Concrete Field Testing Technician Course

Tennessee Department of Transportation

2020 Manual

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WELCOME!
Concrete Field Testing Technician Course

Classroom Rules

• Be Respectful
• Facility Information
• Keep It Clean
• Phone Etiquette
Who Are YOU?

• Name
• Company
• Experience
• Why are you here?

Purpose of Certification

• To ensure proper performance of tests
• To improve reliability of results
• For quality control
• To comply with federal requirements
Course Highlights

- Slide presentations
- Written Exam (No Phones Allowed)
  - Open-book
  - Must get 75% overall
- Performance exam
  - Pass/Fail
- Results
- Recertification – Every 5 years

Resources

- Course materials
  - Course textbook
  - Presentation slides and videos
- TDOT
  - Standard Specifications, January 1, 2015
  - Special Provisions
ADA Notice of Requirements

- Can be found at the following website:
  - [https://www.tn.gov/tdot/government/g/ada-office0.html](https://www.tn.gov/tdot/government/g/ada-office0.html)
- 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
Sampling Freshly Mixed Concrete

AASHTO R 60

ASTM C172
TDOT Standard Method of Test for
Sampling Freshly Mixed Concrete

References
TDOT Standard Specifications
AASHTO R 60
ASTM C172

Scope

• Procedure for obtaining representative samples of fresh concrete as delivered to the project site
• Tests will be performed for quality assurance in accordance with TDOT Specification
• All required tests will be conducted on samples gathered by this procedure
Sampling Sources

- 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 and then composite into one sample for test purposes
  - No portion shall be taken before 10% or after 90% of the batch has been discharged
- Paving Mixers
  - Obtain portions from at least five different portions of the pile and then composite into one sample for test purposes

Sampling

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

• Transport individual portions to testing location then combine and remix to ensure uniformity

Sampling

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

• Begin molding cylinders for strength testing within 15 minutes after obtaining the composite sample

Sampling

• Minimize the time between obtaining and using the sample
• Protect the sample from
  • sun
  • wind
  • other sources of rapid evaporation
  • contamination
Procedure

- Samples to be used for strength tests should be a minimum of one cubic foot (1 ft³).
- Smaller samples are allowed for routine air content and slump tests if cylinders are not being made.

Sampling Video

https://youtu.be/geGqlzEe5gQ?t=11
Sampling Timeline

Let’s Review!

- What part of the batch do we sample from?
- How many portions make up a sample when sampling from the truck? When sampling from a paver?
- What is the maximum allowable time to obtain a complete sample?
- When do we start slump, temperature, and air?
- When do we begin making cylinders? What is the minimum sample size we need to cast cylinders?
Questions?
Temperature of Freshly Mixed
Hydraulic Cement Concrete

AASHTO T 309
ASTM C1064
TDOT Standard Method of Test for Temperature of Freshly Mixed Hydraulic-Cement Concrete

References
TDOT Standard Specifications
AASHTO T 309
ASTM C1064

Equipment

Container
- Nonabsorptive material
- Large enough to provide appropriate cover
  - At least 3” of cover in all directions around the tip of the thermometer
  - Concrete cover must also be at least 3 times the nominal maximum size of the coarse aggregate
**Temperature**

**Equipment**

**Thermometer**
- Shall be capable of measuring the temperature of the concrete to ±1°F throughout a range of 30°-120°F.
- Calibrate once a year or whenever there is a question of accuracy.

![Image of digital and analog thermometers](image)

**Procedure**
- Place the thermometer in the concrete so that the sensor is submerged a minimum of 3” with 3” of cover in all directions.
- Coverage must be at least 3 times the nominal maximum coarse aggregate size.
Procedure

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

Procedure

• Leave the thermometer in the concrete for a minimum of 2 minutes but not more than 5 minutes
• While the thermometer is still in the concrete, read and then record the temperature to the nearest 1°F
Temperature Video

https://youtu.be/YQrl4XVOJcA

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 than 60°F nor more than 100°F at the time of placement

604.11
• The concrete temperature at the point of discharge shall not exceed 90°F
Let’s Review

• What is the minimum concrete cover required? What if we are taking the temperature of Class CP?

• What is the required amount of time to leave the thermometer in the concrete?

• What do we record temperature to?

• What is the maximum allowable concrete temperature at the point of discharge?
Slump of Hydraulic Cement Concrete

AASHTO T 119

ASTM C143
TDOT Standard Method of Test for
Slump of Hydraulic Cement Concrete

References
TDOT Standard Specifications
AASHTO T 119
ASTM C143

Purpose

• To monitor the consistency of plastic concrete
• To approximate the water content
• To estimate the strength of the concrete
Purpose

Consistency
• 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

Workability
• 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

\[
\begin{align*}
\text{high } \frac{w}{cm} &\implies \text{weak concrete} \\
\text{low } \frac{w}{cm} &\implies \text{strong concrete}
\end{align*}
\]

• In field conditions, the slump and strength relationship is unclear and inconsistent
### Purpose

Effect of Additional Water on Slump and Strength of Concrete

![Diagram showing the effect of additional water on slump and strength of concrete.](image)

### Use

- For plastic concrete with coarse aggregate up to 1½”
- If aggregate is larger than 1½”, then wet sieving per AASHTO R-60 is required
  - Pour concrete over 1½” sieve and shake/vibrate by hand or mechanical means
  - Mix for uniformity the concrete that passes through the sieve
- *Not* applicable for non-plastic concrete (slump < ½”)
- *Not* applicable for non-cohesive concrete (slump > 9”)

[TN]

[19]
Equipment

Ruler/Measuring Tape
- At least 12” long
- Marked in increments of ¼” or smaller

Scoop
- Large enough so concrete obtained from the sampling receptacle is representative
- Small enough so concrete is not spilled during placement in the mold

Tamping rod
- Round, straight steel rod
- 5/8” ± ¼” in diameter
- 4” greater than depth of the mold, but no more than 24” long
- Tamping end rounded to a hemispherical tip

Base
- Flat, nonabsorbent
Equipment

Dimensions of slump cone

Procedure

- Place the base on a flat, level surface
- 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
Procedure

- Fill the mold in three layers
- Each layer should be approximately $\frac{1}{3}$ of the mold volume
- Fill the cone to overflowing on the last layer

procedure

- Rod each layer with 25 strokes of the tamping rod
- Tilt the tamping rod for the bottom (first) layer
- When rodding the middle and last layers, penetrate approximately 1” into the previous layer
Procedure

- Cross-sectional 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 12” in 5 ± 2 seconds
- Use a steady upward lift
- No lateral or torsional motion

Procedure

- Do not use lateral or torsional motion
- Complete entire test from the start without interruption in 2 ½ minutes
**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.

![Diagram of True Slump, Shear Slump, and Collapse Slump]

- 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.

---

**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 to the nearest ¼”.

![Diagram of slump test procedure]
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 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 in the proper designated location
• This procedure will be followed for all equipment in future test methods

Slump Video

https://www.youtube.com/watch?v=jDUQO-bn8pU
### Table 604.03-1
Composition of Various Classes of Concrete

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

(1) For slip forming, the slump shall range from 0 to 3 inches
(4) Water reducing admixtures are acceptable; however, do not exceed the maximum water/cement ratio in order to achieve the required slump
(7) Plans specific requirements

- If using a Type A, F, or G water reducer, then allowable slump shall be a maximum of 8 inches

---

**Let’s Review**

- How many layers do we fill the slump cone in?
- How many times do we rod each layer?
- What is the maximum allowable time to complete the slump test?
- Measure slump to the nearest ______.
Unit Weight (Density) and Yield of Concrete

AASHTO T 121

ASTM C138
TDOT Standard Method of Test for Unit Weight (Density) and Yield of Concrete

References
TDOT Standard Specifications
AASHTO T 121
ASTM C138

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
Equipment

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

Capacity of Measure

<table>
<thead>
<tr>
<th>Nominal Maximum Size of Coarse Aggregate (in.)</th>
<th>Minimum Capacity of Measure (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>1 ½</td>
<td>0.4</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

ASTM C138: Table 1
Consolidation Method

Slump > 3"
  • Rodding
Slump < 1"
  • Vibration
Slump is between 1-3"
  • Rodding or Vibration

Procedure

• Select a representative sample
• Determine the mass of the measure
**Procedure**

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

---

**Procedure**

- Rod each layer with 25 strokes of the tamping rod
- Rod the bottom layer throughout its depth without forcibly striking the bottom of the container
- Rod the middle and top layers penetrating about 1” 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 each layer

• Strike off the concrete using a strike-off plate
• Place the plate to cover \( \frac{2}{3} \) of the surface and use a sawing motion to finish the covered area
• Place the plate on the same \( \frac{2}{3} \) of the surface and use a sawing motion to advance the plate until it completely slides off the measure
• Incline the plate and perform final strokes for a smooth surface
UNIT WEIGHT, USE THE PLATE!!!

Procedure

• Clean all excess concrete from exterior of measure
• Determine the mass of the concrete and measure
Unit Weight Video

https://www.youtube.com/watch?v=1mLgdtgRxY8

Unit Weight Calculations

• Unit Weight (Density)

\[ M_{\text{Concrete}} = M_{\text{Measure+C}} - M_{\text{Measure}} \]

\[ \text{Unit Weight (D)} = \frac{M_{\text{Concrete}}}{V_{\text{Measure}}} \]
Unit Weight Example

- Determine the unit weight of concrete if:

\[ V_{\text{Measure}} = 0.50 \text{ ft}^3 \]
\[ M_{\text{Measure}} = 19.6 \text{ lb.} \]
\[ M_{\text{Measure + Concrete}} = 92.1 \text{ lb.} \]
\[ M_{\text{Concrete}} = M_{\text{Measure + Concrete}} - M_{\text{Measure}} = \]
\[ D = \frac{M_{\text{Concrete}}}{V_{\text{Measure}}} = \]

Yield Calculations

- Yield (Y)

\[ Y_{\text{Concrete}}(yd^3) = \frac{W_{\text{Load}}}{(D \times 27)} \]

\[ W_{\text{Load}} = \text{total weight of load} \]
\[ D = \text{Unit Weight} \]
\[ 27 = \text{convert units ft}^3 \text{ to yd}^3 \]
Delivery Tickets

• Contains weight of materials
• Form DT-1756 or equivalent (see Appendix)
• Concrete Plant Quality Control Technician’s signature required
• Batch weights may be given on a separate batch ticket

Batching Tolerances

• Individual material weights, when compared to the mix design, must be within the following:
  • Cementitious material: -1% to +4%
  • Aggregates: ±1.5%
  • Water: ±1%
Delivery Ticket Example

- See appendix for more examples

Relative Yield Calculations

- Relative Yield (Ry)

\[ R_y = \frac{Y}{Y_d} \]

- If Ry > 1.00, an excess of concrete is being produced
- If Ry < 1.00, the batch is “short” of its designed volume
Yield/Relative Yield Example

- Determine the yield and relative yield of the following mix:

  Design batch \( (Y_d) \) = 7 yd\(^3\)
  Total weight of load \( (W_{Load}) \) = 27,300 lbs
  Unit weight of the concrete \( (D) \) = 145 lbs/ft\(^3\)

\[
Y_{Concrete} (yd^3) = \frac{W_{Load}}{(D \times 27)} =
\]

\[
R_y = \frac{Y}{Y_d} =
\]

Let’s Review

- Determine the unit weight, yield, and relative yield:
  - \( V_{Measure} = 0.25 \text{ ft}^3 \)
  - \( M_{Measure} = 7.5 \text{ lbs} \)
  - \( M_{Measure + Concrete} = 43.2 \text{ lbs} \)
  - Total weight of load \( (W_{Load}) = 36,000 \text{ lbs} \)
  - Design batch \( (Y_d) = 9 \text{ yd}^3 \)
Solution

\[ M_{Concrete} = M_{Measure+Concrete} - M_{Measure} = \]

\[ \text{Unit Weight (D)} = \frac{M_{Concrete}}{V_{Measure}} = \]

\[ Y_{Concrete} (yd^3) = \frac{W_{Load}}{(D \times 27)} = \]

\[ R_y = \frac{Y}{Y_d} = \]
Air Content of Freshly Mixed Concrete

By the Pressure Method

AASHTO T 152

ASTM C231
TDOT Standard Method of Test for
Air Content of Freshly Mixed Concrete by the Pressure Method

References
TDOT Standard Specifications
AASHTO T 152
ASTM C231

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

Equipment - Type B Meter
Pressure Method

Procedure

• Obtain a sample of freshly-mixed concrete

Procedure

• Fill the container in three equal layers
• Slightly overfill the last layer
Procedure

- Rod each layer with 25 strokes of the tamping rod
- Rod the bottom layer throughout its depth without forcibly striking the bottom of the container
- Rod the middle and top layers penetrating about 1” 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 each layer
Pressure Method

Procedure

• Strike off the concrete level with the top of the container using the strike-off bar

Procedure

• Clean off the rim
Procedure

• Attach the top of the meter to the bottom

Procedure

• Open both petcocks
Pressure Method

**Procedure**

- Close the airbleeder valve

**Procedure**

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

• Continue injecting water into the petcock while tapping the meter to ensure 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

Procedure

• Adjust the gauge to the initial pressure by _______ and _______ as necessary
Procedure

• Close both petcocks

Procedure

• Open the air valve between the chamber and the bowl
  And *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

Air Content (Pressure Method) Video
### Table 604.03-01: Composition of Various Classes of Concrete

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Min 28-Day Compressive Strength (psi)</th>
<th>Min Cement Content (pound per cubic yard)</th>
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<td>4,000</td>
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<td>6 ± 2</td>
</tr>
</tbody>
</table>

(3) Design Class D, Class DS, 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.

(7) Plans specific requirements

---

**Let’s Review**

- Which type of concrete can this test NOT be used for?
- How many layers do we fill the measure in?
- How many times do we rod? Tap with the mallet?
- What tool do we use for strike-off?
- Record air to the nearest _____.
Questions?
Air Content of Freshly Mixed Concrete

By the Volumetric Method

AASHTO T 196

ASTM C173
TDOT Standard Method of Test for
Air Content of Freshly Mixed
Concrete by the Volumetric Method

References
TDOT Standard Specifications
AASHTO T 196
ASTM C173

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

- Tamping Rod
- Air Meter
- 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

![Diagram of dampening the inside of a bowl]

---

**Procedure**

- Fill the base/bowl with a sample of fresh concrete in 2 equal layers
- Slightly overfill the last layer

![Diagram of filling the base/bowl with concrete layers]

---

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**Procedure**

- Rod each layer 25 times
- 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 each layer
- Rod the top layer throughout its depth and penetrate about 1” into the first layer

---

**Procedure**

- Tap the sides of the mold 10-15 times with the mallet after rodding the each layer
Procedure

• Strike off excess concrete from the top with a strike-off bar to level the top of the sample

Procedure

• Carefully clean the top edge of the flange and the gasket to allow a tight seal
Procedure

• At the same time, clamp the top section to the base
• Insert the baffle bottom funnel
• Add at least 1 pint of water and the selected amount of alcohol
• Record the number of full pints of alcohol added

Correction Factor

<table>
<thead>
<tr>
<th>Pints Used</th>
<th>Correction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>0.25</td>
</tr>
<tr>
<td>4</td>
<td>0.50</td>
</tr>
<tr>
<td>5</td>
<td>0.75</td>
</tr>
</tbody>
</table>

• Subtract the correction factor from the final meter reading
**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

**Procedure**

- Attach and tighten the watertight cap
- Note that the seal works by expanding (compression), not twisting (threading)
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 one hand on the neck and the other on the flange, roll the meter along the floor for approximately 1 minute
  • Roll the meter ¼ to ½ turn back and forth
  • Turn the bowl ½ turn and repeat the rolling process
  • Continue the turning and rolling procedures for 1 minute.
**Procedure**

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

- 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.
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 sample and start a new test
- Use a larger addition of alcohol than was used with the initial sample (alcohol shortens the time frame)

Procedure

- Once the sample has stabilized,
  - Read the liquid level to the nearest 0.25%
  - Record the initial meter reading
  - Retighten the cap and repeat the rolling procedure
Procedure

• To confirm the initial reading, repeat the rolling process.
• Once the sample has stabilized,
  • 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 meter reading
  • If not, use the second reading as the final meter reading

• If a third reading is required, repeat the rolling process, and once stable,
  • 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 meter reading
**Procedure**

- Disassemble the unit
- Examine the contents for undisturbed concrete
- If portions of undisturbed concrete are found, the test is invalid
- If no undisturbed portions are found, the test is valid

**Calculations**

- \( A = AR - C + W \)
- \( A = \) Air Content, \( \% \)
- \( AR = \) Final meter reading, \( \% \)
- \( C = \) Correction Factor
- \( W = \) Number of calibrated cups added to the meter

<table>
<thead>
<tr>
<th>Correction for Effect of 70% Isopropyl Alcohol on Air Meter Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pints Used</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>( \leq 2 )</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>
**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 be added to the final meter reading when testing is complete.

**Air Content by Volumetric Method**
Table 604.03-01: Composition of Various Classes of Concrete

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

(3) Design Class D, Class DS, 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.

(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.

(7) Plans specific requirements

---

Let’s Review

- Which type of concrete can this test be used for?

- Invert and shake the meter for a minimum of ____________.

- How long do we roll the meter?

- Record air to the nearest _____.

- What would constitute repeating the test?
Making and Curing Concrete Test
Specimens in the Field

AASHTO T 23

ASTM C31
TDOT Standard Method of Test for Making and Curing Concrete Test Specimens in the Field

References
TDOT Standard Specifications
AASHTO T 23
ASTM C31

Purpose

• Concrete cylinders 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 cylinders under field conditions
Equipment

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

---

**Tamping Rod Diameter Requirements**

<table>
<thead>
<tr>
<th>Cylinder Diameter (in.)</th>
<th>Rod Diameter (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6</td>
<td>3/8 ± 1/16</td>
</tr>
<tr>
<td>≥ 6</td>
<td>5/8 ± 1/16</td>
</tr>
</tbody>
</table>

Tamping rods must be at least 4” greater than the depth of the mold, but not greater than 24” in length.
Procedure

• Obtain a sample of freshly-mixed concrete

Consolidation

<table>
<thead>
<tr>
<th>Slump</th>
<th>Method of Consolidation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 1”</td>
<td>Rod or Vibration</td>
</tr>
<tr>
<td>≤ 1”</td>
<td>Vibration</td>
</tr>
</tbody>
</table>
Procedure

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

Procedure

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

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
Procedure

• Strike off the concrete using the tamping rod
• Produce a flat even surface that is level with the rim or edge of the mold
• Do not etch on the top surface

Procedure

• Clean off the rim
Procedures

Prior to filling, mark the side of the cylinder with the following:
- Cylinder #
- Date Made
- Contract #
- Date Stripped
- JJ Sample ID
- Mark the cylinder with positive identification
- Do not mark on removable caps

Cylinder 23A
13 Feb 14
CNM123
15 Feb 14
JJ012345678

Finishing

- Produce a flat even surface that is level with the rim or edge of the mold
- No depressions or projections larger than ¼”
- Cylinders that are not level at the top or bottom must be saw cut to be tested
**Cylinder Video**

Click here

---

**Procedure**

**Storage**
- Immediately after finishing move cylinders to initial curing place for storage
  - Supporting surface should be level to within ¼” per foot
- Lift and support the cylinder from the bottom of the molds
  - Improper handling of the cylinders may cause deformation
- Monitor initial curing storage with a minimum and maximum thermometer and record data on the Concrete Cylinder Test Report
Cylinders

Procedure

• Maintain temperature and moisture
  • Temperature can be maintained by using:
    • Ventilation
    • Ice
    • Cooling devices
    • Heating devices
  • Moisture can be maintained by:
    • Immersing cylinders in water
    • Storing in a container or enclosure
    • Placing in damp sand pits
    • Covering with plastic lids
    • Placing inside plastic bags
    • Covering with wet fabric

Initial Curing
• Immediately after molding and finishing, store cylinders for a period up to 48 hours in a temperature ranging from 60 and 80°F
• High early strength cylinders (>6000 psi) shall have initial curing temperature between 68 and 78°F

Final Curing
• Within 30 minutes after removing molds, cure cylinders with free water maintained on surface at all times at temperature of 73.5± 3.5°F
Procedure

Early Break Cylinders
• Field cure in the same manner and method as placed concrete
• Predominately used for:
  • Form Removal
  • Determination of when a structure may be put into service

Transportation
• Cylinders shall not be transported until at least 8 hours after final set
• Transportation time shall not exceed 4 hours
• Protect cylinders from damage by using suitable cushioning material
• Prevent moisture loss
Let's Review

• How many layers do we fill 6x12 cylinders in? 4x8s?

• What size diameter tamping rod is required for making 6x12 cylinders? 4x8s?

• How level should the supporting surface be when storing cylinders?

• What is the initial curing temperature required for high early strength cylinders?

• What is the maximum time allowed to transport cylinders?
Self-Consolidating Concrete

(SCC)

AASHTO T 347 / ASTM C1611

AASHTO T 345 / ASTM C1621

ASTM C1758
TDOT Standard Method of Test for Self-Consolidating Concrete

References
TDOT Standard Specifications
AASHTO T 347 / ASTM C1611
AASHTO T 345 / ASTM C1621
ASTM C1758
ACI 237R-07

SCC

A conventional concrete mix with modified proportions that may use specialized chemical admixtures
Self-Consolidating Concrete (SCC)

- Self-consolidating concrete (SCC) is highly flowable, non-segregating concrete that can spread into place, fill the formwork, and encapsulate the reinforcement without any mechanical consolidation.

  - U-Box Demo
  - Foundation Pour

Usage

- SCC is great for filling in unusual shapes, passing through dense reinforcement, or filling in tight spaces in formwork
- Its highly flowable consistency means that it does not need external consolidation of any kind (vibration)
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)
Aesthetics

Dense Reinforcement
### Advantages

- Reduce labor and equipment
- No vibration needed
- Flows to fill space means less placement points
- Enables placements with very dense reinforcement
- Less people to manage means safer jobsite
- Smooth surfaces free of honeycombing

### Disadvantages

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

Workability
• The ease with which concrete can be mixed, placed, consolidated, and finished
• Workability of SCC is described in terms of
  • filling ability
  • passing ability
  • stability

Filling Ability
• The ability of SCC to flow into and fill completely all spaces within the formwork, under its own weight

Passing Ability
• The ease with which concrete can pass among various obstacles and narrow spacing in the formwork without blockage
Terminology and Properties

Stability
• 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 stability
  • Static stability

Dynamic stability
• The resistance of concrete to the separation of constituent materials during placement

Static stability
• The resistance of concrete to bleeding, segregation, and surface settlement after casting while the concrete is still in a plastic state
Properties

- Stability and filling/passing ability are inversely proportional
- The greater the filling/passing ability, the less stable the mixture
- The greater the stability, the harder it is to get around reinforcement and fill out forms
- The degrees of stability, filling ability, and passing ability of SCC are dictated by the use

Reinforcement Challenges
Concrete Placement

Field Experience

- SCC is much more sensitive to additional water than conventional concrete
- Form pressures are elevated with SCC
  - Contractors performing SCC work are strongly encouraged to consult with their forms manufacturer for best practices
Field Experience

- Correct aggregate moisture is important since SCC is very sensitive to changes in mix water
- New High Range Water Reducers (HRWR) perform better when added at plant during initial mixing
- Use Water Reducers for additional slump flow requirements at the project site instead of water
- The addition of admixtures or water on site is discouraged

Testing Methods

- **AASHTO T347/ASTM C 1611**: Slump Flow of SCC
  - Slump Flow
  - VSI (Visual Stability Index)
  - T-50
- **AASHTO T345/ASTM C 1621**: Passing Ability of SCC by J-Ring
- **ASTM C 1758**: Fabricating SCC Test Specimens
AASHTO T347/ASTM C1611
Slump Flow, T50, & VSI

Two procedures:

• Slump cone upright

• Slump cone inverted

Equipment

• Mold
• 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
• Stopwatch
• Pouring Vessel
Slump Flow and T-50

- 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.
Procedure

1. Select a flat, level, nonabsorbent surface
2. Dampen the mold and place it in the center of the base plate
3. Immediately fill the mold in one lift
   • Position the pouring vessel no more than 5” 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
4. If necessary, repeat step 3 until the container is filled slightly above its rim
5. Strike off the surface of the concrete using a strike off bar level with the top of the mold

   TN

6. Remove the concrete from around the base of the mold
7. Lift the mold vertically to 9 ± 3” in 3 ± 1 seconds with no lateral or torsional motion
8. Wait for the concrete to stop flowing, measure the largest diameter of the spread of concrete to the nearest 0.25”. If a halo is present, include with measurement
9. Measure a second diameter approximately perpendicular to the first

   TN
Procedure

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

Example Problems

Example Problem #1
- **Given:** Spread Diameter (1) = 22 inches
  Spread Diameter (2) = 21.25 inches
- **Determine the slump flow.**
  
  $$\text{Slump Flow} = \frac{d1+d2}{2}$$
  $$= \frac{22+21.25}{2}$$
  $$= 21.625$$
  $$\approx 21.50 \text{ inches}$$

Example Problem #2
- **Given:** Spread Diameter (1) = 22.75 inches
  Spread Diameter (2) = 20.25 inches
- **Determine the slump flow.**
  
  $$\text{Slump Flow} = \frac{d1+d2}{2}$$
  $$= \frac{22.75+20.25}{2}$$
  $$= 21.50$$
  $$\approx 21.50 \text{ inches}$$

(Wrong) **Repeat**

(If diameters differ more than 2 inches, repeat.)

https://www.youtube.com/watch?v=Gm9AdzSEPE4
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.

Visual Stability Index (VSI)

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

VSI
- Using the patty from a slump flow test, inspect the patty's perimeter.
  - Is there a definite mortar halo?
  - If so, how wide is the halo?
- Assess the aggregate distribution in the patty.
  - Did the aggregate spread with the mortar or is there an aggregate pile in the center of the patty?
- 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
- **Assign a VSI value to the SCC patty**
  - Refer to the following table and example pictures
VSI

TABLE X1.1 Visual Stability Index Values

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

No mortar halo
No puddles of water

VSI = 1

Slight sheen on the concrete
False mortar halo caused by excess water on the base plate
VSI = 1

Slight water sheen observed

VSI = 2

Water puddle in concrete patty
Very glossy surface
Mortar halo 0.25” ≤ 0.5”
**VSI = 2**

- Water puddles on concrete patty
- Aggregate pile near the center of patty
- Mortar halo $0.25'' \leq 0.5''$

**VSI = 3**

- Water puddles in patty
- Aggregate pile near the center of patty
- Mortar halo greater than 0.5''.
**ASTM C1621**

**Passing Ability by J-Ring**

**Procedure**

1. Select a flat, level, nonabsorbent surface
2. Dampen the mold and place it in the center of the base plate and concentric with the J-Ring
3. Immediately fill the mold in one lift
   - Position the pouring vessel no more than 5” 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
4. If necessary, repeat step 3 until the container is filled slightly above its rim
5. Strike off the surface of the concrete using a strike off bar level with the top of the mold
Procedure

6. Remove the concrete from around the base of the mold
7. Lift the mold vertically to 9 ± 3” in 3 ± 1 seconds with no lateral or torsional motion
8. Wait for the concrete to stop flowing through the J-Ring. Measure the largest diameter of the spread of concrete to the nearest 0.25”. If a halo is present, include with measurement
9. Measure a second diameter approximately perpendicular to the first

Procedure

10. J-Ring flow is the average of the two diameters
12. Complete slump flow and J-Ring tests within 6 minutes.
Example Problems

Example Problem #1
- Given: Slump Flow = 23.50 inches
  J-ring Flow = 21.00 inches
  VSI = 1
- Determine the passing ability.

\[
\text{Passing Ability} = \text{Slump Flow} - \text{J-ring Flow} = 23.50 - 21.00 = 2.50 \text{ inches}
\]

Passing Ability
- Poor Passing Ability

Example Problem #2
- Given: Slump Flow = 22.5 inches
  J-ring Flow = 22.0 inches
  VSI = 0
- Determine the passing ability.

\[
\text{Passing Ability} = \text{Slump Flow} - \text{J-ring Flow} = 22.5 - 22.0 = 0.50 \text{ inches}
\]

Passing Ability
- Good Passing Ability

Report the passing ability to the nearest 0.5 inches

ASTM C1758
Unit Weight, Air Content, and Cylinders

- Applicable for SCC having a slump flow of 20 inches or greater
- Molds, measures, and containers used for unit weight, air content, and making cylinders shall conform to normal concrete requirements
- Testing procedures are the same as for normal concrete with the exception of filling
  - Fill in one lift
  - No rodding
  - No tapping
Supplemental Specifications
Subsection 604.03.1b

- Fine aggregate ≤ 50% by volume of total aggregate (normally ≤ 44%)
- Maximum coarse aggregate size No. 67 stone
- SCC may be used as alternate for Class A concrete

### Table 604.03-4: Composition of Self-Consolidating Concrete

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Min 28-Day Compressive Strength (psi)</th>
<th>Min Cement Content (pound per cubic yard)</th>
<th>Maximum Water/Cement Ratio (pound/pound)</th>
<th>Air Content % (Design + production tolerance)</th>
<th>Slump Flow (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCC (2,3,4,5)</td>
<td>3,000(1)</td>
<td>564</td>
<td>0.45</td>
<td>6 ±2</td>
<td>26±5</td>
</tr>
<tr>
<td>SH-SCC (2,3,4,5,6)</td>
<td>4,500</td>
<td>620</td>
<td>0.45</td>
<td>6 ±2</td>
<td>26±5</td>
</tr>
</tbody>
</table>

(1) Or as shown on the Plans or approved shop drawings.
(2) Acceptance range for the T50 test in accordance with ASTM C1611 shall be between 2-7 seconds.
(3) Passing ability in accordance with ASTM C1621 shall be equal to or less than 2 inches for acceptance.
(4) Visual Stability Index (VSI) shall not exceed 1.0 as per ASTM C1611 for acceptance.
(5) Static segregation as measured by ASTM C 1610 shall not exceed 20%.
(6) Air Content may be reduced if placed under water or underground if approved by the Engineer.
Supplemental Specifications
Subsection 604.03.2

• Verify self-consolidating concrete (Classes SCC and P-SCC) prior to placement at ready mix facility or prestressed plant
• Mix design reviewed by HQ M&T
• Trial Batch verification by producer with Regional M&T present
• Trial batch not required if using a previously approved SCC design

Let’s Review

• Record T-50 to the nearest _____.

• Measure spread diameters to the nearest _____.
  Average these measurements to the nearest _____.

• How do we calculate passing ability?

• When using SCC, how many lifts are required?

• What does the J-Ring represent?
Questions?
9

Volumetric Concrete

ASTM C685

ACI 304.6R
Volumetric Concrete

References
TDOT Standard Specifications
ASTM C685
ACI 304.6R

• Concrete materials batched by volume not weight
• Continuous mixing happens as the concrete is poured and placed
• Volumetric mixers, stockpiles, bins, and tanks all fit on a truck making an entire plant portable
Typical Applications

- Volumetric Mobile Mixers lend themselves to a wide variety of applications, which TDOT does not limit.
  - Minor structures – Small Deliveries
  - Mixtures with Short Working Times – Rapid Set
  - Bridge Deck Repairs - Latex-modified overlays (PMC)
  - Remote Sites – Long Haul Times
- Typical Volumetric Mobile Mixers carry enough materials to produce 6 to 10 yd³ of concrete.

Volumetric Specification (Specification 604.04.B)

- TDOT Specification 604.04.B for volumetric continuous mixers
  - Equipment requirements
  - Calibration/Operation
    - Must be performed by an individual with BOTH certifications:
      - TDOT Concrete Field Testing Technician
      - VMMB Volumetric Mixer Operator
  - Aggregate moisture contents and gradations
    - Must be performed by an individual with Either Certification:
      - TDOT Plant Quality Control Technician
      - TDOT Aggregate Technician
Volumetric Notables

- Each mobile unit considered its own unique producer
- Paperwork to be kept in each mobile unit
  - Process Control Plan
  - Certified Technicians
  - Approved mix designs
  - Materials list
  - Calibration procedure
- Batch/delivery tickets must be signed by VMMB Certified Volumetric Mixer Operator
- Contractor Daily Reports are still required

Calibration and Yield

- Calibrations are done on each material to make sure proportions are correct for:
  - Cement
  - Fine aggregate
  - Coarse aggregate
  - Water
  - Admixtures
- Yield checks are used to verify precise calibration
Volumetric Concrete Video
10

Site Manager, DWR App, and LIMS Entry
Site Manager, DWR App and LIMS Entry

What You Will Learn

- Navigating the DWR App
- Sample Entry for DWR App/SiteManager
- Navigating the LIMS Windows
- Test Entry for LIMS
Two Options:
1. Samples – Start by adding the material code
2. Requirements – Start by selecting the work Item
Create Sample

- On this window you will click Create Sample

Sample Details Window

- Sample ID
- Sampled By
- Sample Type/Acceptance Method
- Represented Quantity
- **SAVE**
Vendors Window

- Producer/Supplier
- Design Type/Mix ID
- Manufacturer
- **SAVE**

Location Window

- Geographic Area – Required to send the contract to LIMS
- Sampled From – In this case we will be recording an air, slump, and temperature from the truck
### Items Window

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>604-01.01A</td>
<td>Class A, Concrete Mix</td>
<td>0.01</td>
</tr>
</tbody>
</table>

#### Notes
- All items that have the material code tied to it will be available to select in this window.
- Sample option – You will have to select an item
- Requirements option – The item is already selected

### Tests Window

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>604-01.02A</td>
<td>Class A, Concrete Mix</td>
<td>0.01</td>
</tr>
</tbody>
</table>

#### Notes
- Available test in this window will depend on the selected Destination Lab
Any notes for the sample can be added here.

You can add photos and attachments here. You can view them from this window. They will also be stored in Job Box.
Send To LIMS

- Check The Send to LIMS box – If you are missing any information it will show the needed information required to send the sample over to LIMS
- Save and Sync

Sync Message

- All information that is Synced will show here
- Errors that cause the Sync process to fail will show on this screen
LIMS

Enter Test Results Window

- Test Queue Criteria – Best option is to have (All My Lab Units) Selected
- Filter Criteria – Best option is to have (Sample ID/Contains/Your jj#) Selected. This will bring up all available samples that you created
Enter Test Results Window

- You will enter your test data on the associated test template

Enter Test Results Window

- Once you have complete your data entry you will mark the Test Completed and then SAVE
Review Test Window

- On this window you will mark review complete and then save
Status Complete

- Once all tests are completed for your sample, the window will display Complete

Questions
Appendix
Appendix

Contacts

• Regional Contacts
  • Region 1: Brad Baskette - 865-594-4552
  • Region 2: Tony Renfro - 423-510-1190
  • Region 3: Kevin Isenberg - 615-350-4312
  • Region 4: Mitch Blankenship - 731-935-0215

• HQMT Training Coordinator
  • Kim Whitby – 615-350-4158;
    Kimberly.Whitby@tn.gov
Site Manager Support Contacts

- Region 1: Weston Turner – 865-594-0751
  Weston.Turner@tn.gov
- Region 2: Jason Tays – 423-634-7511
  Jason.Tays@tn.gov
- Region 3: Marquitta Primm – 615-217-8902
  Marquitta.Primm@tn.gov
- Region 4: Andrew Webster – 731-935-0358
  Andrew.T.Webster@tn.gov
- HQ Materials and Test: Chris Hampton – 615-626-4519
  C.W.Hampton@tn.gov
- HQ Construction: Grant Heintzman – 615-741-0787
  Grant.Heintzman@tn.gov


AASHTO/ASTM Resources

- Sampling Freshly Mixed Concrete: R 60 / C172
- Temperature of Freshly Mixed Hydraulic-Cement Concrete: T 309 / C1064
- Slump of Hydraulic Cement Concrete: T 119 / C143
- Unit Weight & Yield of Concrete: T 121 / C138
- Air Content of Freshly Mixed Concrete By the Pressure Method: T 152 / C231
- Air Content of Freshly Mixed Concrete By the Volumetric Method: T 196 / C173
- Making & Curing Concrete Test Specimens in the Field: T 23 / C31
- Slump Flow of Self-Consolidating Concrete (SCC): T 347 / C1611
- Passing Ability of SCC by J-Ring: T 345 / C1621
- Fabricating Test Specimens with SCC: C1758
Resources

• Tennessee Department of Transportation
  • https://www.tn.gov/tdot.html
• American Road & Transportation Builders Association
  • https://www.artba.org/
• Tennessee Road Builders Association
  • www.trba.org/
• Tennessee Ready Mixed Concrete Association
  • www.tnconcrete.org/
• American Association of State Highway Transportation Officials
  • https://www.transporation.org
• American Society for Testing and Materials
  • https://www.astm.org/
• American Concrete Institute
  • https://www.concrete.org/
• Construction Materials Engineering Council
  • https://www.cmec.org/
• Portland Cement Association
  • www.cement.org/

Notables

• Specifications
• Concrete Delivery Ticket Information
• Contractor Daily Report
• Concrete Cylinder Report
• SOP 1-1
• SOP 4-1
• SiteManager Guides
• Batch Ticket Examples
Operations Memos

- Concrete Cylinder Acceptance
  - Date: November 16, 2016
  - Subject: Number of Cylinders
- Concrete Cylinder Acceptance
  - Date: November 14, 2017
  - Subject: Making, curing, handling of cylinders

Circular Letters

- C.L. 604.03-01
  - Date: April 1, 2009
  - Subject: Concrete Delivery Tickets
- C.L. 501.09-01
  - Date: July 1, 1992
  - Subject: Concrete Batch Tickets
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 – 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)

Concrete Pavement 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.

Structural Concrete Haul Times

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.
CONCRETE DELIVERY TICKET

Date: _________________ Ticket # _________________

Contract # _________________ County _________________ Region ______ Load # _________________

Project # _________________ Proj. Ref. # _________________

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

<table>
<thead>
<tr>
<th>ACTUAL</th>
<th>TARGET</th>
<th>TOLERANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEMENT</td>
<td>lbs.</td>
<td></td>
</tr>
<tr>
<td>FLYASH</td>
<td>F ☐ C ☐ lbs.</td>
<td></td>
</tr>
<tr>
<td>SLAG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROCK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WATER</td>
<td>gal.</td>
<td></td>
</tr>
</tbody>
</table>

*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

128
## CONTRACTOR'S DAILY REPORT OF CONCRETE INSPECTION

### Daily Inspection Report of Concrete

**Date Tested:**

**Contract No.:**

**Proj. Ref. No.:**

**Ready Mix Co.:**

**Type of Plant Mixer:**

**Transit Mixer Checked for Presence of Water Before Batching:**

**Plant and Trucks Checked (Form T-232):**

**Approved Process Control Plan:**

**Daily Stockpile Check Results:**

**W.R.A. / Retarder oz.:**

**A.E.A. oz.:**

**Remarks:**

### Screen Analysis Total Percent Passing Sieve

<table>
<thead>
<tr>
<th>Size No.</th>
<th>2&quot;</th>
<th>1 1/2&quot;</th>
<th>1&quot;</th>
<th>3/4&quot;</th>
<th>1/2&quot;</th>
<th>3/8&quot;</th>
<th>#4</th>
<th>#8</th>
<th>#200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agg. Size / Other Material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Free Moisture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSD Batch Wts.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture Corrections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual Batch Wts.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Daily Inspection Report of Concrete

**Locations Used on Project**

**Air Temp:**

**Method of Curing Cyl.:**

**Initial Load Quality Control Test Results at Ready Mix Plant**

**Cylinder No.:**

**Station Made:**

**Slump:**

**% Air:**

**Mix Temp.:**

**Age of Test:**

**Cylinder Made By:**

**Ticket Numbers**

**Additional Water Required: Roadway (Gals):**

**Remarks:**

**Reviewed by:**

**TDOT Project Supervisor or Representative**

**Date:**

---

**STATE OF TENNESSEE**

**DEPARTMENT OF TRANSPORTATION**

**DIVISION OF MATERIALS AND TESTS**

**6601 CENTENNIAL BLVD.**

**NASHVILLE, TENNESSEE 37243-0360**

**Item No(s):**

**Report No.:**

**Design No.:**

**Date:**

---

**Completed by Contractor's Concrete Plant Inspector**

---

**Completed by contractor's QC personnel from T-2A information. Use Attachment A for concrete deck pours.**

---

**Original to:**

**Headquarters Materials and Tests**

**Copies to:**

**Regional Materials and Tests**

**Project Supervisor**

**Form DT-0311 (Rev. 03-19)**

---

**129**
# Concrete Cylinder/Core Test Report

**Concrete Class**

**Unit #**

**Slump, in.** (ASTM C-143)

**Air Temp., °F**

**Concrete Temp., °F** (ASTM C-1064)

**% Air** (ASTM C-173, Volumetric)

**% Air (ASTM C-231 Pressure)**

**Unit Weight (lbs/ft\(^3\))** (ASTM C-138)

---

**Diameter (in)**

**Ave. Compressive Strength (psi)**

**Design Number**

**Design Strength**

**Concrete Class**

**Cylinder Curing Data**

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Unit #</th>
<th>Initial Curing Equipment</th>
<th>Min Temp Recorded, °F</th>
<th>Max Temp Recorded, °F</th>
<th>Date Placed in Wet Curing Environment</th>
<th>Contractor Companion Cyl Numbers</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>Cylinder No. / Core No.</th>
<th>Serial No.</th>
<th>Date Received</th>
<th>Date Tested</th>
<th>Date Reported</th>
<th>Diameter (in)</th>
<th>Cross-sectional Area ( in(^2) )</th>
<th>Maximum Load (lbf)</th>
<th>Compressive Strength (psi)</th>
<th>Ave. Compressive Strength (psi)</th>
</tr>
</thead>
</table>

**Field Test Data**

|---------------------------|----------------|----------------------------------|-----------------------------|-----------------------------|----------------------------------------|-------------------------|-----------------------------|

**FOR TDOT LAB USE ONLY ASTM C-39, every ten cylinders**

**DIA:** + =

**DIV BY 2 = AVERAGE =**

**CONDITION OF CYLINDER:**

<table>
<thead>
<tr>
<th>GOOD</th>
<th>FAIR</th>
<th>POOR</th>
</tr>
</thead>
</table>

**CONDITION OF CYLINDER:**

**COMMENTS:**

---

All cylinders will be capped & conditioned using ASTM C-1231 unless >10000 PSI

---

**Original to:**
- Headquarters Materials and Tests
- Copy to:
  - Regional Materials and Tests
  - Project Supervisor

**Approved by:**

Director of Materials and Tests

**Date:**

**Contractor: Received by:**

**Date:**

**SM Sample ID:**
**CONCRETE CYLINDER/CORE TEST REPORT**

*Information to be completed by TDOT personnel for acceptance/assurance testing & cylinders/cores*

<table>
<thead>
<tr>
<th>Reference No.</th>
<th>County</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project No.</td>
<td>Contractor Placing Concrete</td>
<td>Volume Poured this Date (m³, yd³)</td>
</tr>
<tr>
<td>Date</td>
<td>Daily Report No.</td>
<td>Date of Pour</td>
</tr>
<tr>
<td>Cement Type</td>
<td>Concrete Producer</td>
<td>Location</td>
</tr>
<tr>
<td>Cyl./Core Numbers</td>
<td>Volume Represented by Cyls/Cores (m³, yd³)</td>
<td></td>
</tr>
<tr>
<td>Design Number</td>
<td>Design Strength</td>
<td>Concrete Class</td>
</tr>
<tr>
<td>TDOT Supervisor</td>
<td>Unit #</td>
<td>Cylinder Curing Data</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Pay Quantity/Unit</th>
<th>Quantity Delivered</th>
<th>Sta. of Cyl./Core</th>
<th>Description of Pour(s):</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>Cylinder No. / Core No.</th>
<th>Slump Flow, in. (ASTM C-1611)</th>
<th>Field Test Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial No.</td>
<td>Passing Ability, in. (ASTM C-1621)</td>
<td>Concrete Temp., °F (ASTM C-1064)</td>
</tr>
<tr>
<td>Date Received</td>
<td>Concrete Temp., °F (ASTM C-1064)</td>
<td>Air Temp., °F</td>
</tr>
<tr>
<td>Date Tested</td>
<td>% Air (ASTM C-231 Pressure)</td>
<td>T-50, sec. (ASTM C-1611)</td>
</tr>
<tr>
<td>Date Reported</td>
<td>VSI (ASTM C-1611)</td>
<td>Performed by/ Cert. No.</td>
</tr>
</tbody>
</table>
| Diameter (in)            | Contractor Observer/Cert. No. |%
| Cross-sectional Area (in²) |                     |                |
| Maximum Load (lbf)       |                      |                |
| Compressive Strength (psi) |                  |                |
| Ave. Compressive Strength (psi) |                |                |

**Type of Fracture**

- Cone
- Cone and Split
- Cone and Shear
- Shear
- Columnar

Performed by

Technician Certification No.

**FOR TDOT LAB USE ONLY:**

ASTM C-39, every ten cylinders

DIA: +

DIV BY 2 = AVERAGE =

CONDITION OF CYLINDER: GOOD FAIR POOR

COMMENTS:

All cylinders will be capped & conditioned using ASTM C-1231 unless >10000 PSI

---

Original to:

Headquarters Materials and Tests

Copies to:

Regional Materials and Tests

Project Supervisor

Approved by

Director of Materials and Tests

Date

Contractor: Received by

Date

SM Sample ID

Form DT-0062 - SCC(Rev. 03-19)
<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Material</th>
<th>Test</th>
<th>Sampled By</th>
<th>Frequency</th>
<th>Location or Time of Sampling</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Plant Mix Pavements</td>
<td>Plant Mix Asphalt (Grading A, AS, ACRL, and Asphalt Treated Permeable Base)</td>
<td>Aggregate Grading AASHTO T-30 and AASHTO T-11</td>
<td>Project Inspector</td>
<td>Every 1,000 tons</td>
<td>Combined RAP and aggregate bell samples OR Sample completed mix in truck or on roadway.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thickness: Cores (Asphalt Treated Permeable Base Only)</td>
<td></td>
<td>Every 1,000 feet</td>
<td>Prior to being overfilled</td>
<td>Refer to Section 313 of the specification for tolerance guidelines.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small Quantities Visual Inspection</td>
<td></td>
<td>Not to exceed 1,000 tons of each mix type</td>
<td>Placement site</td>
<td></td>
</tr>
<tr>
<td>Asphalt Surface Treatments: Cape Sealing, Fog Sealing, Microsurfacing, Slurry Sealing, Scrub Sealing, etc.</td>
<td>Aggregate</td>
<td>Gradation and Washing Fractured Face Count Glassy Particles by mass Loss on Ignition</td>
<td>Project Inspector or M&amp;T</td>
<td>Every 500 tons for each aggregate size</td>
<td>At source or project site prior to incorporating into work</td>
<td>Plus No. 4 (4.75 mm) sieve material, gravel mixes only.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Per project</td>
<td>Plus No. 4 (4.75 mm) sieve material, slag mixes only.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>From stockpiled materials</td>
<td>If blended aggregate, then after blending.</td>
<td></td>
</tr>
</tbody>
</table>

**CONCRETE**

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Material</th>
<th>Test</th>
<th>Sampled By</th>
<th>Frequency</th>
<th>Location or Time of Sampling</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Prestressed, &amp; Precast</td>
<td>Non-Critical Structures</td>
<td>Cylinders (28-day), Cylinders (28-day), Slump, Air Content, Mix Temperature</td>
<td>Project Inspector</td>
<td>Every 25 cubic yards or less weekly</td>
<td>Placement site</td>
<td>Refer to Standard Specification 604.03.</td>
</tr>
<tr>
<td>Class A, A Paving, S, X</td>
<td></td>
<td>Complete set of tests shall be performed on the initial load for informational purposes, not for acceptance.</td>
<td></td>
<td>Every 100 cubic yards placed per day per structure unless otherwise specified (i.e. Class X)</td>
<td>Test first three loads and every 50 cubic yards thereafter per day per structure</td>
<td></td>
</tr>
<tr>
<td>Class CP</td>
<td></td>
<td></td>
<td></td>
<td>Every 400 cubic yards placed per day</td>
<td>Test first three loads and every 50 cubic yards thereafter per day per structure</td>
<td></td>
</tr>
<tr>
<td>Class D, D, L</td>
<td></td>
<td>Cylinders (28-day), Slump, Air Content, Mix Temperature</td>
<td></td>
<td>One pair of cylinders shall be cast from one of the first three passing loads.</td>
<td>One pair of cylinders shall be cast from one of the first three passing loads.</td>
<td></td>
</tr>
<tr>
<td>Class SCC, SH-SCC</td>
<td></td>
<td>Cylinders (28-day), Slumpflow, Air Content, Mix Temperature, Passing Ability by J-Ring, VSI, &amp; T-90</td>
<td></td>
<td>Beginning, middle, and end of the pour</td>
<td>One pair of cylinders shall be cast from one of the first three passing loads.</td>
<td>Determine depth measurement per Standard Specification 501.24.</td>
</tr>
<tr>
<td>Closure Pour Mix</td>
<td></td>
<td>Cylinders (28-day)</td>
<td></td>
<td>Beginning, middle, and end of the pour</td>
<td>Refer to SOP 4-1 for acceptance of concrete for bridge decks.</td>
<td></td>
</tr>
<tr>
<td>Structural Grout</td>
<td></td>
<td></td>
<td></td>
<td>Beginning, middle, and end of the pour</td>
<td>Refer to SOP 4-1 for acceptance of concrete for bridge decks.</td>
<td></td>
</tr>
<tr>
<td>Pre-packaged Mix</td>
<td></td>
<td></td>
<td></td>
<td>Beginning, middle, and end of the pour</td>
<td>Refer to SOP 4-1 for acceptance of concrete for bridge decks.</td>
<td></td>
</tr>
<tr>
<td>Flowable Fill</td>
<td></td>
<td>Slump, Mix Temperature, &amp; Cylinders (28-day)</td>
<td></td>
<td>Every 100 cubic yards placed per day per use</td>
<td>Cylinders required for excavatable only.</td>
<td>Use limited to 2 cubic yards per day.</td>
</tr>
<tr>
<td>Prestressed Completed Mix</td>
<td></td>
<td>Slump, Air Content, Mix Temperature M&amp;T or Contractor monitored by TDOT personnel</td>
<td></td>
<td>Per pour</td>
<td>Prestress plant</td>
<td>Perform additional tests when slump change is apparent or as directed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylinders (28-day) for Beams T-30</td>
<td></td>
<td>Beginning, middle and end of the bed</td>
<td>One pair of backup cylinders shall be made.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylinders (28-day) for Panels/Piling</td>
<td></td>
<td>Beginning and end of the pour</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylinders (28-day) for Piling</td>
<td></td>
<td>As needed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prestressed Products</td>
<td></td>
<td>Visual Inspection M&amp;T</td>
<td></td>
<td>After casting and before shipment</td>
<td></td>
<td>Refer to SOP 5-4.</td>
</tr>
<tr>
<td>Precast Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Each item shall be inspected after delivery to the project for cracks, spills and/or appearance by project personnel prior to incorporating product into the project.</td>
</tr>
</tbody>
</table>

Acceptance by Certification in accordance with SOP 5-3
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.*
To: Regional Materials & Tests, Regional Operations
From: HQ Materials & Tests, HQ Construction
Date: November 16, 2016
Subject: Concrete Cylinder Acceptance

Effective immediately, concrete strength acceptance testing will be performed utilizing (2) 4”x8” concrete cylinders for all classes of concrete except Class CP on all contracts. Class CP concrete will continue using (2) 6”x12” cylinders. These requirements are outlined in SOP 1-1: Procedures for the Sampling and Testing, and Acceptance of Materials and Products. Prior to this update, we were requiring the submittal of (3) cylinders when the 4”x8” were utilized.

It is imperative that proper procedures are followed during the making, curing, handling, and transporting of cylinders. It is the responsibility of the Contractor to provide proper storage and handling of the concrete cylinders. It is the responsibility of the Project Supervisor to emphasize to the contractor at the pre-construction meeting, pre-pour meeting and the day of the pour the importance of having proper curing equipment (i.e. curing box) on the project site for the concrete cylinders. The Project Supervisor is responsible for ensuring that proper storage is on-site prior to any concrete being placed on the project site. The Department will have the only keys to the storage facility and will control access at all times. Early break cylinders may be stored in the secured curing box if granted access by the Department personnel assigned to the security of the storage area. At no time shall the Contractor have keys to the storage facility.

Immediately after making the concrete cylinders they shall be kept in a controlled temperature environment between 60°F - 80°F for up to 48 hours. If a curing box is used for initial curing, the temperature shall be maintained especially during hot weather concreting. Initial curing of acceptance cylinders should be discussed during the pre-pour conference. Acceptance cylinders shall be picked up from the project site and delivered to a location for final (wet) curing where the cylinders will be stored in an environment with free water maintained on the surface at all times at a temperature of 73.5°F ± 3.5°F until time of test. Cylinders shall be transported to Headquarters Materials and Tests Laboratory for acceptance testing as soon as possible but within 21 days. Form DT 0062 Concrete Cylinder Test Report shall be filled out in its entirety including the “Date Placed in the Wet Curing Environment”.

Please review and advise personnel of these procedures.
STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
MATERIALS & TESTS DIVISION
6601 CENTENNIAL BOULEVARD
NASHVILLE, TENNESSEE 37243-0360
(615) 350-4100

JOHN C. SCHROER
COMMISSIONER

BILL HASLAM
GOVERNOR

To: Regional Operations Staff
Regional Materials & Tests

From: Lori Lange, PE, Construction Division Director
Brian Egan, PE, Materials and Tests Division Director

Date: November 14, 2017

Subject: Concrete Cylinder Acceptance

In light of the vast amount of staff changes and the implementation of newer field personnel to our construction projects, this memo is being sent as a reminder of the proper procedures for concrete cylinder acceptance. There have been several observations recently of unacceptable curing practices and it is essential to bring attention to the proper procedures for the curing and handling of the concrete cylinders.

It is imperative that proper procedures are followed during the making, curing, handling, and transporting of cylinders. If any of these processes are done incorrectly, the strength of the cylinders will be affected and unnecessary price adjustments may be assessed. It is the responsibility of certified TDOT staff to sample and test concrete as stated in SOP 1-1 (temperature, slump/flow, air content, strength) and to properly make and cure acceptance cylinders as stated in the applicable AASHTO Standards. It is the responsibility of the Contractor to provide proper storage on site for the curing of the concrete cylinders (§501.03, 604.03, and 722.09 of the TDOT Standard Specifications).

It is the responsibility of the District Operations Staff to emphasize to the contractor at the pre-construction meeting, pre-pour meeting and the day of the pour the importance of having proper curing equipment (i.e. curing box) on the project site for the concrete cylinders. The Project Supervisor is responsible for ensuring that proper curing and storage facilities are on-site prior to any concrete being placed on the project site. In order to maintain the proper “Chain of Custody”, TDOT is to have the only keys to the storage facility and will control access at all times. Contractor provided early break cylinders are allowed to be stored in the secured curing box if Department personnel provide access. At no time shall the Contractor have keys to the storage facility.

Immediately after making the concrete cylinders, they shall be kept in a controlled temperature environment between 60°-80°F for up to 48 hours and not in direct sunlight. If a curing box is used for initial curing, the temperature shall be maintained especially during hot weather concreting. Initial curing
of acceptance cylinders should be discussed during the pre-pour conference. Acceptance cylinders shall be picked up from the project site and delivered to a location for final (wet) curing where the cylinders will be stored in an environment with free water maintained on the surface at all times at a temperature of 73.5° ± 3.5° F until time of testing. Cylinders shall be transported to Headquarters Materials and Tests Laboratory for acceptance testing as soon as possible but within 21 days. Form DT 0062, "Concrete Cylinder Test Report", shall be filled out in its entirety including the "Date Placed in the Wet Curing Environment".

Please refer your staff to the "Construction Division Job Box ", Construction Guide, Chapter 6, Structures, page 6-38 for the short video on the making and curing of concrete cylinders and emphasize the importance of making and curing cylinders properly (AASHTO T-23).

The photo above, from a TDOT project, shows that the cylinders are not made on a level platform; some cylinders are capped to prevent moisture loss while others are not; the cylinders are not protected from direct sunlight, and the proper curing equipment and storage area are not present.

REFERENCES:

Section 501.03B: "Provide cylinder molds, a wheelbarrow, and a level site to perform testing and for initial curing. Provide a secure storage shed/building for temporary storage of concrete acceptance cylinders as specified in 722.09."

Section 604.03: "Meet the requirements of 501.03.B."

Section 722.09: "Provide a storage shed/building for temporary storage of concrete acceptance cylinders. The storage facility shall be of sufficient size and construction to protect the concrete cylinders from the elements and damage. Obtain the Engineer's approval of the storage facility location. Department personnel will control access to the storage shed/building. Equip the storage shed with a concrete curing box or water curing tank with a heating/circulating system of sufficient size to properly cure all acceptance cylinders before transferring for final storage and testing. The curing box or curing tank and heater/circulator shall comply with AASHTO M 201, and proper curing of the cylinders shall be in accordance with AASHTO T 23."
Initial Curing—Immediately after molding and finishing, the specimens shall be stored for a period up to 48 h in a temperature range from 16 to 27°C (60 to 80°F) in an environment preventing moisture loss from the specimens. For concrete mixtures with a specified strength of 40 MPa (6000 psi) or greater, the initial curing temperature shall be between 20 and 26°C (68 and 78°F). Various procedures are capable of being used during the initial curing period to maintain the specified moisture and temperature conditions. An appropriate procedure or combination of procedures shall be used (Note 8). Shield all specimens from direct sunlight and, if used, radiant heating devices. The storage temperature shall be controlled by the use of heating and cooling devices, as necessary. Record the temperature using a maximum-minimum thermometer. If cardboard molds are used, protect the outside surface of the molds from contact with wet burlap or other sources of water.

Note 8—A satisfactory moisture environment can be created during the initial curing of the specimens by one or more of the following procedures: (1) immediately immerse molded specimens with plastic lids in water saturated with calcium hydroxide; (2) store in properly constructed wood boxes or structures; (3) place in damp sand pits; (4) cover with removable plastic lids; (5) place inside plastic bags; or (6) cover with plastic sheets or nonabsorbent plates if provisions are made to avoid drying and damp burlap is used inside the enclosure, but the burlap is prevented from contacting the concrete surfaces. A satisfactory temperature environment can be controlled during the initial curing of the specimens by one or more of the following procedures: (1) use of ventilation, (2) use of ice, (3) use of thermostatically controlled heating or cooling devices, or (4) use of heating methods such as stoves or lightbulbs. Other suitable methods may be used if the requirements limiting specimen storage temperature and moisture loss are met. For concrete mixtures with a specified strength of 40 MPa (6000 psi) or greater, heat generated during the early ages may raise the temperature above the required storage temperature. When specimens are to be immersed in water saturated with calcium hydroxide, specimens in cardboard molds or other molds that expand when immersed in water should not be used. Early-age strength test results may be lower when stored at 16°C (60°F) and higher when stored at 27°C (80°F). On the other hand, at later ages, test results may be lower for higher initial storage temperatures.
CIRCULAR LETTER

SECTION: 604.03 CLASSIFICATION, PROPORTIONING AND QUALITY ASSURANCE OF CONCRETE
NUMBER: 604.03-01
SUBJECT: CONCRETE DELIVERY TICKETS
DATE: APRIL 1, 2009

When concrete is delivered to a project, it is the TDOT Inspector’s responsibility to verify that the concrete delivery ticket includes the information specified in Section 604 of the Standard Specifications and/or Section 600 of the Supplemental Specifications.

The inspector should also verify the Batch Time and note the Discharge Time on the ticket. He/she should sign the ticket and keep a copy for the project records.
CIRCULAR LETTER

SECTION: 501.09 HANDLING, MEASURING AND BATCHING MATERIAL
NUMBER: 501.09-01
SUBJECT: CONCRETE BATCH TICKETS
DATE: JULY 1, 1992

The following is a suggested method for arriving at water calculations and proper recording of mixing revolutions:

Max. Water (Design) – This quantity represents the total amount of water that may be added at any time to the mix and still not exceed the water-cement ratio. For instance, if your concrete design indicates a mix based on 33 gal. per C.Y. with an additional 2.5 gal. per C.Y. noted under remarks, the Max. Water (Design) would be (33+2.5) 35.5 gal. per C.Y. times the number of C.Y. batched.

Total Water (Plant) – This quantity represents the amount of water metered into the mix plus whatever quantity was present in the aggregates indicated by your moisture tests. For instance, if the free moisture in the fine and coarse aggregate is 16 gals. and the amount of water metered is 246 gals., the Total Water (Plant) would equal 262 gals.

The difference in the above two quantities indicates to the roadway inspector the amount of water that may be added at the job site. The actual quantity added must be shown under Water Added (Project) even if the quantity is zero.

Mixing revolutions at the plant and job site are to be recorded. The mixing revolutions are to be witnessed by the inspector and noted on the tickets for all concrete. Trucks with revolution counters inoperable are not to be used.
# Concrete Mixture Design Report

**Parameters:**
- Contract ID:
- Mix ID:

## Materials and Producers

<table>
<thead>
<tr>
<th>Cementitious Materials</th>
<th>Cements</th>
<th>Type Domestic (Type I)</th>
<th>G = 3.15</th>
<th>CEMEX - KNOXVILLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>supplementary CM</td>
<td>Fly Ash Class F</td>
<td>G = 2.55</td>
<td>SEFA GROUP - CUMBERLAND CITY FOSSIL PLANT</td>
</tr>
<tr>
<td></td>
<td>supplementary CM</td>
<td>GGBFS, Grade</td>
<td>G =</td>
<td>KNOXVILLE, TN</td>
</tr>
<tr>
<td></td>
<td>supplementary CM</td>
<td>Silica Fume</td>
<td>G =</td>
<td>CUMBERLAND CITY, TN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aggregate</th>
<th>Coarse</th>
<th>Crush Stone #57</th>
<th>G = 2.73</th>
<th>VULCAN MATERIALS - NEWPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Manufactured Sand (FM = 2.97)</td>
<td>G = 2.74</td>
<td>VULCAN MATERIALS - MORRISTOWN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Natural Sand (FM = 0.00)</td>
<td>G =</td>
<td>MORRISTOWN, TN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemical Admixtures BASF</th>
<th>1. Air Entrainer</th>
<th>MasterAir AE 200 (Micro-Air)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Reducer</td>
<td>Master Polyheed 900 or Polyheed 900</td>
</tr>
<tr>
<td></td>
<td>3. Reducer/Retarder</td>
<td>Retarder to be used when temperature is 85 degrees F or higher.</td>
</tr>
<tr>
<td></td>
<td>4. Accelerator</td>
<td>Admixture dosage shall be in accordance with manufacturer's recommendations.</td>
</tr>
<tr>
<td></td>
<td>5. High Range Reducer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Other</td>
<td></td>
</tr>
</tbody>
</table>

### Mix Design Data

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Class A, Concrete Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEMENT</td>
<td>145.7</td>
</tr>
<tr>
<td>FLY ASH</td>
<td>423</td>
</tr>
<tr>
<td>GGBFS</td>
<td>141</td>
</tr>
<tr>
<td>SILICA FUME</td>
<td>1794</td>
</tr>
<tr>
<td>CRUSH STONE #57</td>
<td>1322</td>
</tr>
<tr>
<td>NATURAL SAND</td>
<td>254</td>
</tr>
<tr>
<td>MANUFACTURED SAND</td>
<td>1.2</td>
</tr>
</tbody>
</table>

**Remarks:**

Design as specified in TDOT Sections 501, 604, 615, 616, 701, 702, 703, 711, or as applicable. Manufactured sand shall not be used in riding surfaces. Mix designs will expire at the end of the calendar year.

Issued By: Headquarters (Materials & Tests)
<table>
<thead>
<tr>
<th>Material</th>
<th>Design Qty</th>
<th>Required</th>
<th>Batched</th>
<th>Var</th>
<th>Moisture</th>
<th>Actual Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATERGL</td>
<td>30.0 oz</td>
<td>23.0 oz</td>
<td>23.0 oz</td>
<td>0.00%</td>
<td>8.00%</td>
<td>23.0 oz</td>
</tr>
<tr>
<td>CEMENT</td>
<td>56.0 lb</td>
<td>3165.0 lb</td>
<td>3155.0 lb</td>
<td>-1.0%</td>
<td>7.00% N</td>
<td>3155.0 lb</td>
</tr>
<tr>
<td>FLUID</td>
<td>14.0 lb</td>
<td>967.0 lb</td>
<td>967.0 lb</td>
<td>0.00%</td>
<td>0.00%</td>
<td>967.0 lb</td>
</tr>
<tr>
<td>POLYMIX</td>
<td>34.0 oz</td>
<td>23.0 oz</td>
<td>23.0 oz</td>
<td>-1.0%</td>
<td>7.00%</td>
<td>23.0 oz</td>
</tr>
<tr>
<td>KOZITE</td>
<td>177 lb</td>
<td>122 lb</td>
<td>122 lb</td>
<td>0.15%</td>
<td>0.20%</td>
<td>122 lb</td>
</tr>
<tr>
<td>AGGREGATE</td>
<td>1220 lb</td>
<td>930 lb</td>
<td>930 lb</td>
<td>0.15%</td>
<td>0.20%</td>
<td>930 lb</td>
</tr>
</tbody>
</table>

Actual Mix

Load Total: 2587 lb  Design 210.0 gal  Actual 258.7 gal  To Add: 0.0 gal
Slump: 4.00 in  Water in Trucks: 0.0 gal  Adjust Water: 0.0 gal  Load Trim Water: 7.0 gal/ CY

Cy # S-A
Slump 3.5
C Temp 68°
Air Temp 50°
% Air 6.0%
<table>
<thead>
<tr>
<th>Material</th>
<th>Design Qty</th>
<th>Required</th>
<th>Batched</th>
<th>% Var</th>
<th>% Moisture</th>
<th>Actual Wt</th>
</tr>
</thead>
<tbody>
<tr>
<td>W/HSTONE</td>
<td>1798 lb</td>
<td>16194 lb</td>
<td>16140 lb</td>
<td>-0.34%</td>
<td>0.12%</td>
<td>6 gl</td>
</tr>
<tr>
<td>NW/SAND</td>
<td>1232 lb</td>
<td>1232 lb</td>
<td>1232 lb</td>
<td>0.0%</td>
<td>0.0%</td>
<td>85 gl</td>
</tr>
<tr>
<td>CEMENT</td>
<td>356.6 lb</td>
<td>4120 lb</td>
<td>4120 lb</td>
<td>-0.35%</td>
<td>-0.35%</td>
<td>187.8 gl</td>
</tr>
<tr>
<td>FLYASH</td>
<td>141.0 lb</td>
<td>1232 lb</td>
<td>1232 lb</td>
<td>-0.32%</td>
<td>-0.32%</td>
<td>187.8 gl</td>
</tr>
<tr>
<td>AIR</td>
<td>16.00 oz</td>
<td>16.00 oz</td>
<td>16.00 oz</td>
<td>0.0%</td>
<td>0.0%</td>
<td>187.8 gl</td>
</tr>
<tr>
<td>POLYMERD</td>
<td>34.00 oz</td>
<td>365.00 oz</td>
<td>365.00 oz</td>
<td>0.0%</td>
<td>0.0%</td>
<td>187.8 gl</td>
</tr>
<tr>
<td>WATERED</td>
<td>30.00 gal</td>
<td>187.7 gal</td>
<td>187.7 gal</td>
<td>-0.33%</td>
<td>-0.33%</td>
<td>187.8 gl</td>
</tr>
</tbody>
</table>

Actual Num Batches: 1  
Load Totals: 3579 g | Design 0.148 Water/Cement: 0.431 A | Design 270.0 g Load | Actual 279.3 g To Add: 0.0 g | Slump: 4 in | Water in Truck: 0.0 gal | Adjust Water: 0.0 gal | Load Trim Water: 1.0 gal/CT

<p>| Slump - 4&quot; | Air - 7.8% |
| STA - 351+33 | Conc Temp - 68° |
| Air Temp - 48° | in - 1:10 |
| out 1:15 |</p>
<table>
<thead>
<tr>
<th>Material</th>
<th>Design Qty</th>
<th>Required</th>
<th>Batched</th>
<th>% Var</th>
<th>% Moisture</th>
<th>Actual Wet</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATERFILL</td>
<td>196 lb</td>
<td>1653 lb</td>
<td>1653 lb</td>
<td>-0.2%</td>
<td>0.086%</td>
<td>10 gal</td>
</tr>
<tr>
<td>RECLAIMED</td>
<td>123 lb</td>
<td>123 lb</td>
<td>127 lb</td>
<td>-3.0%</td>
<td>0.000%</td>
<td>10 gal</td>
</tr>
<tr>
<td>CEMENT</td>
<td>426.5 lb</td>
<td>426.5 lb</td>
<td>426.5 lb</td>
<td>0.0%</td>
<td>0.000%</td>
<td>10 gal</td>
</tr>
<tr>
<td>FLUSH</td>
<td>144.0 lb</td>
<td>125.5 lb</td>
<td>125.5 lb</td>
<td>-13.6%</td>
<td>0.000%</td>
<td>10 gal</td>
</tr>
<tr>
<td>AIR</td>
<td>5.28 oz</td>
<td>5.28 oz</td>
<td>5.28 oz</td>
<td>0.0%</td>
<td>0.000%</td>
<td>10 gal</td>
</tr>
<tr>
<td>POLYMER</td>
<td>3.00 oz</td>
<td>3.00 oz</td>
<td>3.00 oz</td>
<td>0.0%</td>
<td>0.000%</td>
<td>10 gal</td>
</tr>
<tr>
<td>WATER</td>
<td>36.0 gl</td>
<td>129.3 gl</td>
<td>129.3 gl</td>
<td>-71.7%</td>
<td>0.000%</td>
<td>155.0 gl</td>
</tr>
</tbody>
</table>

Actual Mix Design: 35636 lb

Design: 270.0 gl 8.418 Water/Cement 0.431 A

Actual: 277.9 gl

To Add: 8.0 gl

Slump: 4.0 in

Water in Truck: 0.0 gl

Adjust Water: 0.0 gl

Load Trim Water: 1.6 gl/CY

39-A

STA-351+33

Slump - 4" Air Cont. 7.1%

Concrete Temp - 74°F Air Temp - 56°F

in - 8:30 out - 9:12
<table>
<thead>
<tr>
<th>Material</th>
<th>Design Qty</th>
<th>Required</th>
<th>Batched</th>
<th>% Var</th>
<th>% humidity</th>
<th>Actual Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER</td>
<td>1574 lb</td>
<td>16227 lb</td>
<td>16140 lb</td>
<td>-0.52%</td>
<td>0.50%</td>
<td>10 gal</td>
</tr>
<tr>
<td>CEMENT</td>
<td>1250 lb</td>
<td>1280 lb</td>
<td>1294 lb</td>
<td>-1.08%</td>
<td>8.00%</td>
<td>114 gal</td>
</tr>
<tr>
<td>FLUID</td>
<td>455.0 lb</td>
<td>4152.0 lb</td>
<td>4063.0 lb</td>
<td>-1.58%</td>
<td>1.85%</td>
<td>135.0 gal</td>
</tr>
<tr>
<td>AIR</td>
<td>5.00 oz</td>
<td>54.00 oz</td>
<td>55.00 oz</td>
<td>1.85%</td>
<td>1.85%</td>
<td>135.0 gal</td>
</tr>
<tr>
<td>POL MIXED</td>
<td>34.00 oz</td>
<td>266.00 oz</td>
<td>210.00 oz</td>
<td>-21.3%</td>
<td>1.25%</td>
<td>135.0 gal</td>
</tr>
</tbody>
</table>

Actual Mix Batches: 1

Load Total: 35621 lb  Design 0.418 Water/Cement 0.437 A  Design 270.0 gal  Actual 278.6 gal To Add: 0.0 gal

Slump: 4.00 in  Water in Truck: 0.0 gal  Adjust Water: 0.0 gal / Load Trim Water: 1.0 gal / Cy

ln - 8:50
out - 9:30
<table>
<thead>
<tr>
<th>Material</th>
<th>Design Qty</th>
<th>Required</th>
<th>Batched</th>
<th>% Var</th>
<th>% Moisture</th>
<th>Actual Wat</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEMENT</td>
<td>450.0 lb</td>
<td>1374.0 lb</td>
<td>1045.0 lb</td>
<td>+2.5%</td>
<td>0.58%</td>
<td>3.0 gl</td>
</tr>
<tr>
<td>FLYASH</td>
<td>141.0 lb</td>
<td>423.0 lb</td>
<td>445.0 lb</td>
<td>+5.2%</td>
<td>0.00%</td>
<td>38.0 gl</td>
</tr>
<tr>
<td>AIR</td>
<td>5.00 oz</td>
<td>15.00 oz</td>
<td>17.00 oz</td>
<td>-5.5%</td>
<td>0.00%</td>
<td>2.94 gl</td>
</tr>
<tr>
<td>POLYMERED</td>
<td>34.00 oz</td>
<td>182.00 oz</td>
<td>185.00 oz</td>
<td>+1.6%</td>
<td>0.00%</td>
<td>51.0 gl</td>
</tr>
<tr>
<td>WETMIX</td>
<td>38.0 gl</td>
<td>51.6 gl</td>
<td>51.0 gl</td>
<td>-1.46%</td>
<td>0.00%</td>
<td></td>
</tr>
</tbody>
</table>

**Actual**
- Num Batches: 1
- Load Total: 11963 lb
- Design 0.418 Water/Cement 0.415 A
- Design 90.0 gl
- Actual 92.0 gl
- To Add: 0.0 gl
- Slump: 4.00 in
- Water in Truck: 0.0 gl
- Adjust Water: 0.0 gl
- Trim Waters: 1.0 gl

\[ \text{in} - 9:15 \]
\[ \text{out} - 10:00 \]