HMEC

Highway Materials Engineering Course

PARTICIPANT WORKBOOK

LABORATORY MANUAL

Testing Fresh Concrete

MODULE

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U.S.Department of Transportation
Federal Highway Administration

Contents

Laboratory Safety

Personal Protective Equipment

All participants in the laboratory experience must wear the following safety equipment at all times:

- Safety glasses
- Safety shoes or shoe covers
- Gloves
- Other safety equipment may be necessary for certain tests
- Clothes that can get dirty working with fresh cement

Hazard Exposures

Fresh hydraulic cementitious mixtures are caustic and may cause skin irritation, severe chemical burns, or eye damage.

Ensuring Your Safety

For your safety, please follow all instructions provided by the laboratory experience instructors. Do not touch or handle equipment unless you have been given permission to do so.

Guidance on Precision Estimates

Each of the test methods described herein provide single-operator (repeatability) and multilaboratory (reproducibility) precision estimates. The single-operator precision provides an estimate of the expected variation of tests performed on the same material, by the same operator, using the same equipment, in the same laboratory. The multilaboratory precision provides an estimate of the expected variation of two tests performed on the same material, by different operators, using different equipment, in different laboratories. If the differences between properly performed tests exceeds these values, the testing practices and equipment should be investigated to determine the cause of the variation.

Laboratory Procedures and Time Needed to Complete

Standard Designation	Test Name	Prep Time	Total Time
ASTM C1064	Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete	15 minutes	20 minutes
AASHTO T 119/ ASTM C143	Standard Test Method for Slump of Hydraulic-Cement Concrete	15 minutes	20 minutes
AASHTO T 152/ ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method	15 minutes	22 minutes
--	Air content using the Super Air Meter (SAM)	Optional	If time permits (20 minutes)
AASHTO T 196/ ASTM C173	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method	15 minutes	25–40 minutes
AASHTO T 121/ ASTM C138	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete	15 minutes	50 minutes
AASHTO T 23/ ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field	30 minutes	40 minutes
--	Assessment of finishability using fabricated flat sample container	Optional	If time permits (5 minutes)
--	Assessment of consolidation using Tyler Ley's fabricated sample box	Optional	If time permits (10 minutes)

ASTM C1064, Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete

Significance and Use

This test provides the means for measuring the temperature of freshly mixed concrete. This test indicates the temperature at the time of testing and may not be representative of the temperature at a later time. It is used to determine conformance to a specific requirement.

Related Tests and Specifications

- AASHTO R 60/ASTM C172, Standard Practice for Sampling Freshly Mixed Concrete

Timeline for Completion

Preparation Time: 15 minutes

Sample freshly mixed concrete in accordance with R 60 / C172and begin test within 5 minutes of obtaining sample.

Test Time: 5 minutes

Immerse the temperature measuring device into the freshly mixed concrete and allow it to stabilize for at least 2 minutes, but not exceeding 5 minutes.

TOTAL TEST TIME: 20 minutes

Apparatus

Container –Large enough to allow for 75 mm [3 in.] of coverage in all directions around the temperature probe. Additionally, concrete cover must be at least three times the nominal size of the coarse aggregate.

Temperature Measuring Device –Capable of measuring the temperature of the concrete throughout a range of 0–50°C [30–120°F] and readable to ±0.5°C [1°F]. The temperature measuring device shall be designed so that it allows for 75 mm [3 in.] or more immersion into the concrete. Partial immersion liquid in glass thermometers must have a permanent mark where the device must be immersed without a correction factor.

Reference Temperature Measuring Device –Readable and accurate to ±0.2°C [0.5°F]. A certificate verifying the accuracy must be available for review in the laboratory. The accuracy of liquid in glass reference temperature measuring devices must be verified once. Direct-reading

resistance reference devices shall be verified annually. The certificate shall indicate that the devices used in calibration are NIST traceable.

Sample Preparation

Sample freshly mixed concrete in accordance with R 60 /C172. A composite sample is not necessary if temperature is the only test being performed. Start the test for temperature within 5 minutes of obtaining the sample.

Procedure

Step 1
It is acceptable to measure the temperature of the freshly mixed concrete in either the transportation equipment or after discharging into a form, providing that there is 75 mm [3 in.] of concrete coverage in all directions.

Step 2
If the sample is to be placed in a discharge container, first dampen the container and sample in accordance with R 60 / C172.

Step 3
Position the temperature measuring device such that it is submerged at least 75 mm [3 in.] into the concrete. Close the void left by the probe by gently pressing the concrete around the probe to prevent the ambient air temperature from affecting the reading.

Step 4
Leave the device in the concrete for a minimum of 2 minutes, but not more than 5 minutes, then read and record the temperature to the nearest 0.5°C [1°F] with the device submerged.

Reporting the Test Results

Report the measured temperature to the nearest 0.5°C [1°F].

Common Errors

- Pulling the thermometer out prior to reading.
- Not having enough material around the thermometer.

Data Sheet

Measured Temperature	

AASHTO T 119/ASTM C143, Standard Test Method for Slump of Hydraulic-Cement Concrete

Background Information

This test is used to determine the consistency of concrete. In other words, how wet or dry the concrete is. The slump is generally specified in the project documents.

Significance and Use

This test is used to determine and monitor the consistency of plastic hydraulic cement concrete containing coarse aggregate up to 37.5 mm [1½ in.]. If aggregate larger than 37.5 mm [1½ in.] is present, then it must be removed according to R 60 / C172.

Related Tests and Specifications

- AASHTO R 60/ASTM C172, Standard Practice for Sampling Freshly Mixed Concrete

Timeline for Completion

Sample Time: 15 minutes

The sample shall be obtained in accordance with R 60 / C172.

Active Testing Time: 3 minutes

Freshly mixed concrete is placed in the mold in three equal layers. Each layer is rodded25 times. After the final layer is rodded, the top of the cone is struck off and the cone is lifted within 5 ± 2 seconds.

Measurements: 2 minutes

Measure the slump of the concrete by determining the difference from the original height of the cone to the original displaced center of the slumped concrete.

TOTAL TEST TIME: 20 minutes

Apparatus

Mold – Either metal or plastic conforming to T 119 / C143.

Tamping Rod – A straight steel rod with a diameter of 16 ± 2mm [5/8 ± 1/16 in.] with at least one end of the rod rounded to the same diameter as the rod. The overall length of the rod shall be at least 400 mm [16 in.] but not greater than 600 mm [24 in.].

Measuring Device – Capable of measuring to the 5 mm [¼ in.] and at least 300 mm [12 in.] long.

Scoop – Of sufficient size as to fill the cone using a representative sample but not so large that material is lost during the filling of the cone.

Sample Preparation

Obtain the sample according to R 60 / C172.Thoroughly remix the sample prior to performing the test.

Procedure

Step 1
Dampen all of the equipment. This includes the mold, baseplate or other nonabsorbent surface, and tamping rod.

Step 2
Place the cone on the base plate or other nonabsorbent surface.

Step 3
Fill the cone in three equal layers by volume, rodding each layer 25 times. On the first layer, do not forcibly strike the base plate. For the second and third layer, penetrate into the previous layer by an inch.

Step 4
During the rodding of the final layer, keep the concrete heaped at all times by adding more concrete when needed.

Step 5
Strike off the top of the mold using the tamping rod and clean the excess concrete from the base of the mold.

Step 6
Lift the mold straight up taking care not to twist or angle the mold. Invert the mold and place near the slumped concrete taking care not to disturb the slumped concrete.

Step 7
Place the tamping rod on the inverted cone and measure from the bottom of the tamping rod to the displaced center of the slumped concrete.

Step 8
Record to the nearest 5 mm [¼ in.].

Note: Some base plates have clamps that can be used to hold the mold down during filling. If using some other type of nonabsorbent surface, stand on the foot pieces in order to prevent the mold from lifting during filling and rodding.

Reporting the Test Results

The slump is measured and recorded to the nearest 5 mm [¼ in.].

Common Errors

- Pulling the slump up either too fast or too slow.
- Allowing the cone to move or wobble prior to the lift.
- Putting an object on top of the concrete in the mold prior to lifting the mold up.
- Using a nonabsorbent surface while performing this test.

Data Sheet

Slump	

AASHTO T 152/ASTM C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

Background Information

This test covers the determination of the air content of freshly mixed hydraulic-cement concrete. This test may only be performed on concrete containing dense aggregates.

Significance and Use

This test covers the determination of air content of the entire sample of concrete and is, therefore, only applicable to dense, non-porous aggregates. Additionally, this test requires the determination of an aggregate correction factor.

Related Tests and Specifications

- AASHTO T 23/ASTM C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field
- AASHTO T 121/ASTM C138, Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- AASHTO T 119/ASTM C143, Standard Test Method for Slump of Hydraulic-Cement Concrete
- AASHTO R 60/ASTM C172, Standard Practice for Sampling Freshly Mixed Concrete
- AASHTO T 196/ASTM C173, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- AASHTO R 39/ASTM C192, Standard Practice for Making and Curing Test Specimens in the Laboratory

Timeline for Completion

Preparation Time: 15 minutes

Mix concrete in accordance with R 39 / C192 or sample in accordance with R 60 / C172, whichever is applicable.

Test Time: 5 minutes

Measuring bowl is filled and struck-off and the top portion is attached. Water is added to the meter and air is pumped into the chamber and the pressure is released.

Calculations: 2 minutes

Air content is determined as the final reading on the meter minus any applicable aggregate correction factor.

TOTAL TEST TIME: 22 minutes

Apparatus

Air Meter – Type B meters consist of a measuring bowl and a top section. Must be rigid, resistant to temperature changes, made of a material not attacked by cement, and watertight when assembled. The measuring bowl must have a minimum diameter equal to 0.75 to 1.25 times the height and have a capacity of at least 6.0 L [0.2 ft3] with a flange at the edge to allow for a pressure-tight fit. The cover shall have a dial gauge with a range to at least 8% and readable to 0.1% air. The cover assembly shall be fitted with air valves, a bleeder valve, petcocks, and clamps. A Type B air meter is shown in Figure 1.

Figure 1: Type B air meter

Tamping Rod – A round, smooth, straight steel rod with a 16 mm [5/8 in.] rounded tip at least 100 mm [4 in.] greater than the depth of the measure, but not greater than 600 mm [24 in.] long.

Syringe – Made of rubber and having a capacity of at least 50 mL [2 oz.].

Scoop – Large enough to obtain a representative sample of concrete and small enough that the sample is not spilled during placement in the meter.

Mallet – A mallet with a rubber or rawhide head, having a mass of 0.60 ± 0.25 kg [1.25 ±0.5lbs].

Strike-off bar – A flat straight bar of steel at least 3mm [1/8 in.] thick, 20mm [¾ in.] wide, and 300 mm [12 in.] long.

Strike-off plate – A flat, rectangular metal, glass, or acrylic plate with a width at least 50 mm [2 in.] greater than the diameter of the measure. Metal plates shall be at least 6 mm [¼ in.] thick and glass or acrylic shall be at least 13 mm [½ in.] thick.

Sample Preparation

Mix concrete in accordance with R 39 / C192 or sample freshly made concrete in accordance with R 60 / C172 and begin test within 5 minutes of obtaining the sample.

Procedure

Step 1
Dampen the measuring bowl and fill the bowl in three layers of equal volume. Rod each layer of concrete 25 times, being careful not to forcefully strike the bottom of the measuring bowl on the first layer, and penetrating the first layer by approximately 25 mm [1 in.] on the second and third layers. After rodding each layer, tap the sides with a mallet to close the voids left by rodding. After tapping the final layer, it is acceptable to have a small amount of excess concrete above the lip of the bowl, about3 mm [1/8 in.], and a small amount may be added or removed if necessary.

Step 2
Strike off the measure until it is level using a strike-off bar or a strike-off plate (as prescribed in T 121 / C138) and wipe the flange of the bowl clean.

Step 3
Wet down the inside of the top of the meter and attach it to the bottom section.

Step 4
Using the syringe, add water through one of the petcocks until water comes out through the other petcock. Jar the meter to expel surface air bubbles.

Step 5
Close the bleeder valve and pump air into the chamber to the initial pressure determined by calibration. Gently tap the dial gauge to stabilize the gauge hand.

Step 6

Close both petcocks and release the air into the bowl with the main air valve, striking the side of the bowl smartly with the mallet. Tap the gauge to stabilize the gauge hand and read the percent air on the gauge. Release the pressure by opening the petcocks before opening the meter.

Calculations

Air Content:

$$A_S = A_1 - G$$

Where:

A_s = air content of the sample tested, %

A_1 = apparent air content of the sample tested, %

G = aggregate correction factor, %

Example Calculations

The volume of the measure has been determined to be 0.25 ft^3.

Apparent air content = 2.5 %

Aggregate correction factor = 0.3%

Calculations:

Air Content = (2.5-0.3) = 2.2%

Reporting the Test Results

Report the air content to the nearest 0.1% after subtracting the aggregate correction factor. If the gauge reading exceeds 8%, the corrected reading shall be reported to the nearest ½ scale division on the dial. In addition, the date and time of the test are also to be reported.

Common Errors

- Closing the petcocks prior to pumping to the initial pressure.
- Failing to tap the sides of the meter to relieve localized air pockets.

Data Sheet

Date	
Time	
Apparent Air Content	
Aggregate Correction Factor	
Air Content	

Air content using the Super Air Meter (SAM)

Background Information

A test being evaluated by States.

Significance and Use

The Super Air Meter or SAM is a modified ASTM C231 Type B Pressure Meter. This meter has been developed at Oklahoma State University. The meter can function in two ways. First, it provides all the same information as a Type B meter, under the same analytical conditions as a conventional pressure meter. After completing the conventional testing the meter is then able to move into a second mode of operation that places the concrete under a series of higher pressures. By understanding how the concrete responds to the series of high pressures the meter can assess properties of the air-void system beyond the air content. The result is a measurement that has been shown to correlate well with the spacing factor measurement from ASTM C457 and freeze-thaw performance data such as ASTM C666.

The meter has been validated with over 50 concrete mixtures with different air entraining agents, water reducers, w/cms, and cement contents. These values are shown below. The SAM number has been plotted versus the spacing factor from an ASTM C 457 test. The SAM number is a value calculated from the pressure curves produced in the test. A spacing factor of 0.008 is shown. This value is recommended by ACI 201 as the value needed to produce frost durable concrete. There is almost a linear trend between these two measurements.

Related Tests and Specifications

- Air Content by Volumetric Method (AASHTO T 196/ASTM C173)
- Air Content by Pressure Method (AASHTO T 152/ASTM C231)

Timeline for Completion

TOTAL TEST TIME: 20 minutes

AASHTO T 196/ASTM C173, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

Background Information

This test covers the determination of the air content of freshly mixed hydraulic-cement concrete. This test may be performed on concrete containing any type of aggregate.

Significance and Use

This test covers the determination of air content of the mortar portion of the concrete, and is therefore, the appropriate test for lightweight and porous aggregates. A significant amount of alcohol is added in addition to the water in the top of the meter in order to prevent foam from collecting in the neck.

Related Tests and Specifications

- AASHTO T 19/ASTM C29, Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate
- AASHTO T 23/ASTM C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field
- AASHTO T 121/ASTM C138, Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- AASHTO T 119/ASTM C143, Standard Test Method for Slump of Hydraulic-Cement Concrete
- AASHTO R 60/ASTM C172, Standard Practice for Sampling Freshly Mixed Concrete
- AASHTO R 39/ASTM C192, Standard Practice for Making and Curing Test Specimens in the Laboratory
- AASHTO T 152/ASTM C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C1064, Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete

Timeline for Completion

Preparation Time: 15 minutes

Mix concrete in accordance with R 39 / C192 or sample in accordance with R 60 / C172, whichever is applicable.

Test Time: 8–23 minutes

Measuring bowl is filled and struck-off and the top portion is attached. Water and alcohol are then added and the cap attached. Meter is then inverted and agitated to release concrete from the bowl. Finally, the meter is rolled on an angle two to three times to obtain stable readings.

Calculations: 2 minutes

Air content is determined as the final reading on the meter minus any necessary correction factors.

TOTAL TEST TIME: 25–40 minutes

Apparatus

Air Meter – Consists of a measuring bowl and a top section. Must be rigid, resistant to temperature changes, made of a material not attacked by cement, and watertight when assembled. The neck shall be graduated in increments of 0.5% or less, from 0 at the top to 9% or more. Figure 2 shows a brass volumetric meter.

Figure 2: A typical brass volumetric meter

Funnel – Should fit inside the neck and end above the surface of the concrete without touching. The funnel should be constructed so that there is minimal disturbance to the concrete.

Tamping Rod – A round, smooth, straight steel or plastic rod with a 16 mm [5/8 in.] rounded tip.

Measuring Vessel for Isopropyl Alcohol – Having a minimum capacity of 500 mL [1 pt.] and graduated to 100 mL [4 oz.].

Syringe – Made of rubber and having a capacity of at least 50 mL [2 oz.].

Scoop – Large enough to obtain a representative sample of concrete and small enough that the sample is not spilled during placement in the meter.

Isopropyl Alcohol – 70% by volume.

Mallet – A mallet with a rubber or rawhide head, having a mass of 0.60 ± 0.25 kg [1.25 ± 0.5 lbs.].

Sample Preparation

Sample freshly made concrete in accordance with R 60 / C172 and begin the test within 5 minutes of obtaining the sample.

Procedure

Step 1
Dampen the measuring bowl and fill the bowl in two layers of equal volume. Rod each layer of concrete 25 times, being careful not to forcefully strike the bottom of the measuring bowl on the first layer, and penetrating the first layer by approximately 25 mm [1 in.] on the second layer. After rodding each layer, tap the sides with a mallet to close the voids left by rodding. After tapping the final layer, it is acceptable to have a small amount of excess concrete above the lip of the bowl, about 3 mm [1/8 in.], and a small amount may be added or removed if necessary.

Step 2
Strike off the measure until it is level using a strike-off bar and wipe the flange of the bowl clean.

Step 3
Wet down the inside of the top of the meter and attach it to the bottom section.

Step 4
Using the funnel, add at least 500 mL [1 pt.] of water followed by a predetermined amount of isopropyl. Record the amount of alcohol used and continue adding water through the funnel until liquid is visible in the neck. Remove the funnel and, using the syringe, bring the meniscus to the 0 mark and apply the watertight cap. If the meter is to be found to be leaking at any time, the test should be discarded.

Step 5
Invert and agitate the meter for at least 45 seconds to free the concrete from the base. Do not invert the meter for more than 5 seconds at a time.

Step 6
Place the meter on a 45-degree angle with the neck elevated and roll the meter sharply ¼ to ½ of a turn for 1 minute, turning the meter 1/3 of a turn and continue the rolling procedure for a total of three turns.

Step 7
Set the meter upright and loosen the cap. Allow the meter to stabilize to determine the initial reading. A stable reading does not change by more than 0.25% in 2 minutes. If a stable reading is not determined within 6 minutes, or there is more than 2% foam in the neck, the test is invalid and should be discarded. Redo the test using fresh concrete and more alcohol. If the air content is greater than 9%, use the calibrated cup and add cups of water until liquid is visible in the neck. That number shall be added to the final reading to determine the measured air content.

Step 8
Once a stable reading is determined, re-tighten the cap and repeat the rolling procedure for 1 minute. Allow the meter to stabilize. If the final reading is not within 0.25% of the initial reading, the initial reading is discarded and the second reading becomes the new initial reading and the rolling procedure is repeated for 1 minute. If the second and third readings are not within 0.25%, then the test is discarded and should be re-performed using more alcohol.

Step 9
Dismantle the meter and confirm that there is no mortar stuck to the measuring bowl. The test shall be discarded if there is any mortar adhering to the bowl.

Calculations

Here are the calculation steps.

Step 1
If more than 2.5 pints of alcohol are used, then a correction factor shall be applied using the values in Table 1.

Step 2
Air Content:

$$A = A_R - C + W$$

Where:

A = Air Content, %

A_R = Final Meter Reading, %

C = Correction factor, based on Table 1

W = Number of calibrated cups of water added to the meter

Table 1. Correction Factors for the Effect of Isopropyl Alcohol (70% Isopropyl Alcohol Used)

Pints	**Fluid Ounces**	**Liters**	**Correction, %**
≤ 2.0	≤ 32	≤ 1	0.00
3.0	48	1.5	0.25
4.0	64	2.0	0.50
5.0	80	2.5	0.75

Example Calculations

Information from ASTM C231: The volume of the measure has been determined to be 0.25 ft3.

Apparent Air Content = 3.0

Amount of Alcohol Used = 2.5 pints

Number of Cups of Water Added = 0

Calculations:

Air Content = (3.0 - 0.25 + 0) = 2.75%

Reporting the Test Results

Report the results to the nearest 0.25%.

Common Errors

- Not checking for a watertight seal before running the test.
- Failing to loosen the cap prior to reading the meter.
- Not rolling the meter sharply.

Data Sheet

Apparent Air Content	
Amount of Alcohol Used	
Number of Cups of Water Added	

AASHTO T 121/ASTM C138, Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

Significance and Use

The density or unit weight of concrete is obtained to determine yield and relative yield, which helps verify that you are getting the volume of concrete you ordered and paid for. The data collected from this test can also be used to calculate the air content of the mix.

Related Tests and Specifications

AASHTO R 60/ASTM C172: Standard Practice for Sampling Freshly Mixed Concrete

Timeline for Completion

Sample Time: 15 minutes

The sample shall be obtained in accordance with R 60 / C172.

Test Time: 5 minutes

Measure is filled, weighed, struck-off, and final weight is determined.

Calculations: 30 minutes

Calculate the density (unit weight).When requested, the theoretical density, yield, relative yield, cement content, and air content can also be determined.

TOTAL TEST TIME: 50 minutes

Apparatus

Balance – Capable of weighing the sample mass, including the measure, to 0.3% of the test load.

Tamping Rod – A straight steel rod with a diameter of 16 ± 2mm [5/8 ± 1/16 in.] with either one end or both ends of the rod rounded to the same diameter as the rod. The overall length of the rod shall be at least 400 mm [16 in.] but not greater than 600 mm [24 in.].

Internal Vibrator – With a minimum of 7,000 vibrations per minute and may have either a rigid or flexible shaft. The width shall be 19 to 38 mm [0.75 to 1.50 in.] and the length of the shaft will be a minimum of 600 mm [24 in.].

Measure – Cylindrical and made of steel or other suitable material conforming to the requirements in Table 1 of ASTM C138.

Strike-Off Plate – A flat, rectangular plate made of either steel, glass, or acrylic conforming to the requirements of ASTM C138.

Mallet – With either a rubber or rawhide head.

Scoop – For filling the measure.

Sample Preparation

Obtain the sample of freshly mixed concrete according to R 60 / C172.

Procedure

Step 1
Lightly dampen the inside of the measure, removing any standing water. Record the tare weight of the measure.

Step 2
Fill the measure approximately 1/3 full. Rod the layer 25 times. Using the mallet, tap the outside of the measure 10–15 times to close the voids left by rodding.

Step 3
Repeat Step 2 for the next two layers, penetrating the previous layer by 1 in. during rodding.

Step 4
Using the strike-off plate, place the plate over 2/3 of the top surface of the concrete and press down. Using a sawing motion pull the plate towards you until it slides free of the measure. Place the plate on the original 2/3 of the surface and push it away from you until the plate is fully removed from the surface of the concrete. Incline the plate and pull it across the surface of the concrete to produce a smooth surface.

Step 5
Clean the outside of the measure and weigh.

Note: Make sure there is enough space in the work area to fully strike-off the top surface of the measure without disruption.

Calculations

Step 1
If not already known, determine the volume of the measure.

$$Volume\ of\ measure = \frac{weight\ of\ the\ water\ in\ the\ measure}{density\ of\ water}$$

Step 2
Determine the density (unit weight) of the concrete.

$$Density = \frac{Mass\ of\ Measure\ and\ Concrete - Mass\ of\ Measure}{Volume\ of\ Measure}$$

Example Calculations

Information from ASTM C138: The volume of the measure has been determined to be 0.25 ft3.

Tare Weight of Measure = 12.5 lbs.

Weight of Bucket and Measure = 46.8 lbs.

Calculations:

Density = (46.8-12.5)/.25 = 137.2 ft^3

Reporting the Test Results

The density (unit weight) should be reported to the nearest 0.1 lb./ft^3.

Common Errors

- Improper method of striking-off the top surface of the measure.
- Including the weight of the strike-off plate. (When weighing the measure with the concrete in it, the plate should not be on the measure.)

Data Sheet

Volume of Measure	
Tare Weight of Measure	
Weight of Bucket and Measure	
Weight of Concrete	
Density of Concrete	

AASHTO T 23/ASTM C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field

Background Information

After all on-site adjustments have been made to the fresh concrete, a representative sample and this practice is used for making and curing cylinder and beam specimens.

Significance and Use

This test method is used to standardize making, curing, protecting, and transporting concrete test specimens. The specimens can be used to determine strength of the mixture, which can be used for a variety of strength and quality control applications.

Related Tests and Specifications

- AASHTO T 119/ASTM C143/143M, Standard Test Method for Slump of Hydraulic-Cement Concrete
- AASHTO R 60/ASTM C172, Standard Practice for Sampling Freshly Mixed Concrete
- AASHTO T 196/ASTM C173/173M, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- AASHTO T 152/ASTM C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- AASHTO M 205/ASTM C470/C470M, Standard Specification for Molds for Forming Concrete Test Cylinders Vertically
- AASHTO M 201/ASTM C511, Standard Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
- ASTM C1064/C1064M, Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete

Timeline for Completion

Preparation Time: 30 minutes

Material is sampled in accordance with R 60 / C172.Determine and record results for slump (T 119 / C143), air content (T 196 / C173 or T 152 / C231), and temperature (C1064) of the concrete.

Test Time: 10 minutes

Consolidate cylinders and beams as required by slump, method of consolidation, and size of mold.

TOTAL TEST TIME: 40 minutes

Apparatus

Molds, General – Made of steel, cast iron, or other nonabsorbent material that are nonreactive with concrete. Molds should hold their dimensions and shape while in use and should adhere to the Test Methods for Elongation, Absorption, and Water Leakage section of M 205 / C470.

Tamping Rod – Round, smooth, straight, steel rod with a diameter determined by the size of the mold being consolidated.

Vibrators – An internal vibrator with a frequency of at least 9,000 vibrations per minute.

Mallet – Must be rubber or rawhide and weigh 600 ± 200 g [1.25 ± 0.50 lbs.].

Placement Tools – A scoop or shovel of an appropriate size relative to the mold being filled.

Finishing Tools – Handheld float or trowel.

Slump Apparatus – Apparatus conforming to the requirements of T 119 / C143.

Sampling Receptacle – A metal pan, wheelbarrow, or other sufficiently sized receptacle allowing for easy remixing of the entire sample.

Air Content Apparatus – Apparatus conforming to the requirements of T 196 / C173 or T 152 / C231.

Temperature Measuring Devices – A measuring device conforming to the requirements of C1064.

Sample Preparation

The material is sampled in accordance with R 60 / C172. The method of consolidation changes depending on the type of mold being consolidated, the slump of the material, and the method of consolidation.

Table 2: Method of Consolidation Requirements

Slump mm [in.]	Method of Consolidation
≥ 25 [1]	Rodding or vibration
<25 [1]	Vibration

Table 3: Tamping Rod Diameter Requirements

Diameter of Cylinder or Width of Beam mm [in.]	**Diameter or Rod mm [in.]**
<150 [6]	10 ± 2 [3/8 ± 1/16]
≥ 150 [6]	16 ± 2 [5/8 ± 1/16]

Table 4: Molding Requirements by Rodding - Cylinders

Cylinders – Diameter, mm [in.]

Specimen Type and Size	**Number of Layers of Approximately Equal Depth**	**Number of Roddings per Layer**
100 [4]	2	25
150 [6]	3	25
225 [9]	4	50

Table 5: Molding Requirements by Rodding - Beams

Beams – Width, mm [in.]

Specimen Type and Size	**Number of Layers of Approximately Equal Depth**	**Number of Roddings per Layer**
150 [6] to 200 [8]	2	1 per 50 mm^2 [2 in^2]
>200 [8]	3 or more equal depths, each not to exceed 150 mm [6 in.]	1 per 50 mm^2 [2 in^2]

Table 6: Molding Requirements by Vibration - Cylinders

Cylinders – Diameter, mm [in.]

Specimen Type	**Number of Layers**	**Number of Vibrator Insertions per Layer**	**Approximate Depth of Layer, mm [in.]**
100 [4]	2	1	One-half depth of specimen
150 [6]	2	2	One-half depth of specimen
225 [9]	2	4	One-half depth of specimen

Table 7: Molding Requirements by Vibration - Beams

Beams – Width, mm [in.]

Specimen Type	Number of Layers	Number of Vibrator Insertions per Layer	Approximate Depth of Layer, mm [in.]
150 [6] to 200 [8]	1	<150 mm [6 in.] apart	Depth of specimen
>200 [8]	2 or more	<150 mm [6 in.] apart	200 [8] as near as practicable

Procedure - Cylinders

Step 1
Select the proper tamping rod based on Table 3: and determine the method of consolidation from Table 2: When consolidating, use

Step 2
Table 4 or Table 6.

Step 3
When filling the mold, use a scoop of appropriate size and move the scoop around the perimeter of the mold to ensure even distribution.

Step 4
Fill the mold with the required layers, each of an approximately equal volume.

Step 5
Rodding: Use the rounded end of the rod evenly across each layer, penetrating the previous layer approximately 25 mm [1 in.].

Step 6
Vibration: Distribute insertions uniformly within each layer, penetrating the previous layer approximately 25 mm [1 in.].

Step 7
After rodding or vibration, tap the outside of the mold lightly 10 to 15 times.

Step 8
Finishing is done with the minimum manipulation necessary to produce a flat surface that is level to the rim or edge of the mold.

Procedure – Beams

Step 1
Select the proper tamping rod based on Table 3: and determine the method of consolidation from Table 2: When consolidating, use

Step 2
Table 5: Molding Requirements by Rodding or Table 7: Molding Requirements by Vibration.

Step 3
When filling the mold, use a scoop of appropriate size and move the scoop around the perimeter of the mold to ensure even distribution.

Step 4
Fill the mold with the required layers, each of an approximately equal volume.

Step 5
Rodding: Use the rounded end of the rod evenly across each layer, penetrating the previous layer approximately 25 mm [1 in.].

Step 6
Vibration: Distribute insertions uniformly within each layer, penetrating the previous layer approximately 25 mm [1 in.].

Step 7
After rodding or vibration, tap the outside of the mold lightly 10 to 15 times.

Step 8
When rodding, spade the sides and ends of the mold after closing the voids left by rodding.

Step 9
Finishing is done with the minimum manipulation necessary to produce a flat surface that is level to the rim or edge of the mold.

Curing

Initial Curing: After molding the specimens are stored up to 48 hours in an environment preventing moisture loss at a temperature between 16 and 27 °C [60 and 80 °F].

Final Curing: Remove specimens from the mold and place in a moisture room or water tank with a temperature range of 23.0 2.0 °C [73.5 3.5 °F] within 30 minutes. Beams are cured the same as cylinders, but shall be stored in water at least 20 hours prior to testing.

Field Curing: Cylinders and beams should be cured in as near as possibly temperature and moisture conditions of the structural work. Beams have an additional step of being placed in calcium hydroxide saturated water at 23.0 2.0 °C [73.5 3.5 °F] for 24 4 hours immediately before testing.

Reporting the Test Results

The following information must be included with the specimen: Identification number, location of concrete represented, date, time, names of individual molding specimens, slump, air content, concrete temperature, curing method, and any deviations from the referenced standard test methods.

Interpreting and Utilizing the Test Results

Add additional information on how the results of the test are used. Refer back to the Highway Materials Engineering Course design guides to ensure continuity of the information being shared.

Common Errors

- Incorrect number of layers for the given mold.
- Incorrect size tamping rod used.
- Sides and ends of a beam are not spaded after closing the voids left by rodding.
- Beams being finished by a tool other than a handheld float or trowel.

Data Sheet

Specimen Identification Number	
Location of Concrete Represented	
Date	
Time	
Name of Individual Molding Specimens	
Slump	
Air Content	
Concrete Temperature	
Curing Method	
Any Deviations from the Referenced Standard Test Methods	

Assessment of finishability using fabricated flat sample container

Background Information

N/A

Significance and Use

Visually assess finishability

Related Tests and Specifications

N/A

Timeline for Completion

TOTAL TEST TIME: If time permits (5 minutes)

Assessment of consolidation using Tyler Ley's fabricated sample box

Background Information

A test being evaluated by States

Significance and Use

To assess consolidation of the concrete for slipform paving

Related Tests and Specifications

N/A

Timeline for Completion

TOTAL TEST TIME: If time permits (10 minutes)

Appendix A: Lab Materials

ASTM C1064, Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete

Reporting the Test Results

Report the measured temperature to the nearest 0.5°C [1°F].

Common Errors

- Pulling the thermometer out prior to reading.
- Not having enough material around the thermometer.

Data Sheet

Measured Temperature	

AASHTO T 119/ASTM C143, Standard Test Method for Slump of Hydraulic-Cement Concrete

Reporting the Test Results

The slump is measured and recorded to the nearest 5 mm [¼ in.].

Common Errors

- Pulling the slump up either too fast or too slow.
- Allowing the cone to move or wobble prior to the lift.
- Putting an object on top of the concrete in the mold prior to lifting the mold up.
- Using a nonabsorbent surface while performing this test.

Data Sheet

Slump	

AASHTO T 152/ASTM C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

Reporting the Test Results

Report the air content to the nearest 0.1% after subtracting the aggregate correction factor. If the gauge reading exceeds 8%, the corrected reading shall be reported to the nearest ½ scale division on the dial. In addition, the date and time of the test are also to be reported.

Common Errors

- Closing the petcocks prior to pumping to the initial pressure.
- Failing to tap the sides of the meter to relieve localized air pockets.

Data Sheet

Date	
Time	
Apparent Air Content	
Aggregate Correction Factor	
Air Content	

AASHTO T 196/ASTM C173, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

Reporting the Test Results

Report the results to the nearest 0.25%.

Common Errors

- Not checking for a watertight seal before running the test.
- Failing to loosen the cap prior to reading the meter.
- Not rolling the meter sharply.

Data Sheet

Apparent Air Content	
Amount of Alcohol Used	
Number of Cups of Water Added	

AASHTO T 121/ASTM C138, Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

Reporting the Test Results

The density (unit weight) should be reported to the nearest 0.1 lb./ft3.

Common Errors

- Improper method of striking-off the top surface of the measure.
- Including the weight of the strike-off plate. (When weighing the measure with the concrete in it, the plate should not be on the measure.)

Data Sheet

Volume of Measure	
Tare Weight of Measure	
Weight of Bucket and Measure	
Weight of Concrete	
Density of Concrete	

AASHTO T 23/ASTM C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field

Reporting the Test Results

The following information must be included with the specimen: Identification number, location of concrete represented, date, time, names of individual molding specimens, slump, air content, concrete temperature, curing method, and any deviations from the referenced standard test methods.

Interpreting and Utilizing the Test Results

Add additional information on how the results of the test are used. Refer back to the Highway Materials Engineering Course design guides to ensure continuity of the information being shared.

Common Errors

- Incorrect number of layers for the given mold.
- Incorrect size tamping rod used.
- Sides and ends of a beam are not spaded after closing the voids left by rodding.
- Beams being finished by a tool other than a handheld float or trowel.

Data Sheet

Specimen Identification Number	
Location of Concrete Represented	
Date	
Time	
Name of Individual Molding Specimens	
Slump	
Air Content	
Concrete Temperature	
Curing Method	
Any Deviations from the Referenced Standard Test Methods	