11

Self-Consolidating Concrete (SCC)

AASHTO T 347 / ASTM C1611

AASHTO T 345 / ASTM C1621

ASTM C1758

Introduction to
Self-Consolidating Concrete (SCC)

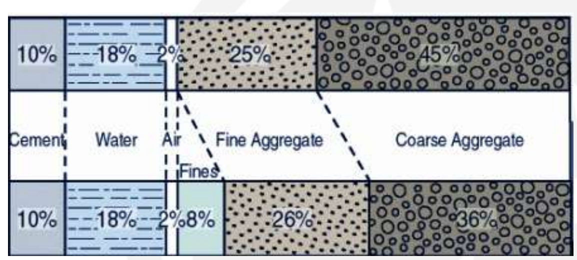
References
ACI 237R-07

Self-Consolidating Concrete

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

Regular Mix

SCC



Self-Consolidating Concrete

- Highly flowable
- Non-segregating
- Fills the formwork
- Encapsulates the reinforcement
- No mechanical consolidation

- U-Box Demo

TN TDOT Department of Transportation

Usage

- Great for filling in unusual shapes, passing through dense reinforcement, or filling in tight spaces in formwork
  - Highly flowable consistency means that it does not need external consolidation of any kind (vibration)

TN TDOT Department of Transportation

Usage

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

TN TDOT Department of Transportation

Usage

- Drilled shafts are required to use Class SH-SCC mixture
  - Helps ensure proper concrete cover around reinforcing cage

TN TDOT Department of Transportation

Comparison to Conventional Concrete

Advantages

- Reduce labor and equipment
- No vibration needed
- Flows to fill space means less placement points
- Smooth surfaces free of honeycombing

Disadvantages

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

TN TDOT Department of Transportation

Field Experience

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

TN TDOT Department of Transportation

Field Acceptance Testing

- Conventional practices and test methods (cylinders, air content, unit weight) for field acceptance testing must be modified
  - Filling
    - **Pouring vessel shall remain no more than 5 inches above top of measure or cylinder**
    - **Fill in one lift**
  - Consolidation
    - **No rodding**
    - **No tapping**
- Slump flow, T-50, VSI, and passing ability

TN TDOT Department of Transportation

TDOT Standard Method of Test for

Slump Flow, T50, VSI of SCC

References

ASTM C1611

AASHTO T 347

TN TDOT Department of Transportation

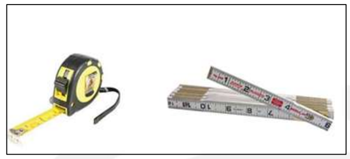
Significance and Use (Slump flow)

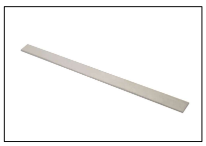
- The slump flow test is a measure of mixture **filling ability**
- The test is similar to the conventional slump test using the same standard slump cone
- Instead of measuring the slumping distance vertically, the average spread of the resulting concrete patty is measured horizontally

TN TDOT Department of Transportation

Equipment

- Mold
- Base Plate
- Strike-off bar
- Stopwatch
- Pouring Vessel
- Measuring Device





Procedure

- Select a flat, level, nonabsorbent surface
- Dampen the mold and place it in the center of the base plate
  - The mold may be placed upright (procedure A) or inverted (procedure B)

TN TDOT Department of Transportation

Procedure

- Immediately fill the mold in **one lift without rodding or tapping**
  - Limit pour height to 5 inches above the container
  - If first attempt does not fill in one lift, repeat until the container is filled slightly above its rim
- Strike off the surface of the concrete using a strike off bar
- Remove the concrete from around the base of the mold

TN TDOT Department of Transportation

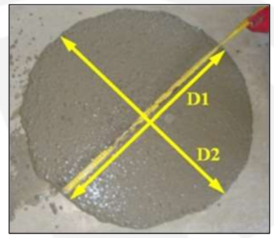
Procedure

- Lift the mold vertically to 9 ± 3 inches in 3 ± 1 seconds with no lateral or torsional motion
- Wait for the concrete to stop flowing

TN TDOT Department of Transportation

Procedure

- Measure the *largest* diameter (D1) of the spread and a *second diameter* (D2) **perpendicular** to the first
  - Record Measurements to the **nearest 0.25 inch**
  - If a halo is present, include with measurement
  - If the two diameters differ more than 2 inches, the test is invalid



- Average the two spread diameters and record the slump flow to the **nearest 0.50 inch**

TN TDOT Department of Transportation

Calculations

- Slump Flow = $\frac{(D1+D2)}{2}$

- D1 = Largest diameter measurement (in.)
- D2 = Perpendicular measurement (in.)

- Check: D1 – D2 < 2.0 inches

TN TDOT Department of Transportation

Problem 1

- Given:
  - Spread Diameter (D1) = 22.00 inches
  - Spread Diameter (D2) = 21.25 inches
- Determine the Slump Flow

$$\text{Slump Flow} = \frac{(D_1+D_2)}{2}$$

$$\text{Slump Flow} = \frac{(22+21.25)}{2}$$

$$\text{Slump Flow} = \frac{(43.25)}{2} = 21.63 \sim 21.50"$$

TN TDOT Department of Transportation

Problem 2

- Given:
  - Spread Diameter (D1) = 22.75 inches
  - Spread Diameter (D2) = 20.25 inches
- Determine the Slump Flow

$$\text{Slump Flow} = \frac{(D_1+D_2)}{2}$$

$$\text{Slump Flow} = \frac{(22.75+20.25)}{2}$$

$$\text{Slump Flow} = \frac{(43.00)}{2} = 21.50 \sim 21.50"$$

$$\textit{However}, 22.75-20.25 = 2.5" > 2.0"$$

TN TDOT Department of Transportation

T-50

- The flow of SCC mixes is particularly important, and the follow are used to modify the flow of an SCC mixture:
  - Special High range water reducers
  - Viscosity Modifying Admixtures
  - Mixture Proportions
- The T-50 test provides a measure of the unconfined flow properties of the SCC mixture

TN TDOT Department of Transportation

T-50 Procedure

- From the time the mold is first lifted
  - Use a stopwatch to measure the time (in seconds) it takes <u>any part</u> of the outer edge of the spreading concrete to reach the inscribed mark on the base plate
- Record the T-50 to the nearest **0.1 seconds**

20 inch
(50 cm)
diameter

TN TDOT Department of Transportation

Visual Stability Index (VSI)

- Determine the apparent stability of the slump flow patty through visual examination
  - Inspect the patty's perimeter
  - Assess the aggregate distribution in the patty
  - Inspect the surface of the patty
- Assign a VSI value to the SCC Patty

TN TDOT Department of Transportation

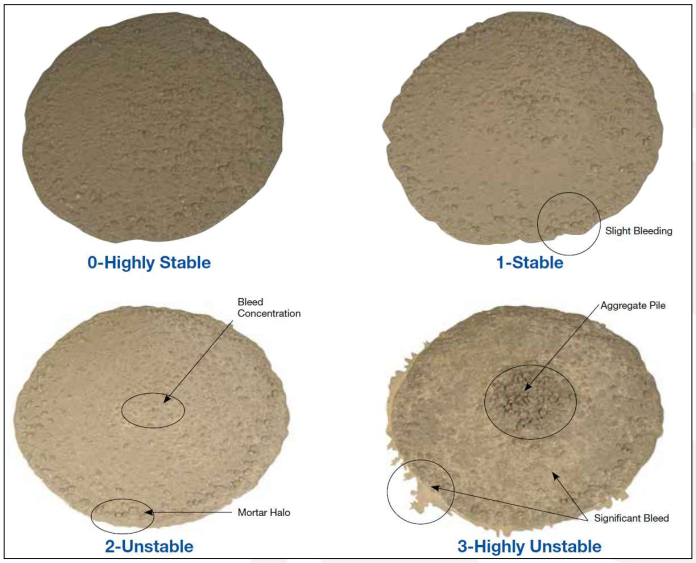
VSI

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.

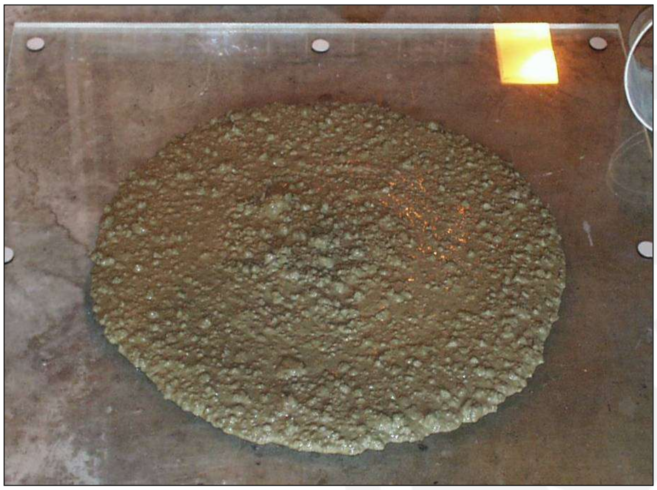
TN TDOT Department of Transportation

VSI Examples



TN TDOT Department of Transportation

VSI = 0

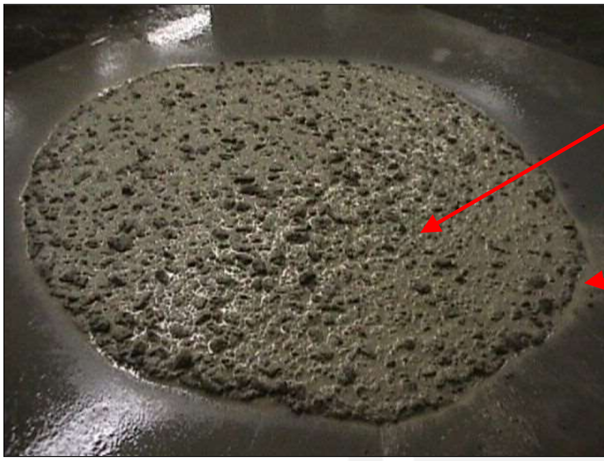


No mortar halo

No puddles of water

TN TDOT Department of Transportation

VSI = 1

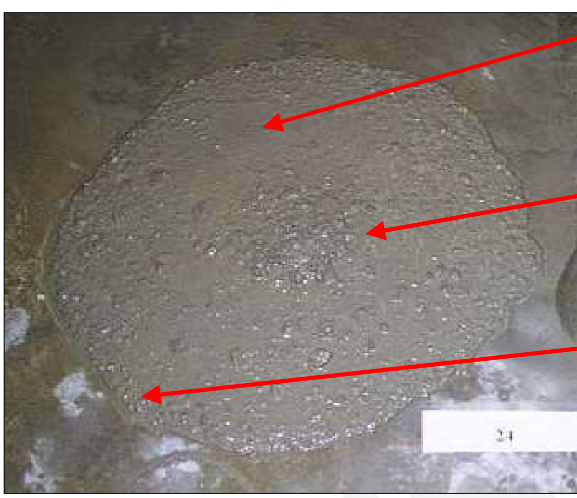


Slight sheen on the concrete

False mortar halo caused by excess water on the base plate

TN TDOT Department of Transportation

VSI = 2



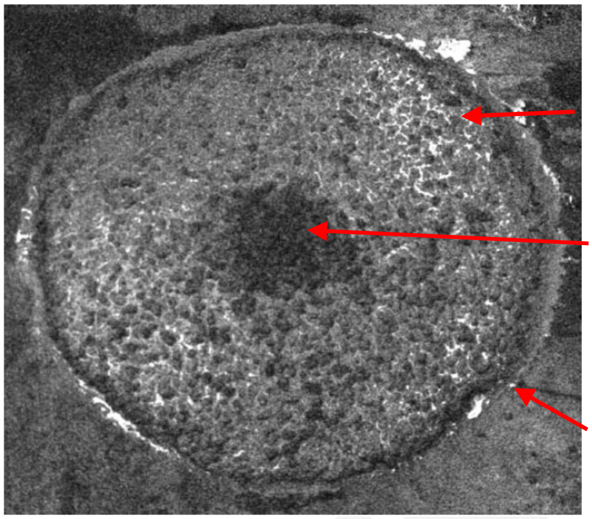
Water puddles on concrete patty

Aggregate pile near the center of patty

Mortar halo 0.25″ ≤ 0.5″

TN TDOT Department of Transportation

VSI = 3



Water puddles in patty

Aggregate pile near the center of patty

Mortar halo greater than 0.5”.

TN TDOT Department of Transportation

Inspector Questions

- **Is there a definite mortar halo?**
  - If so, how wide is the halo?
- **Did the aggregate spread with the mortar or is there an aggregate pile in the center 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

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

TDOT Standard Method of Test for

Passing Ability of SCC by J-Ring

References

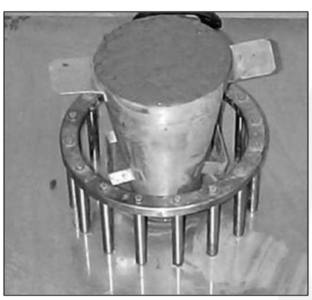
ASTM C1621

AASHTO T 345

TN TDOT Department of Transportation

Significance and Use

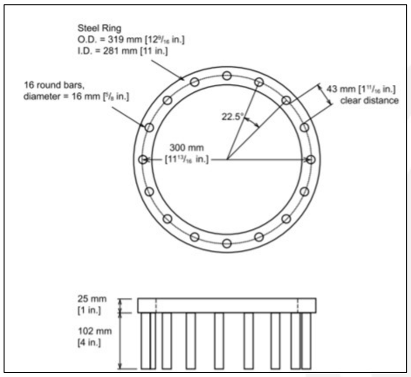
- Determine the passing ability of SCC mixtures
- J-Ring is used to simulate reinforcing elements or an impedance to the flow

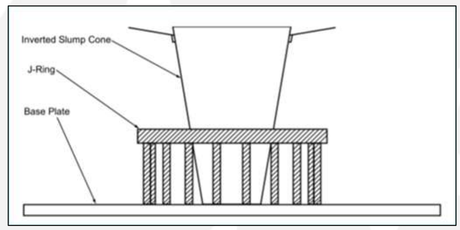


TN TDOT Department of Transportation

Equipment

- Same as slump flow, with addition of J-ring





TN TDOT Department of Transportation

Procedure

- Select a flat, level, nonabsorbent surface
- Dampen the mold and place it in the center of the base plate and concentric with the J-Ring

TN TDOT Department of Transportation

Procedure

- Immediately fill the mold in **one lift without rodding or tapping**
  - Limit pour height to 5 inches above the container
  - If first attempt does not fill in one lift, repeat until the container is filled slightly above its rim
- Strike off the surface of the concrete using a strike off bar
- Remove the concrete from around the base of the mold

TN TDOT Department of Transportation

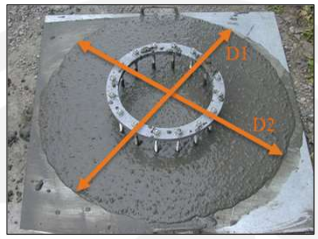
Procedure

- Lift the mold vertically to 9 ± 3 inches in 3 ± 1 seconds with no lateral or torsional motion
- Wait for the concrete to stop flowing through the J-Ring

TN TDOT Department of Transportation

Procedure

- Measure the *largest* diameter (D1) of the spread and a *second diameter* (D2) **perpendicular** to the first
  - Record Measurements to the **nearest 0.25 inch**
  - If a halo is present, include with measurement
  - If the two diameters differ more than 2.00 inches, the test is invalid



- Average the two spread diameters and record the J-Ring flow to the **nearest 0.50 inch**
- Complete slump flow and J-Ring tests within 6 minutes.

TN TDOT Department of Transportation

Calculations

- J-Ring Flow = $\frac{(D1+D2)}{2}$
  - D1 = Largest diameter measurement (in.)
  - D2 = Perpendicular measurement (in.)
- Passing Ability = Slump Flow – J Ring Flow
  - Less than 1" – Good Passing Ability
  - 1" to 2" – Acceptable Passing Ability
  - Greater than 2" – Poor Passing Ability

TN TDOT Department of Transportation

Example Problem 1

- Given:
  - Slump Flow = 23.50 inches
  - J-Ring Flow = 21.00 inches
- Determine the Passing Ability

Passing Ability = Slump Flow - J-Ring Flow

Passing Ability = 23.50 – 21.00 = 2.50

2.50 > 2.0 → Poor Passing Ability

Example Problem 2

- Given:
  - Slump Flow = 22.50 inches
  - J-Ring Flow = 22.00 inches
- Determine the Passing Ability

Passing Ability = Slump Flow - J-Ring Flow

Passing Ability = 22.50 – 22.00 = 0.50

0.50 < 1.0 → Good Passing Ability

Let's Review

- Record T-50 to the nearest ________________?
- Measure spread diameters to the nearest _________. Average these measurements to the nearest _________.
- How do we calculate passing ability?
- When using SCC, how many lifts are required?
- What does the J-Ring represent?

TN TDOT Department of Transportation

? Questions

TN TDOT Department of Transportation

TDOT Standard Specifications for

SCC Mixtures

References

Standard Specifications

TN TDOT Department of Transportation

Design and Production (604.03.1b)

Table 604.03-2: Composition of Self-Consolidating Concrete

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

(1) Or as shown on the Plans or approved shop drawings.
(2) Acceptance range for the T50 test in accordance with ASTM C1611 shall be between 2-7 seconds
(3) Passing ability in accordance with ASTM C1621 shall be equal to or less than 2 inches for acceptance.
(4) Visual Stability Index (VSI) shall not exceed 1.0 as per ASTM C1611 for acceptance.
(5) Static segregation as measured by ASTM C1610 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

Design and Production (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 (at no additional cost to state)

Mix Design Submittal (604.03.2)

- Self-consolidating concrete (Classes SCC, SH-SCC, and P-SCC) may be verified prior to placement at ready mix, precast or prestressed facility
- Trial Batch verification by producer with Regional M&T present
- Mix design reviewed and approved by HQ M&T

Field Experience

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

TN TDOT Department of Transportation

?

Questions

TN TDOT Department of Transportation