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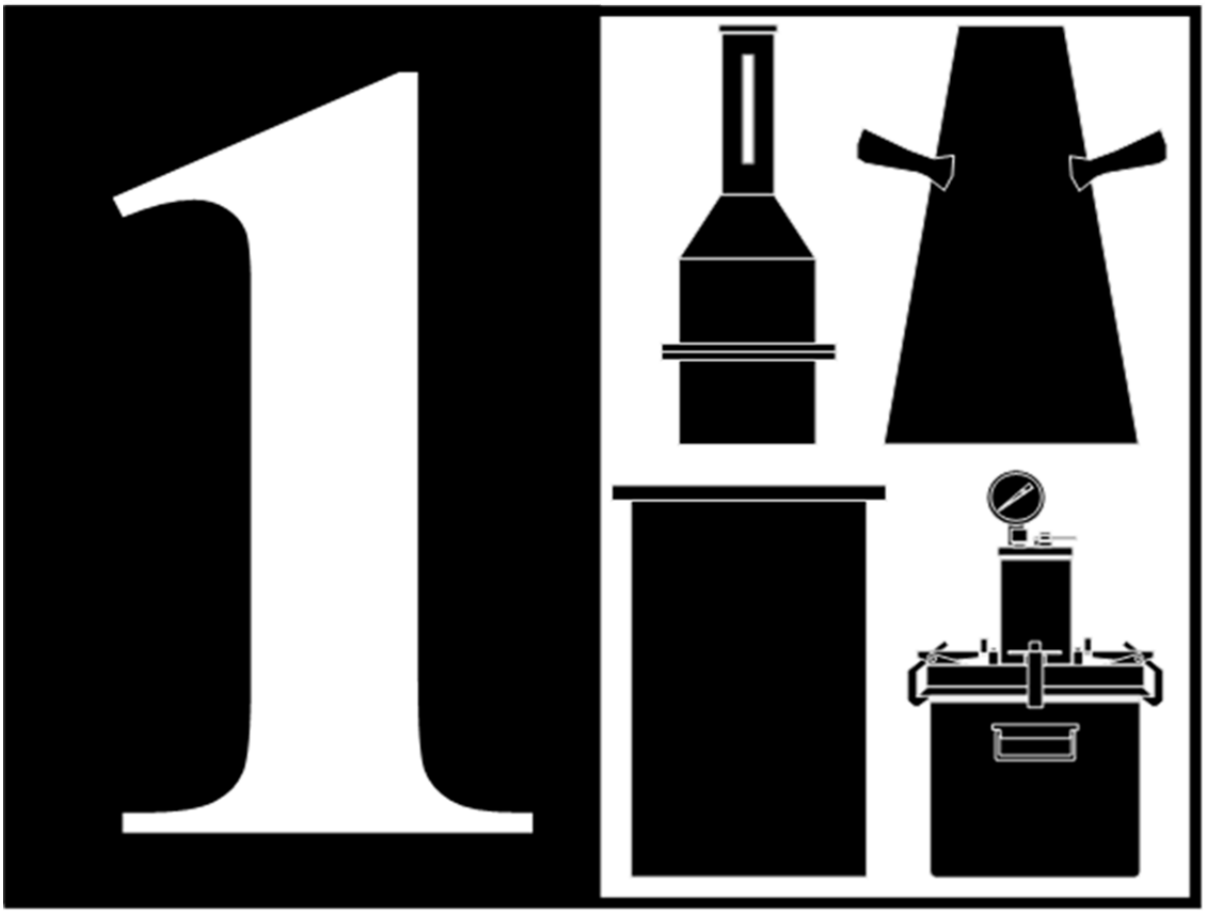

Concrete Field Testing Technician Course

Tennessee Department of Transportation

Volume 3.2

Welcome!

Concrete Field Testing Technician Course

TN TDOT Department of Transportation

Introduction

- Technician Certification Program
- Purpose
- Who's Who
- Course Highlights
- Written Examination
- Results/Certification
- Resources/Contacts
- Summary/Questions

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Instructors

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Technician Certification Program

- Asphalt Roadway Inspector
- Asphalt Plant Inspector
- Asphalt Mix Design
- **Concrete Field Testing**
- Concrete Plant Quality Control
- Concrete Mix Design
- Soils and Aggregate
- Nuclear Gauge Safety (TDOT Employees Only)

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Purpose of Certification

- To ensure proper performance of tests
- To improve reliability of results
- For quality control and acceptance
- To comply with federal requirements

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Course Highlights

- Course schedule
  - Slide presentations
    - 7 Test methods for Concrete Field Testing
    - Self Consolidating Concrete
    - TDOT Specifications / Forms
  - Written exam
  - Performance exam
  - Results
  - Certification
- Recertification
  - every 5 years

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Written Examination

- Consists of:
  - **64** questions
  - Open-book
- To Pass:
  - Must get 70% overall on written exam
  - **45 of 64** questions correct
  - Pass Performance Test

Results

- Available within one week of completion
- Contact the Headquarters Materials & Tests Training Coordinator, Kim Whitby
  - kimberly.whitby@tn.gov
  - 615-350-4158

Resources

- Course materials
  - Course textbook
  - Presentation slides and videos
- TDOT
  - Standard Specifications, January 1, 2015
  - Special Provisions
- Contacts
  - Regional Materials Supervisors

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Resources

- Tennessee Department of Transportation
  - http://www.tdot.state.tn.us/
- American Road & Transportation Builders Association
  - http://www.artba.org/
- Tennessee Road Builders Association
  - http://www.trba.org/
- Tennessee Ready Mixed Concrete Association
  - http://www.trmca.org/
- American Association of State Highway Transportation Officials
  - http://www.aashto.org/
- American Society of Testing Materials
  - http://www.astm.org/
- American Concrete Institute
  - http://www.aci-int.org/
- Construction Materials Engineering Council
  - http://www.cmec.org/
- Portland Cement Association
  - http://www.portcement.org/

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ADA Notice of Requirements

- Can be found at the following website:
  - http://www.tn.gov/tdot/topic/transportation-americans-with-disabilities-notice
- To be in compliance with TDOTs requirements listed on the website above, it is our goal to provide reasonable accommodations to those who identify themselves as having a disability and request such accommodations.
- Please feel free to bring it to any of the course instructors and accommodations will be administered as discretely as possible.

Questions

1

Sampling Freshly Mixed Concrete

AASHTO R 60

ASTM C 172

TDOT Standard Method of Test for

Sampling Freshly Mixed Concrete

References

TDOT Standard Specifications
AASHTO R 60
ASTM C 172

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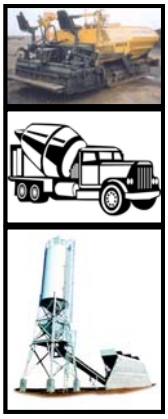
Scope

Procedure for obtaining representative samples of fresh concrete as delivered to the project site.

Tests will be performed for quality control in accordance with TDOT Specification.



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Sampling Sources

Method includes sampling from:

- ***Stationary Mixers & Revolving Drum Truck Mixers or Agitators***
  - **Collect two or more portions taken at regularly spaced intervals during discharge of the middle portion of the batch.**
  - **No sample shall be taken before 10% or after 90% of the batch has been discharge.**

- ***Paving Mixers***
  - **Obtain portions from at least five different portions of the pile and then composite into one sample for test purposes.**

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Sampling

Elapsed time between obtaining first and final portions shall not exceed 15 minutes

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Sampling

Transport individual samples to testing location then combine and remix with a shovel to ensure uniformity and compliance with time limits.

Sampling

Start tests for slump, temperature, and air content within 5 minutes after obtaining the final portion of the composite sample.

Sampling

Begin molding specimens for strength testing within 15 minutes after fabricating the composite sample.

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Sampling

Minimize the time between obtaining and using the sample

Protect the sample from

- **sun**
- **wind**
- **other sources of rapid evaporation**
- **contamination**

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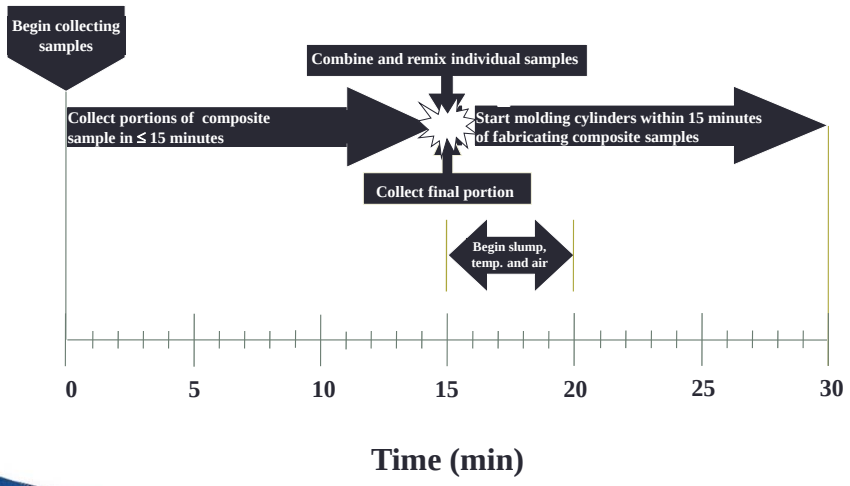
Sampling Timeline



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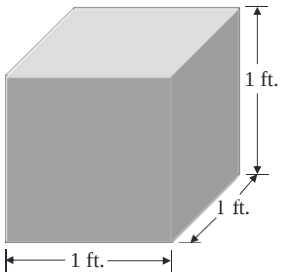
Procedure

- **Make samples to be used for strength tests a minimum of one cubic foot (1 ft^3).**
- **Smaller samples are not prohibited for routine air content and slump tests; the sample size is dictated by the maximum aggregate size.**



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Procedure

Sampling is normally performed as the concrete is delivered from the mixer to the vehicle conveying the concrete to the forms.

- **Specifications may require other points of sampling**

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2

Temperature of Freshly Mixed

Hydraulic Cement Concrete

ASTM C 1064

TDOT Standard Method of Test for

Temperature of Freshly Mixed Hydraulic-Cement Concrete

References

TDOT Standard Specifications
ASTM C 1064

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Summary of Test

- **Freshly-mixed concrete is sampled**
- **A thermometer is placed in the concrete**
- **After appropriate time for stabilization, the temperature is read from the thermometer**

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Applicability

- **May be used in any type of concrete.**
- **Concrete containing aggregate of a nominal maximum size greater than 3 inches may require up to 20 minutes for stabilization.**

Equipment

Container

- **Made of nonabsorptive material large enough to provide at least 3 inches of cover in all directions around the sensor of the thermometer.**
- **The concrete cover must also be at least 3 times the nominal maximum size of the coarse aggregate.**

Equipment

Temperature Measuring Device

- **Shall be capable of measuring the temperature of the concrete to ±1°F throughout the range (30°-120°F) likely to be encountered in freshly-mixed concrete.**
- **Calibrate annually (once a year) or when there is a question of accuracy.**

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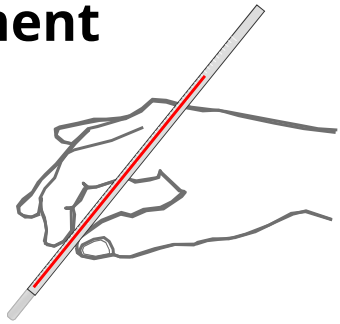
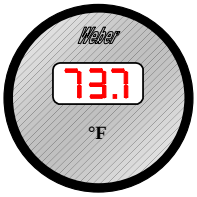
Equipment

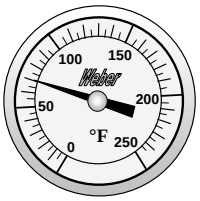
Thermometer types

- **Liquid-in-glass**
- **Metal immersion**





digital models



analog (dial) models

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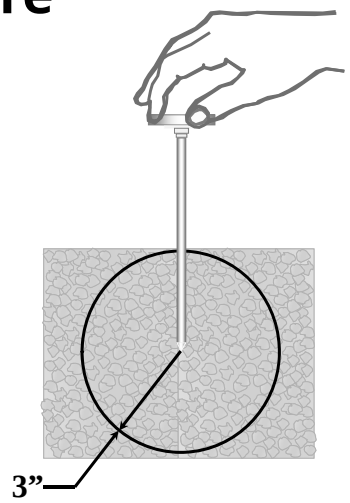
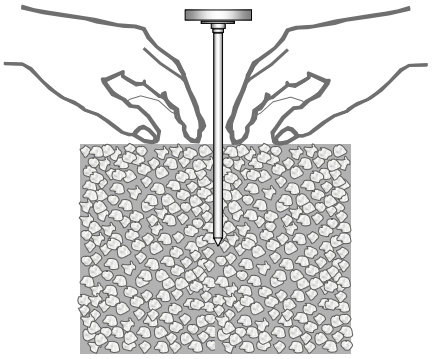
Procedure

- **Place the temperature measuring device in the concrete so that the sensor is submerged a minimum of 3 inches with 3 inches of cover in all directions.**



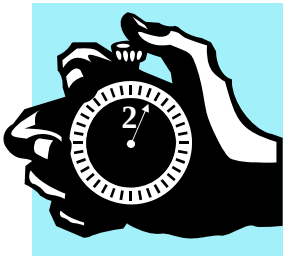
Procedure

- **Gently press the concrete around the device at the surface so that ambient air temperature does not affect the reading.**



Procedure

Leave the device in the concrete for a minimum of 2 minutes but not more than 5 minutes.



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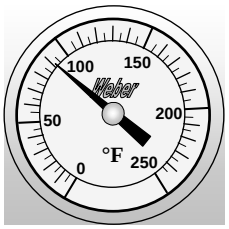
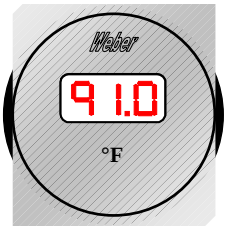
Procedure

Read and record the temperature to the nearest 1ºF.





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Specifications

501.11 & 604.12

- **Mixing concrete shall discontinue when air temperature is 40°F and falling.**
- **Mixing of concrete shall not start/resume until air temperature is 35°F and rising.**
- **Concreting at air temperatures above 35°F**
  - **Concrete temperature at the time of placement shall be no less than 50°F nor more than 90°F**
- **When authorized concreting at air temperatures 35°F or less**
  - **The mixed, heated concrete shall not be less then 60°F nor more than 100°F at the time of placement.**

604.11

- **The temperature at the point of discharge shall not exceed 90°F.**

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3

Slump of Hydraulic Cement Concrete

AASHTO T 119

ASTM C 143

TDOT Standard Method of Test for

Slump of Hydraulic Cement Concrete

References

TDOT Standard Specifications
AASHTO T 119
ASTM C 143

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Summary of Test

- **Freshly-mixed concrete is sampled and compacted into a standard mold.**
- **The mold is removed and the concrete subsides.**
- **The distance between the mold height and the displaced concrete is measured.**
- **The measurement is reported as the *slump.***

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Purpose

- To measure the *consistency* of unhardened concrete
- To measure the *workability* of the concrete mixture
- To provide an approximation of the *water to cement ratio*
- To estimate the *strength* of the concrete

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Purpose

- ***Consistency*** is the ability of freshly-mixed concrete to flow.
- For given proportions of cement and aggregate without admixture, the higher the slump, the wetter the mixture.

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Purpose

- ***Workability*** **refers to, …the ease of placing, consolidating, and finishing freshly-mixed concrete.**
- **Concrete should be workable but should not segregate or bleed excessively.**

Purpose

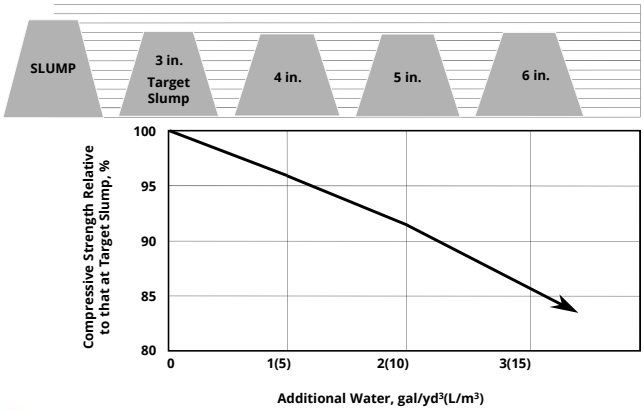
- **Under laboratory conditions, slump and *strength* are inversely proportional.**

$$high\ \frac{w}{cm} \Rightarrow weak\ concrete \qquad low\ \frac{w}{cm} \Rightarrow strong\ concrete$$

- **In field conditions, the slump and strength relationship is unclear and inconsistent.**

Purpose

Effect of Additional Water on Slump and Strength of Concrete



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Applicability

- **For plastic concrete with coarse aggregate up to 37.5 mm (1½ in.) in size.**
- **If aggregate is larger than 1½", then wet sieving of the larger particles are required.**
  - **Wet Sieving per AASHTO R-60**
    - **Pour concrete over sieve and shake/vibrate by hand or mechanical means.**
    - **Mix for uniformity the concrete that passes through the sieve.**

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Applicability

- ***Not* applicable for non-plastic concrete**
  slump < 15 mm (½ in.)
- ***Not* applicable for non-cohesive concrete**
  slump > 230 mm (9 in.)

Equipment

Ruler/Measuring Tape- The ruler shall be at least 12 inches long. The measuring instrument shall be marked in increments of 0.25 inches or smaller.

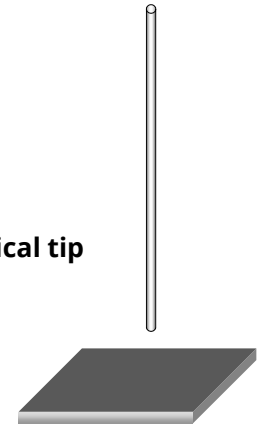
Scoop- The scoop is also composed of steel. The shape of the scoop is the same as a scoop used in a candy store, but it has a handle to provide easier use.

Slump Cone- The cone is composed of steel. Molds other than metal are permitted. The cone is similar in shape to an upside-down ice cream cone with the bottom cut off. The openings are 4 inches and 8 inches for the top and bottom, respectively. The cone is 12 inches tall and it has handles on the side to remove it from the concrete. The mold shall be checked annually for conformance to the mold specified dimensions.

Equipment

Tamping rod

- round, straight steel rod
- 5/8 ± 1/16" in diameter
- 16"-24" long
- tamping end rounded to a hemispherical tip



Base

- flat, nonabsorbent

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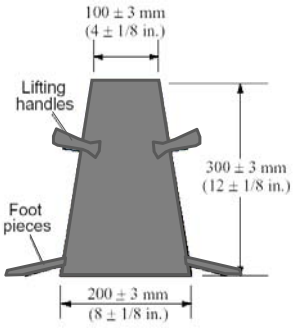
Equipment

Slump cone, base, scoop and tamping rod



Dimensions of slump cone

Plastic slump cone

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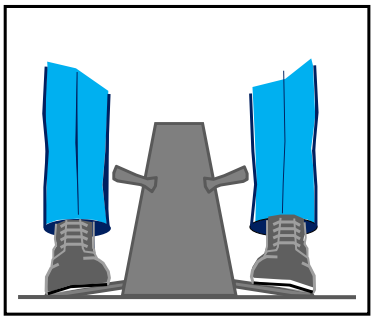
Procedure

- **Dampen the inside of the mold and the surface of the base.**
- **Place the mold onto the base (locking foot pieces)**

or

- **Stand on the two foot pieces to hold the cone firmly in place.**



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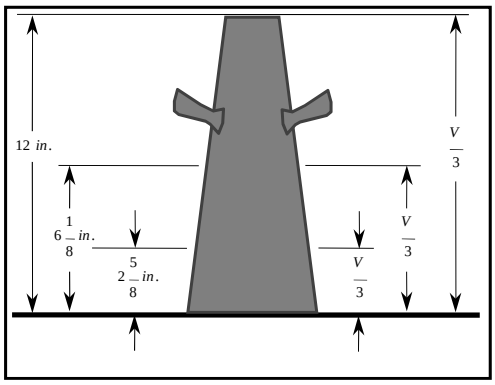
Procedure

- **Fill the mold in three layers.**
- **Each layer should be approximately 1/3 of the mold *volume.***



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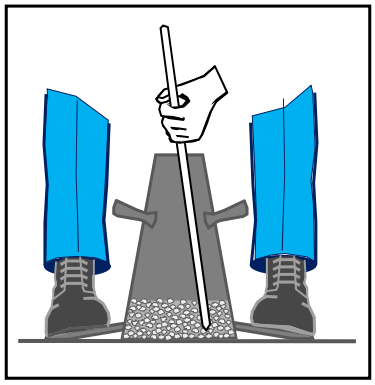
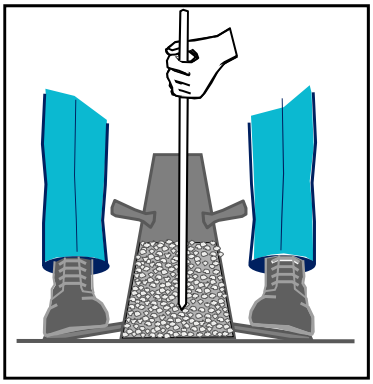
Procedure

- Fill the cone 1/3 full by volume.
- Rod the layer with 25 strokes of the tamping rod.
- Uniformly distribute the strokes over the cross-section of the layer.
- Tilt the tamping rod for the bottom (first) layer.



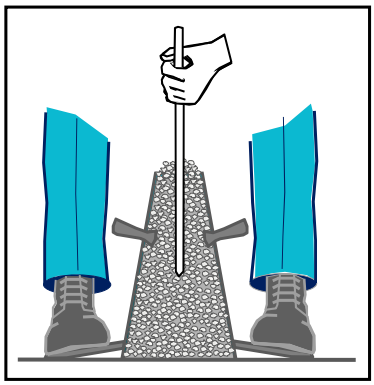
Procedure

- Fill the cone 2/3 full by volume.
- Rod the layer with 25 strokes of the tamping rod.
- Penetrate approximately 1" into the first layer.
- Uniformly distribute the strokes over the cross-section.



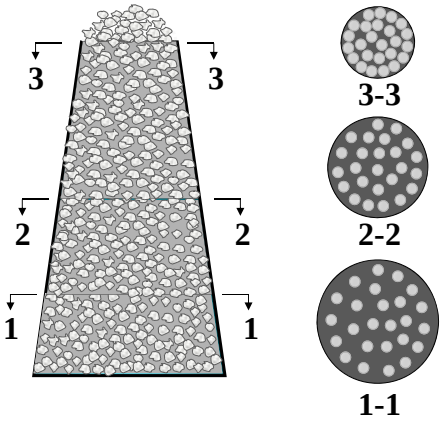
Procedure

- **Fill the cone to overflowing.**
- **Rod the layer with 25 strokes of the tamping rod.**
- **Penetrate approximately 1" into the second layer.**
- **Uniformly distribute the strokes over the cross-section.**



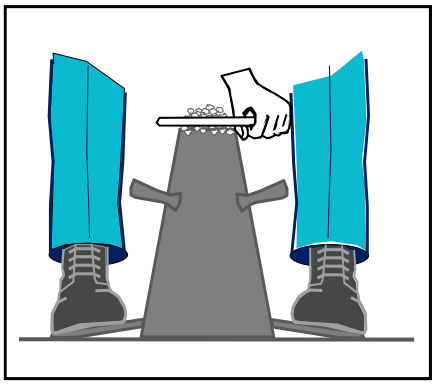
Procedure

- **Cross-section views showing uniform distribution of strokes**



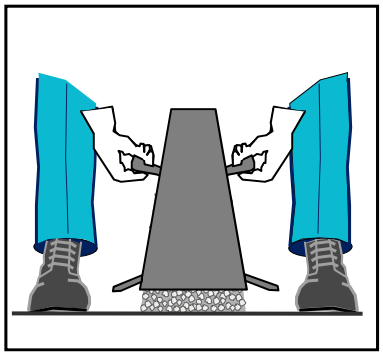
Procedure

- **Strike off excess concrete from the cone by a means of screeding and rolling motion of the rod.**
- **Clean the concrete away from the base of the mold.**



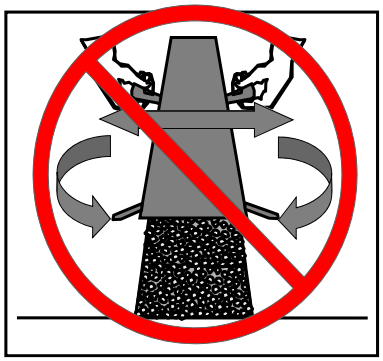
Procedure

- **Raise the mold a distance of 12 in. (300 mm) in 5 ± 2 seconds**
- **Use a steady upward lift**
- **No lateral or torsional motion**
- **Complete entire test from the start without interruption in 2 ½ mins.**



Procedure

- ***Do not*** **use lateral or torsional motion**



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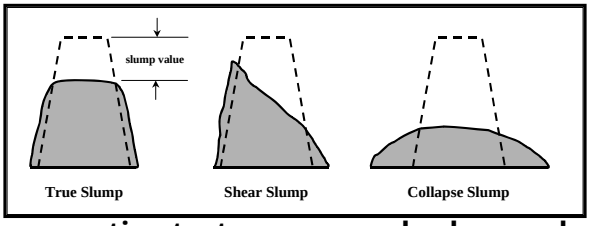
Procedure

- **If a shearing or collapse of the concrete mass is observed, disregard the results and perform the test again on another portion of the sample.**



- **If two consecutive tests on a sample show a shearing or collapse of the concrete mass, the concrete lacks the necessary plasticity and cohesiveness for the test to be applicable.**

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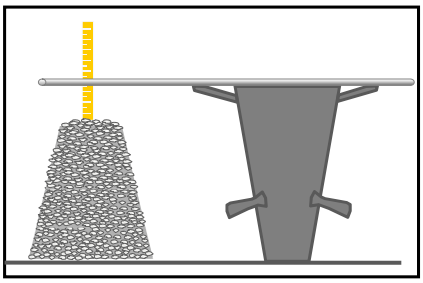
Procedure

- **Place the steel rod horizontally across the inverted mold so that the rod extends over the slumped concrete.**
- **Immediately measure the distance from the bottom of the rod to the displaced center of the concrete.**
- **Record the slump in terms of inches to the nearest 1/4" of subsistence**



Post-Testing Procedures

There is a substantial amount of cleanup required after the slump is measured and before the concrete has time to harden.

- **Rinse out the slump cone. The slump cone must be cleaned so that the residue from the tested concrete won't bond to the cone.**
- **Clean all instruments used during the measurement procedure.**
- **Clean all of the concrete off of the baseplate and surrounding area.**
- **Dispose of all of the concrete.**

Table 604.03-01: Composition of Various Classes of Concrete

Class of Concrete	Min 28-Day Compressive Strength (psi)	Min Cement Content (pound per cubic yard)	Maximum Water/Cement Ratio (pound/pound)	Air Content % (Design ± production tolerance)	Slump (inches)
A	3,000	564	0.45	6 ± 2	3 ± 1 (1)
D (2, 3)	4,000	620	0.40	7 (3)	8 max (4)
L (3, 5)	4,000	620	0.40	7 (3)	8 max (4)
S (Seal) (6)	3,000	682	0.47	6 ± 2	6 ± 2
X (7)					

(1) **For slip forming, the slump shall range from 0 to 3 inches.**

(2) Use Class D concrete in all bridge decks except box and slab type structures unless otherwise shown on the Plans.

(3) Design Class D and Class L concrete at 7% air content. Acceptance range for pumping and other methods of placement is 4.5-7.5%. Sampling will be at the truck chute.

(4) Water reducing admixtures are acceptable; however, do not exceed the maximum water/cement ratio in order to achieve the required slump.

(5) The unit weight of air dried Class L concrete (lightweight concrete) shall not exceed 115 pounds per cubic foot as determined according to ASTM C567.

(6) The use of fly ash as a cement replacement will be allowed in Class S (Seal) concrete.

(7) Plan specific requirements

Table 604.03-2: Use of Chemical Admixtures

Table 604.03-2 : Use of Chemical Admixtures

Class of Concrete	Temperature less than 85°F and falling	Temperature 85°F or greater and rising
A	Type A or F	Type D or G or A and B
D	Type A or F	Type A or F and B or G
L	Type F	Type F and Bor G
S	Type D or G or A and B	Type D or G or A and B

If usinga Type A, F, or G water reducer, then the allowable slump shall be a maximum of 8 inches.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4

Unit Weight (Density) and Yield of Concrete

AASHTO T 121

ASTM C 138

TDOT Standard Method of Test for

Unit Weight (Density) and Yield of Concrete

References

TDOT Standard Specifications
AASHTO T 121
ASTM C 138

Scope

- **Unit Weight: Mass per cubic foot of freshly-mixed concrete.**
- **Yield: Volume of concrete produced from a mixture of known quantities of component materials.**
- **Relative Yield: Ratio of actual volume of concrete obtained to the volume as designed for the batch.**

Equipment

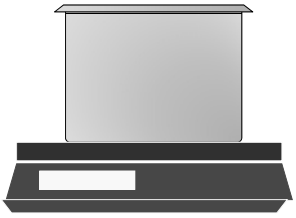
- Balance
- Tamping rod
- Internal vibrator
- Measure
- Strike-off plate
- Mallet

Consolidation Method

- <u>Slump > 3 inches</u>
  Consolidate by Rodding
- <u>Slump < 1 inch</u>
  Consolidate by Vibration
- <u>Slump is between 1-3 inches</u>
  Consolidate by Rodding or Vibration

Procedure

- **Select a representative sample**
- **Determine the mass of the measure**



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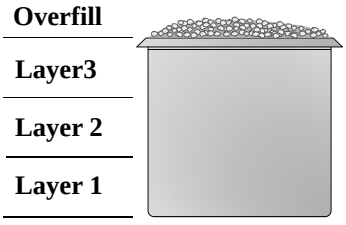
Procedure

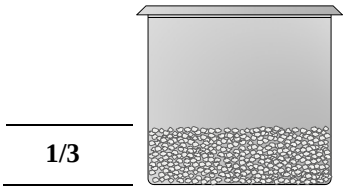
- **Fill the container in three equal layers**
- **Slightly overfill the last layer**



TN TDOT Department of Transportation

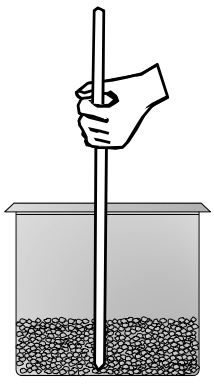
Procedure

- **Fill the bowl 1/3 full**
- **Rod the layer with 25 strokes of the tamping rod when the volume of the measure is 0.5 ft³ or less.**



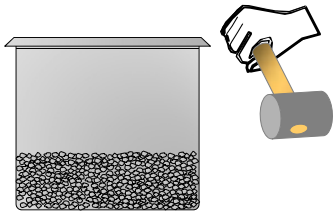
Procedure

- **Rod the bottom layer throughout its depth without forcibly striking the bottom of the container.**
- **Uniformly distribute the strokes over the cross-section of the layer.**



Procedure

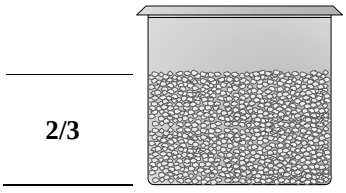
- **Tap the sides of the container smartly 10-15 times with the mallet after rodding the layer.**



TN TDOT Department of Transportation

Procedure

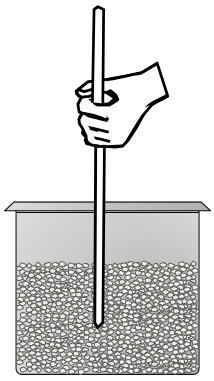
- **Fill the bowl 2/3 full**
- **Rod the layer with 25 strokes of the tamping rod.**



TN TDOT Department of Transportation

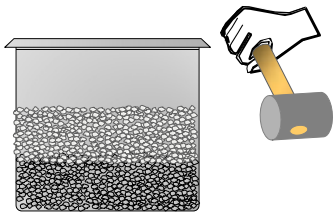
Procedure

- **Rod the middle layer throughout its depth and penetrate about 1 inch into the underlying layer.**
- **Uniformly distribute the strokes over the cross-section of the layer.**



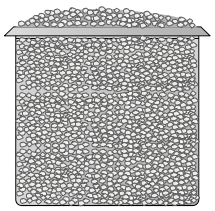
Procedure

- **Tap the sides of the container smartly 10-15 times with the mallet after rodding the layer.**



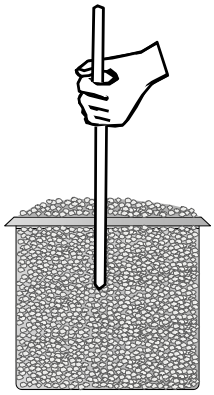
Procedure

- **Fill the bowl completely**
- **Overfill slightly**
- **Rod the layer with 25 strokes of the tamping rod.**



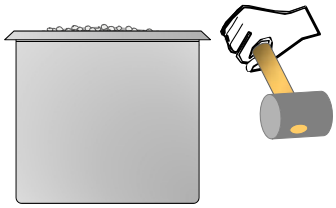
Procedure

- **Rod the top layer throughout its depth and penetrate about 1 inch into the underlying layer.**
- **Uniformly distribute the strokes over the cross-section of the layer.**



Procedure

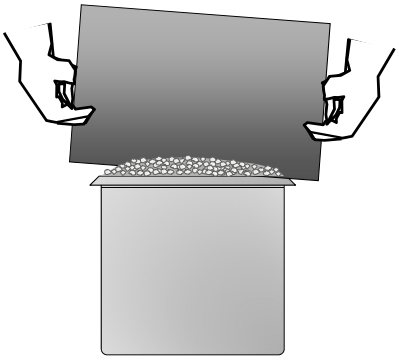
- **Tap the sides of the container smartly 10-15 times with the mallet after rodding the layer.**



TN TDOT Department of Transportation

Procedure

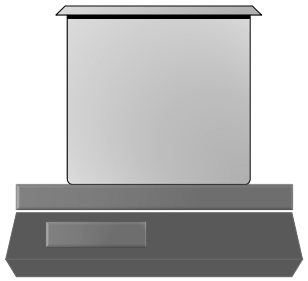
- **Strike off the concrete level with the top of the container using a strike-off plate.**
- **Clean all excess concrete from exterior of measure.**



TN TDOT Department of Transportation

Procedure

- **Determine the mass of the concrete and measure.**



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Unit Weight Calculations

- **Unit Weight (D)**

$$M_{Concrete} = M_{Measure+Concrete} - M_{Measure}$$

$$Unit\ Weight = \frac{M_{Concrete}}{V_{Measure}}$$

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Unit Weight Example

Determine the unit weight of concrete if:

volume of measure = 0.50 ft^3

mass of empty measure = 19.6 lb.

mass of measure and concrete = 92.1 lb.

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Unit Weight Solution

Determine the unit weight of concrete if:

volume of measure = 0.50 ft^3

mass of empty measure = 19.6 lb.

mass of measure and concrete = 92.1 lb.

$$M_{Concrete} = M_{Measure+Concrete} - M_{Measure} = 92.1 - 19.6 = 72.5 lbs.$$

$$Unit\ Weight = \frac{M_{Concrete}}{V_{Measure}} = \frac{72.5 lbs}{0.50\ ft^3} = \underline{\underline{145\ \frac{lbs}{ft^3}}}$$

TN TDOT Department of Transportation

Yield Calculations

- **Yield (Y)**

$$Y_{Concrete}(ft^3) = \frac{W_{material}}{D}$$

$$Y_{Concrete}(yd^3) = \frac{W_{material}}{27D}$$

Relative Yield Calculations

- **Relative Yield (R_y)**

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

If $R_y > 1.00$, an excess of concrete is being produced

If $R_y < 1.00$, the batch is "short" of its designed volume

Yield Example

Determine the yield of the following mix:

Design batch = 7 yd^3

Total mass of materials = 27,300 lbs.

Unit weight of the concrete = 145 lbs./ft^3

Yield Solution

$$Y_{ft3} = \frac{W}{D} = \frac{27{,}300 lbs}{145 \frac{lbs}{ft^3}} = \underline{\underline{188.28\, ft^3}}$$

$$Y_{yd3} = \frac{188.28\, ft^3}{27 \frac{ft^3}{yd^3}} = \underline{\underline{6.97\, yd^3}}$$

Relative Yield Solution

$$R_y = \frac{Y}{Y_d} = \frac{188.28\,ft^3}{7\,yd^3} = \underline{\underline{26.90\,\frac{ft^3}{yd^3}}}$$

$$R_y = \frac{Y_{yd3}}{Y_{yd3}} = \frac{6.97\,yd^3}{7\,yd^3} = \underline{\underline{0.996}}$$

5

Air Content of Freshly Mixed Concrete

By the Pressure Method

AASHTO T 152

ASTM C 231

TDOT Standard Method of Test for

Air Content of Freshly Mixed Concrete by the Pressure Method

References

TDOT Standard Specifications
AASHTO T 152
ASTM C 231

Summary of Test

- **Freshly-mixed concrete is sampled and compacted into a standard mold.**
- **The mold is covered, sealed and the remaining free space is filled with water.**
- **The contents are pressurized.**
- **The *air content* is shown on a dial.**

Applicability

- **Applicable to concrete made with relatively *dense* aggregate particles**
- ***Not* applicable to *lightweight aggregate***

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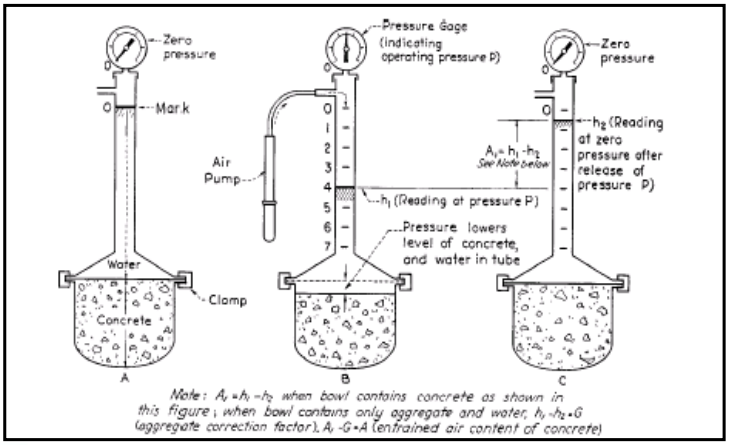
Equipment-Type A Meter



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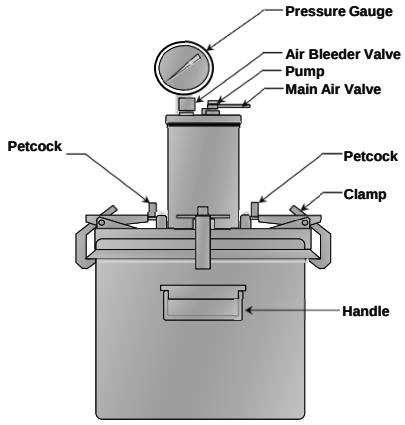
Equipment -Type B Meter

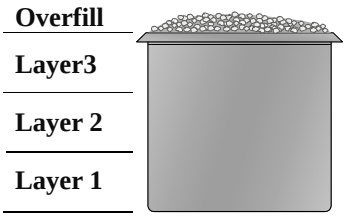


Procedure

- **Select a representative sample**

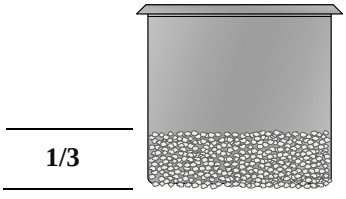
Procedure

- **Fill the container in three equal layers**
- **Slightly overfill the last layer**



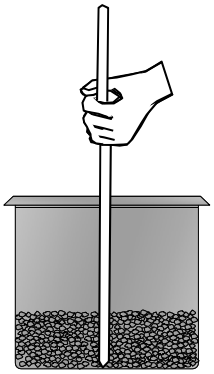
Procedure

- **Fill the bowl 1/3 full**
- **Rod the layer with 25 strokes of the tamping rod.**



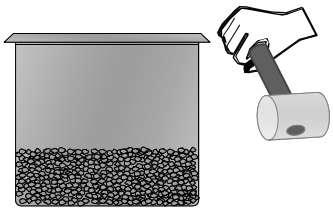
Procedure

- **Rod the bottom layer throughout its depth without forcibly striking the bottom of the container.**
- **Uniformly distribute the strokes over the cross-section of the layer.**



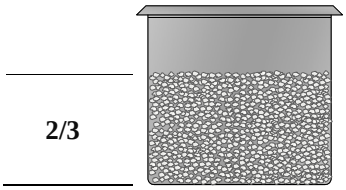
Procedure

- **Tap the sides of the container smartly 10-15 times with the mallet after rodding the layer.**



Procedure

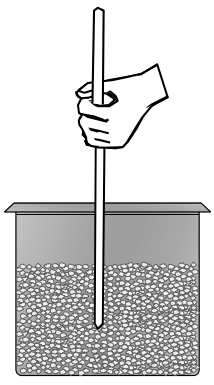
- **Fill the bowl 2/3 full**
- **Rod the layer with 25 strokes of the tamping rod.**



TN TDOT Department of Transportation

Procedure

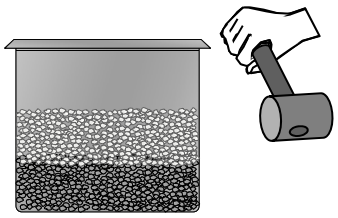
- **Rod the middle layer throughout its depth and penetrate about 1 inch into the underlying layer.**
- **Uniformly distribute the strokes over the cross-section of the layer.**



TN TDOT Department of Transportation

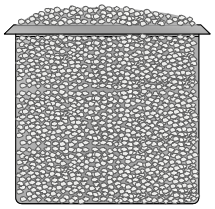
Procedure

- **Tap the sides of the container smartly 10-15 times with the mallet after rodding the layer.**



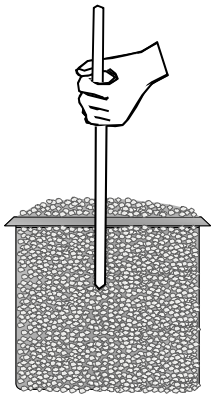
Procedure

- **Fill the bowl completely**
- **Overfill slightly**
- **Rod the layer with 25 strokes of the tamping rod.**



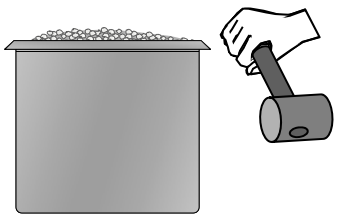
Procedure

- **Rod the top layer throughout its depth and penetrate about 1 inch into the underlying layer.**
- **Uniformly distribute the strokes over the cross-section of the layer.**



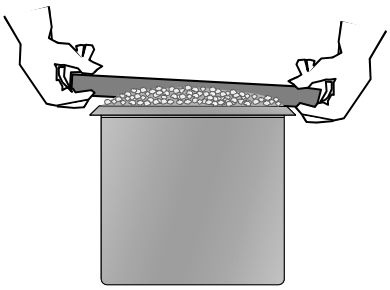
Procedure

- **Tap the sides of the container smartly 10-15 times with the mallet after rodding the layer.**



Procedure

- **Strike off the concrete level with the top of the container using the bar.**



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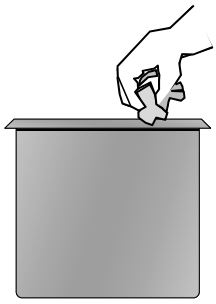
Procedure

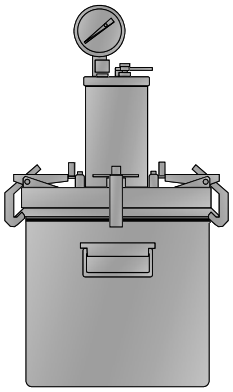
- **Clean off the rim**



TN TDOT Department of Transportation

Procedure

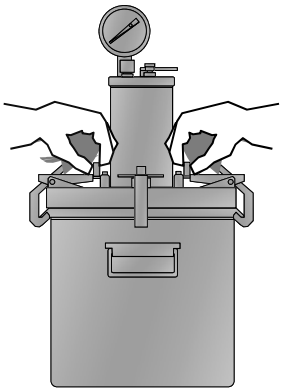
- **Attach the top of the meter to the bottom**



TN TDOT Department of Transportation

Procedure

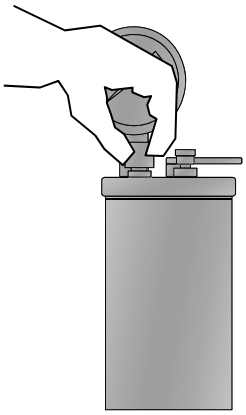
- **Open both petcocks**



TN TDOT Department of Transportation

Procedure

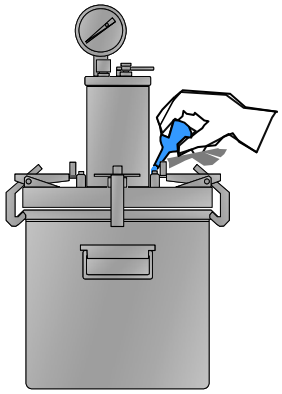
- **Close the airbleeder valve**



TN TDOT Department of Transportation

Procedure

- **Inject water through the petcock until it flows out of the other petcock.**



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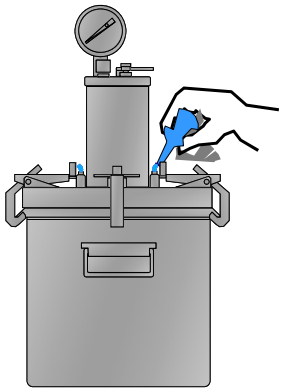
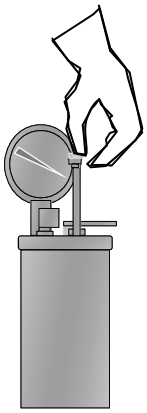
Procedure

- **Continue injecting water into the petcock while tapping the meter to insure that all of the air is expelled.**



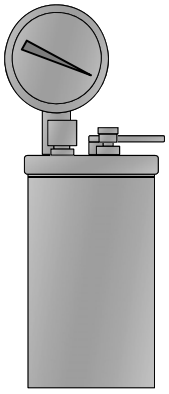
Procedure

- **Pump air up to the initial pressure line.**



Procedure

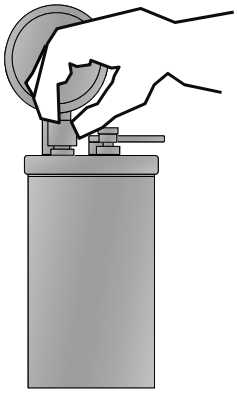
- **Allow a few seconds for the compressed air to stabilize.**



TN TDOT Department of Transportation

Procedure

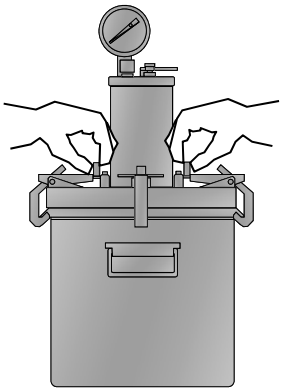
- **Adjust the gauge to the initial pressure by _____ and _____ as necessary.**



TN TDOT Department of Transportation

Procedure

- **Close both petcocks**

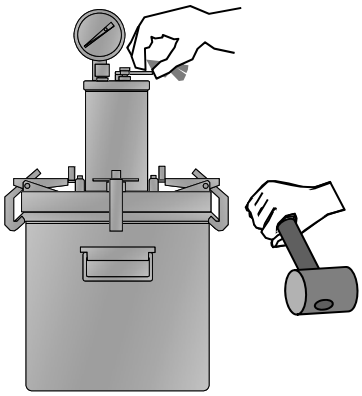


Procedure

- **Open the air valve between the chamber and the bowl**

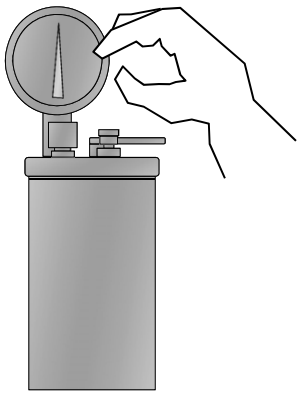
  While simultaneously

- **Tap the sides of the bowl with the rubber mallet.**



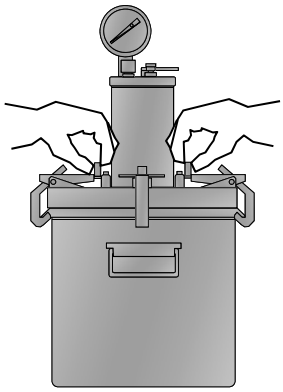
Procedure

- **Lightly tap the gauge to stabilize the needle.**
- **Read the percentage of air to the nearest 0.1%.**



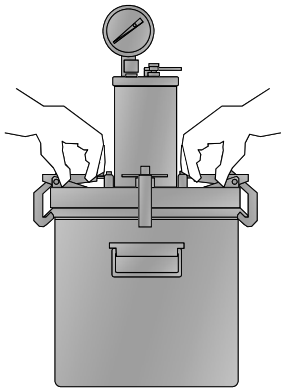
Procedure

- **Open both petcocks to release pressure**



Procedure

- **Remove the cover**



Example – Air Content (Pressure Method)

Table 604.03-01: Composition of Various Classes of Concrete

Class of Concrete	Min 28-Day Compressive Strength (psi)	Min Cement Content (pound per cubic yard)	Maximum Water/Cement Ratio (pound/pound)	Air Content % (Design ± production tolerance)	Slump (inches)
A	3,000	564	0.45	6 ± 2	3 ± 1 (1)
D (2, 3)	4,000	620	0.40	7 (3)	8 max (4)
L (3, 5)	4,000	620	0.40	7 (3)	8 max (4)
S (Seal) (6)	3,000	682	0.47	6 ± 2	6 ± 2
X (7)					

(1) For slip forming, the slump shall range from 0 to 3 inches.

(2) Use Class D concrete in all bridge decks except box and slab type structures unless otherwise shown on the Plans.

(3) **Design Class D and Class L concrete at 7% air content. Acceptance range for pumping and other methods of placement is 4.5-7.5%. Sampling will be at the truck chute.**

(4) Water reducing admixtures are acceptable; however, do not exceed the maximum water/cement ratio in order to achieve the required slump.

(5) The unit weight of air dried Class L concrete (lightweight concrete) shall not exceed 115 pounds per cubic foot as determined according to ASTM C567.

(6) The use of fly ash as a cement replacement will be allowed in Class S (Seal) concrete.

(7) Plan specific requirements

TN TDOT Department of Transportation

6

Air Content of Freshly Mixed Concrete

By the Volumetric Method

AASHTO T 196

ASTM C 173

TDOT Standard Method of Test for

Air Content of Freshly Mixed Concrete by the Volumetric Method

References

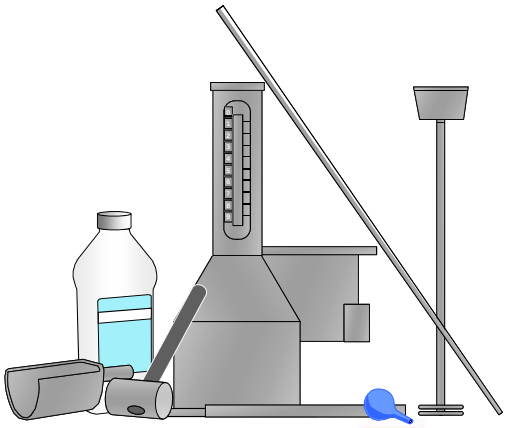
TDOT Standard Specifications
AASHTO T 196
ASTM C 173

Purpose

- **To determine the *air content* of freshly mixed concrete having dense or lightweight aggregate.**
- **To measure the air content in the mortar (paste) fraction of the concrete.**
- **Results are not affected by air that may be present within porous aggregate particles.**

Equipment

- Air Meter
- Tamping Rod- 16 inches long and 5/8 inches in diameter.
- Funnel
- Strike-Off Bar
- Calibrated Cup
- Syringe
- Pouring Vessel
- Scoop
- Isopropyl Alcohol
- Mallet

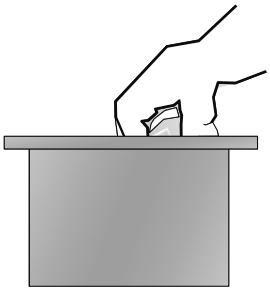


Procedure

- Obtain a sample of freshly-mixed concrete

Procedure

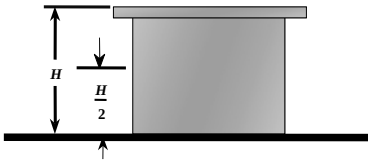
- **Dampen the inside of the bowl**



TN TDOT Department of Transportation

Procedure

- **Fill the base/bowl with a sample of fresh concrete in 2 equal layers.**



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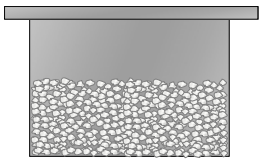
Procedure

- **Fill the base 1/2 full**
- **Rod the first layer with 25 strokes of the tamping rod.**



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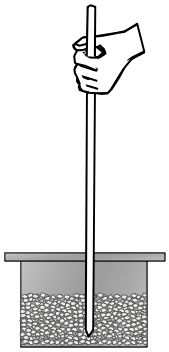
Procedure

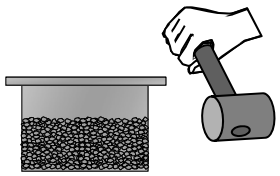
- **Rod the bottom layer throughout its depth without forcibly striking the bottom of the base.**
- **Uniformly distribute the strokes over the cross-section of the first layer.**



TN TDOT Department of Transportation

Procedure

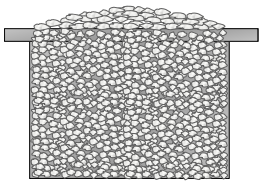
- **Tap the sides of the mold 10-15 times with the mallet after rodding the first layer.**



TN TDOT Department of Transportation

Procedure

- **Fill the base completely**
- **Slightly overfill**
- **Rod the second layer with 25 strokes of the tamping rod.**



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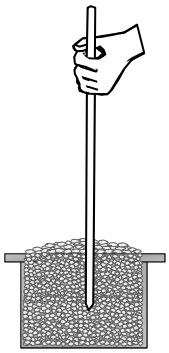
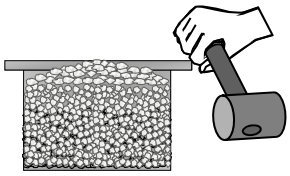
Procedure

- **Rod the top layer throughout its depth and penetrate about 1 inch into the first layer.**
- **Uniformly distribute the strokes over the cross-section of the second layer.**



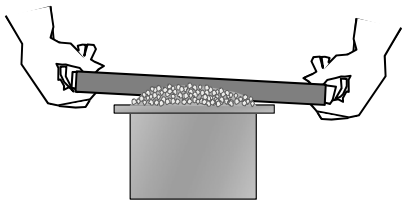
Procedure

- **Tap the sides of the mold 10-15 times with the mallet after rodding the second layer.**



Procedure

- **Strike off excess concrete on the top with a strike-off bar to level the top of the sample.**



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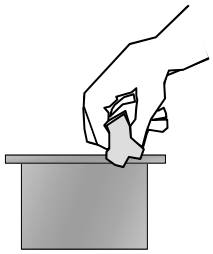
Procedure

- **Carefully clean the top edge of the flange and the gasket to provide a tight seal.**



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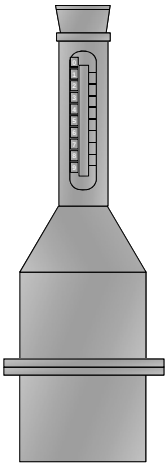
Procedure

- **Clamp the top section into position on the base**
- **Insert the baffle bottom funnel**
- **Add at least 1 pint (0.5 L) of water and the selected amount of alcohol**
- **Record the amount of alcohol added**



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Correction Factor

TABLE 1 Correction for the Effect of Isopropyl Alcohol on C173/C173M Air Meter Reading

70 % Isopropyl Alcohol Used			
Pints	Fluid Ounces	Litres	Correction, %[A]
≤ 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 are applied only when 1.25 L [2.5 pt] or more of isopropyl alcohol is used. The values given are for air meters that have a measuring bowl volume of 2.1 L [0.075 ft^3] and a top section that is 1.2 times the volume of the meauring bowl.

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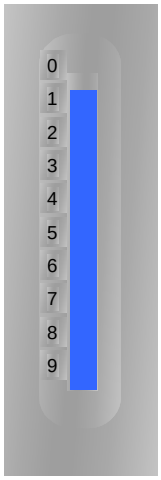
Procedure

- **Add more water until it appears in the top section.**
- **When the water line begins approaching zero, remove funnel and add water using the rubber syringe until the bottom of the meniscus is level with the zero line.**



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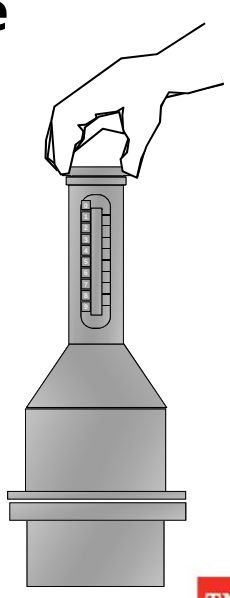
Procedure

- **Attach and tighten the watertight cap.**
- **Note that the seal works by expanding, not twisting.**



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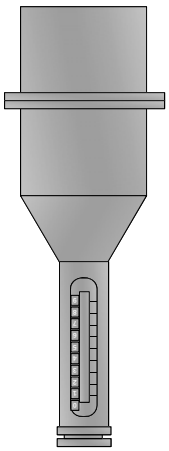
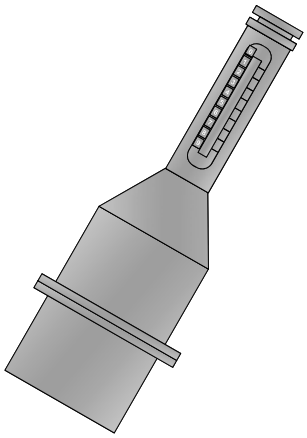
Procedure

- Quickly invert the meter, shake the base horizontally, and return the meter to the upright position.
- Do not keep the meter inverted for more than 5 seconds at a time.
- Repeat the inversion and shaking process a minimum of 45 seconds to free the concrete from the base.



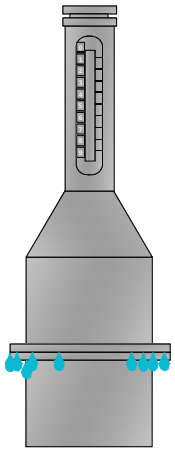
Procedure

- With the neck elevated, roll the meter along the floor for at least 1 minute until air appears to have been removed from the concrete.



Procedure

- **If the air meter leaks while inverting or rolling, start a new test on a new sample.**



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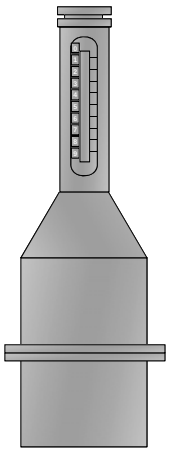
Procedure

- **Set the unit upright**
- **Loosen the cap to allow any pressure to stabilize.**
- **Allow the meter to stand until the liquid level stabilizes.**
- **It is considered stable when it does not change more than 0.25% air within a 2-minute period.**



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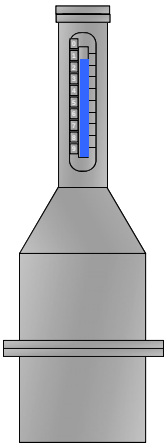
Procedure

- If it takes more than 6 minutes for the liquid level to stabilize

or

- If there is more foam than that equivalent to 2% air on the meter scale over the liquid level.



- **Discard the trial and start a new test.** Use a larger addition of alcohol than was used in the initial trial.

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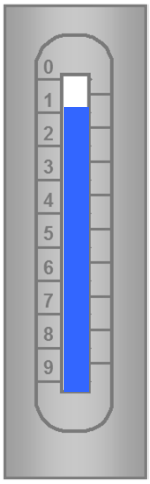
Procedure

- When finished rolling once,
  - Read the liquid level to the nearest 0.25%
  - Record the initial meter reading
  - Retighten the cap and repeat the rolling procedure



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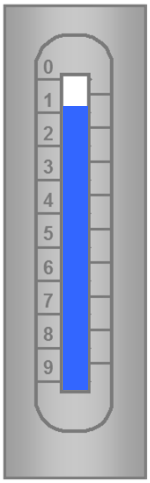
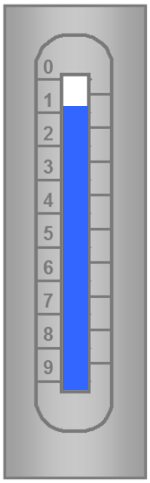
Procedure

- When finished rolling twice,
  - Read the liquid level to the nearest 0.25%
  - If the second reading changed from the initial reading by more than 0.25% use the second reading as the new initial reading
  - Otherwise, use the second reading as the final reading



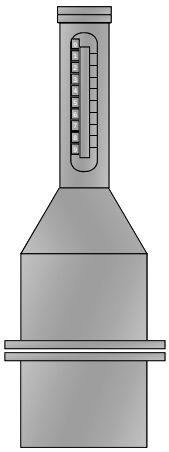
Procedure

- When finished rolling three times,
  - Read the liquid level to the nearest 0.25%
  - If the third reading changed from the initial reading by more than 0.25%, discard the sample and start a new test with a greater amount of alcohol.
  - Otherwise, use the third reading as the final reading



Procedure

- Disassemble the unit
- Examine the contents
- If portions of undisturbed concrete are found, the test is <u>invalid.</u>
- If no undisturbed portions are found, the test is <u>valid</u>.



Procedure

- Only if the air content is greater than the 9% range of the meter, add a sufficient number of calibrated cups of water to bring the liquid level within the graduate range.
- Read the bottom of the meniscus to the nearest 0.25%.
- Record the number of cups of water added. This number will to be ***added*** to the final meter reading when testing is complete.

Calculations

- $A = A_R - C + W$

  A = Air Content, %

  A_R = Final meter reading, %

  C = Correction Factor

  W = Number of calibrated cups added to the meter

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Example- Air Content (Volumetric Method)

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Table 604.03-01: Composition of Various Classes of Concrete

Class of Concrete	Min 28-Day Compressive Strength (psi)	Min Cement Content (pound per cubic yard)	Maximum Water/Cement Ratio (pound/pound)	Air Content % (Design ± production tolerance)	Slump (inches)
A	3,000	564	0.45	6 ± 2	3 ± 1 (1)
D (2, 3)	4,000	620	0.40	7 (3)	8 max (4)
L (3, 5)	4,000	620	0.40	7 (3)	8 max (4)
S (Seal) (6)	3,000	682	0.47	6 ± 2	6 ± 2
X (7)					

(1) For slip forming, the slump shall range from 0 to 3 inches.

(2) Use Class D concrete in all bridge decks except box and slab type structures unless otherwise shown on the Plans.

(3) **Design Class D and Class L concrete at 7% air content. Acceptance range for pumping and other methods of placement is 4.5-7.5%. Sampling will be at the truck chute.**

(4) Water reducing admixtures are acceptable; however, do not exceed the maximum water/cement ratio in order to achieve the required slump.

(5) **The unit weight of air dried Class L concrete (lightweight concrete) shall not exceed 115 pounds per cubic foot as determined according to ASTM C567.**

(6) The use of fly ash as a cement replacement will be allowed in Class S (Seal) concrete.

(7) Plan specific requirements

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7

Making and Curing Concrete Test Specimens in the Field

AASHTO T 23

ASTM C 31

TDOT Standard Method of Test for

Making and Curing Concrete Test Specimens in the Field

References

TDOT Standard Specifications
AASHTO T 23
ASTM C 31

Purpose & Applicability

- **Concrete specimens used for testing strength must be made by this method to ensure reliability of test results.**
- **Standardized requirements for making, curing, protecting, and transporting concrete tests specimen under field conditions.**

Equipment

- **Molds**
- **Scoop**
- **Tamping rod**
- **Vibrators**
- **Mallet**
- **Capping Material**

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Equipment

TABLE 1 Tamping Rod Diameter Requirements

Diameter of Cylinder or Width of Beam in. [mm]	Diameter or Rod in. [mm]
<6 [150]	⅜ ± 1/16 [10 ± 2]
≥6 [150]	⅝ ± 1/16 [16 ± 2]

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Procedure

- **Select a representative sample**

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Consolidation

- **Slump > 1” Rod or Vibration**
- **Slump ≤ 1” Vibration**

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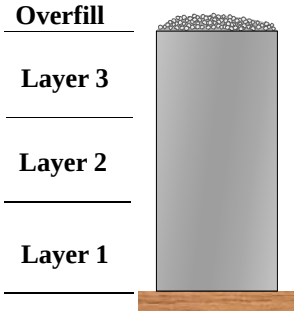
Procedure - 6x12 Cylinders

- Class CP only
- Fill the mold in three equal layers
- Slightly overfill the last layer
- Rod each layer with 25 strokes of the tamping rod.
- Tap the sides of the mold 10-15 times with the mallet after rodding each layer.



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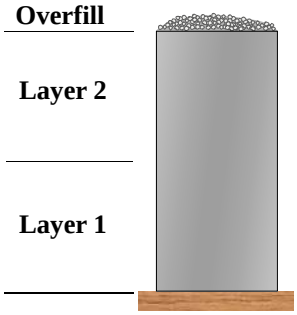
Procedure - 4x8 Cylinders

- Fill the mold in two equal layers
- Slightly overfill the last layer
- Rod each layer with 25 strokes of the tamping rod.
- Tap the sides of the mold 10-15 times with the mallet after rodding each layer.



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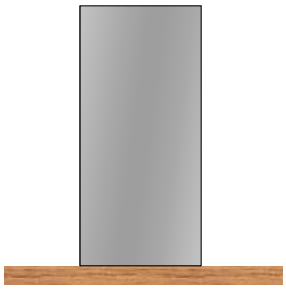
Procedure

- **Place the mold on a level, horizontal, rigid surface that is free of vibration.**



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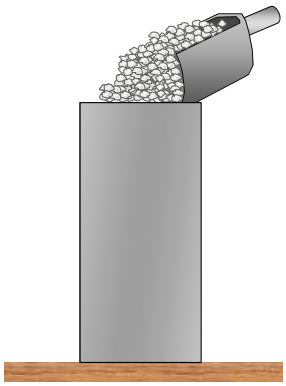
Procedure

- **Place the concrete in the mold using a scoop.**
- **Move the scoop around the top edge of the mold to evenly distribute the concrete.**



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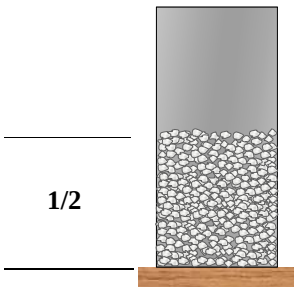
Procedure

- **Fill the mold ½ full**
- **Rod the first layer with 25 strokes of the tamping rod.**



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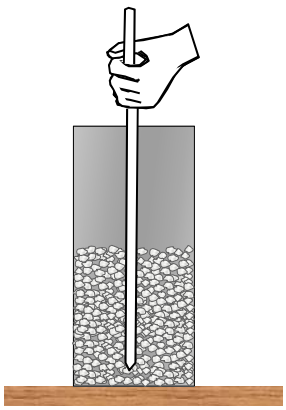
Procedure

- **Rod the first layer throughout its depth without forcibly striking the bottom of the container.**
- **Uniformly distribute the strokes over the cross-section of the first layer.**



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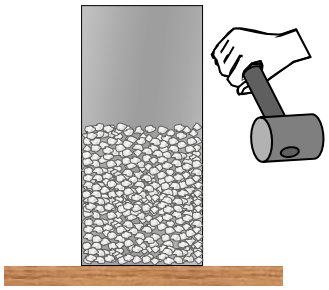
Procedure

- **Tap the sides of the mold lightly 10-15 times with the mallet after rodding the first layer.**



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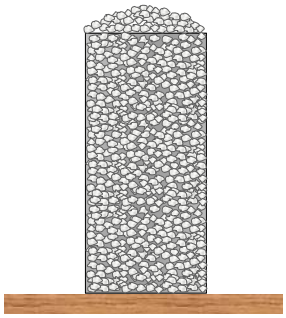
Procedure

- **Fill the mold completely**
- **Overfill slightly**
- **Rod the second layer with 25 strokes of the tamping rod.**



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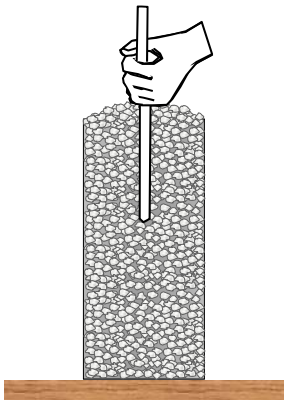
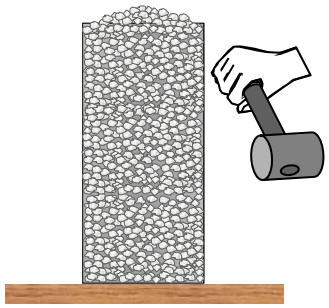
Procedure

- **Rod the top layer throughout its depth and penetrate about 1 inch into the first layer.**
- **Uniformly distribute the strokes over the cross-section of the second layer.**



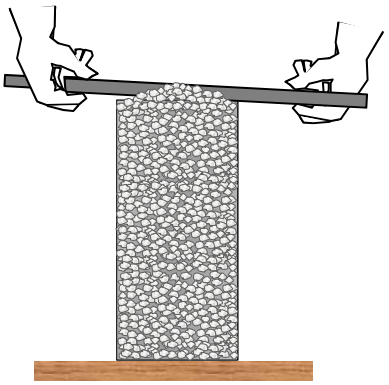
Procedure

- **Tap the sides of the mold lightly 10-15 times with the mallet after rodding the second layer.**



Procedure

- **Strike off the concrete level with the top of the mold using the tamping rod.**



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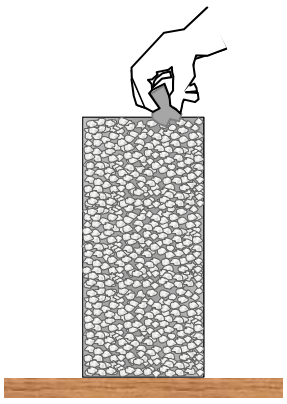
Procedure

- **Clean off the rim**



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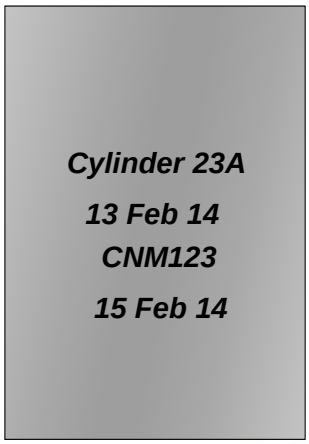
Procedure

- **Mark the specimen with positive identification**
- **Do not mark on removable caps**
- **<u>Do not etch on the top surface.</u>**
- **Mark the side of the cylinder with the following:**
  - **Cylinder #**
  - **Date Made**
  - **Contract #**
  - **Date Stripped**



Procedure

<u>Finishing</u>

- **Produce a flat even surface that is level with the rim or edge of the mold.**
- **No depressions or projections larger than 1/8 in.**

Procedure

Storage

Immediately after finishing move specimens to initial curing place for storage.

- **Supporting surface should be level to within ¼ in. per ft.**
- **Lift and support the cylinder from the bottom of the molds.**

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Procedure

- **Use an appropriate method of maintaining required moisture and temperature conditions.**

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Procedure

Initial Curing

- **Immediately after molding and finishing, store specimens for a period up to 48 hrs in a temperature ranging from 60 and 80ºF.**
- **High early strength cylinders(>6000 psi) shall have initial curing temperature between 68 and 78ºF.**
- **Storage temperature shall be controlled by use of heating and cooling devices, as necessary.**

Procedure

Final Curing

- **Within 30 min. after removing molds, cure specimens with free water maintained on surface at all times at temperature of 73.5± 3.5ºF.**

Transportation

- **Specimens shall not be transported until at least 8 hours after final set.**
- **Transportation time shall not exceed 4 hrs.**
- **Protect specimens from damage by using suitable cushioning material**
- **Prevent moisture loss**

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8

Self-Consolidating Concrete

(SCC)

ASTM C 1611

ASTM C 1621

ASTM C 1758

TDOT Standard Method of Test for
Self-Consolidating Concrete

References

TDOT Standard Specifications
ASTM C 1611
ASTM C 1621
ASTM C 1758

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Self-Consolidating Concrete (SCC)

- *"Self-consolidating concrete (SCC) is a highly fluid, **non-segregating** concrete that can spread through reinforcement and completely fill formwork without the use of mechanical consolidation." (ACI 237 2007)*

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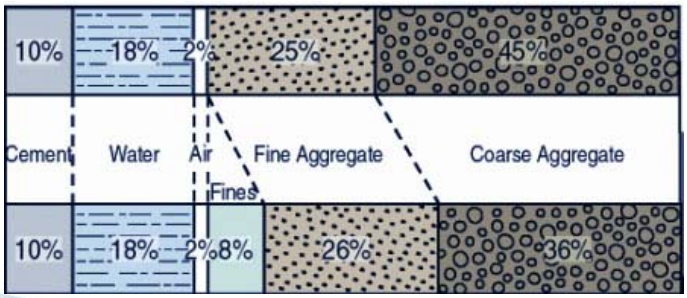
What is SCC?

- SCC is composed of the
  - Same components as conventional concrete with different proportions.
  - Specialized chemical admixtures (HRWRA & VMA)

Regular Mix



SCC

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What Is SCC?

U-Box Demo

- https://www.youtube.com/watch?v=Wul92-_wy28

Foundation Placement

- https://www.youtube.com/watch?v=KJuKlRutzhU

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History

Developed in Japan in 1980s.

- For concrete durability and service life
- Where proper consolidation was critical.

- Later it was used to facilitate
  - Construction operations
  - Reduce construction time and cost.

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Usage

- Because it is a high-performance concrete in the fluid state
  - Heavily reinforced and irregularly shaped structural elements that would be difficult or impossible to properly consolidate with traditional vibratory techniques.

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Usage

Usage

- Increasingly popular implementation of SCC:
  - Precast Production
  - Prestressed Bridge Girders (where narrow forms and congested reinforcement make proper filling and consolidation using conventional concrete difficult and labor-intensive)

Conventional Precast Beams

- https://www.youtube.com/watch?v=jZk3rI-PTyk

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Aesthetics

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Advantages

- Reduce labor and equipment
- Concrete that develop desired mechanical properties independent of the skill of vibrating crew
- Expedited placement time
- Enables placements with very dense reinforcement
- More flexibility in placement points
- Reduced noise on the job site
- Decreased employee injuries
  - Less employee congestion
  - Reduced cords and tripping hazards
- Smooth surfaces free of honeycombing

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Disadvantages

- Concrete unit cost
- Significantly increased formwork pressure
- Formwork joints must be more tightly sealed
- Higher quality control needed at batch plant due to complex admixture interactions.

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Terminology and Properties

- **Rheology** refers to the science of deformation, and flow (or Viscosity) of matter is fundamental to understanding the flow of fresh SCC.
- **Workability** describes the ease with which concrete can be mixed, placed, consolidated, and finished. Workability of SCC is described in terms of **filling ability**, **passing ability**, and **stability**.

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Terminology and Properties

- The **filling ability** (unconfined flowability) describes the ability of SCC to flow into and fill completely all spaces within the formwork, under its own weight.
- The **passing ability** (confined flowability) refers to the ease with which concrete can pass among various obstacles and narrow spacing in the formwork without blockage.

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Terminology and Properties

- **Stability** of concrete describes the ability of a material to maintain homogeneous distribution of its various constituents during its flow and setting. There are two types of stability characteristics that are important for SCC: **dynamic** and **static** stability.

Terminology and Properties

- **Dynamic stability** refers to the resistance of concrete to the separation of constituents during placement into the formwork.
- **Static stability** refers to the resistance of concrete to bleeding, segregation, and surface settlement after casting while the concrete is still in a plastic state.

Properties

- Generally speaking, stability and filling/passing ability are inversely proportional.
- The greater the filling/passing ability, the harder it is to get a very stable mixture.
- The greater the stability, the harder it is to get greater filling/passing ability.

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Characteristics

- The degrees of stability, filling ability, and passing ability of SCC are dictated by the application.
- For example, passing ability is only important for reinforced concrete applications and in sections that will restrict the flow of concrete into place. The level of passing ability is dictated by the amount and spacing of reinforcement in the proposed structure.

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Characteristics

- If SCC is properly proportioned to prevent segregation, the hardened properties can be designed in the same way as conventional concrete.
- The test methods for hardened SCC are the same for conventional concrete. For example:
  - ASTM C 39 – Compressive Strength
  - ASTM C 469 – Modulus of Elasticity
  - ASTM C 496 – Splitting Tensile Strength

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Field Experiences

- Chattanooga manufacturer of components for the electrical industry was building an addition – a new testing tunnel for turbines.
- The drawings for the project made it apparent that conventional concrete would never work.
- Mix required excellent flowing characteristics (slump flow 28" to 30") with good passing ability and low segregation when dropped from 40'

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Reinforcement Challenges

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Reinforcement Challenges

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Concrete Placement

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Chattanooga Turbine Testing Tube - Complete

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Field Experience has taught…

- SCC is much more sensitive to additional water on jobsite than conventional concrete.

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Field Experience has taught…

- Visual stability index (VSI) – Indicator for segregation in the structure
- Correct Aggregate Moisture - since SCC is much more sensitive to changes in water
- New generation of Polycarboxylate HRWRs - perform better when added at plant (initial mixing).
- Add HRWR for additional slump flow requirements at the project site instead of adding water.

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Testing Methods

- ASTM C 1611: Slump Flow of Self-Consolidating Concrete
  - Slump Flow
  - VSI (Visual Stability Index)
  - T-50
- ASTM C 1621: Passing Ability of Self-Consolidating Concrete by J-Ring
- ASTM C 1758 – Fabricating Test Specimen with Self-Consolidating Concrete

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Slump Flow, T50, & VSI

- Two procedures:
  - Slump cone upright

  - Slump cone inverted

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Apparatus

- Mold –Conform to that described in ASTM C143
- Base Plate –Nonabsorbent, smooth, rigid with a minimum diameter of 36 inches
  - For T-50, inscribed with concentric circles for the slump cone and one with a 20 inch diameter.
- Strike-off bar – Described in ASTM C173
- Stopwatch – 0.01 second precision

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Slump Flow and T-50

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T-50 Procedure

- The T-50 is measured when the slump flow is being performed.
- To determine T-50,
  - Use a stopwatch to measure the time (in seconds)
  - Time it takes any part of the outer edge of the spreading concrete to reach the inscribed mark on the base plate from the time the mold is first lifted
- Record the T-50 to the nearest 0.2 seconds.

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Slump Flow

The slump flow test is a measure of mixture filling ability.

- The test is similar to the conventional slump test using the same standard slump cone.
- Instead of measuring the slumping distance vertically, the average spread of the resulting concrete patty is measured horizontally.

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Summary of Test Method

- A sample of freshly mixed concrete is placed in a mold shaped.
- The concrete is placed in one lift without tamping or vibration.
- The mold is raised, and the concrete allowed to spread.
- After spreading ceases, two diameters of the concrete mass are measured in approximately diagonal directions
  - slump flow is the average of the two diameters.

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Procedure

1. Select a flat, level, nonabsorbent surface (such as a pre-moistened concrete floor or a base plate).
2. Dampen the mold and place it in the center of the base plate.
3. Fill the mold, upright or inverted, in one lift (slightly overfilling the concrete above the top of the mold).

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Procedure (continued)

4. Strike off the surface of the concrete using a strike off bar level with the top of the mold.
5. Remove the concrete from around the base of the mold.
6. Lift the mold vertically to 9 ± 3 inches in 3 ± 1 seconds with no lateral or torsional motion.

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Procedure (continued)

7. Wait for the concrete to stop flowing
8. Measure the largest diameter of the spread of concrete to the nearest 0.25 inch (When a halo is observed in the circular spread, it shall be included as part of the diameter)
9. Measure a second diameter approximately perpendicular to the first.

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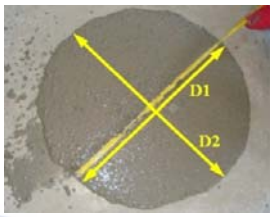
Procedure (continued)

10. If the two diameters are more that 2 inches different, the test shall be repeated.
11. Average the two spread diameters and record the slump flow to the nearest 0.50 inch.

https://www.youtube.com/watch?v=Gm9Adz5EPE4



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Example Problems

Example Problem#1

- **Given:** Spread Diameter (1) = 22 inches

  Spread Diameter (2) = 21.25 inches

- **Determine the slump flow.**

Slump Flow = [d(1)+d(2)]/2

= [22+21.25]/2

= 43.25/2

=21.625 ⇒ **21.50 inches**

Example Problem#2

- **Given:** Spread Diameter (1) = 22.75 inches

  Spread Diameter (2) = 20.25 inches

- **Determine the slump flow.**

Slump Flow = [d(1)+d(2)]/2

= [22.75+20.25]/2

= 43.00/2

=**21.50 inches**

WRONG ⇒ **REPEAT**

(Diameters differ more than 2 inches)

The reported slump flow is the average of the two diameters reported to the nearest 0.5 inches.

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Visual Stability Index

- After the Slump Flow test is performed, the visual stability index (VSI) is determined through rating the apparent stability of the slump flow patty.

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Terminology

- **Halo**: An observed cement paste or mortar ring around the outside circumference of the slump flow patty.
- **Spread**: The distance of lateral flow of concrete during the slump-flow test.
- **Stability**: The ability of a concrete mixture to resist segregation of the paste from the aggregates.
- **Viscosity**: Resistance of a material to flow under its own weight.

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Visual Stability Index (VSI)

- Perform the slump flow test.
- Inspect the perimeter of the concrete patty. **Is there a definite mortar halo?** If so, how wide is the halo?
- Inspect the surface of the patty. **Is there sheen on the surface (excess water)?**
  - Bleed water will cause a sheen on the surface or cause puddles on top of the patty.
- Assess the aggregate distribution in the patty. **Did the aggregate uniformly spread with the mortar or is there an aggregate pile in the center of the patty?**
- **Assign a VSI value to the SCC patty.**
- Refer to the following table and example pictures.

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Visual Stability Index (VSI)

TABLE X1.1 Visual Stability Index Values

VSI Value	Criteria
0 = Highly Stable	No evidence of segregation or bleeding.
1 = Stable	No evidence of segregation and slight bleeding observed as a sheen on the concrete mass.
2 = Unstable	A slight mortar halo ≤ 0.5 in.(≤ 10 mm) and/or aggregate pile in the of the concrete mass.
3 = Highly Unstable	Clearly segregating by evidence of a large mortar halo > 0.5 in. (> 10 mm) and/or a large aggregate pile in the center of the concrete mass.

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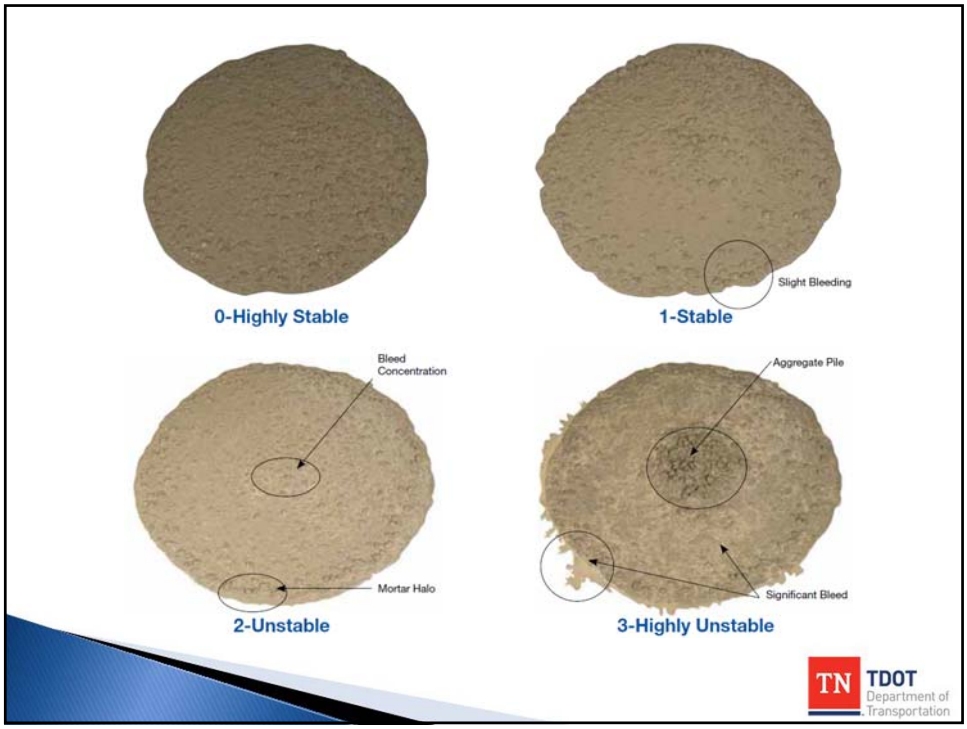
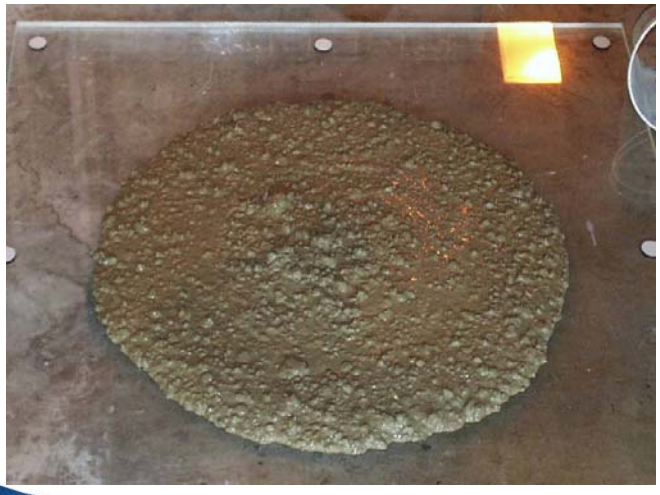


VSI = 0



- No mortar halo
- No puddles of water

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VSI = 1

Slight sheen on the concrete

False mortar halo caused by excess water on the base plate

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VSI = 1.5

Small mortar halo but very uniform concrete patty

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VSI = 2

Water puddle in concrete patty

Very glossy surface

Mortar halo 0.25" ≤ 0.5"

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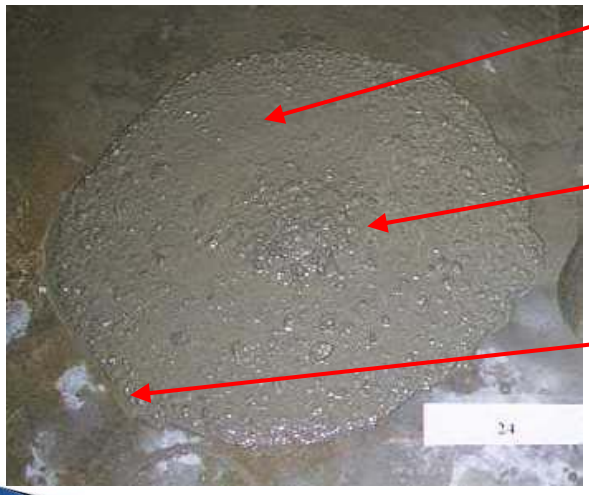
VSI = 2



Water puddles on concrete patty

Aggregate pile near the center of patty

Mortar halo 0.25" ≤ 0.5"

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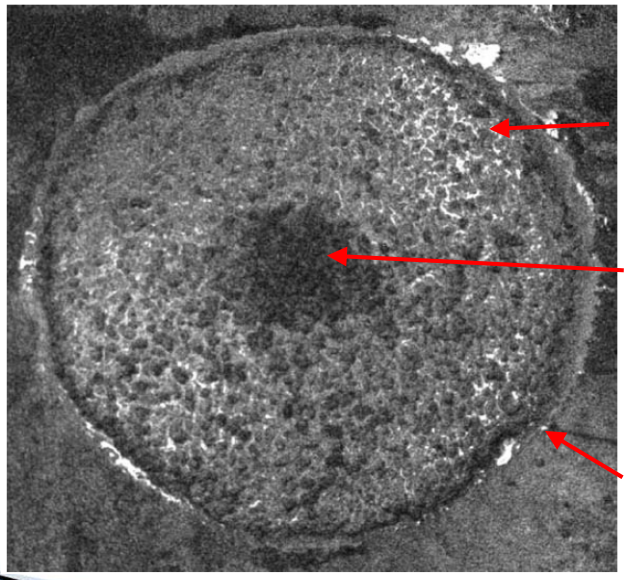
VSI = 3



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Passing Ability: J-Ring

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Summary of Test Method

The J-ring consists of a ring of reinforcing bars that will fit around the base of a standard slump cone.

- The slump cone is filled with concrete and then lifted
- The final spread of the concrete is measured, and the difference between the conventional slump flow value and the J-ring slump flow value is calculated.

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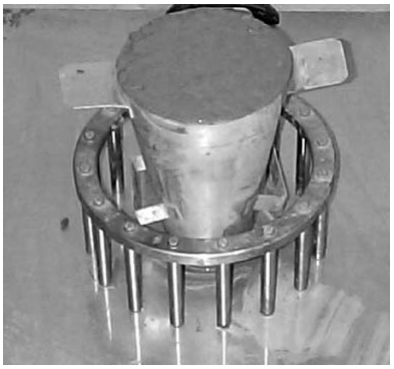
Passing Ability by J-Ring



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Procedure

1. A sample of freshly mixed concrete is placed in a mold, either in the upright or inverted position, that is concentric with the J-Ring.
2. The concrete is placed in one lift without tamping or vibration. The mold is raised, and the concrete is allowed to spread through the J-Ring.
3. After spreading ceases, two diameters of the concrete are measured in approximately diagonal directions.
4. J-Ring flow is the average of the two diameters.
   - The test is repeated without the J-Ring to obtain the slump flow. The difference between the slump flow and J-Ring flow is an indicator of the passing ability of the concrete.

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Example Problems

Example Problem#1

- **Given:** Slump Flow = 23.50 inches
  J-Ring Flow = 21.00 inches
  VSI = 1
- **Determine the passing ability.**

Passing Ability = Slump Flow - J-Ring Flow

= 23.50 - 21

= 2.50 → 2.50 inches

Poor Passing Ability

Example Problem#2

- **Given:** Slump Flow = 22.5 inches
  J-Ring Flow = 22.0 inches
  VSI = 0
- **Determine the passing ability.**

Passing Ability Slump Flow - J-Ring Flow

= 22.5 – 22.0

= 0.50 inches

Good Passing Ability

Report the passing ability to the nearest 0.5 inches

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Example Problems

Example Problem#1

- **Given:** Slump Flow = 23.50 inches
  J-Ring Flow = 21.00 inches
  VSI = 1
- **Determine the passing ability.**

Passing Ability = Slump Flow - J-Ring Flow

= 23.50 - 21

= 2.50 → **2.50 inches**

Poor Passing Ability

Example Problem#2

- **Given:** Slump Flow = 22.5 inches
  J-Ring Flow = 22.0 inches
  VSI = 0
- **Determine the passing ability.**

Passing Ability Slump Flow - J-Ring Flow

= 22.5 – 22.0

= **0.50 inches**

Good Passing Ability

Report the passing ability to the nearest 0.5 inches

Unit weight, Air Content, and Cylinders

- Existing practices and test methods for conventional concrete are not suited for SCC.
- Applicable for SCC having a slump flow of 20 inches or greater.

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Apparatus

- Shall conform to the requirements described in the standard for which the test specimen is required.
  - Molds
  - Measures
  - Measuring bowls
  - Containers

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Procedure

1. Obtain a sample of freshly mixed self-consolidating concrete
2. Measure and record the slump flow of the sampled concrete
3. For concrete with a slump flow of 20 inches or greater:
   - test unit weight, air content, and fabricate test specimens as follows:

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Procedure (continued)

4. Immediately fill the container with SCC by tilting the pouring vessel
   - Position the lowest point on the rim of the pouring vessel no more than 5 inches above the top of the container
   - Ensure an even distribution of concrete, without rodding the concrete or tapping the sides of the container, while filling the container

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Procedure (continued)

5. If necessary, repeat step 4 until the container is filled slightly above its rim
6. After filling, follow testing procedures as specified in the applicable test method.

References

- ACI 237R -07, “Self-Consolidating Concrete”
- ASTM C 1611-05, “ Standard Test Method for Slump Flow of Self-Consolidating Concrete”
- ASTM C 1621-14, “Standard Test Method for Passing Ability of Self-Consolidating Concrete by J-Ring”
- ASTM 1758-15, “Standard Practice for Fabricating Test Specimens with Self-Consolidating Concrete”

Questions?

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Appendix

Notable Specifications

501.10 - Total revolutions at mixing speed - 70 to 100 for drum mixers

604.13 – If water, air entrainers, or chemical admixtures are added at the placement site, mix the concrete a minimum of 30 revolutions at mixing speed after making the additions.

604.13 – Water added at the placement site for Class A, D, and L concrete shall not exceed 1 gallon per cubic yard.

604.13 – Total amount of water in the mix shall not exceed the maximum in the approved mix design. (Cannot add water after the acceptance tests have been performed)

Haul times

501.10 - Non-agitating trucks: No more than 30 minutes shall elapse from the time water is added to the mix

501.10 – Truck Mixers or Truck Agitators: No more than 60 minutes shall elapse from the time water is added to the mix.

604.13 – Truck Mixers: No more than 90 minutes shall elapse from when the water is added to the mix until the concrete is deposited in place.

604.13 – When the temperature exceeds 90˚F, no more than 60 minutes shall elapse for concrete placed in bridge decks.

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

SAMPLE

DIVISION OF MATERIALS AND TESTS
6601 CENTENNIAL BLVD.
NASHVILLE, TENNESSEE 37243-0360

CONCRETE CYLINDER/CORE TEST REPORT

Information to be completed by TDOT personnel for cylinders/cores tested for acceptance

Reference No. *STP-M-1234(5)* County *Davidson* Region *3*
Project No. *01234-5678-90* Contract No. *1234* Date *12-Jan-03*
Contractor Placing Concrete *Bob Jones* Volume Poured this Date (m^3, yd^3) *600 cu. yds.*
Daily Report No. *5678* Date of Pour *30-Jan-03* Requested Age of Test *28 days*
Concrete Producer *Nashville Ready Mix* Location *Nashville*
Cyl./Core Numbers *45, 45A, 45B* Volume Represented by Cyls/Cores (m^3, yd^3) *402 cu. yds.*
Design Number *02 1234* Design Strength *3000 psi* Concrete Class *A - PCCP*
TDOT Supervisor *Bill Smith* Date Placed in Wet Curing Environment *08-Feb-03*

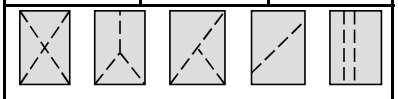
Item Number	*501.01*	*501.01*	*604.03.01*		
Pay Quantity	*150 sq. yds.*	*150 sq. yds.*	*368 cu. yds.*		
Quantity Delivered	*16.67 cu. yds.*	*16.67 cu. yds.*	*368 cu. yds.*		
Sta. of Cyl./Core	*012+3.67*	*123+4.67*	*123+4.67*		

Description of Pour(s):

Remarks: *Partly cloudy, 80 degrees F, 60% RH, winds from NW at 4 mph.*

Laboratory Test Data *(ASTM C-39, C-511, and C1231)*

Cylinder No. / Core No.	*45*	*45A*	*45B*
Serial No.	*12345*	*67890*	*98765*
Date Received	*31-Jan-03*	*31-Jan-03*	*31-Jan-03*
Date Tested	*14-Feb-03*	*14-Feb-03*	*14-Feb-03*
Date Reported	*15-Feb-03*	*15-Feb-03*	*15-Feb-03*
Diameter (in)	*6*	*6*	*6*
Cross-sectional Area (in²)	*28.26*	*28.26*	*28.26*
Maximum Load (lbf)	*97497*	*100323*	*10032*
Compressive Strength (psi)	*3450*	*3550*	*3550*
Ave. Compressive Strength (psi)	*3517*		
Type of Fracture	*Cone*	*Cone-Split*	*Shear*
Performed by	*RPG*	*RPG*	*RPG*
Technician Certification No.	*2345*	*2345*	*2345*



Field Test Data

Slump, in. *(ASTM C-143)*	
Air Temp., °F	
Concrete Temp., °F *(ASTM C-1064)*	
% Air *(ASTM C-173, C-231 , or C-138)*	
Unit Weight (lbs/ft³) *(ASTM C-138)*	
Performed by/ Cert. No.	
Contractor Observer/Cert. No.	

Comments:

Original to:
Headquarters Materials and Tests
Copies to:
Regional Materials and Tests
Project Supervisor
Copy to Contractor to accompany shipment of cylinders

Approved by _____
Director of Materials and Tests

Date _____

Contractor: Received by _____ Date _____

Form DT-0062 (Rev. 06-14)

State of Tennessee
Department of Transportation
6601 Centennial Blvd.
Nashville, TN 37243-0360
Division of Materials and Tests

MEMORANDUM

TO: Regional Materials & Tests, Regional Construction

FROM: Headquarters Materials & Tests

DATE: March 25, 2014

SUBJECT: Concrete Cylinder Molds and Labeling-UPDATED

The Department will be changing from a pair of 6"x12" cylinders to a set of three 4"x8" cylinders for all acceptance testing of concrete except Class CP as outlined in SOP 1-1 (Procedures for the Sampling and Testing, and Acceptance of Materials and Products) on all contracts let after May 1, 2014. The Contractor has the option to use 4"x8" or 6"x12" cylinders on contract let before May 1st, 2014. Class CP concrete will continue to utilize a pair of 6"x12" cylinders due to the nominal maximum aggregate size. Contractors should be notified as soon as possible in order to supply the proper molds to upcoming state projects.

Also, the Department is requiring the labeling of concrete molds and cylinders instead of etching effective immediately. The cylinders shall be labeled with a permanent marker. ASTM C31 recommends that the top surface not be disturbed. The following steps for cylinder molding, labeling, and curing are below.

1) Inspectors shall label the side of each cylinder mold with the contract number, cylinder number, and date before making the cylinders.
2) Concrete cylinders shall be made according to AASHTO T-23.
3) Cylinders shall be moved immediately after molding and finishing to an initial curing location. Cylinders shall be kept in a temperature range of 60 to 80°F for initial curing.
4) The cylinders shall be removed from initial curing and placed in a wet curing environment within 48 hours.
5) Once received at the final (wet) curing location, the inspector shall write the contract number and cylinder number on top of the concrete cylinder.
6) When the numbers are placed on top of the concrete cylinder, the mold can be stripped.

7) After the mold is stripped, label the side of the concrete cylinder with the contract number, cylinder number, date cylinder was made, and date cylinder is placed in wet curing environment.
8) Within 30 minutes of stripping, the cylinder shall be placed in a final (wet) curing environment with free water maintained on the surface at all times at a temperature of 73.5 ± 3.5°.
9) Cylinders shall be transported to Headquarters Materials and Tests Laboratory for acceptance testing as soon as possible but within 21 days.

Please review and advise personnel of all the new changes.

Brian K. Egan
Materials & Tests Director

BKE:am

Cc: File

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
6601 CENTENNIAL BLVD.
NASHVILLE, TN 37243

CONCRETE DELIVERY TICKET

Date: _____ Ticket # _____

Contract # _____ County _____ Region _____ Load # _____

Project # _____ Proj. Ref. # _____

Conc. Design # _____ Concrete Class: _____ No. Cubic Yards: _____ Actual W/C : _____

		ACTUAL	TARGET[3]	TOLERANCE
CEMENT	**lbs.**			
FLYASH	**F☐C☐ lbs.**			
SLAG	**lbs.**			
ROCK	**lbs.**			
SAND	**lbs.**			
WATER	**gal.**			

		ACTUAL	TARGET
A.E.A.	**oz.**		
W.R.A.	**oz.**		
WATER	**oz.**		
MISC.	**oz.**		

Will accept computer generated equivalent

Max. water allowed[1] (Actual) _____ Gallons

Total water [2](Plant) _____ Gallons

Max. water allowed (Project) _____ Gallons

Water added (Project) _____ Gallons

No. Rev. @ Mixing Speed (Plant) _____

No. Rev. @ Mixing Speed (Project) _____

Time loaded: _____ Time discharged: _____

Truck No. _____ Loc. Sta. _____

_____
(Unit of Structure)

_____ Print Name (Plant Tech)

_____ Plant Tech Cert. No.

_____ Plant Tech. Signature

_____ Print Name (Inspector at delivery point)

_____ Field Tech Cert. No. (TDOT Rep.)

_____ Inspector Signature

1 Based on actual cementious material allowed by design

2 Actual used at plant

3 May be adjusted to meet specification requirements.

Form DT-1756 (Rev.06-17-14)
RDA# 1942

PART TWO: ACCEPTANCE SAMPLES AND TESTS

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Portland Cement Concrete (Except Prestressed, Precast, Pavement and Base)	Cement, Fly Ash, and GGBFS	Acceptance from Qualified Products List (Verification Sampling Required)				Must be from approved source; if not, must have complete lab tests before being used on project.
	Curing Compound	Acceptance from Qualified Products List (Verification Sampling Required)				A compatible Type 1-D, Class B membrane shall be used when texture coating is specified.
	Chemical Admixtures	Acceptance from Qualified Products List				Admixture must be on approved list and have the brand shown on concrete design. Check dosage amounts for compliance with concrete design.
	Aggregate: Coarse and Fine	Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
	Reinforcing Steel (Bars)	Acceptance by Certification (Verification Sampling Required)				See attached Verification Check Samples and Tests section.
	Completed Concrete Mix	Cylinders (28-day) Slump, Air, Mix Temp. *All early break cylinders shall conform to the requirements as stated in Part 1 of the SOP Guide.	Project Inspector	A complete set of tests and set of cylinders for each 100 yd3 placed per critical unit of structure. For Class D or L, One complete set of tests for each of the first three loads. One set of cylinders shall be cast from one of the first three passing loads; add'l tests and sets of cyl to be made for each add'l 50 yd3.	Randomly selected during placement.	Determine Slump and Air Content from the same sample of concrete that cylinders are made from. For Class D or L, Bridge Deck Concrete per SOP 4-1; concrete placed by pumping shall be checked for air content at the discharge end of the truck chute immediately prior to pumping. *Complete set of tests shall be performed on the initial load for quality control/informational purposes, not for acceptance. The volumes of noncritical items may be combined when utilizing the same ready mix plant.
Portland Cement Concrete Non-Structural Concrete for **Small Quantities Not to exceed 25 yd3 per week or 500 yd3 per project for combined concrete items.**	Cement and Fly Ash GGBFS	Acceptance from Qualified Products List (Verification sampling required)				Must be from approved source; if not, must have complete lab tests before being used on project.
	Curing Compound	Acceptance from Qualified Products List (Verification sampling required)				A compatible Type 1-D, Class B membrane shall be used when texture coating is specified.
	Chemical Admixtures	Acceptance from Qualified Products List				Admixture must be on approved list and have the brand shown on concrete design. Check dosage amounts for compliance with concrete design.
	Aggregate: Coarse and Fine	Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
	Reinforcing Steel (Bars)	Acceptance by Certification (Verification Sampling Required)				
	Completed Concrete Mix	Visual Inspection, Cylinders, (28 day) Slump and Air Content *All early break cylinders shall conform to the requirements as stated in Part 1 of the SOP Guide.	Project Inspector	Complete set of tests and set of cylinders for pours of 25 yd3 or less weekly. If over 25 yd3 per week or more than 500 yd3s per project are poured then follow procedures outlined in Portland Cement Concrete (Except Prestressed, Precast, Pavement and Base). Delivery tickets must accompany each load & contain batch weights, class of concrete & time of batching.	Randomly selected at placement site.	NOT TO BE USED IN MAJOR STRUCTURES OR STRUCTURALLY CRITICAL ITEMS. ONLY FOR: Sidewalks, Curbs & Gutter, Building Foundations, Slope Paving, Ditch Paving, Guardrail Anchorage, Small Culvert Headwalls (30" or less), Fence Posts, Catch Basins, Manhole Bases & Inlets, and Small Sign Bases.
	Pre-approved Pre-packaged Concrete Mixtures	Acceptance from Qualified Products List				To be limited to 2 yd^3 per day for items as listed above.

PART TWO: ACCEPTANCE SAMPLES AND TESTS

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Portland Cement Concrete - Pavement & Base	Cement, Fly Ash, and GGBFS	Acceptance from Qualified Products List (Verification sampling required)				Must be from approved source. If not, must have complete lab analysis and approved before being used.
	Curing Compound	Acceptance from Qualified Products List (Verification sampling required)				A compatible Type 1-D, Class B membrane shall be used when texture coating is specified.
	Chemical Admixtures	Acceptance from Qualified Products List				Admixture must be on approved list and have the brand shown on concrete design. Check dosage amounts for compliance with concrete design.
	Aggregate: Coarse and Fine	Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
	Completed Concrete Mix	Compressive Strength (Cylinders) Slump, Air, Mix Temperature *All early break cylinders shall conform to the requirements as stated in Part 1 of the SOP Guide.	Project Inspector	One pair each 400 yd3; In areas where class A is allowed, the frequency shall be the same as Portland Cement Concrete.	Placement site	Additional test specimens will be required if pavement is to be opened to traffic within 14 days after placement. Determine Slump and Air Content from same sample of mix used for cylinders. Make additional Slump and Air Content determinations as required for control. Class CP concrete use 6x12 cylinders.
		Depth Measurement	Contractor Monitored by Project Inspector	One core per 1,000 lin. ft. of poured width, with a minimum of 1 core for each interchange ramp.	Completed pavement	When thickness of core from a unit is deficient more than 1/4" and not more than 1" from Plan thickness, take 2 additional cores at intervals of not less than 300' within the unit. Use the average of the three cores to determine thickness.
	Dowel and Tie Bars	Acceptance by Certification (Verification sampling required)				Assembly to be approved by the Engineer.
	Sealant	Acceptance by Qualified Products List				
Prestressed Concrete	Cement, Fly Ash, and GGBFS	Acceptance from Qualified Products List (Verification sampling required)				Must be from approved source; if not, must have complete lab tests before being used on project.
	Curing Compound	Acceptance from Qualified Products List (Verification sampling required)				
	Chemical Admixtures	Acceptance by Qualified Products List				Admixture must be on approved list and have the brand shown on concrete design. Check dosage amounts for compliance with concrete design.
	Aggregate: Coarse and Fine	Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
	Reinforcing Steel (Bars)	Acceptance by Certified Mill Test Report (Verification Sampling Required)				
	Prestressing Strands	Acceptance by Certified Mill Test Report (Verification Sampling Required)				
	Finished Product	Visual Inspection	Materials & Tests	After casting and before shipment	Prestress producer's plant	Each item to be inspected for straightness, cracks, honeycomb, size and appearance. Cosmetic Patching shall be cured prior to shipment.
	Completed Concrete Mix	Slump, Air and Mix Temperatures	Materials & Tests or Contractor monitored by TDOT personnel.	1 set of tests per beam	At the discretion of the Inspector or a minimum of one per pour.	Additional tests performed when apparent slump change is indicated.
		Cylinders (Acceptance)	Materials & Tests or Contractor monitored by TDOT personnel.	At least 1 set per beam per pour.		1 set for 28 day strength, 1 set for back up.
		Cylinders (Panels/Piling)	Materials & Tests or Contractor monitored by TDOT personnel.	One set at beginning, and one set at the end of the pour		1 set for 28 day strength, 1 set for back up.
		Cylinders (Tension Release)	Materials & Tests or Contractor monitored by TDOT personnel.	One set at beginning, and one set at the end for tension release of the bed.		Additional Specimans may be necessary

PART TWO: ACCEPTANCE SAMPLES AND TESTS

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Precast concrete noise w all panels, retaining w all panels, and precast drainage structures including pipes, headw alls, manholes, catchbasins, box culverts, and structural spans.	Finished Product	Acceptance by Certification in accordance w ith SOP 5-3 (Verification sampling required)				Each shipment must be accompanied by a completed certification form. Each item shall be inspected after delivery to the project for cracks, spalls and/or appearance by project personnel prior to incorporating product into the w ork.
Precast Concrete Abutment Blocks and Approach Slabs	Finished Product	Slump, Temperature, and Air	Materials & Tests or Contractor monitored by TDOT personnel.	Minimum 1 set of test per pour	Precast Producer Pant	
		Cylinders	Materials & Tests or Contractor monitored by TDOT personnel.	One set at beginning, and 1 set at the end of the pour	Precast Producer Pant	
Earth Retaining Structures	Backfill	Density	Project inspector	1 per every 500 tons or fraction there of.	Project site	
		Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
	Select Granular Backfill	Quality Ph Internal angle of friction.	Materials & Tests	1 @ beginning of Project and then every 6 months	Aggregate plant	
		Density	Project inspector	1 per every 500 tons	Project site	
		Eletro-Chemical Analysis	Producer	1 per Source @ Beg of Project & every 2 years thereafter	Aggregate plant	Add'l Test required w / appearance change
		Gradation	Materials & Tests	Beginning of project	Aggregate plant or Roadw ay	
			Project Inspector	One test every 1000 tons (Min. 1 per w eek)	Aggregate plant or Roadw ay	
	Finished Product	Precast concrete Products	Acceptance in accordance w /SOP 5-1 and Special Provision 624 (Verification testing required)			
		Modular block	Acceptance in accordance w /Special Provision 624 (Verification testing required)			Verification required before use
Prime, Tack and Sealer	Emulsions	Acceptance by Certification in accordance w ith SOP 3-2 (Verification Sampling Required)				Each shipment must be accompanied by TDOT form DT-0293E materials certification report.
Prime Tack and Sealers (small Quantities)	Emulsions	Visually inspect for contamination	Project Inspector	1 per project	Project Site	Not to exceed 3 tons tack and 3 tons prime per project. Supplier to furnish certification (may be non-project specific) and delivery tickets show ing quantities.
Bituminous Plant Mix Pavements	Aggregate	Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
		Fractured Face Count, Glassy particles by w eight	Project Inspector	Min. of 1 per project	Coarse aggregate Stockpile	Plus #4 (4.75mm) Material
	Performance-Graded Asphalt Cement	Acceptance by Certification in accordance w ith SOP 3-1 (Verification Required in accordance w ith Part Three herein)			Governed by process See SOP 3-1.	Each shipment must be accompanied by TDOT form DT-0293PG materials certification report.
	All Plant Mix Asphalt	Mix temperature	On Roadw ay by Project Insp.	Every fifth load.	From truck prior to leaving plant and on roadw ay prior to deposit into paver or transfer device.	Temperatures to be recorded on the delivery ticket. Tests at the plant by producer at the discretion of Materials & Tests Supervisor.
		Stripping-10 min. boil	Project Inspector	Once daily	Truck and Asphalt Plant	Plus #4 (4.75mm) Material on selected
	Plant Mix Asphalt Gradings A, B, BM, BM2, C, CW, D, E, and E Shoulder	Density	Project Inspector	1,000 tons	As soon as practical after compaction, w hen nuclear method is used. When used, cores w ill be obtained in accordance w ith SP407DEN.	Each lot shall be divided into 5 equal-sized sublots, and one test should be performed per each sublot. Longitudinal test locations should be determined randomly. No single transverse test location shall be duplicated w ithin any single lot.

PART TWO: ACCEPTANCE SAMPLES AND TESTS

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Bituminous Plant Mix Pavements	Plant Mix Asphalt Grading B, BM, BM2, C, CW, D, E, CS, TLD, & TL	Asphalt Content AASHTO T-164, Method E-II by extraction, or AASHTO T-308 by ignition oven	Project Inspector	1 test for every 1000 tons randomly.	Completed mix in truck or on roadway.	AASHTO T-164 Method E-II will be performed by pouring the extracted asphalt and solvent through nested No. 16 and No. 200 mesh sieves. AASHTO T 164 Method A may be used for modified asphalt or when problems are encountered filtering according to Method E-II. May not be required on production days of less than 100 tons. Ignition oven may be utilized to determine AC content and gradation.
		Aggregate Gradation AASHTO T-30				
		Air Voids & Volumetric Properties (T166, T209, T269)	Project Inspector or Materials and Tests	During Test Strip Construction or Mix Verification.	Completed mix in truck or on roadway.	Applies only to mixes requiring a design. Verification Sample required to be submitted to Regional Lab.
		LOI (Surface Mix only)	Project Inspector	One sample per day for Surface Mix only.	Completed mix in truck.	If daily sample fails, take 3 cores per lot placed that day to determine LOI. Penalty for failure to meet.
	Plant Mix Asphalt Grading A, A-S, A-CRL, & Asphalt Treated Permeable Base	Aggregate Gradation AASHTO T-27	Project Inspector	1 test for every 1000 tons randomly.	Bin sample for Batch Plant. Belt sample for Dryer-Drum Plant.	Normally, dry gradation through the No. 200 sieve for control and acceptance. AASHTO T-27 for referee tests, including AASHTO T-11. May not be required on production days of less than 100 tons. No extraction required.
Bituminous Plant Mix Pavements for Small Quantities	Bituminous Mixture	Visual Inspection	Project Inspector	Occasionally. Delivery ticket must accompany each load & contain weight of mix.	Placement site	Not to exceed 1000 tons of each type mix per project. Supplier to furnish certification showing type of mix and compliance with TDOT specifications. TDOT reserves right to perform any testing deemed necessary. Mix shall be formulated from a previously approved Job Mix Formula.
Bituminous Surface: Surface Treatment, Microsurfacing, Slurry Sealing, and related similar processes	Aggregate	Gradation & Washing	Project Inspector or Materials & Tests	One each 500 tons for each size aggregate.	At source or at project prior to incorporating into work.	Inspection required before material use.
		Fractured face count	Project Inspector or Materials & Tests	Minimum of 1 per project.	At project prior to incorporating into work.	Plus No. 4 (4.75mm) sieve material, gravel mixes only.
		Loss on Ignition (LOI)	Project Inspector or Materials & Tests	Minimum of 1 per week	From stockpiled materials. If blended aggregate, then after blending.	Accept/deduct in accordance with 411.10, pgf 6
		Glassy particles by weight	Project Inspector or Materials & Tests	Minimum of 1 per project.	At project prior to incorporating into work.	Plus No. 4 (4.75mm) sieve material, slag mixes only.
		Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
	Emulsions	Acceptance by Certification in accordance with SOP 3-2. (Verification Sampling Required)				Each shipment must be accompanied by a notarized materials certification report. DT0293E See attached Verification/Check Samples & Tests section.
Treated Permeable Base	Asphalt Treated Permeable Base or Portland Cement Treated Permeable Base	Thickness	Contractor to obtain specimen at locations identified by Project Inspector	One core per unit or fraction of unit. A unit is equal to a paver mat width 1,000 ft in length.	Prior to being overlaid.	When thickness of core from a unit is deficient more than 1/4" and not more than 1" from Plan thickness, take 2 additional cores at intervals of not less than 300' within the unit. Use the averaged of the three cores to determine thickness.

PART TWO: ACCEPTANCE SAMPLES AND TESTS

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Embankment	Soil	Proctor Density & Optimum Moisture	Materials & Tests	As required by material changes.	Cuts sampled prior to construction. Borrow pits sampled as required prior to placement.	
		Density, Moisture	Project Inspector	One test each 10" of lift not to exceed 1500 ft roadway or 5000 yd^3. Exception: Within 50 ft of a bridge end (deck or box) 1 test will be performed for each lift. The test will be performed alternately on the embankment and on the backfill material.	All tests will be performed at random locations. During construction, immediately after compaction.	Density tests will not be required for embankment containing more than 50% of plus 3/4" sieve material. See Standard Specs. 205 for correct formation of embankment.
Subgrade Preparation	Soil	Proctor Density & Optimum Moisture	Materials & Tests	As required by material changes.	May be sampled before grading construction or after grading prior to sub-grade preparation.	
		Density, Moisture	Project Inspector	5 tests per10,000 yd^2 lot for top 6 inches.	Immediately before placing pavement structure.	Average of 5 tests in lot used to determine pass-fail, with no individual test below 95% of Proctor. Average lot to be no less than 100%.
Subgrade Treatment: Lime	Soil-Lime Mixture	Proctor Density, Optimum Moisture	Project Inspector	Prior to beginning of construction.	At beginning of compaction.	Additional tests may be required to account for material changes. Prior to beginning of construction, samples of soil & lime will be submitted to Central Lab for Proctor Density lab tests.
		Density, Moisture	Project Inspector	5 tests per 10,000 yd^2 lot.	Immediately following compaction.	Average of 5 tests in lot to determine pass - fail.
		Pulverization	Project Inspector	1 test per 10,000 yd^2.	At the beginning of compaction.	Sieve test requirement See Standard Specs. 304.06
		Thickness	Project Inspector	5 tests per 10,000 yd^2.	Job site.	
Soil-Cement Base	Cement	Acceptance by Certification (Verification Sampling Required)				Cement must be from an approved source or be approved prior to use.
	Water	Visual Inspection	Project Inspector	At the beginning of work.	As source changes.	
	Soil-Cement Mixture	Pulverization	Project Inspector	1 test per 10,000 yd^2.	After mixing, before compaction.	See Standard Specs. 304.06
		Density, Moisture	Project Inspector	5 tests per 10,000 yd^2 lot.	Immediately following compaction.	Average of 5 tests in lot to determine pass - fail.
		Thickness	Project Inspector	5 tests per 10,000 yd^2 lot.	After final finish of base.	

PART TWO: ACCEPTANCE SAMPLES AND TESTS

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Mineral Aggregate Base & Surface	Aggregate	Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
		Proctor, Sp. Gravity, Optimum Moisture	Materials & Tests	Once per year for producers or as material changes.	Sampled at source.	Quality report required for each project.
		Gradation, Moisture	Project Inspector	Initial and each 2500 tons	Sampled from plant or roadway.	A minimum of 1 sample per week for small quantities not to exceed 500 tons per week. Note: A minimum of 1 sample per week when aggregate is used for maintenance or incidental purposes. First sample should be taken at beginning of day.
		Density, Moisture	Project Inspector	5 tests per 10,000 yd^2 lot.	Immediately following Compaction.	Average of 5 test in lot used to determine pass - fail. (Check sp. gravity not always required. See Standard Specs. 303.09
		Thickness	Project Inspector or Survey Party	Five test holes per lot of approx. 10,000 yd^2 or profile check at each break point at 50 ft intervals.	After base completed.	On test holes - lot average considered one test.
	Calcium Chloride, Sodium Chloride	Quality	Project Inspector	One sample each shipment to project.	Sample from stock before use.	
Mineral Aggregate Base and Surface for Small Quantities	Mineral Aggregate	Visual Inspection	Project Inspector	As directed by Project Engineer.	Project site.	Not to exceed 500 tons per project. Must be from approved source.
Aggregate for Underdrains	Mineral Aggregate	Gradation	Project inspector or Material and Tests representative	One test every 1000 tons (Min. 1 per week)	Project site or plant stockpile	Must be from an Approved Source
Aggregate-Cement Base Courses	Cement	Acceptance by Certification (Verification Sampling Required)				Cement must be from approved source or to be accepted prior to use.
	Aggregate	Gradation	Project Inspector	One each 2500 tons.	Sampled from plant stockpile.	In special cases, this test run by Materials & Tests.
		Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
	Water	Quality	Project Inspector	At the beginning of construction and when source changes.	Source prior to start of work.	Water of potable quality may be used without testing.
	Aggregate-Cement Mixture	Density, Moisture	Project Inspector	5 tests per lot of approx. 10,000 yd^2.	Immediately following compaction.	Average of 5 tests in lot used to determine pass - fail. Not required for Cement Treated Permeable Base.
		Thickness	Project Inspector or Survey Party	Five test holes per lot of approx. 10,000 yd^2 or profile check at each break point at 50 ft intervals.	After base completed.	On test holes - lot average considered one test.
		Moisture	Project Inspector	1 each 2500 tons or 2 per day.	At time of weighing.	First sample should be taken at beginning of day.

PART TWO: ACCEPTANCE SAMPLES AND TESTS

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Aggregate - Lime Fly Ash Base Course	Hydrated Lime	Acceptance by Certification (Verification Sampling Required)				Must be from approved source or tested and approved prior to use.
	Fly Ash	Acceptance from Qualified Products List (Verification Sampling Required)				Must be from approved source or tested and approved prior to use.
	Aggregate	Gradation	Project Inspector	One each 2500 tons.	Sampled from plant stockpile.	Must be from approved source. In special cases, this test is performed by Materials & Tests.
	Water	Quality	Project Inspector	At the beginning of construction and when source changes.	Source prior to start of work.	Water of potable quality may be used without testing.
	Aggregate-Lime-Fly Ash Mixture	Density, Moisture	Project Inspector	5 tests per lot of approx. 10,000 yd^2.	Immediately following compaction.	Average of 5 tests in lot used to determine pass - fail. Not required for Cement Treated Permeable Base.
		Thickness	Project Inspector or Survey Party	Five test holes per lot of approx. 10,000 yd^2 or profile check at each break point at 50 ft intervals.	After base completed.	On test holes - lot average considered one test.
		Moisture	Project Inspector	1 each 2500 tons or 2 per day.	At time of weighing.	First sample should be taken at beginning of day.
Conditioning Mineral Aggregate Base	Aggregate	Optimum Moisture	Materials & Tests	1 per project and as materials change.	Sampled from roadway prior to beginning the conditioning.	
		Proctor	Materials & Tests	1 per year for producers or as material changes.	Sampled from roadway prior to beginning the conditioning.	
		Density, Moisture	Project Inspector	5 tests per 10,000yd^2 lot.	Immediately following compaction.	Average of 5 tests per lot used to determine pass - fail.
	Calcium Chloride, Sodium Chloride	Chemical Analysis	Project Inspector	1 sample each shipment to project.	Sampled from stock before use.	Submit sample to Headquarters Lab for testing.
Miscellaneous and Small Quantities For Non-Critical Items	Aggregate: For use other than in Portland Cement Concrete	Visually inspect for contamination	Project Inspector	Occasionally.	Placement site.	Must be from approved source. Not to exceed 100 tons per day nor more than 500 tons per project. For use in pipe bedding, underdrains, etc.
	Masonry Items including: Concrete Block, Brick, R/W Markers	Visual Inspection and Dimension Check	Project Inspector	Occasionally.	Placement site.	Supplier to furnish certification. Not to exceed: Concrete block - 100 Brick ---------- 1,000 R/W markers --- 20
	Fence Fabric or Wire, Fence Posts & Braces, etc.	Visual Inspection and Dimension Check	Project Inspector	Occasionally.	Placement site.	Not to exceed 1000 lin. Ft. (300 m) per project. Supplier to furnish certification.
	P.V.C. Pipe and Underdrain Pipe 300 mm (12") D	Visual Inspection and Dimension Check	Project Inspector	Occasionally.	Placement site.	Not to exceed 500 lin. ft. per project. Supplier to furnish certification.
	Delineators & Posts	Acceptance from Qualified Products List (No Verification Sampling Required)				Not to exceed 100 pieces of each per project. Supplier to furnish certification.

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Tennessee Department of Transportation
Division of Materials and Tests

Quality Control and Acceptance of Portland Cement Concrete for Bridge Decks (SOP 4-1)

Purpose- The purpose of this document is to establish the minimum TDOT requirements for the quality control and acceptance testing of Portland cement concrete for bridge decks.

Background- Quality control for concrete, both at the plant and at the job site, is critical to the final performance. Though designs call for 7% air content, many loads of concrete are being rejected due to air content below the minimum of 4.5%. Other loads of concrete are rejected due to being out of specification on slump or temperature. This costs both the contractor and the TDOT in both time and money. It has been determined that a better system, one in which the quality control testing at the plant cooperates with that at the job site, be developed in order to cut these losses and promote better quality concrete.

Procedure- Before any deck pour there shall be a "pre-pour conference". The purpose of the conference shall be to discuss the Quality Control (QC) and acceptance procedures and responsibilities. A representative from the contractor and/or subcontractor, ready-mix supplier, concrete pump operator (if applicable), and the Tennessee Department of Transportation shall attend. The authority and responsibilities for each of the following shall be discussed: addition of water, plant operations, concrete mix design, boom configurations, sampling and testing, concrete delivery/# of trucks, specifications, acceptance testing, and mixture rejection. A TDOT or ACI Level One Certified Technician shall complete all QC and Acceptance sampling and testing. As required in Section 604.03 of the TDOT Specifications, the Contractor or concrete material supplier shall complete all QC sampling and testing. The TDOT inspector shall conduct all acceptance sampling and testing for air content, slump, and temperature. The TDOT inspector shall also make, cure, and transport the acceptance cylinders for strength testing.

During placement operations, whether by direct pouring, by bucket, or by pumping, there is an assumed air loss. Research has shown that an air loss of 0-2.0% as a result of pumping can be expected. Furthermore, it is assumed that a smaller air loss can be expected during other placement means, and during finishing. This air loss will be assumed to be 0.5%. These assumed air losses shall be addressed as follows:

Bridge Deck Concrete placed by pumping or other placement methods shall have an air content of **4.5% - 7.5%** at the discharge end of the truck chute* immediately prior to pumping or placement, no exceptions. The concrete shall be tested before placed in the pump truck, bucket, or deck. Any load of concrete failing to meet these specifications or those for slump or temperature, shall be rejected and not used in a TDOT project.

Each truck shall be tested for air content, slump, and temperature at the beginning of each day until three consecutive trucks meet specification. Once that specific truck meets specifications, it shall be allowed to pour. One set of cylinders shall randomly be cast from one of the first three passing loads. Thereafter QC and acceptance testing shall be conducted at least once every fifty cubic yards (50 CY), including cylinders for compressive strength. The samples taken every fifty cubic yards (50 CY) are to be taken randomly within the lot, so as not to establish a pattern, i.e. every fifth truck. Should a load be found not to be in the allowable air content, slump, or temperature range, then it shall be rejected. Each truck thereafter is to be tested until two consecutive trucks are found to be within the acceptable range(s). At that point, testing frequency shall return to at least once in every fifty cubic yard (50 CY) lot.

All QC and acceptance test results conducted in accordance with this procedure shall be documented on TDOT form DT-0311 and DT-0311A.

- The TDOT/Consultant Inspector may request additional Q.C. testing at any time at either the plant or at the job site, including during the pumping operation. The TDOT/Consultant inspector and the Contractor QC technician have full authority to reject any truckload of concrete not in compliance with this procedure or with the TDOT Specifications.
- If taking a concrete sample during pumping operations, the pump is not to be stopped. The sample is to be obtained from the pumped concrete stream during placement.
- Before concrete is placed, it must be in full compliance with the TDOT specifications including air content, slump, temperature, and time. Any mixture not in compliance shall be rejected.
- When possible, a TDOT Project Inspector should either be at the ready mix plant, or make a short visit to the plant to assure proper Q.C. techniques and procedures.

*Sample per AASHTO R 60, Section 5.2, Note 3: sample for tests may be taken after at least one-quarter cubic yard of concrete has been discharged.