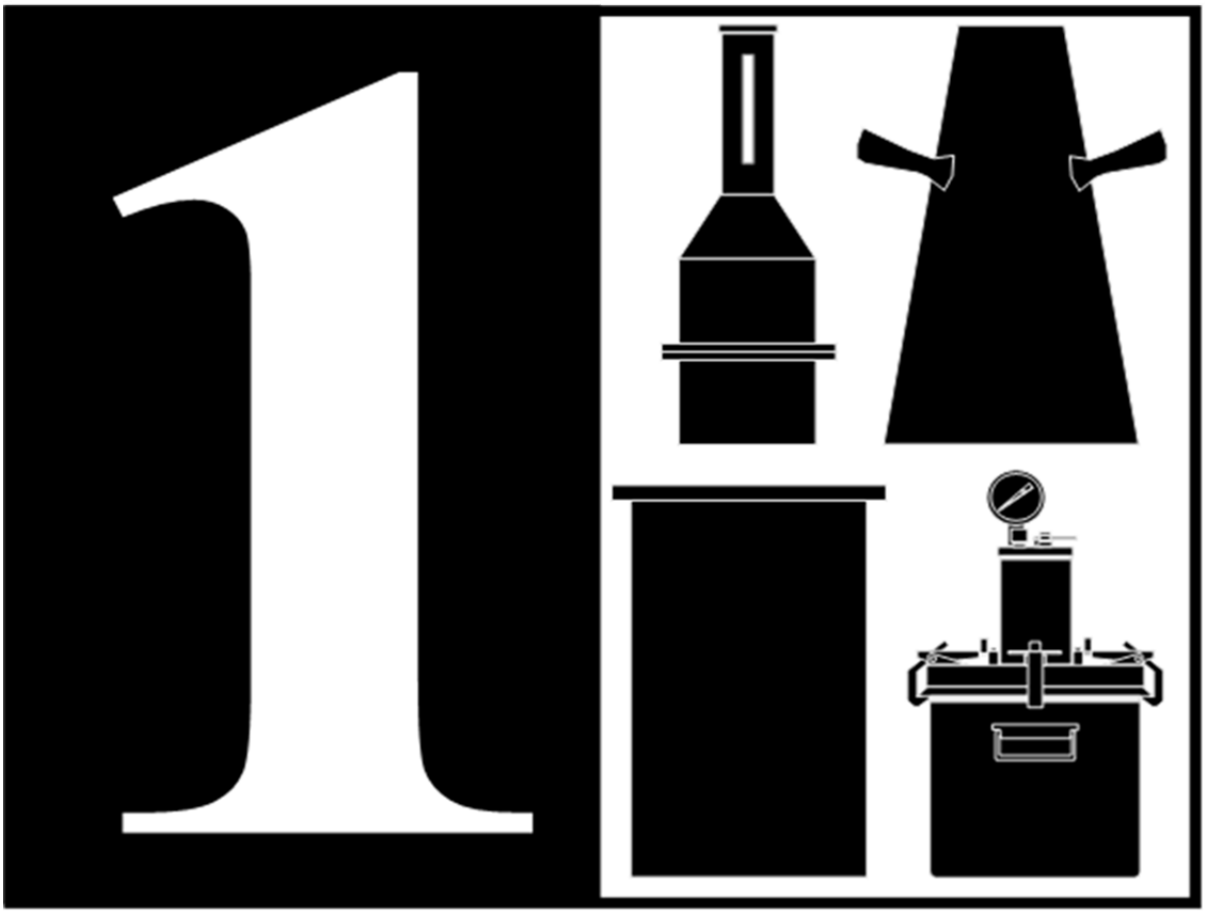
TDOT Department of Transportation



Concrete Field Testing Technician

Recertification Course

Tennessee Department of Transportation

Volume 18.0

Concrete Field Testing Technician
Recertification Course

Tennessee Department of Transportation

Volume 18.0

Class Schedule

Day 1:

1. Registration
2. Introduction
3. Self-Consolidating Concrete (SCC)
4. Review Appendix
5. Written Exam

Day 2 (To be determined):

6. Performance Exam

Concrete Field Testing Technician
Recertification Course

Tennessee Department of Transportation

Volume 18.0

Table of Contents

Welcome!

Concrete Field Testing Technician
Recertification Course

TN TDOT Department of Transportation

Introduction

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

TN TDOT Department of Transportation

Technician Certification Program

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

Purpose of Certification

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

Course Highlights

- Course schedule
  - Slide presentations
    - Self Consolidating Concrete
    - TDOT Specifications / Forms
  - Written exam
  - ***Performance exam at a later date***
  - Results
  - Certification (Upon successful completion of written and performance exams)
- Recertification
  - Every 5 years

TN TDOT Department of Transportation

Written Examination

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

TN TDOT Department of Transportation

Results

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

Resources

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

Resources

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

ADA Notice of Requirements

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

Questions

TN TDOT Department of Transportation

Self-Consolidating Concrete

(SCC)

ASTM C 1611

ASTM C 1621

ASTM C 1758

TDOT Standard Method of Test for
Self-Consolidating Concrete

References

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

TN TDOT Department of Transportation

Self-Consolidating Concrete (SCC)

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

(ACI 237 2007)

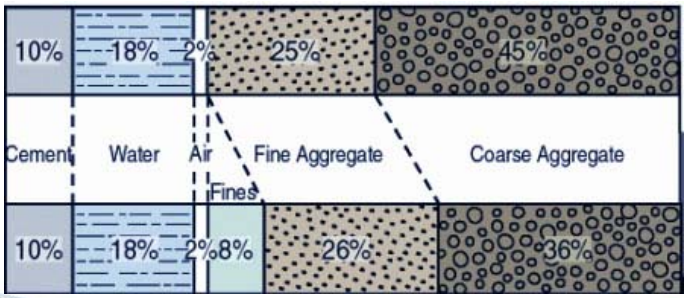
TN TDOT Department of Transportation

What is SCC?

SCC is composed of the

- Same components as conventional concrete with different proportions.
- Specialized chemical admixtures (HRWRA & VMA)

Regular Mix



SCC

TN TDOT Department of Transportation

What Is SCC?

U-Box Demo

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

Foundation Placement

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

TN TDOT Department of Transportation

History

- Developed in Japan in 1980s.
  - For concrete durability and service life.
  - Where proper consolidation was critical.
- Later it was used to facilitate:
  - Construction operations.
  - Reduce construction time and cost.

TN TDOT Department of Transportation

Usage

Because it is a high-performance concrete in the fluid state

- Heavily reinforced and irregularly shaped structural elements that would be difficult or impossible to properly consolidate with traditional vibratory techniques.

TN TDOT Department of Transportation

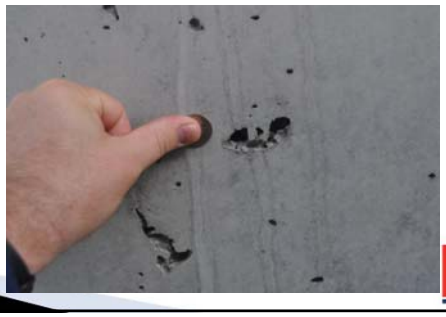
Usage

Usage

Increasingly popular implementation of SCC:

- Precast Production
- Prestressed Bridge Girders (where narrow forms and congested reinforcement make proper filling and consolidation, using conventional concrete, difficult and labor-intensive)

Conventional Precast Beams



TN TDOT Department of Transportation

Aesthetics

TN TDOT Department of Transportation

Advantages

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

TN TDOT Department of Transportation

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.

TN TDOT Department of Transportation

Terminology and Properties

- **Workability** describes the ease with which concrete can be mixed, placed, consolidated, and finished. Workability of SCC is described in terms of **filling ability**, **passing ability**, and **stability**.

TN TDOT Department of Transportation

Terminology and Properties

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

TN TDOT Department of Transportation

Terminology and Properties

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

TN TDOT Department of Transportation

Terminology and Properties

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

TN TDOT Department of Transportation

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.

TN TDOT Department of Transportation

Characteristics

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

TN TDOT Department of Transportation

Characteristics

- If SCC is properly proportioned to prevent segregation, the hardened properties can be designed in the same way as conventional concrete.
- The test methods for hardened SCC are the same for conventional concrete.

  For example:
  - ASTM C 39 – Compressive Strength
  - ASTM C 469 – Modulus of Elasticity
  - ASTM C 496 – Splitting Tensile Strength

TN TDOT Department of Transportation

Field Experiences

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

TN TDOT Department of Transportation

Reinforcement Challenges

TN TDOT Department of Transportation

Reinforcement Challenges

TN TDOT Department of Transportation

Concrete Placement

TN TDOT Department of Transportation

Chattanooga Turbine Testing Tube - Complete

TN TDOT Department of Transportation

Field Experience has taught…

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

TN TDOT Department of Transportation

Form pressures are elevated with SCC. Contractors performing SCC work for the first time are strongly encouraged to consult with their forms manufacturer for best practices.

Field Experience has taught…

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

TN TDOT Department of Transportation

Testing Methods

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

TN TDOT Department of Transportation

Slump Flow, T50, & VSI

Two procedures:

- Slump cone upright

- Slump cone inverted

Apparatus

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

Slump Flow and T-50

TN TDOT Department of Transportation

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.

TN TDOT Department of Transportation

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.

TN TDOT Department of Transportation

Summary of Test Method

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

TN TDOT Department of Transportation

Procedure

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

TN TDOT Department of Transportation

Procedure (continued)

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

TN TDOT Department of Transportation

Procedure (continued)

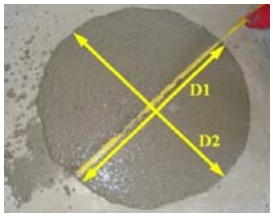
7. Wait for the concrete to stop flowing.
8. Measure the largest diameter of the spread of concrete to the nearest 0.25 inch. (When a halo is observed in the circular spread, it shall be included as part of the diameter).
9. Measure a second diameter approximately perpendicular to the first.

TN TDOT Department of Transportation

Procedure (continued)

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

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



TN TDOT Department of Transportation

Example Problems

Example Problem#1

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

  Spread Diameter (2) = 21.25 inches

- **Determine the slump flow.**

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

= [22+21.25]/2

= 43.25/2

=21.625 → **21.50 inches**

Example Problem#2

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

  Spread Diameter (2) = 20.25 inches

- **Determine the slump flow.**

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

= [22.75+20.25]/2

= 43.00/2

=**21.50 inches**

WRONG → **REPEAT**

(Diameters differ more than 2 inches)

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

Visual Stability Index

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

TN TDOT Department of Transportation

Terminology

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

TN TDOT Department of Transportation

Visual Stability Index (VSI)

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

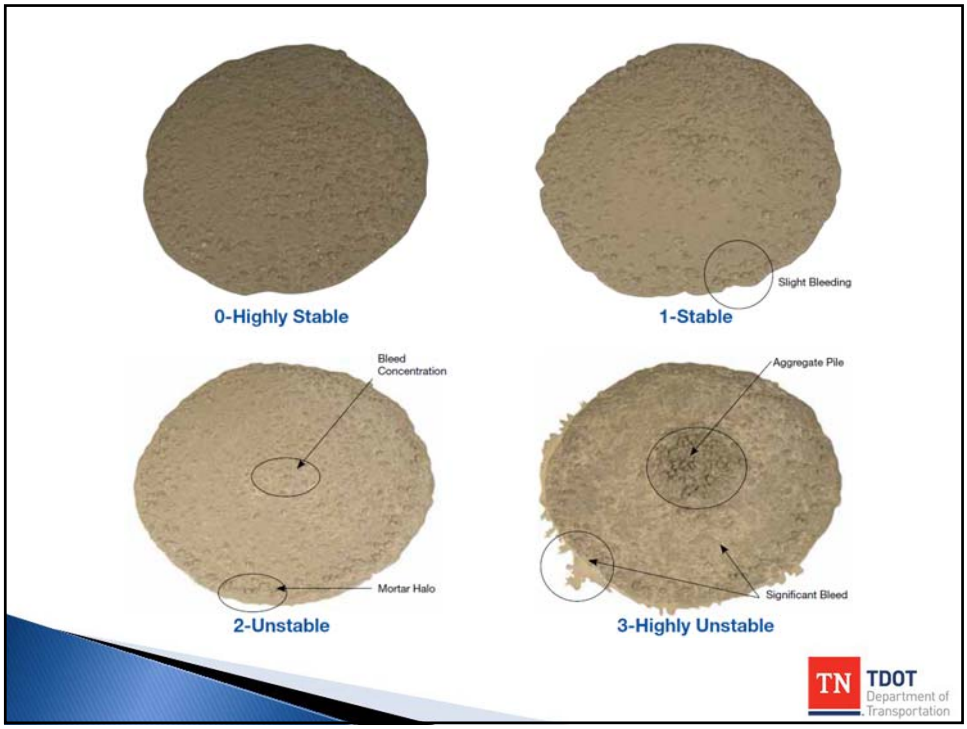
TN TDOT Department of Transportation

Visual Stability Index (VSI)

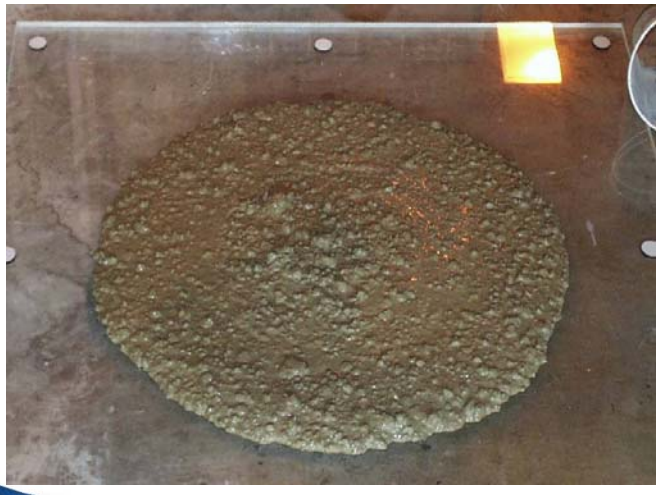
TABLE X1.1 Visual Stability Index Values

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

TN TDOT Department of Transportation



VSI = 0



No mortar halo

No puddles of water

TN TDOT Department of Transportation

VSI = 1

Slight sheen on the concrete

False mortar halo caused by excess water on the base plate

TN TDOT Department of Transportation

VSI = 1

TN TDOT Department of Transportation

VSI = 2

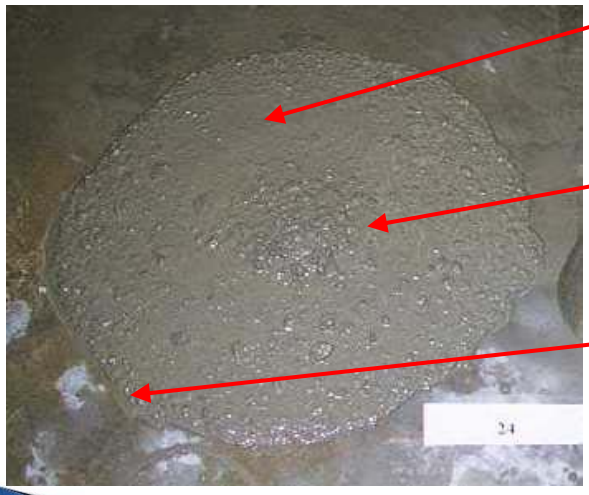
Water puddle in concrete patty

Very glossy surface

Mortar halo 0.25” ≤ 0.5”

TN TDOT Department of Transportation

VSI = 2



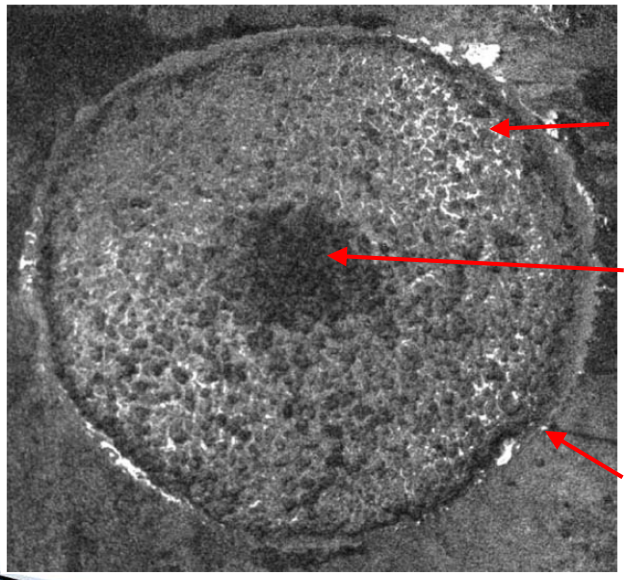
Water puddles on concrete patty

Aggregate pile near the center of patty

Mortar halo 0.25” ≤ 0.5”

TN TDOT Department of Transportation

VSI = 3



TN TDOT Department of Transportation

Passing Ability: J-Ring

TN TDOT Department of Transportation

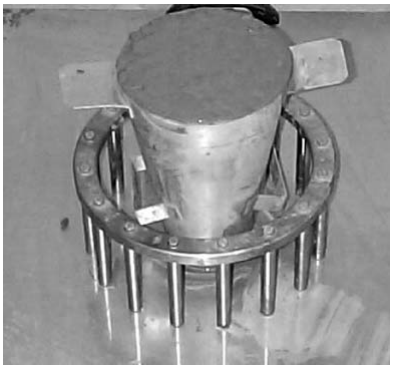
Summary of Test Method

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

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

TN TDOT Department of Transportation

Passing Ability by J-Ring



TN TDOT Department of Transportation

Procedure

1. A sample of freshly mixed concrete is placed in a mold, either in the upright or inverted position, that is concentric with the J-Ring.

2. The concrete is placed in one lift without tamping or vibration. The mold is raised, and the concrete is allowed to spread through the J-Ring.

3. After spreading ceases, two diameters of the concrete are measured in approximately diagonal directions.

4. J-Ring flow is the average of the two diameters.
   - The test is repeated without the J-Ring to obtain the slump flow. The difference between the slump flow and J-Ring flow is an indicator of the passing ability of the concrete.

TN TDOT Department of Transportation

Example Problems

Example Problem#1

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

Passing Ability = Slump Flow - J-Ring Flow

= 23.50 - 21

= 2.50 → **2.50 inches**

Poor Passing Ability

Example Problem#2

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

Passing Ability Slump Flow - J-Ring Flow

= 22.5 – 22.0

= **0.50 inches**

Good Passing Ability

Report the passing ability to the nearest 0.5 inches

Unit Weight, Air Content, & Cylinders

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

TN TDOT Department of Transportation

Apparatus

Shall conform to the requirements described in the standard for which the test specimen is required.

- Molds
- Measures
- Measuring bowls
- Containers

TN TDOT Department of Transportation

Procedure

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

TN TDOT Department of Transportation

Procedure (continued)

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

TN TDOT Department of Transportation

Procedure (continued)

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

References

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

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

TN TDOT Department of Transportation

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 ±1	25±4
SH-SCC (2,3,4,5,6)	4,500	620	0.45	6 ±1	25±4

(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 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

TN TDOT Department of Transportation

Supplemental Specifications Subsection 604.03.1b

- Chemical admixtures usage based on ambient air temperature and expected weather conditions.
- Viscosity Modifying Admixtures (VMA) used as part of the chemical admixtures if shown in approved mix design.

TN TDOT Department of Transportation

Supplemental Specifications Subsection 604.03.2

- Verify self-consolidating concrete (Classes SCC, SH-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.

TN TDOT Department of Transportation

Questions?

TN TDOT Department of Transportation

Appendix

Table 604.03-01: Composition of Various Classes of Concrete

Class of Concrete	Min 28-Day Compressive Strength (psi)	Min Cement Content (pound per cubic yard)	Maximum Water/Cement Ratio (pound/pound)	Air Content % (Design ± production tolerance)	Slump (inches)
A	3,000	564	0.45	6 ± 2	3 ± 1 (1)
D, 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 D concrete in all bridge decks except box and slab type structures unless otherwise shown on the Plans.

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

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

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

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

(7) Plan specific requirements

TN TDOT Department of Transportation

See pg. 80

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 Bor 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 inches.

TN TDOT Department of Transportation

See pg. 45

See pg. 51

Notable Specifications

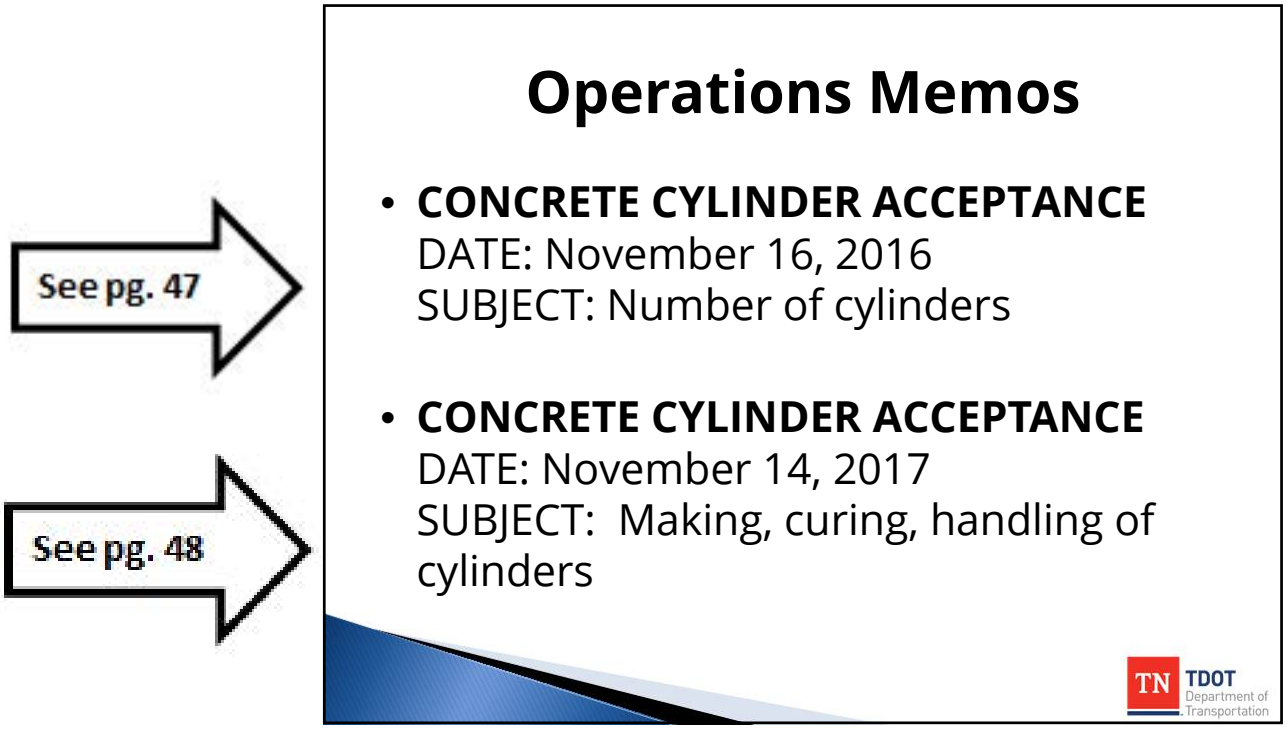
- **501.10:**
  - Total revolutions at mixing speed
  - Haul times
- **604.13:**
  - Total amount of water in mix
  - Haul times
- **Concrete Delivery Ticket Information**

TN TDOT Department of Transportation

CIRCULAR LETTERS

- **C.L. 604.03-01**
  SUBJECT: CONCRETE DELIVERY TICKETS
  DATE: APRIL 1, 2009
- **C.L. 501.09-01**
  SUBJECT: CONCRETE BATCH TICKETS
  DATE: JULY 1, 1992

TN TDOT Department of Transportation



See pg. 47

See pg. 48

Notable Specifications

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

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

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

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

Haul times

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

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

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

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

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
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

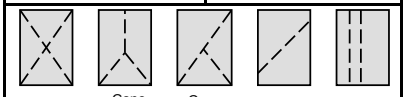
Reference No. _____ County _____ Region _____
Project No. _____ Contract No. _____ Date _____
Contractor Placing Concrete _____ Volume Poured this Date (m^3, yd^3) _____
Daily Report No. _____ Date of Pour _____ Requested Age of Test _____
Concrete Producer _____ Location _____
Cyl./Core Numbers _____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

Item Number					
Pay Quantity/Unit					
Quantity Delivered					
Sta. of Cyl./Core					

Description of Pour(s):	
Remarks:	

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/ft³) *(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. 12-17)

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.

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.

PART TWO: ACCEPTANCE SAMPLES AND TESTS

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

Part Two: Acceptance Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Portland Cement Concrete - Pavement & Base	Cement, Fly Ash, and GGBFS	Acceptance from Qualified Products List (Verification sampling required)				Must be from approved source or have complete lab analysis and approved before being used.
	Curing Compound	Acceptance from Qualified Products List (Verification sampling required)				A compatible Type 1-D, Class B membrane shall be used when texture coating is specified.
	Chemical Admixtures	Acceptance from Qualified Products List				Admixture must be on approved list and have the brand shown on concrete design. Check dosage amounts for compliance with concrete design.
	Aggregate: Coarse and Fine	Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
	Completed Concrete Mix	Compressive Strength (Cylinders) Slump, Air Content, Mix Temperature *All early break cylinders shall conform to the requirements as stated in Part 1 of the SOP Guide.	Project Inspector	*One pair each 400 yd^3; In areas where class A is allowed, the frequency shall be the same as Portland Cement Concrete.	Placement site	Additional test specimens required if pavement is to be opened to traffic within 14 days after placement. Determine Slump and Air Content from same sample of mix used for cylinders. Make additional Slump and Air Content determinations as required for control. Use 6x12 cylinders for Class CP concrete. ***Complete set of tests shall be performed on the initial load for quality control/informational purposes, not for acceptance.**
		Depth Measurement	Contractor Monitored by Project Inspector	One core per 1,000 linear feet of poured width, with a minimum of 1 core for each interchange ramp	Completed pavement	When thickness of core from a unit is deficient more than 1/4" and not more than 1" from plan thickness, take 2 additional cores at intervals of not less than 300' within the unit. Use the average of the three cores to determine thickness.
	Dowel and Tie Bars	Acceptance by Certification (Verification sampling required)				Assembly to be approved by the Engineer.
	Sealant	Acceptance by Qualified Products List				
Prestressed Concrete	Cement, Fly Ash, and GGBFS	Acceptance from Qualified Products List (Verification sampling required)				Must be from approved source or have complete lab tests before being used on project.
	Curing Compound	Acceptance from Qualified Products List (Verification sampling required)				
	Chemical Admixtures	Acceptance by Qualified Products List				Admixture must have the brand shown on concrete design. Check dosage amounts for compliance with concrete design.
	Aggregate: Coarse and Fine	Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
	Reinforcing Steel (Bars)	Acceptance by Certified Mill Test Report (Verification Sampling Required)				
	Prestressing Strands	Acceptance by Certified Mill Test Report (Verification Sampling Required)				
	Finished Product	Visual Inspection	Materials & Tests	After casting and before shipment	Prestress producer's plant	Each item to be inspected for straightness, cracks, honeycomb, size and appearance. Cosmetic patching shall be cured prior to shipment.
	Completed Concrete Mix	Slump, Air and Mix Temperatures	Materials & Tests or Contractor monitored by TDOT personnel	1 set of tests per pair of cylinders	At discretion of inspector or min. of one per pour	Additional tests performed when apparent slump change is indicated or as directed.
		Cylinders (Beams)	Materials & Tests or Contractor monitored by TDOT personnel	At least 1 pair at the beginning, middle and end of the bed		1 pair for 28 day strength, 1 pair for back up
		Cylinders (Panels/Piling)	Materials & Tests or Contractor monitored by TDOT personnel	One pair at beginning, and one pair at the end of the pour		1 pair for 28 day strength, 1 pair for back up
		Cylinders (Tension Release)	Materials & Tests or Contractor monitored by TDOT personnel.	One pair at beginning, one pair at end for tension release of bed		Additional specimens may be necessary

PART TWO: ACCEPTANCE SAMPLES AND TESTS

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Precast concrete noise wall panels, retaining wall panels, and precast drainage structures including pipes, headwalls, manholes, catch basins, box culverts, and structural spans	Finished Product	Acceptance by Certification in accordance with SOP 5-3 (Verification sampling required)				Each shipment must be accompanied by a completed certification form. Each item shall be inspected after delivery to the project for cracks, spalls and/or appearance by project personnel prior to incorporating product into the work.
Precast Concrete Abutment Blocks and Approach Slabs	Finished Product	Slump, Temperature, and Air	Materials & Tests or Contractor monitored by TDOT personnel	Minimum 1 set of test per pour	Precast producer plant	
		Cylinders	Materials & Tests or Contractor monitored by TDOT personnel	One set at beginning, and 1 set at the end of the pour	Precast producer plant	
Earth Retaining Structures	Backfill	Density	Project inspector	1 per every 500 tons or fraction there of	Project site	
		Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
	Select Granular Backfill	Quality pH Internal angle of friction	Materials & Tests	1 @ beginning of Project and then every 6 months	Aggregate plant	
		Density	Project inspector	1 per every 500 tons	Project site	
		Eletro-Chemical Analysis	Producer	1 per Source @ Beg of Project & every 2 years thereafter	Aggregate plant	Additional Test required w/ appearance change
		Gradation	Materials & Tests	Beginning of project	Aggregate plant or Roadway	
			Project Inspector	One test every 1000 tons (Min. 1 per week)	Aggregate plant or Roadway	
	Finished Product	Precast concrete Products	Acceptance in accordance w/SOP 5-3 and Special Provision 624 Retaining Walls (Verification testing required)			
		Modular block	Acceptance in accordance w/Special Provision 624 Retaining Walls (Verification testing required)			Verification required before use
Prime, Tack and Sealer	Emulsions	Acceptance by Certification in accordance with SOP 3-2 (Verification Sampling Required)				Each shipment must be accompanied by TDOT form DT-0293E materials certification report.
Prime Tack and Sealers (Small Quantities)	Emulsions	Visually inspect for contamination	Project Inspector	1 per project	Project Site	Not to exceed 3 tons tack and 3 tons prime per project. Supplier to furnish certification (may be non-project specific) and delivery tickets showing quantities.
Bituminous Plant Mix Pavements	Aggregate	Acceptance from Producer's Supplier's List (Verification Sampling Required)				Must be approved material.
		Fractured Face Count, Glassy particles by weight	Project Inspector	Min. of 1 per project	Coarse aggregate Stockpile	Plus #4 (4.75mm) Material
	Performance-Graded Asphalt Cement	Acceptance by Certification in accordance with SOP 3-1 (Verification Required in accordance with Part Three herein)			Governed by process See SOP 3-1	Each shipment must be accompanied by TDOT form DT-0293PG materials certification report.
	All Plant Mix Asphalt	Mix temperature	On Roadway by Project Insp.	Every fifth load.	From truck prior to leaving plant and on roadway prior to deposit into paver or transfer device.	Temperatures to be recorded on the delivery ticket. Tests at the plant by producer at the discretion of Materials & Tests Supervisor.
		Stripping-10 min. boil test	Project Inspector	Once daily	Truck and Asphalt Plant	Plus #4 (4.75mm) Material on selected visually from mix sample.
	Plant Mix Asphalt Gradings A, B, BM, BM2, C, CW, D, E, and E Shoulder	Density	Project Inspector	1,000 tons	As soon as practical after compaction, when nuclear method is used. When used, cores will be obtained in accordance with SP407DEN.	Each lot shall be divided into 5 equal-sized sublots, and one test should be performed per each sublot. Longitudinal test locations should be determined randomly. Transverse locations are determined randomly with one test 1' off each edge, one test in each wheel path, and one test in the center of the lane.

PART TWO: ACCEPTANCE SAMPLES AND TESTS

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

PART TWO: ACCEPTANCE SAMPLES AND TESTS

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

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.

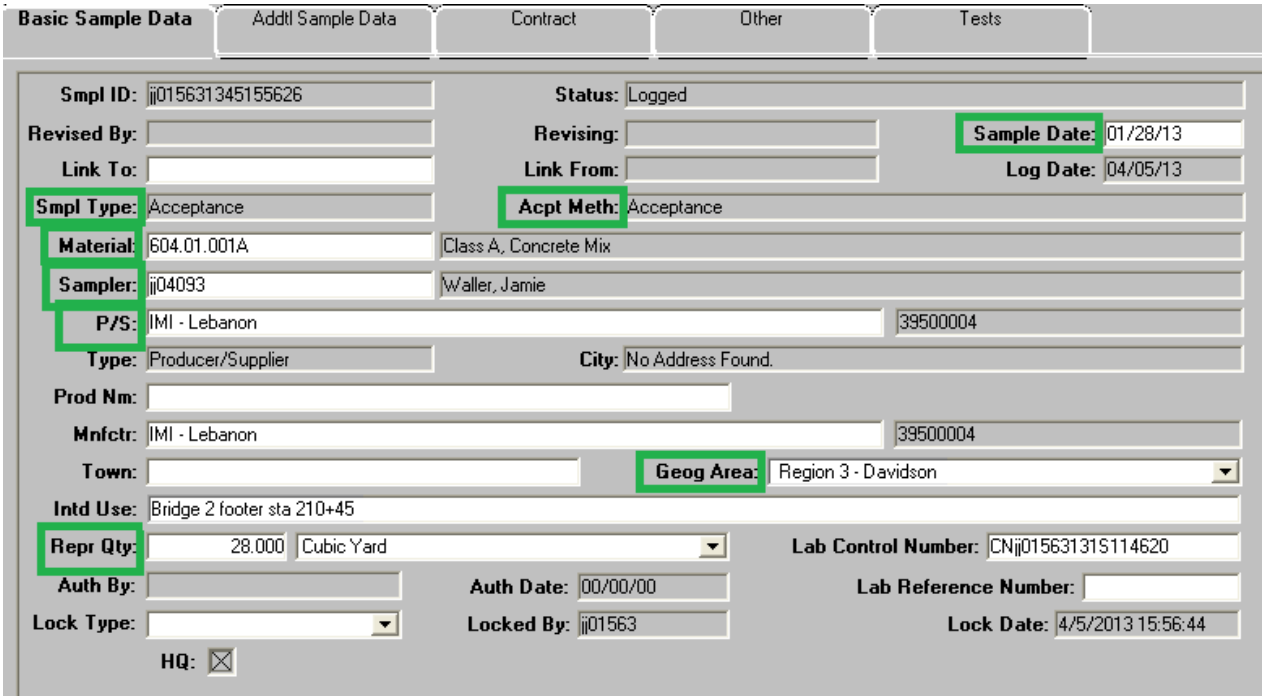
All QC and acceptance test results conducted in accordance with this procedure shall be documented on TDOT form DT-0311 and DT-0311A.

- 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.

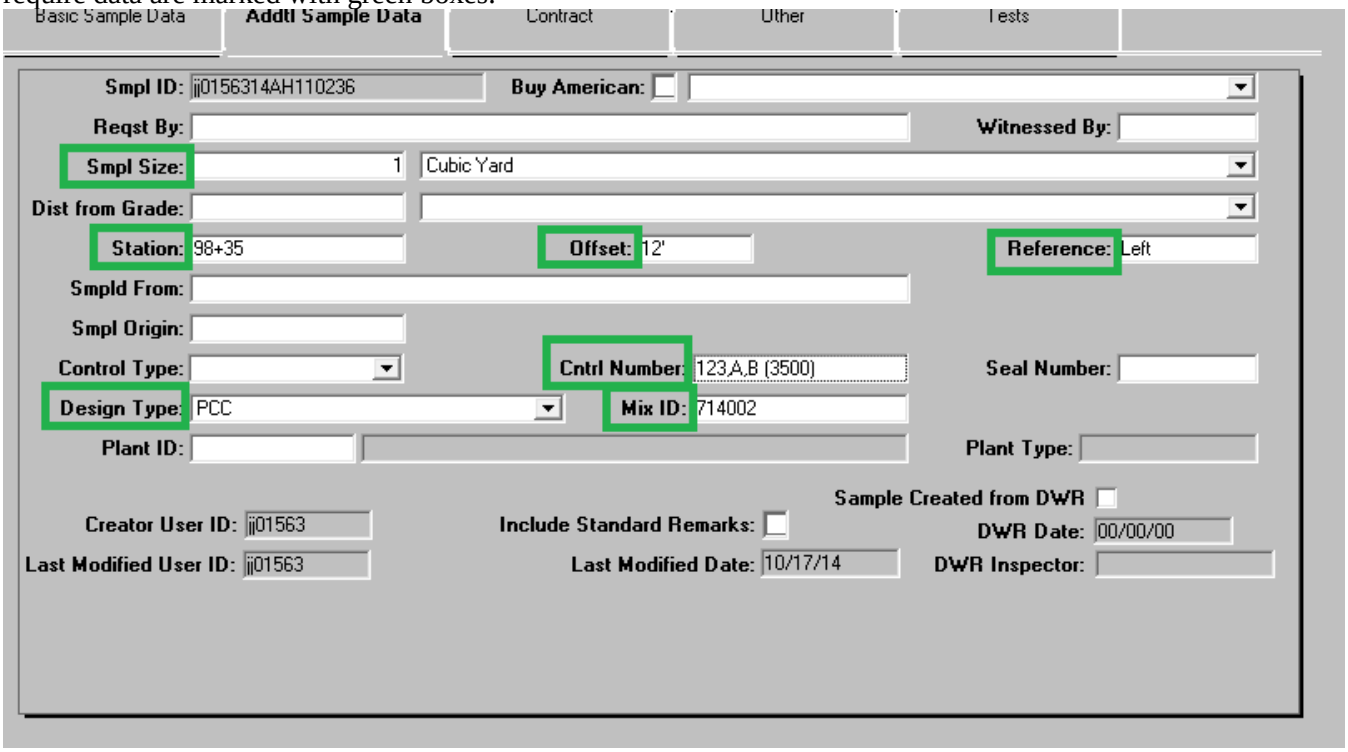
FIELD - Operations Inspector Performs Concrete Field Tests

Open the Maintain Sample Information window (main panel/Materials Management/Sampling and Testing/Sample Information) to create a new sample record. The system displays the **Basic Sample Data** panel.



In the **Intd Use** field note the location where represented material was used on the job (in case cylinders fail and/or cores need to be taken). If the field is not big enough for locations details, use the remarks field (Icon at top of window) to give location details. In the **Repr Qty** field, type the overall quantity the sample represents.

Click the **Addtl Sample Data** tab. The system displays the **Addtl Sample Data** panel. Fields that require data are marked with green boxes.

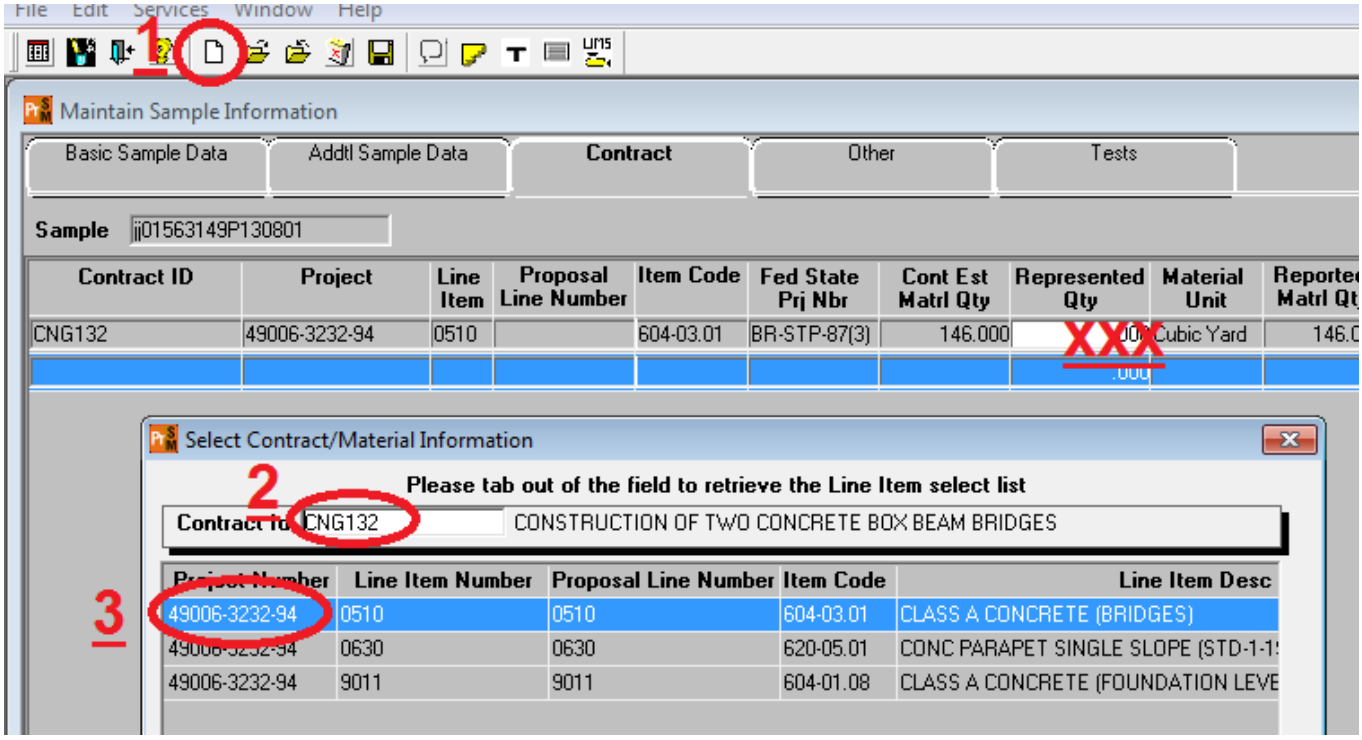


Mix ID field, **Warning!** The mixes available are all approved and associated to the selected material code, but are not filtered by any contract. Confirm the mix ID against paperwork and the Contract Mixes window.

If cylinders are to be made, enter the cylinder numbers in the **Control Number** field. Example: 234,A,B

> **Note:** Although it is a rare occurrence, if the concrete mix design has a 'Required Average Minimum Strength' greater than the standard 3000 or 4000 psi, note the required strength in parenthesis after the cylinder numbers for the Lab Tech and Lab Supervisor performing and approving tests. Example: **234,A, B (3500)**

Click the **Contract** tab. The system displays the **Contract** panel.



Now, record the contract items that the sample represents.

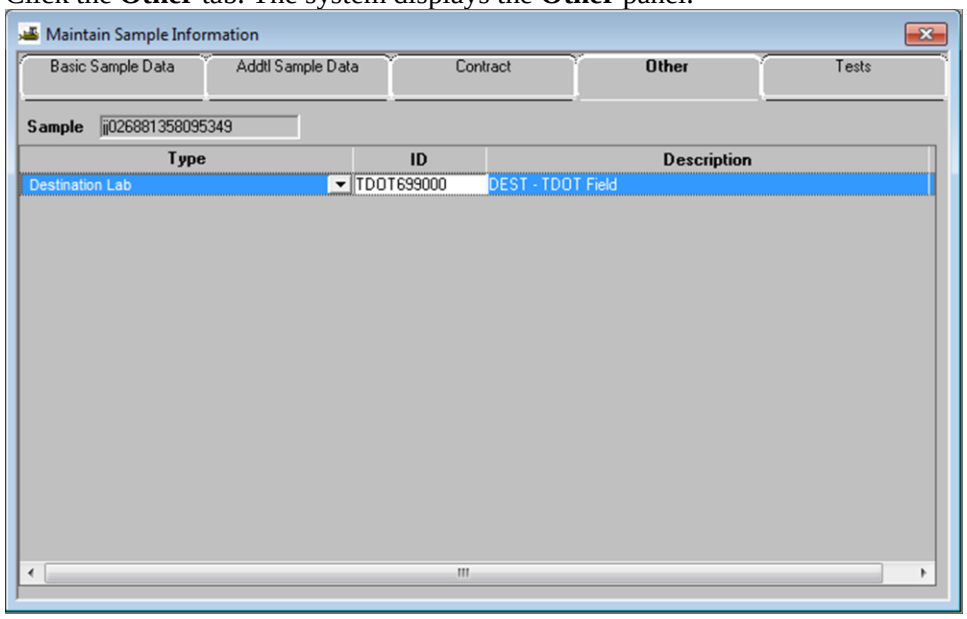
1 On the toolbar, click **New**. Then,

2 search for and select the desired contract

3 select the desired contract line item(s)

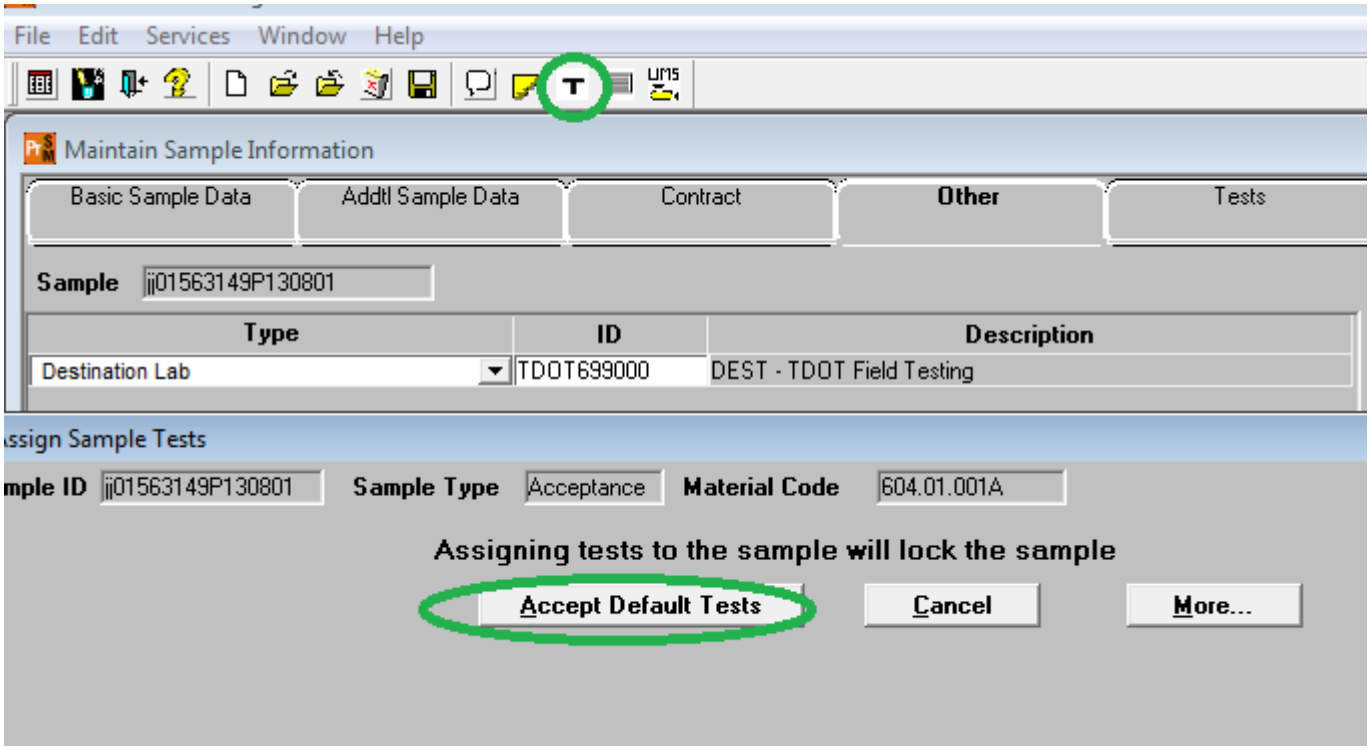
Warning! Do not enter a quantity. The quantity to be paid is entered in a DWR. The material has a rate/frequency of testing linked to it, and entering a quantity here will possibly cause a shortage of test results resulting in money being withheld.

Click the **Other** tab. The system displays the **Other** panel.



In the **Type** dropdown list, select **Destination Lab**. In the **ID** field, search for and select **DEST - TDOT Field Testing**. **Save**.

Now, assign tests.



On the toolbar, click the **Open Assign Tests** button. The system displays the Assign Sample Tests window.

Click the **Accept Default Tests** button. The system associates 'M016 - Field Tests of Freshly Mixed Concrete' to the sample record.

You are now ready to either navigate to LIMS and enter test results or copy sample to prepare sample for cylinders.

Rev 12/28/15

FIELD - Operations Inspector Casts Cylinders and Creates Sample Record

1. Cast the cylinders in the field.

2. Once the surface of sampled material dries enough, write the sample taken date, contract ID and cylinder number on the top with a permanent marker.

Now, open and copy the air/slump/temperature sample record.

3. Open the Maintain Sample Information window (main panel/Materials Management/Sampling and Testing/Sample Information)

4. In the Maintain Sample Information window, on the toolbar, click the **Open** button. Scroll to and double-click the air/slump/temperature sample record.

   Tip! If the air/slump/temperature sample record was still open in Maintain Sample Information window, from the **File** menu, select **Refresh** (CTRL + F) to update the sample status.

5. From the **Services** menu, click the **Copy Sample** choice. SiteManager displays the Copy Sample window.

6. Select **Copy lab control number from existing sample**.

7. Click the **OK** button. SiteManager displays the copied sample record in the Maintain Sample Information window. Verify all needed data copied over to new sample, add if any is missing. **Make sure "Sample Taken Date" field has correct date that physical cylinder sample was created. HQ lab will use this date to calculate due date for testing cylinders.**

8. **Save**.

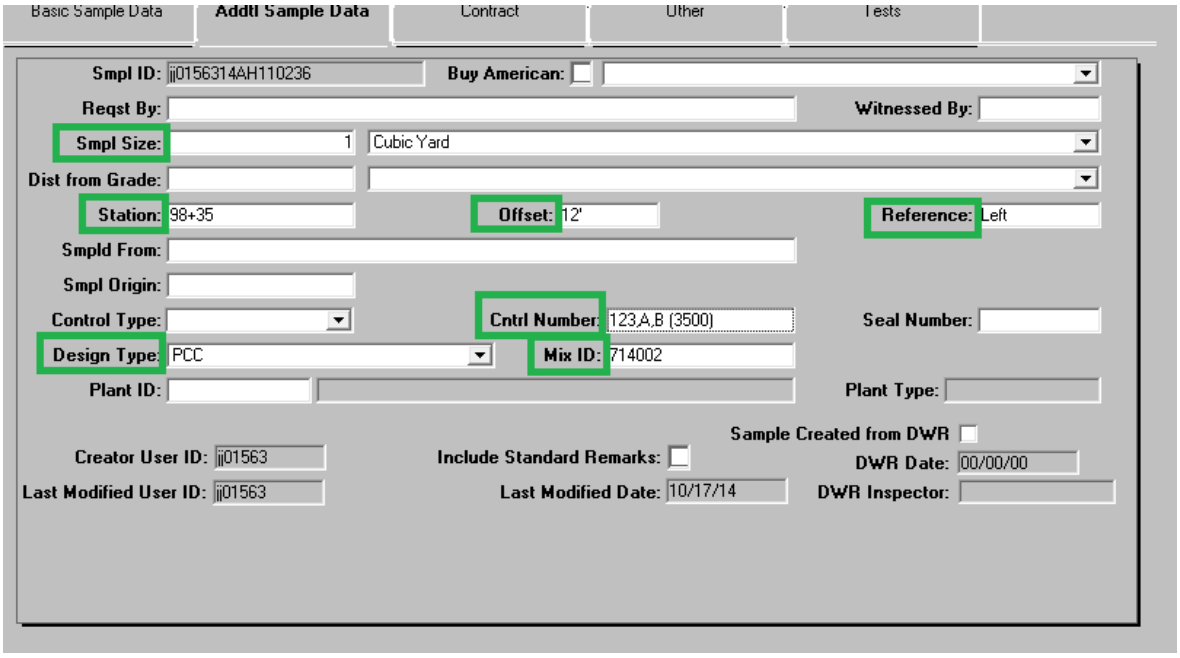


Figure 1. Maintain Sample Information Window – Addtl Sample Data Panel

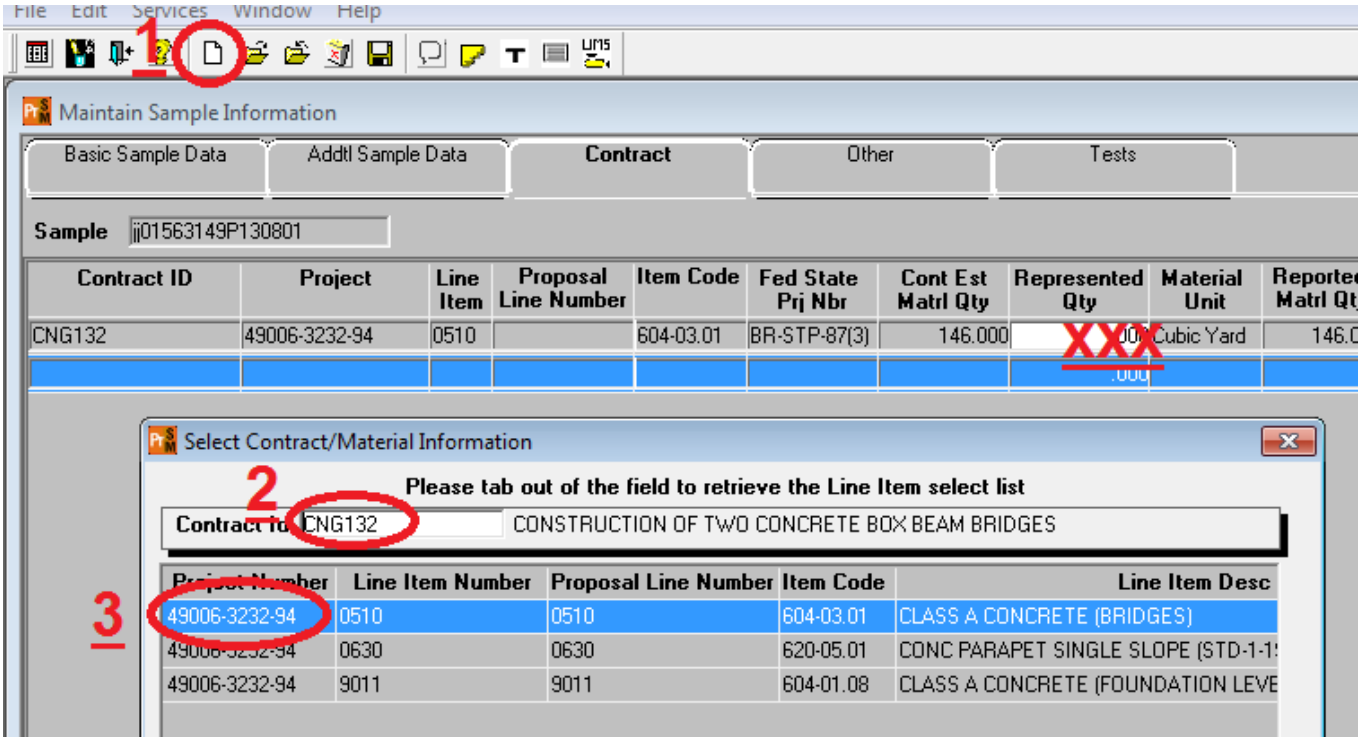
9. Click the **Addtl Sample Data** tab. The system displays the **Addtl Sample Data** panel. Design type, Mix ID & info in Cntrl Number field should transfer from copied sample. Verify this data is there.

Below are some details about the the cylinder numbers represented by this sample record.

In the **Control Number**, enter the cylinder numbers. Example: 234,A,B

Note: Although it is a rare occurrence, if the concrete mix design has a 'Required Average Minimum Strength' greater than the standard 3000 or 4000 psi, note the required strength in parenthesis after the cylinder numbers for the Lab Tech and Lab Supervisor performing and approving tests. Example: **234,A, B (3500)**

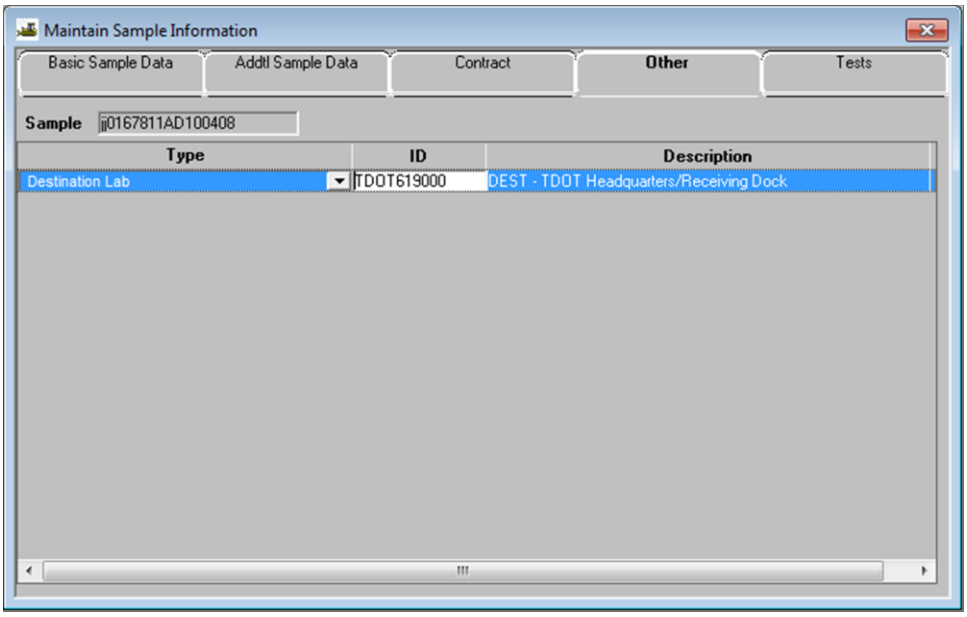
10. **Save**.



11. Click the Contract tab. The system displays the Contract panel.

12. Verify this copied sample kept the contract items that the sample represents.

13. Warning! Do not enter a quantity. The quantity to be paid is entered in a DWR. The material has a rate/frequency of testing linked to it, and entering a quantity here will possibly cause a shortage of test results resulting in money being withheld.



14. Click the **Other** tab. The system displays the **Other** panel.

Now, record the location where the testing will be performed.

15. In the **Type** dropdown list, select **Destination Lab** if it is not already populated.

16. In the **ID** field, search for and select **DEST – TDOT Headquarters/Receiving Dock**.

    Note: While acceptance cylinders always go to the TDOT Concrete Cylinder/Core Lab, intermittent cylinders (that is, 7- or 14-day),will not be tracked in SiteManager and will be sent to the appropriate TDOT regional lab with completed form DT-0062.

17. **Save**.

Now, assign tests.

1. On the toolbar, click the **Open Assign Tests** button. The system displays the Assign Sample Tests window.

18. Click the **Accept Default Tests** button. The system associates 'T22 - Compressive Strength of Cylindrical Concrete Specimens' [Template: T22] to the sample record.

19. **Save Tests**. The system displays the Maintain Sample Information window's **Other** panel.

20. Set the cylinder aside to cure.

    NOTE: The inspector who created the cylinders will be responsible for making sure correct "Date Transported to Wet Curing" is added to the "Other" tab of the sample record when the cylinders are transported.

FIELD - Operations Inspector Prepares and Delivers the Cylinders to the Regional M&T Lab

1. Strip the molds from the cylinders.

21. Deliver the cylinders to the regional M&T lab.

HQ Lab performs testing

1. If cylinders break above required strength, no notifications we be sent to Operations or Regional M&T Staff. There are several methods anyone who wants/needs to see the results can access the data

    i. Run BOE report RR038-Cylinder Breaks - List

    ii. Open sample record in SiteManager, go to "Tests" tab. Select test T22. Then go to "Services" menu and select "Enter/View Test Results". Read only version of the test template w/ results will open in new window.

    iii. Break info will also be posted on-line for persons without SiteManager access.

2. If the cylinders break below required strength, automatic notifications will be sent to the Operations unit & Materials & Tests office in charge of the contract. Below are the steps to be followed in that circumstance

Regional M&T Runs Report for Deficient Strength

Scenario: For the cylinder breaks that do not meet the requirements for strength, the following occurs:

3. Regional M&T personnel run the *Concrete Evaluation for Deficient Strength* [Report: RR050] report and print it. This report includes: the sample IDs of the cylinders that failed; item codes, and locations where the defective concrete was used; and the average strength of the cylinders breaks.

4. Send the printed report to the FIELD - Operations Office Staff.

5. Regional M&T personnel calls FIELD - Operations Office Staff to notify them of the low break.

FIELD - Operations Office Staff Notifies the Contractor of Deficient Strength

1. If the contractor decides not to core, FIELD - Operations Office Staff uses this report to create the deduction in SiteManager.

   If the contractor decides to core, REG - M&T Inspector copies and edits the acceptance cylinder sample record with the **Failed, but Left in Place** sample status. Including copying the Lab Control Number. Follow the same process used to send a cylinder through the queues, with the addition of writing the sample ID **legibly (neatly)** on the side of the core.

2. If the cores still do not meet strength requirements, Regional M&T personnel run the *Concrete Evaluation for Deficient Strength* [Report: RR050] report and print it. Send the printed report to the FIELD - Operations Office Staff. FIELD - Operations Office Staff will use this report to aid in creating the deduction in SiteManager.

S T A T E **O F** **T E N N E S S E E**
(Rev. 5-18-15) January 1, 2015
(Rev. 11-16-15)
(Rev. 5-15-17)
(Rev. 11-6-17)

Supplemental Specifications - Section 500

of the

Standard Specifications for Road and Bridge Construction

January 1, 2015

Subsection 501.03 (pg. 395), 5-18-15;, 3. Mix Design Submittal, Replace the first paragraph with the following:

"Instead of the above mix design submittal, a request to use an existing design may be submitted for approval provided the design has been used on a state funded project within the last six (6) months. The approval of this concrete design submittal will not relieve the Contractor of the responsibility of providing concrete meeting the requirements of these Specifications. A temporary mix design may be issued if the 7-day or 14-day compressive strengths exceed the required 28-day strengths."

Subsection 501.03 A. Proportioning (pg. 395) 5-15-17; Add water as 22. on the list of Design Submittal requirements, update the paragraph below the list to add water requirements:

"A. Proportioning

3. Design Submittal. Include the following information as a minimum in the proposed concrete design submittal:

1. Source of all aggregate
2. Brand and type of cement
3. Source and class of fly ash (if used)
4. Source and grade of ground granulated blast furnace slag (if used)
5. Specific gravity of cement
6. Specific gravity of fly ash (if used)
7. Specific gravity of ground granulated blast furnace slag (if used)
8. Admixtures (if used)
9. Gradation of aggregates
10. Specific gravities of aggregates (saturated surface dry)
11. Air content (if air entrainment is used)
12. Percentage of fine aggregate of the total aggregate (by volume)
13. Slump
14. Weight per cubic yard
15. Yield
16. Temperature of plastic concrete
17. Water/cement ratio (pound/pound)
18. 7-day compressive strength [minimum of two 4-inch x 8-inch cylinders]
19. 14-day compressive strength [minimum of two 4-inch x 8-inch cylinders]

20. 28-day compressive strength [minimum of two 4-inch x 8-inch cylinders]
21. Weight of each material required to produce a cubic yard of concrete
22. Water – submit testing results per Tables 921.01-1 & 921.01-2

Instead of the above mix design submittal, a request to use an existing design may be submitted for approval provided the design has been used on a state funded project within the last six (6) months. When submitting for the use of an existing mix design, the most current water testing results per 921.01 shall accompany the submittal. The approval of this concrete design submittal will not relieve the Contractor of the responsibility of providing concrete meeting the requirements of these Specifications. A temporary mix design may be issued if the 7-day or 14-day compressive strengths exceed the required 28-day strengths."

Subsection 501.03 (pg. 399-402) 11-16-15; B. Quality Control and Acceptance of Concrete, adjust the following:

"1. Test to determine aggregate gradations (AASHTO T 27 with AASHTO T 11 when required). Conduct a combined belt gradation before work starts and at least daily to verify consistency if using a dynamic, multi-aggregate feed system.

3. Calibrate the weighing systems, aggregate feed flow rate and weigh bridges, water meters, and admixture dispensing systems before starting production.

4. Ensure accurate weighing or flow rate of the aggregates and cement, the proper metering of water and admixtures, and the quality of water.

6. Adjust mix proportions due to actual moisture content of both coarse and fine aggregates, with moisture content determined according to AASHTO T 255. If using a dynamic aggregate weighing system, multi-aggregate proportioning adjustments are to be made by using an in-bin moisture sensor."

7. Conduct slump (AASHTO T119) or slump flow (ASTM C1611) and air tests (AASHTO T152).

Page 401- "Make, cure, and transport all early break cylinders (7-14 day, etc.) according to AASHTO T 23, and deliver to the Regional laboratory or other established satellite laboratories for testing. Make all early break cylinders (7-14 day, etc.) for self-consolidating concrete according to ASTM C1758, and deliver to the Regional laboratory or other established satellite laboratories for testing."

Page 402 - "Correct batch weights or aggregate feed flow rates to compensate for surface moisture on the aggregate at the time of use. The Contractor…"

Subsection 501.04 (pg. 402) 11-16-15; replace the following:

"A. Batching Plant, Multi-Aggregate Feed System, and Equipment,

1. General. The batching plant shall include bins, weighing hoppers or belt feeds with weigh bridges and load cells, and scales. If using cement in bulk,…

2. Bins and Hoppers- Add the following new paragraph under the existing paragraph

For multi-aggregate feed systems, provide bins as noted with variable size openings and variable speed belts. Each bin must have a calibrated moisture sensor to adjust aggregate feed flow rates. Assure consistent, uninterrupted aggregate flow and consistent belt speeds once aggregate feed system is calibrated.

3.Scales- Add the following new paragraph under the last paragraph in the section.

For multi-aggregate feed systems, provide a dual idler weight bridge with load cells to accurately weigh the actual aggregate flow rate."

Subsection 501.04 A. 1. (pg. 402), 11-6-17; General, Add the following after the first paragraph:

"All producers of concrete shall be on the Department's approved producer list and be actively certified by the National Ready Mixed Concrete Association (NRMCA) Plant Certification Program."

Subsection 501.04 B. 3. (pg. 403), 11-6-17; Truck Mixers and Truck Agitators, Add the following to the beginning of the first paragraph:

"Truck mixers shall be certified by the National Ready Mix Concrete Association (NRMCA) Delivery Vehicle Certification Program Option A or Option B."

Subsection 501.04 (pg. 404) 11-16-15; B. Mixers, removed the complete 4th paragraph.

Subsection 501.12 – Placing Concrete (pg. 413-415) 5-15-17; replace the subsection:

"**501.12 Placing Concrete**

Either unload the concrete into an approved spreading device, or deposit it directly on the base, and mechanically spread the concrete in a manner that prevents segregation of the materials. When using central or transit mixed concrete, deposit it in an approved spreader. Place the mixture so as to minimize rehandling and relocation from point of placement. The mechanical spreader will not be required on areas too small to accommodate the paving equipment, projects that contain 10,000 square yards or less of concrete paving, and on variable width sections and ramps. Placing shall be continuous between transverse joints without the use of intermediate bulkheads. Do not place concrete on frozen grade.

Perform any necessary hand spreading with shovels or other approved tools. Do not allow workmen to walk in the freshly mixed concrete with boots or shoes coated with earth or other foreign substances.

If placing concrete adjacent to a previously constructed lane of pavement and mechanical equipment is to be operated on this existing lane of pavement, that lane shall meet the requirements for opening to traffic specified in **501.22**. If the existing lane is to only carry finishing equipment, the Contractor may begin paving the adjoining lanes after 7 days.

Deposit concrete as near to expansion and contraction joints as possible without disturbing them; do not dump concrete from the discharge bucket or hopper onto a joint assembly unless the hopper is well centered on the joint assembly.

Immediately remove all concrete materials that may fall on or be worked into the surface of a completed slab using approved methods.

When using the slip-form method of concrete paving, place the concrete with an approved slip-form paver meeting the requirements of **501.04.D.11**.

Ensure that the sliding forms are rigidly held together laterally to prevent spreading of the forms. The forms shall trail behind the paver for such a distance that no appreciable slumping of the concrete will occur and so that necessary finishing can be accomplished while the concrete is still within the forms. Before the concrete has hardened, correct any edge slump of the pavement, exclusive of edge rounding, in excess of 1/4 inch.

Operate the slip-form paver with as nearly a continuous forward movement as possible, and coordinate all operations of mixing, delivering, and spreading of concrete so as to provide uniform progress while minimizing the stopping and starting of the paver. If, for any reason, it is necessary to stop the forward movement of the paver, also immediately stop the vibratory and tamping elements. Apply no tractive force

to the machine, other than that which is controlled from the machine. Replace slabs with random cracks before completion of paving operations.

Contractor may choose to utilize a single lift or two lift paving process according to the following requirements.

A. Single Lift Pavement

Use vibrators to thoroughly consolidate the concrete against and along the faces of all forms and along the full length and on both sides of all joint assemblies. Do not allow vibrators to come in contact with a joint assembly, the grade, or a side form. Do not operate the vibrator for longer than 5 seconds in any one location.

The Contractor may only use hand-operated vibrators on projects containing 10,000 square yards or less of concrete paving and on variable width sections. Only operate vibrators mounted on a machine while the machine is in motion.

Equip the slip-form paver with vibrators meeting the applicable requirements of **501.04.D.1** to vibrate the concrete for the full width and depth of the strip of pavement being placed.

B. Two Lift Composite Pavement

When placing two lift composite pavements, the upper lift shall be of a lesser thickness as designated by contract design. It shall be placed such that the result is a wet-on-wet application. The lower lift will be one foot less in width than the upper lift.

Paving operations shall be adjusted and approved by the Engineer as necessary to assure a wet-on-wet monolithic pavement section. If the bonding between lifts or the consolidation of concrete is determined to be unsuitable by the Engineer, the lower lift shall be removed and replaced prior to the upper lift placement.

1. Lower Lift. Uniformly spread concrete with a spreader or slipform machine. Internal vibration will be required for the lower lift. Tie bars and dowel bars (with the use of dowel baskets) shall be placed in the lower lift at mid-depth of the finished concrete pavement thickness. The lower lift shall not require curing, texturing, or sawing before the upper lift is placed. The lower lift shall be struck off to provide a nominal lower lift thickness that complies with the pavement design. The upper lift shall be struck off to allow for the finished total pavement to conform to the cross section shown in the contract plans.

2. Upper Lift. Place the upper lift within 45 minutes following the placement of the lower lift. Placement of the upper lift shall be such that intermingling of the two concrete mixtures is minimal. External vibration for the upper lift will be allowed if proper consolidation and finishing can be demonstrated in accordance with **501.16.** Dowel bars can be inserted during the placement of the upper lift. Cure the upper lift only in accordance with **501.18**. At no time shall the total thickness be less than shown on the pavement design and the cross section shown in the contract plans.

Frequency of the vibrators shall be established based on the workability of the concrete mixture and past experiences. Electronic, internal, T-shaped, poker vibrators shall be used. Other types of vibrating equipment may be approved by the Engineer. Vibrator impulses shall be delivered directly to the concrete and the intensity of vibration shall be sufficient to consolidate the concrete thoroughly and uniformly throughout the depth and width of the lift. Increase in the speed of the vibrators will be allowed with the permission of the Engineer.

A paving plan shall be supplied to the Engineer for review and approval prior to pouring. The plan shall document procedures to ensure consistency of material properties during concrete placement and finishing,

identify and eliminate potential for load misidentification, and maintain speed of production and paving. Concrete for each lift shall be produced from the same ready-mix facility."

Subsection 501.17 (pg. 424) 11-16-15; A. Surface Testing, modify the following:

"3. Ramps where the design speed is greater than 40 miles per hour
(a) Test sections shall terminate 100 feet from a stop or slow speed yield condition
(b) Superelevated sections greater than 40 miles per hour design speed must be ground in accordance with **Table 501.17-1**
4. Ramps where the design speed is 40 miles per hour or less
(a) Test sections shall terminate 100 feet from a stop or slow speed yield condition
(b) Superelevated sections with a design speed of 40 miles per hour or less must be ground in accordance with **Table 501.17-2**

Subsection 501.17 (pg. 425) 11-16-15; B. Pay Factors and Required Corrective Action, modify the following:

"Payment factors and required corrective actions relative to profile indexes for ramps with design speeds of 40 MPH or less shall conform to Table 501.17-2.

Table 501.17-2: Pay Factors & Corrective Action for Ramps with Design Speeds of 40 mph or less

Profile Indexes	Pay Factor	Corrective Action
<10 inches per mile	105%	None
10 to < 20 inches per mile	100%	None
20 to < 23 inches per mile	98%	Grind to 20 inches per mile
23 plus inches per mile	95%	Grind to 20 inches per mile

Subsection 501.26 – Basis of Payment (pg. 434) 5-15-17; add the following sentence to the 7th paragraph of the subsection:

"The Department will pay for additional concrete, measured in accordance with **501.25**, at the purchase price, F.O.B. the unloading point, as verified by invoices, with no compensation allowed for further handling. The State will be reimbursed from monies due the Contractor for a decrease in concrete measured in accordance with **501.25** in an amount equal to the purchase price of the cement, F.O.B. the unloading point. No payment will be allowed for any changes in the proportions of the aggregates. No additional payment will be made if two-lift composite pavement alternate is selected."

S T A T E **O F** **T E N N E S S E E**

(Rev. 5-18-15)
(Rev.11-16-15)
(Rev. 6-27-16)
(Rev. 12-2-16)
(Rev. 5-15-17)
(Rev. 11-6-17)

January 1, 2015

Supplemental Specifications - Section 600

of the

Standard Specifications for Road and Bridge Construction

January 1, 2015

Subsection 602.17 (pg.459-477), 12-2-16; Entire Subsection: Replace all references to AASHTO M164 and AASHTO M253 with ASTM F3125, Grade A325 and A490

Subsection 602.17 (pg. 459) 12-2-16; modify the first paragraph of A.:

> "All high strength bolts, or equivalent fasteners, tightened to a high tension shall be coated with permitted coatings in accordance with ASTM F3125 for their respective grade. Use the bolts in holes conforming to 602.06, 602.07, and 602.08. All Grade A325 and A490 bolts, except Type 3 bolts used in weathering steel, shall be coated. Permitted coatings for Grade A325 and Grade A490 bolts are listed in ASTM F3125, Annex A1."

Subsection 602.17 (pg. 465–469), 12-2-16; Update Tables:

Table 602.17-1: Minimum Bolt Tension [1]

Bolt Diameter (inches)	Bolt Tension (pounds)	
	(GradeA325)	GradeA490 Bolts
½	12,000	15,000
5/8	19,000	24,000
¾	28,000	35,000
7/8	39,000	49,000
1	51,000	64,000
1-1/8	64,000	80,000
1-1/4	81,000	102,000
1-3/8	97,000	121,000
1-1/2	118,000	148,000

[1] Equal to 70% of the specified minimum tensile strength of bolts.

Bolt Diameter (inches)	Grade A325 Snug Tension (kips)	Grade A490 Snug Tension (kips)
½	1	1
5/8	2	2
¾	3	4
7/8	4	5
1	5	6
1-1/8	6	8
1-1/4	8	10
1-3/8	10	12
1-1/2	12	15

Table 602.17-3: Minimum Installation Tension

Bolt Diameter (inches)	Grade A325 Tension (kips)	Grade A490 Tension (kips)
1/2	12	15
5/8	19	24
3/4	28	35
7/8	39	49
1	51	64
1-1/8	64	80
1-1/4	81	102
1-3/8	97	121
1-1/2	118	148

Table 602.17-4: Rotation from Snug Condition

Bolt Length (measured in Step 1)	Grade A325 Required Rotation	Grade A490 Required Rotation
Up to and including 4 diameters	2/3	2/3
Over 4 diameters, but not exceeding 8 diameters	1	5/6
Over 8 diameters to 12 diameters	1-1/6	1

Table 602.17-5: Turn Test Tension

Bolt Diameter (inches)	Grade A325 Tension (kips)	Grade A490 Tension (kips)
1/2	14	17
5/8	22	28
3/4	32	40
7/8	45	56
1	59	74
1-1/8	74	92
1-1/4	94	117
1-3/8	112	139
1-1/2	136	170

Table 602.17-6

Bolt Length (measured in Step 1)	Required Rotation (All Grades)
Up to and including 4 diameters	1/3
Over 4 diameters, but not exceeding 8 diameters	½

Table 602.17-7

Bolt Diameter (inches)	Grade A325 Torque (ft-lbs)	Grade A490 Torque (ft-lbs)
1/2	150	180
5/8	290	370
3/4	500	630
7/8	820	1020
1	1,230	1540
1-1/8	1,730	2160
1-1/4	2,450	3050
1-3/8	3,210	3980
1-1/2	4,250	5310

Table 602.17-8

Bolt Length (measured in Step 1)	Additional Required Rotation Grade A325	Additional Required Rotation Grade A490
Up to and including 4 diameters	1/3	¼
Over 4 diameters, but not exceeding 8 diameters	1/2	1/3

Table 602.17-9: DTI Requirements for A325 Bolts

Bolt Diameter (inches)	Verification Tension (kips)	Maximum Verification Refusals	DTI Spaces	Minimum Installation Refusals
1/2	13	1	4	2
5/8	20	1	4	2
3/4	29	2	5	3
7/8	41	2	5	3
1	54	2	6	3
1-1/8	67	2	6	3
1-1/4	85	3	7	4
1-3/8	102	3	7	4
1-1/2	124	3	8	4

Table 602.17-11

Bolt Diameter (inches)	Bolt Tension (kips)	
	AASHTO M 164 Bolts (ASTM A325)	ASTM A490 Bolts
1/2	13	16
5/8	20	25
3/4	29	37
7/8	41	51
1	54	67
1-1/8	67	84
1-1/4	85	107
1-3/8	102	127
1-1/2	124	155

Table 602.17-12

Bolt Diameter (inches)	Number of Spaces	
	Bolts (GradeA325)	Grade A490 Bolts
1/2	4	N/A
5/8	4	N/A
3/4	5	6
7/8	5	6
1	6	7
1-1/8	6	7
1-1/4	7	8
1-3/8	7	8
1-1/2	8	N/A

Subsection 602.19 (pg. 478), 6-27-16; add the following as the 2nd paragraph:

"All welders shall be qualified in accordance with the AASHTO/AWS D1.5, Bridge Welding Code, current edition. Welders shall be certified for each weld process and position which they will be using."

Subsection 602.39 (pg.488), 6-27-16; revise the title as follows:

"CONSTRUCTION REQUIREMENTS – ERECTION – REMOVAL"

Subsection 602.42 (pg.489), 6-27-16; revise as follows:

"All contractors and subcontractors directly engaged in the erection or removal of structural steel, precast prestressed or mild steel reinforced concrete bridge beams or girders over active highway traffic lanes, on any route, railroad or any stream deemed navigable to commercial or pleasure water craft, shall submit an erection or removal plan prepared and stamped by a Professional Engineer licensed in the State of Tennessee. Include the following in these plans: the sequences of erection or removal, the generalized location of all pick points, and the plan to adequately stabilize the structure throughout the erection or removal process. Submit this plan to the Engineer at least 30 days before starting erection. At each stopping point in the erection or removal sequence, have a competent contractor's representative inspect the beams to ensure adequate stability.

Do not begin any erection or removal work without the Engineer's approval. The Engineer's approval does not relieve the Contractor of the responsibility for the safety of its method or equipment or from carrying out the work in accordance with the Plans and Specifications."

Subsection 604.02 (pg. 519), 11-16-15; C. 2nd paragraph, 1st sentence:

"Prior to construction, submit for approval shop drawings of the proposed precast structure and design calculations for any details which deviate from the standard box culvert drawings."

Subsection 604.02 (pg. 517-518), 5-15-17; A. General, add Class DS Concrete to the index:

604.02 Materials

A. General

Provide materials as specified in:

Hydraulic cement[1] **901.01**
Fine Aggregate, (all Classes of concrete)..... **903.01**
Coarse Aggregate
For Class A Concrete: Size No. 57 ..... **903.03**
For Class D Concrete: Size No. 57 ..... **903.03**

[1]Use Type I, Type IL, or Type IS unless otherwise specified or permitted, or Type I or Type IL cement with either fly ash and/or ground granulated blast furnace slag as a partial cement replacement unless otherwise specified or permitted. When using Type I or Type IL cement with either fly ash and/or ground granulated blast furnace slag as a partial cement replacement, comply with the requirements of **604.03**.

Subsection 604.02 C. (pg. 519), 11-6-17; Precast Box Sections, remove mylar reference in second paragraph:

"Submit shop drawings of the proposed precast box section and design calculations for approval before construction. As a minimum, the shop drawings shall include a plan and elevation view of the box culvert showing all precast sections, a typical precast box section showing dimensions and reinforcing, and notes and details required for construction. After obtaining the necessary approval, furnish the Structures Division a reproducible design file. ~~a permanent, 4-mil mylar reproducible of the design for their file~~. The Department will pay the Contractor for the precast box based on the price bid for the quantity of the items in the cast-in-place structure it replaces. Manufacture the precast reinforced box sections in accordance with Departmental procedures."

Subsection 604.03 (pg. 520-521), 5-15-17; Table 604.03-1: Composition of Various Classes of Concrete and Table 604.03-2: Use of Chemical Admixtures, Add class DS to the Tables, revise footnotes 2 and 3 of Table 604.03-1 and the note below Table 604.03-3; Update Table 604.03-4: Composition of Self-Consolidating Concrete and Table 604.03-5: Use of Chemical Admixtures to add SH-SCC, update :

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.

Include chemical admixtures in the concrete mixture as specified in Table 604.03-2 based on the ambient air temperature and expected weather conditions.

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

Table 604.03-3: Type I or Type IL Cement Modified by Fly Ash or Ground Granulated Blast Furnace Slag (GGBFS)

Modifier	Maximum Cement Replacement Rate % (by weight)	Minimum Modifier Cement Substitution Rates (by weight)
GGBFS (grade 100 or 120)	35.0	1:1
Class "F" Fly Ash	25.0	1:1
Class "C" Fly Ash	25.0	1:1

The Contractor may use ternary cementitious mixtures (mixtures with Portland cement, ground granulated blast furnace slag, and fly ash) for Class A, Class D, and Class DS concrete provided that the minimum Portland cement content is 50%. The maximum amount of fly ash substitution in a ternary cementitious mixture shall be 20%. The Department will allow Type IS cement with ternary cementitious mixtures. When using a Type IS cement, do not use any additional slag as a partial replacement for the hydraulic cement.

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 ± 1	25 ± 4
SH-SCC (2,3,4,5,6)	4,500	620	0.45	6 ± 1	25 ± 4

(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 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

Table 604.03-5: Use of Chemical Admixtures

Class of Concrete	Temperature less than 85 °F and falling	Temperature 85 °F or greater and rising
SCC, SH-SCC	Type A or F Type S (Viscosity Modifying)	Type D or G or A and B Type S (Viscosity Modifying)

Subsection 604.03 (pg. 522-523) 5-15-17; A. Classification and Proportioning and Quality Assurance: Add 22.-28, add sentence to 5th paragraph:

2. **"Mix Design Submittal.** Submit the proposed concrete design to the Engineer for approval. Develop the design using saturated surface dry aggregate weights and trial batches meeting the requirements of these Specifications. The concrete design shall be prepared by a TDOT certified Class 3 concrete technician or approved independent testing laboratory under the direction of a registered civil engineer licensed by the State of Tennessee. The concrete plant technician or the civil engineer shall certify that the information contained on the design is correct and is the result of information gained from the trial batches. The concrete design shall produce an average compressive strength to indicate that the specified 28-day strength can be obtained in the field. Make all strength determinations using equipment meeting the requirements of, and in the manner prescribed by, AASHTO T 22. Provide concrete of the design strength specified in all applicable Special Provisions, Plans, and Standard Specifications. Build trial batches for design no more than 90 days before submitting the concrete design. The approved mix design will expire after 6 months if it is not used on a Department funded project and meet the minimum 28-day strength requirements. Assume responsibility for all costs of concrete design, preparation, and submittal.

   As a minimum, include the following information in the proposed concrete design submittal:
   1. Source of all aggregates
   2. Brand and type of cement
   3. Source and class of fly ash (if used)
   4. Source and grade of ground granulated blast furnace slag (if used)
   5. Specific gravity of cement
   6. Specific gravity of the fly ash (if used)
   7. Specific gravity of the ground granulated blast furnace slag (if used)
   8. Admixtures (if used)
   9. Gradations of aggregates
   10. Specific gravity of aggregates (saturated surface dry)
   11. Air content (if air entrainment is used)
   12. Percentage of fine aggregate of the total aggregate (by volume)
   13. Slump
   14. Weight per cubic yard
   15. Yield
   16. Temperature of plastic concrete
   17. Water/cement ratio (pound/pound)
   18. 7-day compressive strength (minimum of two 4-inch x 8-inch cylinders)
   19. 14-day compressive strength (minimum of two 4-inch x 8-inch cylinders)
   20. 28-day compressive strength (minimum of two 4-inch x 8-inch cylinders)
   21. Weight of each material required to produce a cubic yard of concrete
   22. Water – submit testing results per Tables 921.01-1 & 921.01-2

In addition to the above mentioned items, for self-consolidating concrete include as a minimum the following information in the proposed SCC design submittal:

23. Slump flow, VSI, and T50, in accordance with ASTM C1611, shall be required in place of the slump test.
24. Passing ability in accordance with ASTM C1621.
25. Static segregation in accordance with ASTM C1610.
26. 7-day compressive strength (minimum of two 4-inch x 8-inch cylinders), in accordance with ASTM C1758.
27. 14-day compressive strength (minimum of two 4-inch x 8-inch cylinders), in accordance with ASTM C1758.
28. 28-day compressive strength (minimum of two 4-inch x 8-inch cylinders), in accordance with ASTM C1758.

Self-consolidating concrete (Classes SCC, SH-SCC and P-SCC) shall be verified prior to placement either at the ready mix facility or prestressed plant. The submitted mix design shall be reviewed by Headquarters Materials and Tests for specification compliance. The concrete producer shall then perform a trial batch verification of the submitted mix design in the presence of Regional Materials and Tests. The trial batch will ensure that all batch quantities and target admixture dosage rates are acceptable and meet TDOT specification prior to full mix design approval. If using a previously approved SCC design additional verification of the trial batch is not required. All quantities and identified admixture target dosage rates shall meet the tolerances specified in **501.09**

Instead of the above mix design submittal, an existing design may be submitted for approval provided the design has been used on a state funded project within the last six (6) months. When submitting for the use of an existing mix design, the most current water testing results per 921.01 shall accompany the submittal. The approval of this concrete design submittal will not relieve the Contractor of the responsibility of providing concrete meeting the requirements of these Specifications. A temporary mix design may be issued if the 7-day or 14-day compressive strengths exceed the required 28-day strengths."

Subsection 604.03 (pg. 522 and 523), 5-18-15; 2. Mix Design Submittal; Replace the first sentence of the last paragraph on page 522 with the following:

"Instead of the above mix design submittal, an existing design may be submitted for approval provided the design has been used on a state funded project within the last six (6) months."

Subsection 604.03 (pg. 519-522), 11-16-15; A. Classification and Proportioning and Quality Assurance, modify the following:

"1a. Design and Production Parameters. Proportion the concrete based on a pre-determined minimum cement content, and a water-cement ratio that does not exceed the maximum shown in **Table 604.03-1**. Below this limit, adjust the quantity of water to meet the slump requirements. The fine aggregate shall not exceed 44% by volume calculation of the total aggregate, with the exception of slip formed Class A concrete incorporated into parapets and median barriers.
For slip formed parapet and median barriers exclusively, the percentages of fine and coarse aggregate in an approved concrete mix design may be adjusted plus or minus 2%, such that the….

1b. Self-Consolidating Concrete (SCC) Design and Production Parameters. Proportion the concrete based on a pre-determined minimum cement content, and a water-cement ratio that does not exceed the maximum shown in **Table 604.03-4**. The fine aggregate shall not exceed 50% by volume calculation of the total aggregate volume. Maximum size of coarse aggregate shall not exceed a No. 67 stone. The Contractor may elect to use SCC as an alternate/option in replacement of Class A concrete.

Document mixture adjustments in the field book and daily concrete report. Ensure that the adjusted mix complies with all of the performance criteria specified in **Table 604.03-4**.

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 ± 1	25 ± 4

(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 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%.

Include chemical admixtures in the self-consolidating concrete mixture as specified in Table **604.03-5** based on the ambient air temperature and expected weather conditions. Approved viscosity modifying admixtures (VMA) may be used as part of the chemical admixtures if they are shown in the approved mixture design.

Table 604.03-5: Use of Chemical Admixtures

Class of Concrete	Temperature less than 85 °F and falling	Temperature 85 °F or greater and rising
SCC	Type A or F Type S (Viscosity Modifying)	Type D or G or A and B Type S (Viscosity Modifying)

Dosage rates for any admixtures incorporated into the concrete shall be stated during the mix design submittal process. All admixtures shall be compatible and from the same manufacturer.

2.Mix Design Submittal. Submit the proposed concrete design to the Engineer for approval. Develop the design using saturated surface dry aggregate weights and trial batches meeting the requirements of these Specifications….

As a minimum, include the following information in the proposed concrete design submittal:

1. Source of all aggregates
2. Brand and type of cement

3. Source and class of fly ash (if used)
4. Source and grade of ground granulated blast furnace slag (if used)
5. Specific gravity of cement
6. Specific gravity of the fly ash (if used)
7. Specific gravity of the ground granulated blast furnace slag (if used)
8. Admixtures (if used)
9. Gradations of aggregates
10. Specific gravity of aggregates (saturated surface dry)
11. Air content (if air entrainment is used)
12. Percentage of fine aggregate of the total aggregate (by volume)
13. Slump
14. Weight per cubic yard
15. Yield
16. Temperature of plastic concrete
17. Water/cement ratio (pound/pound)
18. 7-day compressive strength (minimum of three 4-inch x 8-inch cylinders)
19. 14-day compressive strength (minimum of three 4-inch x 8-inch cylinders)
20. 28-day compressive strength (minimum of three 4-inch x 8-inch cylinders)
21. Weight of each material required to produce a cubic yard of concrete

In addition to the above mentioned items, for self-consolidating concrete include as a minimum the following information in the proposed SCC design submittal:

22. Slump flow, VSI, and T50, in accordance with ASTM C1611, shall be required in place of the slump test.
23. Passing ability in accordance with ASTM C1621.
24. Static segregation in accordance with ASTM C1610.
25. 7-day compressive strength (minimum of three 4-inch x 8-inch cylinders), in accordance with ASTM C1758.
26. 14-day compressive strength (minimum of three 4-inch x 8-inch cylinders), in accordance with ASTM C1758.
27. 28-day compressive strength (minimum of three 4-inch x 8-inch cylinders), in accordance with ASTM C1758.

Self-consolidating concrete (Classes SCC and P-SCC) shall be verified prior to placement either at the ready mix facility or prestressed plant. The submitted mix design shall be reviewed by Headquarters Materials and Tests for specification compliance. The concrete producer shall then perform a trial batch verification of the submitted mix design in the presence of Regional Materials and Tests. The trial batch will ensure that all batch quantities and target admixture dosage rates are acceptable and meet TDOT specification prior to full mix design approval. If using a previously approved SCC design additional verification of the trial batch is not required. All quantities and identified admixture target dosage rates shall meet the tolerances specified in **501.09**.

Subsection 604.03 (pg. 522), 12-2-16; Mix Design Submittal, modify the following:

"18. 7-day compressive strength (minimum of two 4-inch x 8-inch cylinders)
19. 14-day compressive strength (minimum of two 4-inch x 8-inch cylinders)
20. 28-day compressive strength (minimum of two 4-inch x 8-inch cylinders)"

Subsection 604.03 B. (pg.524), 11-6-17; B. Quality Control and Acceptance of Concrete, Add the following as the last sentence of the 1st paragraph:

"If the quantity exceeds 2 cubic yards, prior approval must be obtained from the Engineer prior to placement."

Subsection 604.13 (pg. 541), 5-15-17; Mixing Concrete, add Class DS concrete to the 2nd paragraph, 3rd sentence:

"Do not retemper concrete by adding water or by other means. However, the Contractor may withhold a portion of the mixing water or chemical admixtures from transit mixers and add at the work site if all requirements of the approved mix design are met. Water added at the placement site for Class A, Class D, Class DS and Class L concrete shall not exceed 1 gallon per cubic yard. The total amount of water in the mix shall not exceed the maximum in the approved mix design. To achieve additional slump, use a water reducing admixture. 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. Do not use concrete that is not within the specified slump limits, air content limits, temperature limits, or time limits at the time of placement."

Subsection 604.14 (pg. 542), 11-16-15; Consistency of Concrete, modify the following:

"The slump of the concrete when measured according to AASHTO T 119 shall meet 604.03 - **1A**. The slump flow of self-consolidating concrete when measured according to ASTM C1611 shall meet **604.03 1B**."

Subsection 604.15 (pg. 542-543), 11-16-15; B. Concrete Acceptance Cylinders, modify the following:

"The Department will test the specimens for compressive strength according to AASHTO T 22. Provide the necessary concrete for making test specimens and adequate curing and storage facilities at no additional cost to the Department.

Concrete cylinders submitted for testing beyond 28 days shall comply with the strength requirements specified in Table 604.15-1.

Table 604.15-1: Strength Requirements

Class of Concrete	**Compressive Strength (psi) at:**		
	Less than 31 days	**31 to 42 days**	**43 days to 56 days**
A, S, CP, SCC	3,000	3,300	3,500
D, L	4,000	4,400	4,600
X	Plans Requirement (Req)	Req. + Req. * (10%)	Req. + Req. * (15%)

If the acceptance cylinders fail to meet the specified strengths, the Contractor may drill core samples from the hardened concrete as verification of concrete strength instead of using the concrete cylinders. The Contractor must provide QC data from companion cylinders that meet or exceed the required strength, and TDOT Materials and Test shall perform a nondestructive test

using a Swiss Hammer on the concrete to prove required strength is achieved. If the above mentioned requirements are met, the Contractor may then elect to drill a maximum of three core samples per set of cylinders from the hardened concrete. The Contractor shall obtain the cores in accordance with the Department's Standard Operating Procedure 4-2, and bear all costs of obtaining the cores and repairing the core holes."

Subsection 604.15 (pg. 543), 5-15-17; Table 604.15-1: Strength Requirements, Add Class DS to Table, update 2nd paragraph 3rd sentence to remove "cylinders and":

Table 604.15-1: Strength Requirements

Class of Concrete	Compressive Strength (psi) at:		
	Less than 31 days	31 to 42 days	43 days to 56 days
A, S, CP, SCC	3,000	3,300	3,500
D, DS, L	4,000	4,400	4,600
SH-SCC	4,500	4,950	5,175
X	Plans Requirement (Req)	Req. + Req. * (10%)	Req. + Req. * (15%)

If the acceptance cylinders fail to meet the specified strengths, the Contractor may drill core samples from the hardened concrete as verification of concrete strength instead of using the concrete cylinders. The Contractor must provide QC data from companion cylinders that meet or exceed the required strength, and TDOT Materials and Test shall perform a nondestructive test using a Swiss Hammer on the concrete to prove required strength is achieved. If the above mentioned requirements are met, the Contractor may then elect to drill a maximum of three core samples per set of cylinders from the hardened concrete. The Contractor shall obtain the cores in accordance with the Department's Standard Operating Procedure 4-2, and bear all costs of obtaining the cores and repairing the core holes.

Acceptance for payment may be based on cores provided by the Contractor at its expense. These cores shall meet the strength requirements specified in Table 604.15-1. The Engineer will not accept concrete cores submitted for testing beyond 56 days.

Subsection 604.16 (pg. 545) 5-15-17; Placing Concrete, A. General – revise the 1st paragraph to add Class DS in the first sentence:

"Unless otherwise specified, before placing a bridge deck overlay of Class D , Class DS, or Class L concrete, machine scarify the surface to be covered to a minimum depth of 1 inch. In areas inaccessible to machine scarifying, and in areas of spalling where steel reinforcement is exposed, remove deteriorated concrete using hand tools or other methods approved by the Engineer. After scarifying, clean the deck of all deleterious material. Do not allow traffic on the scarified deck."

Subsection 604.27 (pg. 560), 11-16-15; Rideability of New or Resurfaced Bridge Decks and Roadway Approaches, A. General, revise the 1st paragraph to the following:

"On all highway sections with a posted speed greater than 40 miles per hour, the following rideability provisions shall apply to new or resurfaced bridge decks and roadway approaches."

Subsection 604.31 (pg. 567-568) 5-15-17; Basis of Payment, add Class DS to item and pay unit list:

604.31 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Class A Concrete (Description)	Cubic Yard
Class D Concrete (Description)	Cubic Yard
Class DS Concrete (Description)	Cubic Yard
Class L Concrete (Description)	Cubic Yard
Class S Concrete (Description)	Cubic Yard
Steel Bar Reinforcement	Pound
Epoxy Coated Reinforcing	Pound
Scarifying	Square Yard
Applied Texture Finish	Square Yard
Hydro-demolition	Square Yard

Subsection 606.04.B.1(b) (pg. 578), 6-27-16; replace 1.b. with the following:

"(b) Except as provided in paragraph 2(b) below, develop an energy per blow in foot-pounds not less than 250 multiplied by R, where R is the required minimum bearing resistance of the pile in tons."

Subsection 606.07.A. (pg. 581), 6-27-16; revise the 1st paragraph:

"Construct cast-in-place concrete piles of the design shown on the Plans and that consist of concrete cast in drilled holes or in steel shells or pipes driven to the required bearing. Use Class A concrete meeting **604**, or use Class X concrete, as required by design, meeting **604**. Provide and place suitable casing when required to prevent caving of the hole before concrete is placed.

Subsection 611.02 (pg. 620), 11-6-17; Materials, revise the last sentence of the last paragraph to remove the mylar reference:

"After obtaining the necessary approval, furnish the Engineer an electronic reproducible design file.~~, 4 mil mylar reproducible of the design~~."

Subsection 613.02 (pg. 633), 6-27-16; add the following section:

"Brick Paving Units ……..912.05"

Subsection 615.09 (pg. 644), 11-16-15; Proportioning and Mixing of Concrete, update Table 615.09-1 and add the 3rd paragraph below the table, modify the last paragraph:

Table 615.09-1: Composition of Prestress Concrete Classes

Class of Concrete	Minimum 28-Day Compressive Strength (psi)	Minimum Pounds Cement per Cubic Yard	Maximum Water/Cement Ratio (pound/pound)	Air Content %	Slump or Slump Flow (inches)
P	5,000 (1)	658	0.45	0-8 (2)	2 ± 1 (3)
P-SCC (4)	5,000 (1)	658	0.45	0-6 (2)	25 ± 4

(1) Or as shown on the Plans or approved shop drawings.

(2) Air entraining is optional with the Contractor, unless otherwise shown on the Plans or shop drawings.

(3) Not to exceed 3 inches before the addition of high range admixtures, and not to exceed 10 inches after the addition of high range admixtures. If water-cement ratio is equal to or less than 0.35 then the maximum slump is 10 inches. If the water-cement ratio is 0.36 – 0.45, the maximum slump is 8 inches.

(4) Maximum coarse aggregate size of a No. 67 stone.

Comply with all applicable provisions of **604.03** except as modified herein.

Submit a concrete design to the Department for review and approval. In addition to the proportions, identify in the design submittal the source or brand of all materials and the type of cement to be used. The Contractor may use Type I or Type III cement, unless otherwise specified. Do not use calcium chloride. Use a retardant admixture when the ambient temperature is 75 °F or higher. The slump of the concrete shall be 2 inches with a tolerance of ±1 inch at the time of placement. When an approved superplasticizer is to be used, the slump of the concrete shall be the same as above before the superplasticizer is added to the mix. After the addition of the superplasticizer, the slump may be increased to a maximum of 8 inches at the time of placement.

The slump flow of self-consolidating concrete shall be determined and within the design and production tolerances stated in **Table 615.09-1**. Include chemical admixtures in the self-consolidating concrete mixture as specified in **Table 604.03-5** based on the ambient air temperature and expected weather conditions. Approved viscosity modifying admixtures (VMA) may be used as part of the chemical admixtures if they are shown in the approved mixture design.

Handle, measure, and batch materials; mix concrete; and comply with the limitations of mixing as specified in **501.09**, **501.10**, and **501.11**, respectively.

Make concrete test specimens for Class P and Class P-SCC, in accordance with AASHTO T 23 and ASTM C1758 respectively, to determine the adequacy of the concrete design and the minimum time at which the stress may be applied to the concrete. Cure the test specimens used to determine the time at which stress may be applied in the same manner and under the same conditions as the bridge members. The initial curing of specimens to determine the design strength of the concrete shall be as specified above with additional curing water, as provided in AASHTO…

Subsection 615.17 (pg. 652), 5-18-15; Table 615.17-1: Manufacturing Tolerances in Standard Sections, Update Table 615.17-1:

Table 615.17-1: Manufacturing Tolerances in Standard Sections

Description	Tolerance	
	I-Sections	**Box Sections**
Nominal Depth	± 1/2 inch	± 1/2 inch
Nominal Width	± 1/2 inch	± 1/2 inch
Nominal Length	Computed Elastic Shortening ±1/2 inch	Computed Elastic Shortening ±1/2 inch
Variation in Straightness, inches	1/4 inch x (Total Length in feet)/10	1/4 inch x (Total Length in feet)/10
Variation in Camber, inches	Beams in any 1 span not more than: 1/8 inch x (Total Length in feet)/10	Beams in any 1 span not more than: 1/8 inch x (Total Length in feet)/10
Location of Voids	---------	Length ± 1/2 in Wall Thickness ± 1/2 in
Bearing	Full Bearing - Full Width of Beam	Full Bearing on at Least 2/3 of Width of Beam
Tendon Placement	± 1/2 inch	± 1/2 inch
Reinforcing Steel Placement	± 1/2 inch	± 1/2 inch
Reinforcing Steel Concrete Cover	± 1/2 inch	± 1/2 inch
Reinforcing Steel Splice Lengths	Minus 1-1/2 inches	Minus 1-1/2 inches

Subsection 622.03 (pg. 686) 12-2-16; Add the following paragraph at the beginning of the section:

"Same-as designs shall not be submitted for Shotcrete."