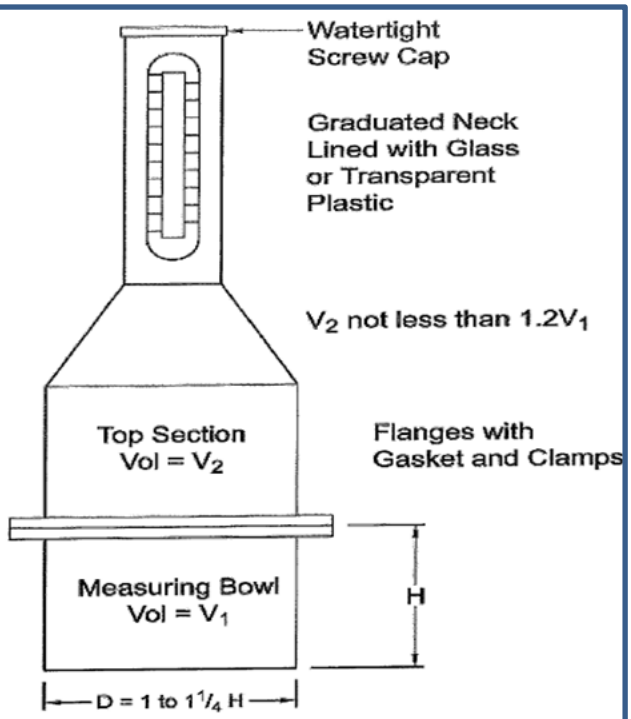


Figure 1

Bowl- The bowl diameter is equal to 1 to 1.25 times the height and constructed with a flange at or near the top surface. Bowls shall not have a capacity of less than 2.0 Liters.

Top Section – the top shall have a capacity at least 20% larger than the bowl and equipped with a flexible gasket with a device to attach the top section to the bowl to create a water tight connections. The top section shall be have a transparent scale, graduated in increments not greater than 0.5% from zero at the top, to 9% or more of the volume of the bowl. Graduations shall be accurate to ±0.1% by volume of the bowl. The upper end of the neck shall have a watertight cap that will maintain a seal when the meter is inverted and rolled.

Funnel – A funnel with a spout of a size permitting it to be inserted through the neck of the top section and long enough to extend to a point just above the bottom of the top section. The discharge end of the spout shall be constructed so when water is added to the container there will be very little disturbance of the concrete.

Tamping Rod – a round, straight steel rod, with a 16±2-mm (5/8 inches ± 1/16 inch) diameter. The rod length shall be 100mm (4 inches) greater than the depth of the measure in which rodding is being performed but not greater than 600mm (24inches) in overall length. The length tolerance for the tamping rod shall be ±4mm (±1/8 inch). The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

NOTE 1 – A rod length of 400mm. (16 inches) to 600mm (24 inches) meets the requirements of the following AASHTO Test Methods: T23, T119M/T 119, T121M/T 121, T152, and T196M/T 196.

Strike-Off Bar – A flat, straight steel bar at least 3 by 20 by 300mm (0.125 by 0.75 by 12 inch), or a flat, straight, high-density polyurethane bar, or other plastic of equal or greater abrasion resistance, at least 6 by 20 by 300mm (1/4 by ¾ by 12 inch).

Calibrated Cup – A metal or plastic cup either having a capacity of or being graduated in increments equal to 1.0 ± 0.04 percent of the volume of the bowl of the air meter. The calibrated cup is only to be used to add water when the concrete air content exceeds 9% or the calibrated range of the meter.

Measuring Vessel for Isopropyl Alcohol – a vessel with a minimum capacity of 500mL (1pt) with graduations not larger than 100ml (4oz) for measuring a quantity of isopropyl alcohol.

Syringe – A rubber syringe having a capacity of at least 50mL (2oz).

Pouring Vessel for Water – A container of approximately 1L (1qt) capacity.

Scoop – Of a size large enough so each amount of concrete obtained from the sampling receptacle is representative and small enough so it is not spilled during placement in the bowl.

Isopropyl Alcohol – Use 70% by volume isopropyl alcohol (approximately 65%by mass). Other foam-dispersing agents are permitted if tests demonstrate that he use of the agent does not change the indicated air content, in the amounts being used, by more than 0.1% or if correction factors are developed similar to those in table 1. When other dispensing agents are used, a copy of the records documenting the testing or calculations shall be available in the laboratory.

Note 2 – Seventy % isopropyl alcohol is commonly available as rubbing alcohol. More concentrated grades can be diluted with water to the required concentration.

Mallet – A mallet (with a rubber or rawhide head) with a mass of approximately 600 ± 200g (1.25 ± 0.5lb.).

Calibration

Calibrate the meter and calibrated cup initially and at three-year intervals or whenever there is reason to suspect damage or deformation of the meter or calibrated cup.

Determine the volume of the bowl, with an accuracy of at least 0.1%, by determining the mass of water required to fill it at room temperature and dividing this weight by the density of water at the same temperature. Follow the calibration procedure outlined in AASHTO T19M/T19.

Determine the accuracy of the graduations on the neck of the top section of the air meter by filling the assembled measuring bowl and top section with water to a preselected air content graduation and then determining the quantity of 21.1°C water required to fill the meter to the zero mark. The quantity of water added shall equal the preselected air content graduation within ±0.1 volume percent of the measuring bowl. Repeat the procedure to check a minimum of three gradations within the expected range of use.

Add water in increments of 1.0 percent of the volume of the bowl to check accuracy throughout the graduated range of air content. The error at any point throughout the graduated range shall not exceed 0.1% of air.

Determine the volume of the calibrated cup using water at 21.1°C by the method outlined in Section 5.2., a quick check can be made by adding one or more calibrated cups of water to the assembled apparatus and observing the increase in the height of the water column after filling to a given level.

Apparatus

Beam Molds – beam molds shall be of the shape and dimensions required to produce the specimens that are at least 2 inches greater in length than three times the depth as tested. The ratio of width to depth as molded shall not exceed 1.5. The minimum cross setional dimension of the beam shall be as stated in Table 2. Unless otherwise specified by MoDOT, the standard beam shall be 6 X 6 inches cross section.

TABLE 2	
TABLE 2Nominal Maximum Aggregate Size (NMAS)	**Minimum Cross-Sectional Dimension**
≤1 inch	4 x 4 inches
≤1 inch < NMAS ≤2 inches	6 X6 inches

The inside surfaces of the beam molds shall be smooth. The sides, bottom, and ends shall be at right angles to each other and shall be straight and true and free of warpage. Maximum variation from the nominal cross section shall not exceed 3.2mm (1/8 inch) for molds with depth or breadth of 6 inches or more, or 1/16th inch for molds of smaller depth or breadth. Except for flexure specimens, molds shall not vary from the nominal length by more than 1/16th inch of the required length. NOTE: Greater lengths are allowed.



Tamping Rods – A round, smooth, straight, steel rod with a diameter conforming to the requirements in Table 1. The length of the tamping rod shall be at least 100mm (4inch) greater than the depth of the mold in which rodding is being performed, but got greater than 600mm (24inch) in overall the rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter at the rod.



Table 1—Tamping Rod Requirements

Diameter of Cylinder or Width of Beam, mm (in.)	Rod Dimensions[a]	
	Diameter, mm (in.)	Length of Rod, mm (in.)
<150 (6)	10 (3/8)	300 (12)
150 (6)	16 (5/8)	500 (20)
225 (9)	16 (5/8)	650 (26)

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



Vibrators – An Internal vibrator shall be used. The vibrator frequency shall be at least 9000 vibrations per minute (150Hz) while the vibrator is operating in the concrete. The diameter of a round vibrator shall be no more than ¼ of the diameter of the cylinder mold or ¼ the width of the beam mold. Other shaped vibrators shall have a perimeter equivalent to the circumference of an appropriate round vibrator. The combined length of the vibrator shaft and vibrating element shall exceed the depth of the section being vibrated by at least 75mm (3inches). The vibrator ferequency shall be checked periodically.

Air content apparatus – The apparatus for measureing air content shall conform to the requirements of T196M/T196 or T152

Temperature Measureing Devices – the temperature mesureing devices shall conform to the applicable requirements of MT 20.

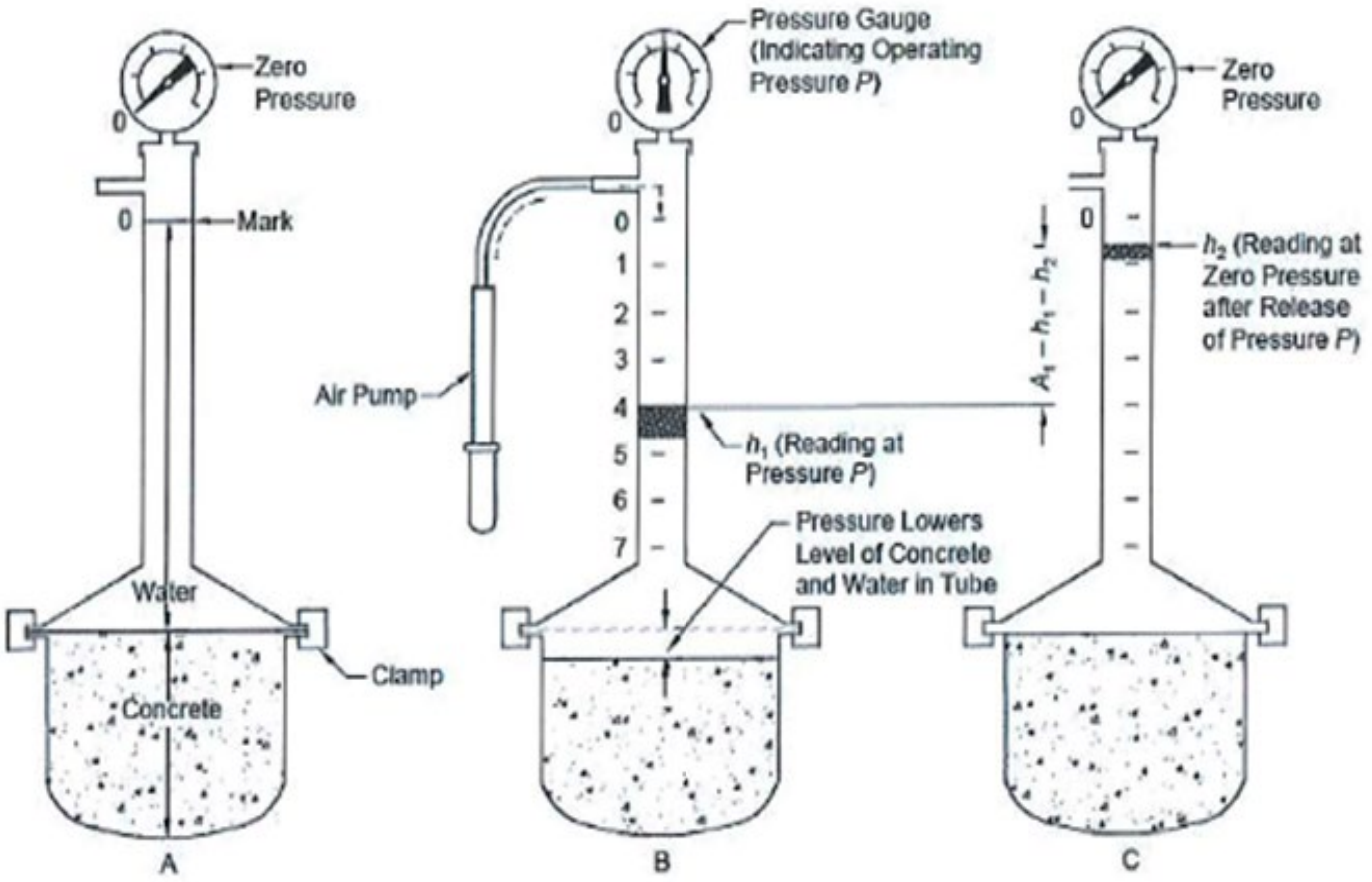
4.-- APPARATUS

4.1-- Air Meters – There are two basic designs Meter Type A and Meter Type B.

4.1.1-- Meter Type A – an air meter consisting of a measuring bowl and cover assembly, see image below:



Meter Type A



Note: $A_1 = h_1 - h_2$ when measuring bowl contains concrete as shown in this figure; when measuring bowl contains only aggregate and water, $h_1 - h_2 =$ (aggregate correction factor).
$A_1 - G = A$ (entrained air content of concrete).

Figure 1—Illustration of the Pressure Method for Air Content: Type A Meter

The operational principle of this meter consists of introducing water to a predetermined height above a sample of concrete of known volume and the application of a predetermined air pressure over the water. The determination consists of the reduction in volume of the air in the concrete sample by observing the amount the water level is lowered under the applied pressure, the latter amount being standardized in terms of percent of air in the concrete sample.

4.1.2-- Meter Type B – An air meter consisting of a measuring bowl and cover assembly, see image below:

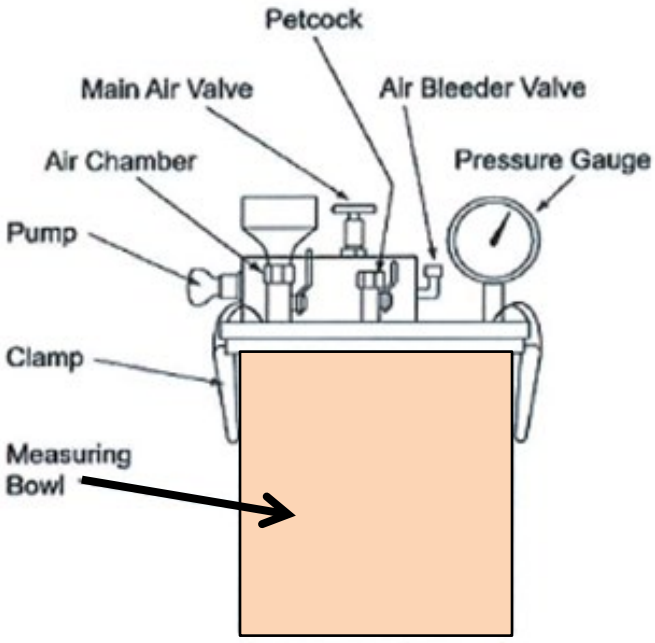


Meter Type B

The operational principle of this meter consists of equalizing a known volume of air at a known pressure in a sealed air chamber with the unknown volume of air in the concrete sample, the dial on the pressure gauge being standardized in terms of percent air for the observed pressure in which equalization takes place. Working pressures of 7.5 to 300 psi have been used satisfactorily.

4.2-- Measuring Bowl – Must be cylindrical in shape, made of steel, hard metal, or other hard material not readily attacked by the cement paste, having a minimum diameter equal to 0.75 to 1.25 times the height, and a capacity of at

least 0.20 ft^3. It shall be flanged or otherwise constructed to provide for a pressure-tight fit between the measuring bowl and the cover assembly. The interior surfaces of the measuring bowl and surfaces of rims, flanges, and other component fitted parts shall be machined smooth. The measuring bowl and cover assembly shall be sufficiently rigid to limit the expansion factor, ***D***, of the apparatus assembly **(Annex A1.5)** to not more than 0.1% of air content on the indicator scale when under normal operating pressure.



2a. Horizontal Air Chamber

4.3-- Cover Assembly:

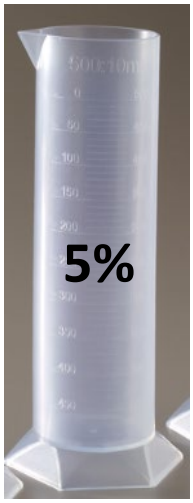
4.3.1-- The cover assembly shall be made of steel, hard metal, or other hard material not readily attacked by the cement paste. It shall be flanged or otherwise constructed to provide for a pressure-tight fit between measuring bowl and cover assembly and shall have machined smooth interior surfaces contoured to provide an air space above the level of the top of the measuring bowl. The cover shall be rigid to limit the expansion factor of the apparatus assembly as prescribed in Section **4.2**.

4.3.2 --The cover assembly shall be fitted with a means of direct reading of the air content. The cover for the **Type A meter** shall be fitted with a standpipe, which may be a transparent graduated tube or may be a metal tube of uniform bore with a glass water gauge attached. In the **Type B meter**, the dial of the pressure gauge shall be standardized to indicate the percent of air. Graduations shall be provided for a range in air content of at least 8%, easily readable to 0.1%, as determined by the proper air pressure standardization test.

4.3.3-- The cover assembly shall be fitted with air valves, air bleeder valves, for bleeding off air, and petcocks through which water may be introduced as necessary. The cover shall have a way to clamp or tighten down to the measuring bowl and provide a pressure-tight seal without entrapping air at the joint between the flanges of the cover and the measuring bowl. A suitable hand pump shall be provided with the cover, either as an attachment or as an accessory.

4.4-- Standardization Vessel – A measure having an internal volume equal to a percent of the volume of the measuring bowl corresponding to the approximate percent of air in the concrete to be tested; or, if smaller, it shall be possible to check standardization of the meter indicator at the approximate percent of air in the concrete to be tested by repeated filling of the measure. When the design of the meter requires placing the standardization vessel within the measuring bowl to check standardization, the measure shall be cylindrical in shape and of an inside depth ½ inch less than that of the measuring bowl.

NOTE: When design of the meter requires withdrawing of water from the water-filled measuring bowl and cover assembly to check standardization, the measure may be an integral part of the cover assembly or maybe a separate cylindrical measure.



4.5-- The designs of various available types of air meters are such that they differ in operating techniques and, therefore, all of the items described in sections 4.6 through 4.16 may not be required.

4.6-- Coil Spring or Other Device – for Holding Standardization Cylinder in Place

4.7-- Spray Tube – a brass tube of appropriate diameter, which may be an integral part of the cover assembly or which may be provided separately. It shall be so constructed that when water is added to the container, it is sprayed to the walls of the cover in such a manner as to flow down the sides causing a minimum of disturbance to the concrete.

4.8 --Trowel – A standard brick mason's trowel

4.9-- Tamping Rod – A round, straight steel rod, with a ⅝ inch ± 1/16 inch diameter, the length shall be at least 4 inches greater than the depth of the measure in which rodding is being performed but not greater than 24 inches in overall length. The length tolerance for the tamping rod is ± ⅛ inch. The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

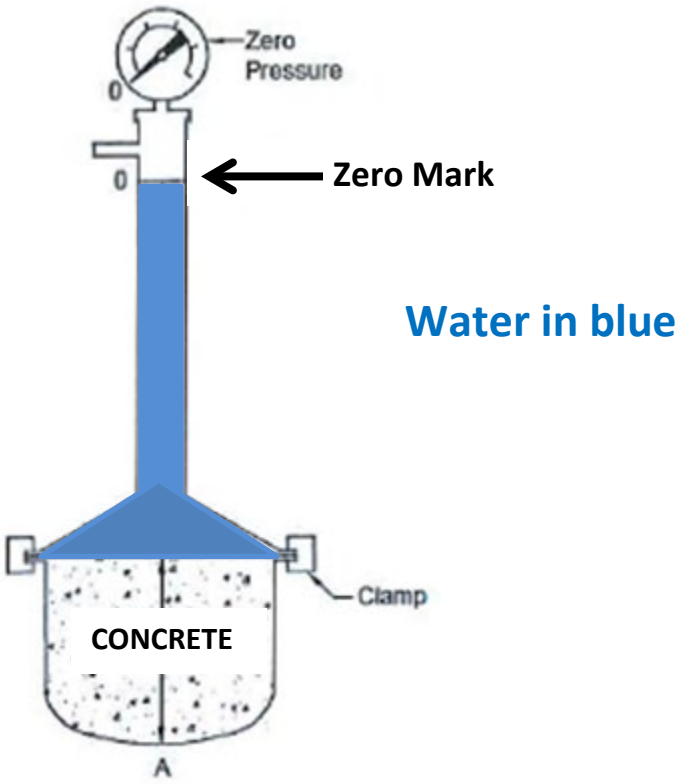
4.10-- Mallet – a mallet (with a rubber or rawhide head) weighing approximately 1.25 ± 0.50 pounds for use with measures of 0.5 ft^3 or smaller and a mallet weighting approximately 2.25 ± 0.50 pounds for use with measures larger than 0.5ft^3.

4.11-- Strike-Off Bar – a flat straight bar of steel or other suitable metal at least ⅛ inch thick and ¼ inch wide by 12 inches long.

4.12-- Strike-Off Plate – A flat rectangular metal plate at least ¼ inch thick or a glass or acrylic plate at least ½ inch thick with a length and width at least 2 inches 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 a tolerance of 1/16 inch.

4.13-- Funnel – With the spout fitting into a spray tube.

4.14-- Measure for Water – Having the necessary capacity to fill the indicator with water from the top of the concrete to the zero mark.



4.15 -- Vibrator – as described in R39.



4.16 – Sieves - 1½ inch with not less than 2 ft² of sieving area.

4.17 – Scoop – Of a size large enough so each amount of concrete obtained from the sampling receptacle is representative and small enough so it is not spilled during placement in the measuring bowl.

6-- Standardization of a Type A Meter

6.1 Make standardization tests in accordance with procedures prescribed in the annex. Rough handling will affect the standardization of Type A meters. Changes in barometric pressure will also affect the standardizations of Type A meters.

The steps described in **Sections A1.2 to A1.6**, as applicable to the meter type under consideration, are prerequisites for the final standardization test to determine the operating pressure, P, on the pressure gauge of the Type ammeter as described in **Section A1.7**. Normally the steps in **Sections A1.2 to A1.6** need be made only once (at the time of initial standardization) or only occasionally to check volume constancy of the standardization cylinder and measuring bowl. On the other hand the standardization test described in **Sections A1.8 and A1.9**, as applicable to the meter type being standardized, must be made as frequently as necessary to ensure that the proper gauge pressure, P is being used for the Type A meter. A change in elevation of more than 600 feet from location at which a Type A meter was last standardized will require re-standardization in accordance with **Section A1.8**.

7.4-- Aggregate Correction Factor Determination for Type A meters

7.4.1 – Initial Procedure for Type A Meter – When all of the aggregate has been placed in the measuring bowl (see slide show for 7.3 for placement of Aggregate in the Measuring Bowl), remove excess foam and keep the aggregate inundated for a period of time approximately equal to the time between introduction of the water into the mixer and the time of performing the test for air content before proceeding with the determination as directed in section 7.4.2 or 7.4.3

7.4.2 – Type A Meter – Complete the test as described in section 8.1 through 9.3.2. The aggregate correction factor, G, is equal to h1 – h2. (See figure 1) The aggregate correction factor will vary with different aggregates. It can be determined only by test, because apparently is not directly related to absorption of the particles. The test can be easily made and should not be ignored. Ordinarily the factor will remain reasonable constant for given aggregates, but an occasional check test is recommended.

9.3 – Procedure for Determining Air Content of Concrete– Type A Meter

Preparation for Test – NOTE: See section 9 on the slide show for placement of, and consolidation by Rodding or Vibrating the concrete sample.

Thoroughly clean the flanges or rims of the measuring bowl and of the cover assembly 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 until it rises to about the halfway mark in the standpipe. Incline the apparatus assembly about 30 degrees from vertical and, using the bottom of the measuring bowl as a pivot, describe several complete circles with the upper end of the column, simultaneously tapping the cover lightly to remove any entrapped air bubbles above the concrete sample. Return the apparatus assembly to a vertical position and fill the water column slightly above the zero mark, while lightly tapping the side of the measuring bowl. Bring the water level to the zero mark of the graduated tube before closing the vent at the top of the water column.

9.3.3—Test Procedure – Apply slightly more than the desired test pressure, P (about 0.2psi), to the concrete by means of the small hand pump. To relieve local restraints, tap the sides of the measure sharply and, when the pressure gauge indicates the exact test pressure, P, as determined in accordance with Section A1.7, read the water level, h1, and record to the nearest division or half-division on the graduated precision-bore tube or gauge glass of the standpipe. See figure 1B, for extremely harsh mixes, it may be necessary to tap the measuring bowl vigorously until further tapping procedures no change in the indicated air content. Gradually release the air pressure through the vent at the top of the water column and tap the sides of the measuring bowl lightly for about 1 minute record the water level, h2, to the nearest division or half-division.

See figure 1C, calculate the apparent air content as follows:

$$A1 = h1 - h2$$

Where:

A1 = apparent air content

h1 = water level reading at pressure, P

h2 = water level reading at zero pressure after release of pressure, P

9.3.4-- Check Test – Repeat the steps described in section 9.3.3 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 percent of air and shall be averaged to give the value A1 to be used in calculating the air content, As, in accordance with Section 10.

9.3.5—In the event the air content exceeds the range of the meter when it is operated at the normal test pressure P, reduce the test pressure to the alternative test pressure P1 and repeat the steps outlined in sections 9.3.3 and 9.3.4.

$$P1 = Pa\ p/(2Pa - P)$$

Where:

P1 = alternative test pressure, psi

Pa = atmospheric pressure, psi (approximately 14.7psi but will vary with altitude and weather conditions);

P = normal test or operating gauge pressure, psi

Apparatus

Molds, General – Molds for specimens or fastenings in contact with the concrete shall be made of steel, cast iron, or other nonabsorbent material, nonreactive with concrete containing portland or other hydraulic cements. Molds shall hold their dimensions and shape under conditions of use. Provisions for tests of watertightness are given in M205M/M205. A suiable sealant, such as heavy greases, modeling clay or microcrystallne wax shall be used where necessary to prevent leakage through the joints. Poisitive means shall be provided to hold base plates firmly to the molds. Reusable molds shall be lighly coated with mineral oil or a suitable nonreactive form release material before use.

Cylinder – Molds for casting concrete test specimens shall conform to the requirements of M205M/M 205.



Beam Molds – beam molds shall be of the shape and dimensions required to produce the specimens stipulated in section in R100. The inside surfaces of the molds shall be smooth. The sides, bottom, and ends shall be at right angles to each other and shall be straight and true and free of warpage. Maximum variation from the nominal cross section shall not exceed 3.2mm (1/8 inch) shorter than the requied length in accordance with section 6.2 in AASHTO T23.



Tamping Rods – A round, smooth, straight, steel rod with a diameter conforming to the requirements in Table 1. The length of the tamping rod shall be at least 100mm (4inch) greater than the depth of the mold in which rodding is being

performed, but got greater than 600mm (24inch) in overall the rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter at the rod.



Table 1—Tamping Rod Requirements

Diameter of Cylinder or Width of Beam, mm (in.)	Rod Dimensions[a]	
	Diameter, mm (in.)	Length of Rod, mm (in.)
<150 (6)	10 (3/8)	300 (12)
150 (6)	16 (5/8)	500 (20)
225 (9)	16 (5/8)	300 (24)

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



Vibrators – An Internal vibrator shall be used. The vibrator frequency shall be at least 9000 vibrations per minute (150Hz) while the vibrator is operating in the concrete. The diameter of a round vibrator shall be no more than ¼ of the diameter of the cylinder mold or ¼ the width of the beam mold. Other shaped vibrators shall have a perimeter equivalent to the circumference of an appropriate round vibrator. The combined length of the vibrator shaft and vibrating element shall exceed the depth of the section being vibrated by at least 75mm (3inches). The vibrator ferequency shall be checked periodically.

Air content apparatus – The apparatus for measureing air content shall conform to the requirements of T196M/T196 or T152

Temperature Measureing Devices – the temperature mesureing devices shall conform to the applicable requirements of MT 20.

Glossary



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Use For Notes If Needed

Glossary of Terms

AASHTO
American Association of State Highway and Transportation Officials

ASTM
American Society for Testing and Materials

Absolute Volume (V)
The absolute volume of each ingredient in cubic yards is equal to the quotient of the mass of the ingredient divided by the product of its specific gravity times 62.4. The absolute volume of each ingredient in cubic meters is equal to the mass of the ingredient in kilograms divided by 1000 times its specific gravity.

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.

Bulk Specific Gravity and Mass
For the aggregate components, the bulk specific gravity and mass should be based on the saturated surface-dry condition. For cement, the actual specific gravity should be determined by T133. A value of 3.15 may be used for cements manufactured to meet the requirements of M85.

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.

Total Mass (M)
The total mas of all materials batched is the sum of the masses of the cement, the fine aggregate in the condition used, the coarse aggregate in the condition used, the mixing water added to the batch, and any other solid or liquid materials used.

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

Volumetric Method

Air is removed from a known volume of concrete by agitation in an excess of water. It may be used with any type of aggregate including light weight and porous material. The test is not affected by atmospheric pressure and the specific gravity of the material need not be known.