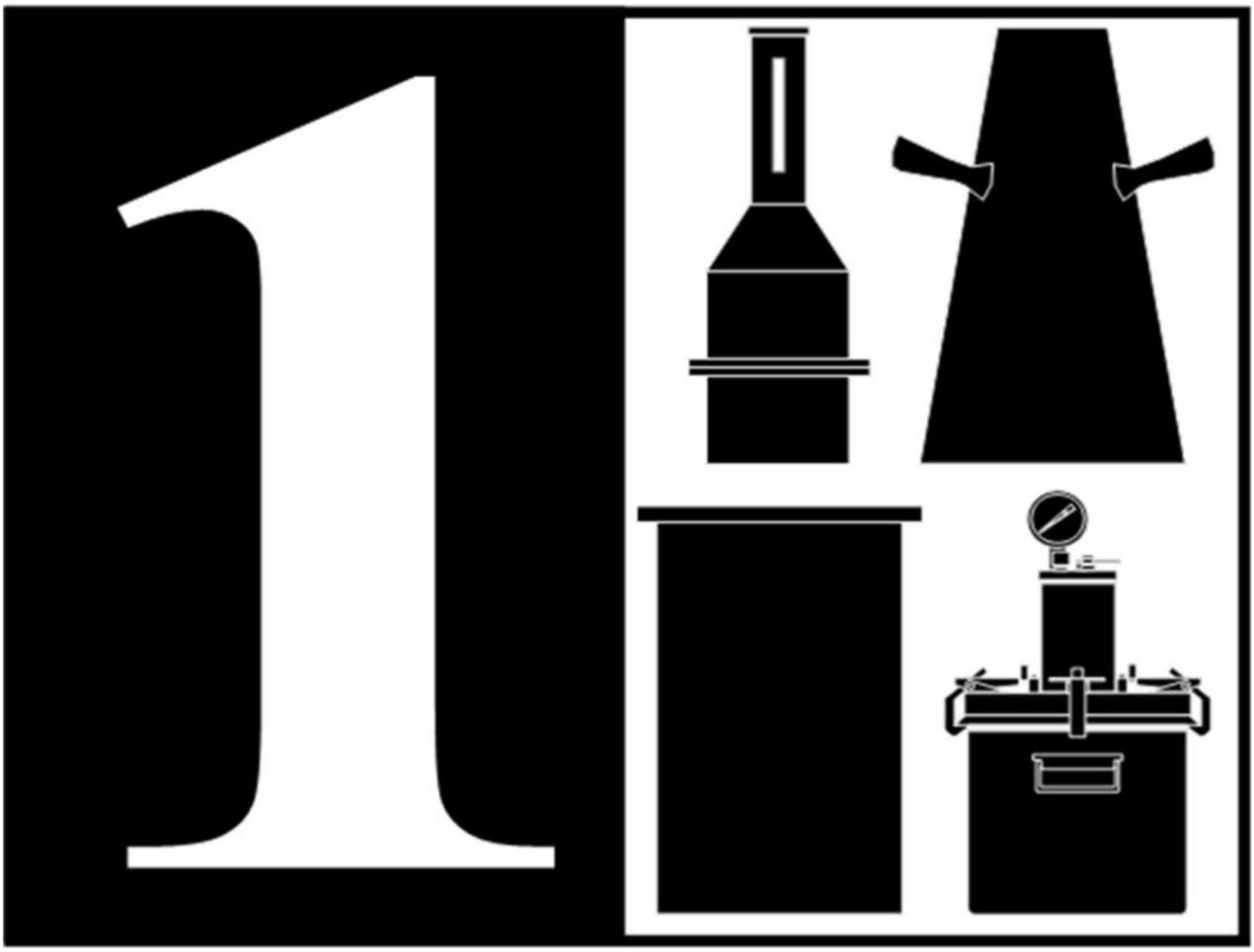
TN TDOT Department of Transportation



Concrete Field Testing Technician

Recertification Course

Tennessee Department of Transportation

2020 Manual

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TN TDOT Department of Transportation

WELCOME!

Concrete Field Testing Technician Recertification Course

Classroom Rules

- Be Respectful
- Facility Information
- Keep It Clean
- Phone Etiquette

TN

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

- Course schedule
  - Review test methods
  - Self-Consolidating Concrete
  - TDOT Specifications / Forms
  - Examination
    - Written exam (No Phones Allowed)
      - Open-book
      - Must get 75% overall
    - Performance exam at a later date (Pass/Fail)
  - Results
- Recertification - Every 5 years

Resources

- Course materials
  - Course textbook
  - Presentation slides and videos
- TDOT
  - Standard Specifications, January 1, 2015
  - Special Provisions
  - HQMT website: https://www.tn.gov/tdot/materials-and-tests.html

ADA Notice of Requirements

- Can be found at the following website:
  - https://www.tn.gov/tdot/government/g/public-accessibility-office/ada.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

1

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

Sampling

- Obtaining a representative sample from a revolving drum truck
  - Sample the concrete at two or more regularly-spaced intervals during discharge of the middle portion of the batch
  - No sample shall be taken before 10% or after 90% of the batch has been discharged
  - Pass the receptacle through the entire discharge stream or completely divert the discharge into the sample container
- When sampling from a paving mixer, obtain at least 5 different portions then combine into one sample

TN

Sampling

- Transport the sample to testing location
- Remix to form the composite sample
- Obtain the composite sample within 15 minutes
- Protect the sample against rapid evaporation and contamination
- Ensure that an accurate representation of the concrete in the truck is obtained

Sampling

- Start the tests for slump, temperature, and air content within 5 minutes after obtaining the final portion of the composite sample
- Start molding cylinders within 15 minutes after fabricating the composite sample
  - Minimum of 1 ft^3 required for making cylinders

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?

TN

2

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

Temperature

- At least 3" of cover in all directions around the tip of the thermometer

OR

- Cover at least 3 times the nominal maximum size of the coarse aggregate

Temperature

- Use an approved thermometer accurate to ±1°F
- Calibrate thermometers once a year or whenever there is a question of accuracy
- Concrete temperature at point of discharge shall not be greater than 90°F

Temperature

- Gently press concrete around the thermometer.
- 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 1ºF.

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?

TN

3

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

Slump

- Applicable when coarse aggregate passes 1 ½" sieve
- Dampen the cone and the floor base plate
- Hold the cone firmly against the base by standing on the two foot pieces or locking onto the baseplate
- Fill the cone in three layers equal by volume

Slump

- Rod each layer 25 times, distributing the strokes uniformly over the cross section of each layer
- Rod the second and third layers to penetrate into the underlying layer approximately 1”
- Strike off concrete level with top of cone using the tamping rod

Slump

- Lift the cone upward 12" in one smooth motion, without twisting the cone, in 5±2 seconds
- Immediately measure the vertical distance from the top of the cone to the displaced original center, also known as slump, to the nearest ¼"
  - If the concrete shears or collapses, disregard and repeat the test on another portion of the sample
- Perform the test from start to finish within 2 ½ minutes

Table 604.03-2
Use of Chemical Admixtures

Table 604.03-2 : Use of Chemical Admixtures

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

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

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 _____.

4

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

Unit Weight

Nominal Maximum Size of Coarse Aggregate (in.)	Minimum Capacity of Measure (ft^3)
1	0.2
1 ½	0.4
2	0.5

ASTM C138: Table 1

Unit Weight

- Determine the weight of the empty container
- Fill the container in three equal layers
- Rod each layer with the tamping rod 25 times
- Rod the bottom layer throughout its depth, without forcibly striking the container
- Rod the middle and top layers so that the strokes penetrate the previous layer by approximately 1”

Unit Weight

- Distribute the strokes uniformly for each layer
- After rodding each layer, tap the sides of the container smartly 10 - 15 times with the mallet
- Strike off the concrete to a smooth surface with the flat **strike-off plate**
- Clean off all excess concrete and determine the weight of the full container

Unit Weight

- Calculate concrete weight
  - Concrete Weight = Full Weight - Empty Weight
- Calculate the mass per cubic foot of freshly mixed concrete also called unit weight (lbs/ft^3)
  - Unit Weight = Concrete Weight / Container Volume

Yield Calculations

- Yield (Y)

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

W_{Load} = total weight of load
D = Unit Weight
27 = convert units ft^3 to yd^3

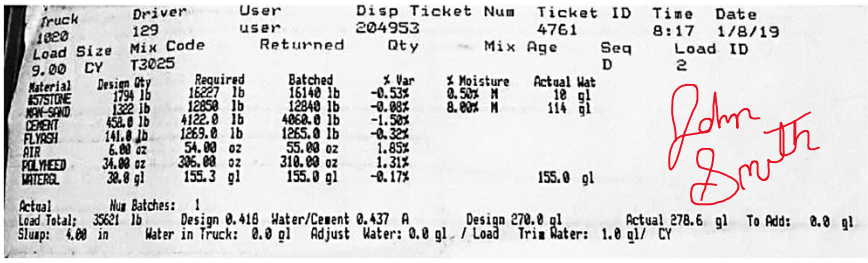
Delivery Tickets

- Contains weight of materials
- Form DT-1756 or equivalent
- 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



Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1020	129	user	204953	4761	8:17	1/8/19

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
9.00 CY	T3025				D	2

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
#57STONE	1794 lb	16227 lb	16140 lb	-0.53%	0.50% M	10 gl
MAN-SAND	1322 lb	12850 lb	12840 lb	-0.08%	8.00% M	114 gl
CEMENT	458.0 lb	4122.0 lb	4060.0 lb	-1.50%		
FLYASH	141.0 lb	1269.0 lb	1265.0 lb	-0.32%		
AIR	6.00 oz	54.00 oz	55.00 oz	1.85%		
POLYHEED	34.00 oz	306.00 oz	310.00 oz	1.31%		
WATERGL	38.0 gl	155.3 gl	155.0 gl	-0.17%		155.0 gl

Actual Num Batches: 1
Load Total: 35621 lb Design 0.418 Water/Cement 0.437 A Design 270.0 gl Actual 278.6 gl To Add: 0.0 gl
Slump: 4.00 in Water in Truck: 0.0 gl Adjust Water: 0.0 gl / Load Trim Water: 1.0 gl/ CY

John Smith

- 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

Let's Review

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

Solution

- $M_{Concrete} = M_{Measure+Concrete} - M_{Measure} =$
- $Unit\ Weight\ (D) = \frac{M_{Concrete}}{V_{Measure}} =$
- $Y_{Concrete}(yd^3) = \frac{W\ Load}{(D \times 27)} =$
- $R_y = \frac{Y}{Y_d} =$

5

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

Air Content – Pressure Method

- Not to be used for lightweight concrete
- Select a representative sample
- Fill container in three equal layers, slightly overfilling the last layer
- Rod each layer 25 times, uniformly distributing strokes
- Rod the bottom layer throughout its depth without forcibly striking the bottom of the container

Air Content – Pressure Method

- Rod the middle and top layers penetrating about 1“ into the underlying layer
- After rodding each layer, tap the sides of the measure smartly 10 - 15 times with the mallet
- Strike off the concrete level with the top of the container using the bar and clean off the rim
- Dampen inside of meter before clamping to base

TN

Air Content – Pressure Method

- Open both petcocks
- Close air valve between air chamber and bowl
- Inject water through one petcock until only water flows out the other petcock
- Continue injecting water into petcock while jarring and tapping the meter to insure that all air is expelled

TN

Air Content – Pressure Method

- Close the air bleeder valve and pump air up to initial pressure line
- Adjust the gauge to the initial pressure by pumping and bleeding as necessary and tapping the gage lightly
- Close both petcocks

Air Content – Pressure Method

- Open the air valve between the chamber and bowl and simultaneously tap the sides of the bowl sharply with the mallet
- Read the air percentage to the nearest 0.1% after lightly tapping the gauge to stabilize the hand
- Close the air valve then open petcocks to release pressure before removing cover

Table 604.03-1
Composition of Various Classes of Concrete

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

(1) For slip forming, the slump shall range from 0 to 3 inches.
(2) Use Class DS concrete in riding surfaces as described in 903.03 and in accordance to Specification 903.24 requirements. Use Class D concrete in all other bridge decks except box and slab type structures unless otherwise shown on the Plans.
(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.
(4) Water reducing admixtures are acceptable; however, do not exceed the maximum water/cement ratio in order to achieve the required slump.
(5) The unit weight of air dried Class L concrete (lightweight concrete) shall not exceed 115 pounds per cubic foot as determined according to ASTM C567.
(6) The use of fly ash as a cement replacement will be allowed in Class S (Seal) concrete.
(7) Plan specific requirements

TN

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 _____.

TN

6

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

Air Content – Volumetric Method

- Can be used on any type of concrete
- Must be used for lightweight concrete
- Fill the bowl in two equal layers
- Rod each layer 25 times
- After rodding each layer, tap the sides of the measure smartly 10 - 15 times with the mallet
- Strike off the concrete flush with the top of the container using the strike-off bar and wipe the flange clean

Air Content – Volumetric Method

- Clamp the top section into position
- Add at least 1 pint of water and the selected amount of alcohol
- Record the number of full pints of alcohol added
- Adjust the water level using a rubber syringe until the bottom of the meniscus is level with the zero mark
- Attach and tighten the water cap

Air Content – Volumetric Method

- Invert and agitate the air meter for a minimum of 45 seconds to free the concrete from the base
  - Do not invert the meter more than 5 seconds at a time
- Roll the air meter for approximately 1 minute with the neck elevated to remove the air from the concrete
- Place the meter upright and loosen the cap to allow any pressure to stabilize
  - The air is considered stable when it does not change by more than 0.25% within a 2-minute period

Air Content – Volumetric Method

- Record air content and repeat rolling process
- Repeat rolling and recording until two consecutive readings do not change by more than 0.25%
- Record final reading to nearest 0.25% and calculate air content
  - Correction factor if more than 2 pints alcohol used
  - Use calibrated cups when air content is greater than 9%
- Air Content = Final Reading – Alcohol Correction Factor + Calibrated Cups

Volumetric Method Correction Factor

Correction for Effect of 70% Isopropyl Alcohol on Air Meter Reading

Pints Used	Correction (%)
≤ 2	0.0
3	0.25
4	0.50
5	0.75

- Subtract the correction factor from the final meter reading

Air Content – Volumetric Method

Discard test and start over IF:

- The third reading changes by more than 0.25%
- Meter leaks
- It takes more than 6 minutes for liquid level to stabilize
- There is more foam than equivalent to 2% air
- Portions of undisturbed concrete found when disassembling meter

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?

7

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

Making Cylinders

- Place molds on a level, rigid, horizontal surface free of vibration
- Fill 6x12 molds in three equal layers (Class CP)
- Fill 4x8 molds in two equal layers

TN

Making Cylinders

Tamping Rod Diameter Requirements	
Cylinder Diameter (in.)	Rod Diameter (in.)
< 6	3/8 ± 1/16
≥ 6	5/8 ± 1/16

Making Cylinders

- Rod each layer 25 times with the tamping rod penetrating the previous layer approximately 1”
- Tap the sides of the mold 10-15 times with a mallet
- Strike off the surface with the tamping rod
- Cover cylinders with a non-absorptive cap

Making Cylinders

- Mark the side of the cylinder with the following:
  - Cylinder #
  - Date Made
  - Contract #
  - Date Stripped
  - JJ Sample ID
- Do not etch on the top surface
- Finish cylinders with no depressions or projections larger than ⅛"
- Store test cylinders on a surface level within ¼" per foot

Curing Cylinders

Initial Curing

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

Final Curing

- Within 30 minutes of removing from molds, cure cylinders with free water maintained on surface at all times at temperature of 73.5± 3.5ºF

Early Break Cylinders

- Field cure in the same manner and method as placed concrete

Transporting Cylinders

- 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?

Questions

8

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

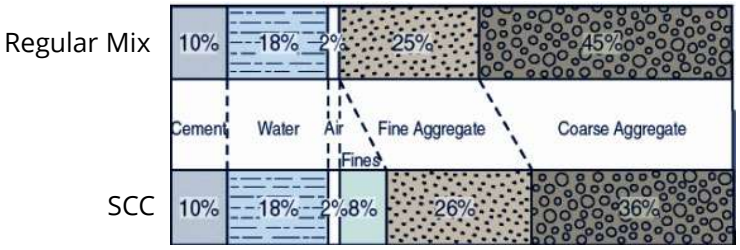
Self-Consolidating Concrete (SCC)

- 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

SCC

- A conventional concrete mix with modified proportions that may use specialized chemical admixtures



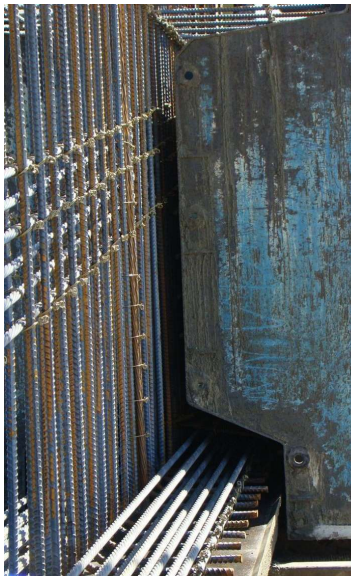
Usage

- 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)

Precast/Prestressed



Aesthetics

Dense Reinforcement

Advantages

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

Disadvantages

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

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

Terminology and Properties

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

Terminology and Properties

Dynamic stability

- The resistance of concrete to the separation of constituents during placement into the formwork

Static stability

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

Properties

- Generally speaking, stability and filling/passing ability are inversely proportional
- The greater the filling/passing ability, the harder it is to get a very stable mixture
- The greater the stability, the harder it is to get greater filling/passing ability
- The degrees of stability, filling ability, and passing ability of SCC are dictated by the application

Reinforcement Challenges

Concrete Placement

Field Experience

- SCC is much more sensitive to additional water on jobsite 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 has taught…

- 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

Testing Methods

- **AASHTO T 347/ASTM C 1611**: Slump Flow of SCC
  - Slump Flow
  - VSI (Visual Stability Index)
  - T-50
- **AASHTO T 345/ASTM C 1621**: Passing Ability of SCC by J-Ring
- **ASTM C 1758**: Fabricating SCC Test Specimens

ASTM C1611
Slump Flow, T50, & VSI

- Two procedures:
  - Slump cone upright

  - Slump cone inverted

Apparatus

- Mold
- Base Plate
  - Nonabsorbent, smooth, rigid with a minimum diameter of 36"
  - For T-50, inscribed with concentric circles for the slump cone and one with a 20“ diameter
- Strike-off bar
- Stopwatch
- Pouring Vessel

Slump Flow and T-50

Slump Flow

- The slump flow test is a measure of mixture filling ability
- The test is similar to the conventional slump test using the same standard slump cone
- Instead of measuring the slumping distance vertically, the average spread of the resulting concrete patty is measured horizontally

Procedure

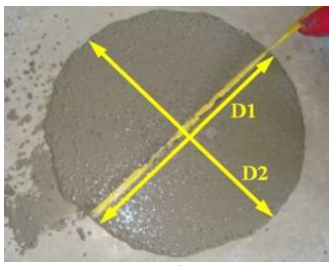
1. Select a flat, level, nonabsorbent surface
2. Dampen the mold and place it in the center of the base plate
3. Immediately fill the mold in one lift
   - Position the pouring vessel no more than 5" above the top of the container
   - Ensure an even distribution of concrete, without rodding the concrete 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

Procedure (continued)

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

Procedure (continued)

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



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

Example Problems

Example Problem#1

- **Given:** Spread Diameter (1) = 22 inches
  Spread Diameter (2) = 21.25 inches
- **Determine the slump flow.**

Slump Flow = [d(1)+d(2)]/2
= [22+21.25]/2
= 43.25/2
=21.625 → 21.50 inches

Example Problem#2

- **Given:** Spread Diameter (1) = 22.75 inches
  Spread Diameter (2) = 20.25 inches
- **Determine the slump flow.**

Slump Flow = [d(1)+d(2)]/2
= [22.75+20.25]/2
= 43.00/2
=21.50 inches
WRONG → REPEAT
(Diameters differ more than 2 inches)

T-50 Procedure

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

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

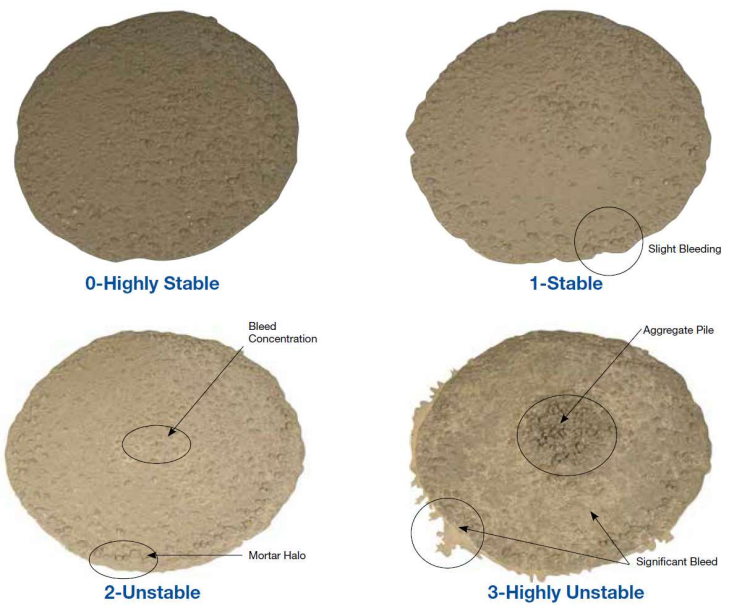
VSI

- 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?
- Inspect the surface of the patty.
  - **Is there sheen on the surface (excess water)?**
  - Bleed water will cause a sheen on the surface or cause puddles on top of the patty
- Assess the aggregate distribution in the patty.
  - **Did the aggregate spread with the mortar or is there an aggregate pile in the center of the patty?**
- **Assign a VSI value to the SCC patty**
  - Refer to the following table and example pictures

VSI

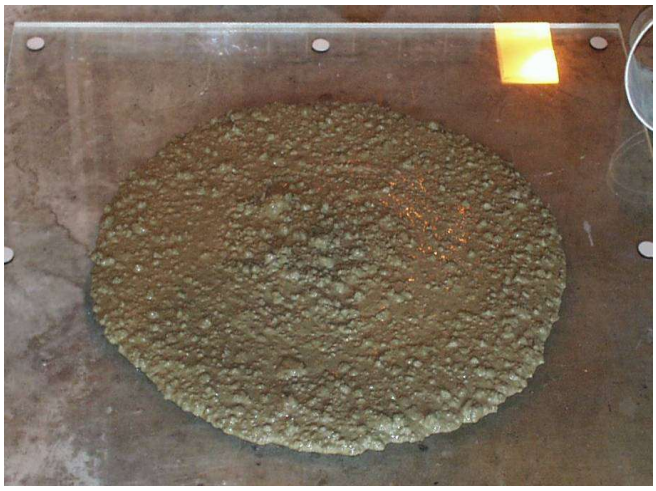
TABLE X1.1 Visual Stability Index Values

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



VSI = 0

- No mortar halo
- No puddles of water



VSI = 1

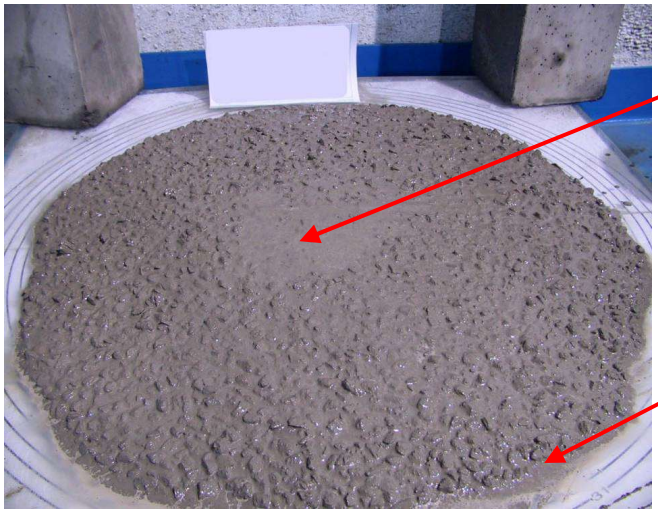
Slight sheen on the concrete

False mortar halo caused by excess water on the base plate

VSI = 1

Slight water sheen observed

VSI = 2

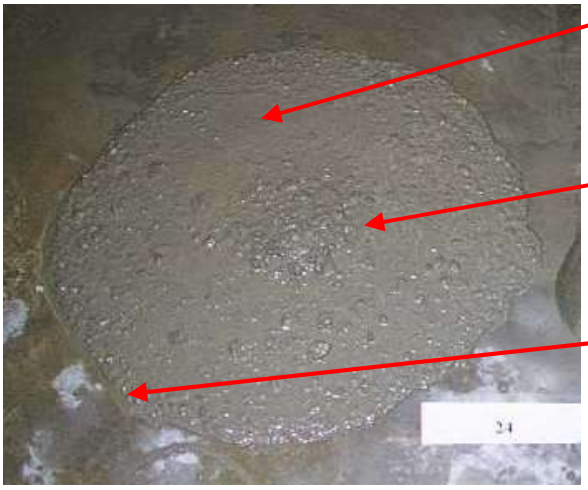


Water puddle in concrete patty

Very glossy surface

Mortar halo 0.25” ≤ 0.5”

VSI = 2

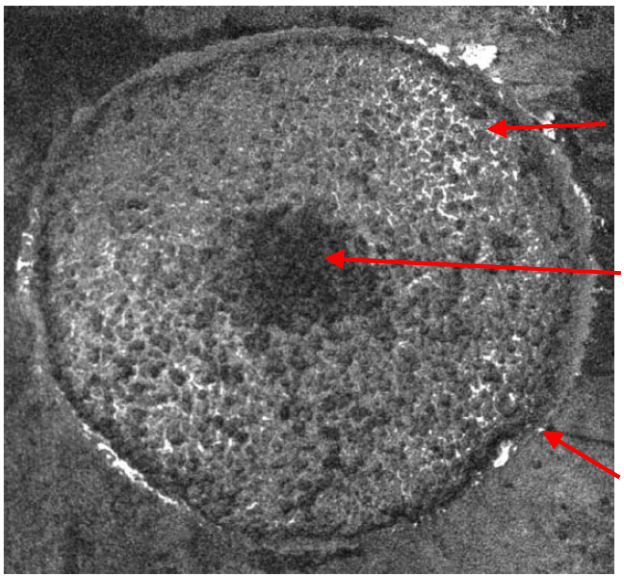


Water puddles on concrete patty

Aggregate pile near the center of patty

Mortar halo 0.25″ ≤ 0.5″

VSI = 3

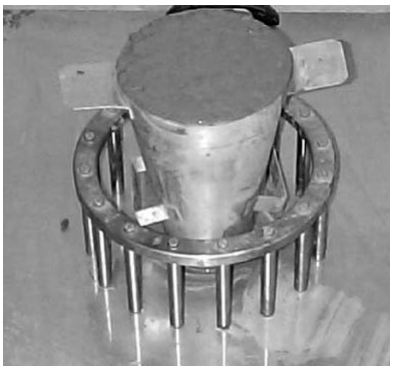


Water puddles in patty

Aggregate pile near the center of patty

Mortar halo greater than 0.5″.

ASTM C1621
Passing Ability by J-Ring



Procedure

1. A sample of freshly mixed concrete is placed in one lift without tamping or vibration in a mold that is concentric with the J-Ring
2. The mold is raised, and the concrete is allowed to spread through the J-Ring
3. After spreading ceases, two diameters of the concrete are measured in approximately diagonal directions
4. J-Ring flow is the average of the two diameters
5. **Passing Ability = Slump Flow – J Ring Flow**
6. Complete slump flow and J-Ring tests within 6 min.

Example Problems

Example Problem#1

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

Passing Ability = Slump Flow - J-Ring Flow
= 23.50 - 21
= 2.50 → 2.50 inches
Poor Passing Ability

Example Problem#2

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

Passing Ability Slump Flow - J-Ring Flow
= 22.5 – 22.0
= 0.50 inches
Good Passing Ability

Report the passing ability to the nearest 0.5"

ASTM C1758
Unit Weight, Air Content, and Cylinders

- Applicable for SCC having a slump flow of 20" or greater
- Molds, measures, and containers used for unit weight, air content, and making cylinders shall conform to conventional concrete requirements
- Testing procedures are the same as for conventional 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

Supplemental Specifications Subsection 604.03.1b

Table 604.03-4: Composition of Self-Consolidating Concrete

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

(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

Volumetric Concrete

- 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 yd^3 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

Appendix

Appendix

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

TN

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

Reference Guides: https://www.tn.gov/tdot/materials-and-tests/field-operations/site-manager-materials.html

TN

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

TN

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.transportation.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.

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

CONCRETE DELIVERY TICKET

Date: _____ Ticket # _____

Contract # _____ County _____ Region _____ Load # _____

Project # _____ Proj. Ref. # _____

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

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

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

Will accept computer generated equivalent

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

Total water [2](Plant) _____ Gallons

Max. water allowed (Project) _____ Gallons

Water added (Project) _____ Gallons

No. Rev. @ Mixing Speed (Plant) _____

No. Rev. @ Mixing Speed (Project) _____

Time loaded: _____ Time discharged: _____

Truck No. _____ Loc. Sta. _____

_____
(Unit of Structure)

Print Name (Plant Tech)	Plant Tech Cert. No.	Plant Tech. Signature
Print Name (Inspector at delivery point)	Field Tech Cert. No. (TDOT Rep.)	Inspector Signature

1 Based on actual cementious material allowed by design

2 Actual used at plant

3 May be adjusted to meet specification requirements.

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

Item No(s) _____
Report No. _____
Design No. _____

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

CONTRACTOR'S DAILY REPORT OF CONCRETE INSPECTION

Completed by Contractor's Concrete Plant Inspector

Date _____
Contract No. _____
Proj. Ref. No. _____ County _____ Region _____ Project _____
Contractor _____ Sub-Contractor _____
Ready Mix Co. _____ Location _____
Type of Plant Mixer _____ Date Scales Checked: _____
Transit Mixer Checked for Presence of Water Before Batching: ☐ Yes ☐ No
Plant and Trucks Checked (Form T-232): ☐ Yes ☐ No Date _____
Approved Process Control Plan: ☐ Yes ☐ No Date _____
Daily Stockpile Check Results: ☐ Satisfactory ☑ Unsatisfactory
W.R.A. / Retarder oz. _____ A.E.A. oz. _____
W.R.A. / Retarder oz. _____ A.E.A. oz. _____ Total C.Y. Batched _____

Batch Size _____ yd^3 (m^3)	Water gal (L)	Water lbs. (kg)	Cement lbs. (kg)	Fly Ash lbs. (kg)	GGBFS lbs. (kg)	Coarse Aggregate lbs. (kg)		Fine Aggregate lbs. (kg)	
Agg. Size / Other Material									
Percent Free Moisture									
SSD Batch Wts.									
Moisture Corrections									
Actual Batch Wts.									

Remarks _____

SCREEN ANALYSIS TOTAL PERCENT PASSING SIEVE

Size No.	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#8	#200
Size No.	3/8"	#4	#8	#16	#30	#50	#100	#200	F.M.

Date Tested: C.A. _____ F.A. _____ Plant Technician _____ Cert. No. _____

DAILY INSPECTION REPORT OF CONCRETE

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

Locations Used on Project _____
Air Temp: High _____ Low _____ Brand or Type of Curing _____
Method of Curing Cyl. _____ Technican Responsible for Cyl. _____
Average Time in Truck _____

Initial Load Quality Control Test Results at Ready Mix Plant	Slump	% Air	Mix Temp.	Plant Technician	Cert No.

Cylinder No.	Station Made	Slump	% Air	Mix Temp.	Age of Test	Cylinder Made By

Ticket Numbers _____
Additional Water Required: Roadway (Gals). _____ Requested by: _____
Remarks: _____
Technician _____ Cert. No. _____

Original to:
Headquarters Materials and Tests
Copies to:
Regional Materials and Tests
Project Supervisor
Form DT-0311 (Rev. 03-19)

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

CONCRETE CYLINDER/CORE TEST REPORT

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

Reference No. _____ County _____ Region _____
Project No. _____ Contract No. _____ Date _____
Contractor Placing Concrete _____ Volume Poured this Date (m^3, yd^3) _____
Daily Report No. _____ Date of Pour _____ Requested Age of Test _____
Concrete Producer _____ Location _____
Cyl./Core Numbers _____ Volume Represented by Cyls/Cores (m^3, yd^3) _____
Design Number _____ Design Strength _____ Concrete Class _____
TDOT Supervisor _____ Unit # _____

Item Number			
Pay Quantity/Unit			
Quantity Delivered			
Sta. of Cyl./Core			
Description of Pour(s):			
Remarks:			

Cylinder Curing Data

Initial Curing Equipment	
Min Temp Recorded, °F	
Max Temp Recorded, °F	
Date Placed in Wet Curing Environment	
Contractor Companion Cyl. Numbers	

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

Cylinder No. / Core No.		
Serial No.		
Date Received		
Date Tested		
Date Reported		
Diameter (in)		
Cross-sectional Area (in²)		
Maximum Load (lbf)		
Compressive Strength (psi)		
Ave. Compressive Strength (psi)		
Type of Fracture		
Performed by		
Technician Certification No.		

Field Test Data

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)*	
Performed by/ Cert. No.	
Contractor Observer/Cert. 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 (Rev. 03-19)

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

6601 CENTENNIAL BLVD.
NASHVILLE, TENNESSEE 37243-0360

CONCRETE CYLINDER/CORE TEST REPORT

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

Reference No. _____ County _____ Region _____
Project No. _____ Contract No. _____ Date _____
Contractor Placing Concrete _____ Volume Poured this Date (m^3, yd^3) _____
Daily Report No. _____ Date of Pour _____ Requested Age of Test _____
Concrete Producer _____ Location _____
Cyl./Core Numbers _____ Volume Represented by Cyls/Cores (m^3, yd^3) _____
Design Number _____ Design Strength _____ Concrete Class _____
TDOT Supervisor _____ Unit # _____

Item Number			
Pay Quantity/Unit			
Quantity Delivered			
Sta. of Cyl./Core			
Description of Pour(s):			
Remarks:			

Cylinder Curing Data

Initial Curing Equipment	
Min Temp Recorded, °F	
Max Temp Recorded, °F	
Date Placed in Wet Curing Environment	
Contractor Companion Cyl. Numbers	

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

Cylinder No. / Core No.		
Serial No.		
Date Received		
Date Tested		
Date Reported		
Diameter (in)		
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.		

Field Test Data

Slump Flow, in. *(ASTM C-1611)*	
Passing Ability, in. (ASTM C-1621)	
Concrete Temp., °F *(ASTM C-1064)*	
Air Temp., °F	
% Air *(ASTM C-231 Pressure)*	
T-50, sec. *(ASTM C-1611)*	
VSI *(ASTM C-1611)*	
Performed by/ Cert. No.	
Contractor Observer/Cert. 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)

Part Two: Acceptance Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
ASPHALT						
Asphalt Plant Mix Pavements	Plant Mix Asphalt (Grading A, AS, ACRL, and Asphalt Treated Permeable Base)	Aggregate Gradation: AASHTO T-30 and AASHTO T-11	Project Inspector	Every 1,000 tons	Combined RAP and aggregate belt samples OR Sample completed mix in truck or on roadway.	If testing completed mix, perform extraction using AASHTO T-164 Method E-II utilizing nested sieves (No. 16 and No. 200). AASHTO T-164 Method A may be used for modified asphalt or when problems are encountered filtering according to Method E-II. Not required on production days of less than 100 tons. Ignition oven may be utilized to determine gradation.
		Thickness: Cores (Asphalt Treated Permeable Base Only)		Every 1,000 feet	Prior to being overlaid	Refer to Section 313 of the specification for tolerance guidelines.
	Small Quantities	Visual Inspection		Not to exceed 1,000 tons of each mix type	Placement site	
Asphalt Surface Treatments: Cape Sealing, Fog Sealing, Microsurfacing, Slurry Sealing, Scrub Sealing, etc.	Aggregate	Gradation and Washing	Project Inspector or M&T	Every 500 tons for each aggregate size	At source or project site prior to incorporating into work	
		Fractured Face Count		Per project		Plus No. 4 (4.75 mm) sieve material, gravel mixes only.
		Glassy Particles by mass				Plus No. 4 (4.75 mm) sieve material, slag mixes only.
		Loss on Ignition			From stockpiled materials	If blended aggregate, then after blending.
CONCRETE						
Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Prestressed, & Precast	Non-Critical Structures	Cylinders (28-day), Slump, Air Content, & Mix Temperature Complete set of tests shall be performed on the initial load for informational purposes, not for acceptance.	Project Inspector	Every 25 cubic yards or less weekly	Placement site	Refer to Standard Specification 604.03.
	Class A, A Paving, S, X			Every 100 cubic yards placed per day per structure unless otherwise specified (i.e. Class X)		
	Class CP			Every 400 cubic yards placed per day		Determine depth measurement per Standard Specification 501.24.
	Class D, DS, L	Cylinders (28-day), Slump, Air Content, & Mix Temperature		Test first three loads and every 50 cubic yards thereafter per day per structure One pair of cylinders shall be cast from one of the first three passing loads.		Refer to SOP 4-1 for acceptance of concrete for bridge decks.
	Class SCC, SH-SCC	Cylinders (28-day), Slumpflow, Air Content, Mix Temperature, Passing Ability by J-Ring, VSI, & T-50				
	Closure Pour Mix	Cylinders (28-day)		Beginning, middle, and end of the pour		
	Structural Grout			Per day		
	Pre-packaged Mix					Use limited to 2 cubic yards per day.
	Flowable Fill	Slumpflow, Mix Temperature, & Cylinders (28-day)		Every 100 cubic yards placed per day per use		Cylinders required for excavatable only.
	Prestressed Completed Mix	Slump, Air Content, and Mix Temperature	M&T or Contractor monitored by TDOT personnel	Per pour	Prestress plant	Perform additional tests when slump change is apparent or as directed.
		Cylinders (28-Day) for Beams		Beginning, middle and end of the bed		One pair of backup cylinders shall be made.
		Cylinders (28-Day) for Panels/Piling		Beginning and end of the pour		
		Cylinders (28-Day) for Tension Release		As needed		
	Prestressed Products	Visual Inspection	M&T	After casting and before shipment		Refer to SOP 5-4.
	Precast Products	Acceptance by Certification in accordance with SOP 5-3				Each item shall be inspected after delivery to the project for cracks, spalls and/or appearance by project personnel prior to incorporating product into the project.

April 1, 2004
October 17, 2012
REV: February 20, 2014

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.

TN TDOT Department of Transportation

MEMO

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˚-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˚ ± 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."

AASHTO T-23- Section 10.1.2

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.

Print Date: 01/04/2019

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
Concrete Mixture Design Report

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

Contract ID:
Project:
County:

MATERIALS AND PRODUCERS

CONCRETE PRODUCER					
CEMENTITIOUS MATERIALS	CEMENT	TYPE DOMESTIC (TYPE I)	G=3.15	CEMEX - KNOXVILLE	KNOXVILLE, TN
	SUPPLEMENTARY CM	FLY ASH CLASS F	G=2.55	SEFA GROUP - CUMBERLAND CITY FOSSIL PLANT	CUMBERLAND CITY, TN
	SUPPLEMENTARY CM	GGBFS, GRADE	G=		
	SUPPLEMENTARY CM	SILICA FUME	G=		
AGGREGATE	COARSE	CRUSH STONE #57	G=2.73	VULCAN MATERIALS - NEWPORT	NEWPORT, TN
	FINE	MANUFACTURED SAND (FM=2.97	G=2.74	VULCAN MATERIALS - MORRISTOWN	MORRISTOWN, TN
		NATURAL SAND (FM=0.00)	G=		
CHEMICAL ADMIXTURES BASF	1. AIR ENTRAINER	MASTERAIR AE 200 (MICRO-AIR)		Retarder to be used when temperature is 85 degrees F or higher.	
	2. REDUCER	MASTER POLYHEED 900 OR POLYHEED 900		Admixture dosage shall be in accordance with manufacturer's recommendations .	
	3. REDUCER/RETARDER				
	4. ACCELERATOR				
	5. HIGH RANGE REDUCER				
	6. OTHER				

MIX DESIGN DATA

CLASS OF CONCRETE:	CLASS A, CONCRETE MIX		
	lb/yd³		
CEMENT	423	THEORETICAL UNIT WEIGHT, PCF	145.7
FLY ASH	141	% FA VOLUME OF TOTAL AGGREGATE	42.3
GGBFS		DESIGN W/CM RATIO	0.45
SILICA FUME		DESIGN AIR CONTENT	6%
CRUSH STONE #57	1794	REQUIRED COMPRESSIVE STRENGTH 28 DAYS, PSI	3000
		REQUIRED COMPRESSIVE STRENGTH 28 DAYS, PSI	3000
NATURAL SAND			
MANUFACTURED SAND	1322	MIX ID	
WATER	254		
CHEMICAL ADMIXTURES	1, 2		

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)

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1023	134	user	204654	4476	10:16	12/3/18

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
7.00 CY	T3025				D	12

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
#57STONE	1794 lb	12596 lb	12620 lb	0.19%	0.30% M	5 gl
MAN-SAND	1322 lb	9902 lb	9840 lb	-0.62%	7.00% M	77 gl
CEMENT	458.0 lb	3206.0 lb	3165.0 lb	-1.28%		
FLYASH	141.0 lb	987.0 lb	1275.0 lb	+ 29.18%		
AIR	12.00 oz	84.00 oz	84.00 oz	0.00%		
POLYHEED	34.00 oz	238.00 oz	235.00 oz	-1.26%		
WATERGL	30.0 gl	176.9 gl	177.0 gl	0.08%		177.0 gl

Actual Num Batches: 1
Load Total: 28397 lb Design 0.418 Water/Cement 0.486 A Design 210.0 gl Actual 258.7 gl To Add: 0.0 gl
Slump: 4.00 in Water in Truck: 0.0 gl Adjust Water: 0.0 gl / Load Trim Water: 7.0 gl/ CY

Cyl # 5-A
SLUMP 3.5"
C. Temp. 68°
Air Temp. 50°
% Air 6.0%

11:00 in
out

24 ov
CORE 6

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1020	129	user	204764	4582	12:16	12/12/18

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
9.00 CY	T3025				D	11

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
#57STONE	1794 lb	16194 lb	16140 lb	-0.34%	0.30% M	6 gl
MAN-SAND	1322 lb	12612 lb	12600 lb	-0.09%	6.00% M	85 gl
CEMENT	458.0 lb	4122.0 lb	4120.0 lb	-0.05%		
FLYASH	141.0 lb	1269.0 lb	1265.0 lb	-0.32%		
AIR	8.00 oz	72.00 oz	72.00 oz	0.00%		
POLYHEED	34.00 oz	306.00 oz	305.00 oz	-0.33%		
WATERGL	30.0 gl	187.7 gl	187.0 gl	-0.35%		187.0 gl

Actual Num Batches: 1
Load Total: 35709 lb Design 0.418 Water/Cement 0.431 A Design 270.0 gl Actual 278.3 gl To Add: 0.0 gl
Slump: 4.00 in Water in Truck: 0.0 gl Adjust Water: 0.0 gl / Load Trim Water: 1.0 gl/ CY

Slump - 4"
Air - 7.8%
Conc Temp - 68°
Air Temp - 48°

26-A

STA-351+33

in - 1:10
out 1:15

- Water
- Scale Hopper - Wayne Ford Identical

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
208	043	user	204952	4760	7:47	1/8/19

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
9.00 CY	T3025				D	1

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
#57STONE	1794 lb	16227 lb	16180 lb	-0.29%	0.50% M	10 gl
MAN-SAND	1322 lb	12850 lb	12760 lb	-0.70%	8.00% M	113 gl
CEMENT	458.0 lb	4122.0 lb	4110.0 lb	-0.29%		
FLYASH	141.0 lb	1269.0 lb	1270.0 lb	0.08%		
AIR	6.50 oz	58.50 oz	58.00 oz	-0.85%		
POLYHEED	34.00 oz	306.00 oz	305.00 oz	-0.33%		
WATERGL	30.0 gl	155.3 gl	155.0 gl	-0.17%		155.0 gl

Actual Num Batches: 1
Load Total: 35636 lb Design 0.418 Water/Cement 0.431 A Design 270.0 gl Actual 277.9 gl To Add: 0.0 gl
Slump: 4.00 in Water in Truck: 0.0 gl Adjust Water: 0.0 gl / Load Trim Water: 1.0 gl/ CY

39-A
STA-35/+33

Slump - 4"
Air Cont - 7.1 %
Conc. Temp - 74°
Air Temp - 56°

in - 8:30
out - 9:12

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1020	129	user	204953	4761	8:17	1/8/19

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
9.00 CY	T3025				D	2

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
#57STONE	1794 lb	16227 lb	16140 lb	-0.53%	0.50% M	10 gl
MON-SAND	1322 lb	12850 lb	12840 lb	-0.08%	8.00% M	114 gl
CEMENT	458.0 lb	4122.0 lb	4060.0 lb	-1.50%		
FLYASH	141.0 lb	1269.0 lb	1265.0 lb	-0.32%		
AIR	6.00 oz	54.00 oz	55.00 oz	1.85%		
POLYHEED	34.00 oz	306.00 oz	310.00 oz	1.31%		
WATERGL	30.0 gl	155.3 gl	155.0 gl	-0.17%		155.0 gl

Actual Num Batches: 1
Load Total; 35621 lb Design 0.418 Water/Cement 0.437 A Design 270.0 gl Actual 278.6 gl To Add: 0.0 gl
Slump: 4.00 in Water in Truck: 0.0 gl Adjust Water: 0.0 gl / Load Trim Water: 1.0 gl/ CY

in - 8:50
out - 9.30

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
157	129	user	204955	4763	8:44	1/8/19

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
3.00 CY	T3025				D	4

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
#57STONE	1794 lb	5409 lb	5360 lb	-0.90%	0.50% M	3 gl
MAN-SAND	1322 lb	4283 lb	4260 lb	-0.54%	8.00% M	38 gl
CEMENT	458.0 lb	1374.0 lb	1405.0 lb	+ 2.26%		
FLYASH	141.0 lb	423.0 lb	445.0 lb	+ 5.20%		
AIR	6.00 oz	18.00 oz	17.00 oz	-5.56%		
POLYHEED	34.00 oz	102.00 oz	105.00 oz	2.94%		
WATERGL	30.0 gl	51.8 gl	51.0 gl	-1.46%		51.0 gl

Actual Num Batches: 1
Load Total: 11983 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 / Load Trim Water: 1.0 gl/ CY

in - 9:15
out - 10:00