

Section 8.4 Volume II

SELF-CONSOLIDATING CONCRETE (SCC) FOR PRECAST/ PRESTRESSED CONCRETE PRODUCTS

8.4.1 PURPOSE

This procedure provides guidance to the precast/prestressed concrete fabrication facilities (Plants) that are involved in the manufacture of products using SCC. The procedure includes requirements related to the Plants' Quality Control (QC) Plans, field trial batches of the concrete mix designs, and inspection and testing of production concrete. Obtain SCC from a concrete plant listed on the Department's Structural Concrete Production Facility Listing.

8.4.2 AUTHORITY

Sections 334.044(10)(a) and 334.048(3), Florida Statutes.

8.4.3 REFERENCES

Manual for Quality Control for Plants and Production of Structural Precast Concrete Products, Precast/Prestressed Concrete Institute (PCI), Manual MNL 116

American Society for Testing and Materials (ASTM) Standard Test Methods and Specifications

American Concrete Institute (ACI), Publication 237R-07, Self-Consolidating Concrete, April 2007

Florida Department of Transportation (FDOT) Standard Specifications for Road and Bridge Construction

Florida Department of Transportation Florida Sampling and Testing Methods (FSTM)

American Association of State Highway and Transportation Officials (AASHTO), Part I Specifications, and Part II Tests

8.4.4 SCOPE

This procedure establishes guidelines for Plants that utilize SCC for the manufacturing of precast/prestressed concrete products (Products). The Plants shall comply with the requirements of the **Specifications**.

8.4.5 SCC RELATED QC PLAN PROVISIONS

The Plants' QC Plans shall address the following SCC related items in addition to/or in lieu of the items that are included for conventional concrete:

- A. Routine SCC QC tests.
- B. Placement, finishing, and curing methods.
- C. The appropriate SCC placement pattern and methods for the manufacturing of each Product.
- D. The qualifications and training of personnel who are involved in SCC QC inspection and testing activities.
- E. The proposed inspection and test methods for field trial and production batches.
- F. The adequacy of the forming strength to support the pressure of SCC during placement. Provide information about form joint sealing methods to prevent paste or mortar leakage.
- G. Considering weather conditions, include guidelines regarding the starting time of finishing, application of water fog mist, evaporation reducer or finishing aid if needed, and finishing methods for each type of Product.
- H. The lifting device placement method and capacity to handle the Products.

8.4.6 SCC TESTING REQUIREMENTS

Table I			
SCC Properties	Test	Standard Method	Acceptance Criteria
Filling Ability	Slump Flow	ASTM C1611	Tolerance = ± 2.5 in
	Relative Viscosity (T_{50})	ASTM C1611	$2 \text{ sec} \leq T_{50} \leq 7 \text{ sec}$
Passing Ability	J-Ring (Δ Flow)	ASTM C1621	$\Delta \text{ Flow} \leq 2.0$ in
Static Segregation	Column Segregation (S)	ASTM C1610	$S \leq 15\%$
	Rapid Assessment of Static Segregation (P_d)	ASTM C1712	$P_d \leq 25$ mm

	Visual Stability Index (VSI)	ASTM C1611	VSI ≤ 1
	Aggregate Distribution of Hardened SCC	FM 5-617	CAI ≤ 15%
	Hardened Visual Stability Index (HVSI)	AASHTO R 81	HVSI ≤ 1
Compressive Strength	Compressive Strength	ASTM C39	Depends on the application
Assessment of Durability	Surface Resistivity	AASHTO T 358	Depends on the application

8.4.6.1 SPECIFIED 346 CLASS CONCRETE

Proposed SCC mix designs require State Materials Office (SMO) approval. The District Materials and Research Offices (DMRO) review the proposed concrete mix designs and verify they meet the requirements of **FDOT Specifications Section 346, Materials Manual Volume II, Section 9.2**, and this Section.

Upon the Department's approval of the proposed mix design and satisfactory field demonstration, the use of SCC will be allowed for the fabrication of Products.

8.4.6.2 ASTM OR AASHTO CLASS OF CONCRETE

The proposed **ASTM** or **AASHTO** class of SCC mix design for the fabrication of Products shall meet the requirements of this Section and **Materials Manual Volume II, Section 9.2** except for the mix design approval process. The DMRO reviews and approves mix designs for Products that require **ASTM** or **AASHTO** class concrete with specified strength requirements. Production testing requirements for **ASTM** or **AASHTO** class concrete are specified in the applicable **Materials Manual** sections.

8.4.7 FIELD DEMONSTRATION OF SCC

Perform a field demonstration of the proposed mix design following a satisfactory laboratory trial batch. Perform the field trial batches and cast a partial or full-scale mockup in accordance with **FM 5-617**. Submit the mockup design to the DMRO for approval. Coordinate with the DMRO to witness the field demonstration.

Ensure that the field demonstration concrete is placed, consolidated, and cured in accordance with the proposed methods and sequences that are addressed in the QC Plan.

Perform inspection and testing of the field demonstration concrete during delivery, placement, and post placement. Observe the placement methods and sequences of the SCC. During placement, ensure that the concrete batches meet all plastic property requirements of the **Specifications** and maintain their cohesive nature without excessive bleeding, segregation, or abnormal retardation. Observe the finishing and curing methods of the concrete.

8.4.7.1 NUMBER AND QUANTITY OF BATCH SIZES

Place a total volume of 9 cubic yards in a minimum of three batches of at least 3 cubic yards each. Plants that are placing concrete with batch sizes of less than 3 cubic yards are required to place the necessary batches to reach the required volume of 9 cubic yards.

8.4.7.2 SAMPLING AND TESTING OF THE FIELD DEMONSTRATION CONCRETE

Perform the field demonstration tests, in accordance with **Table II**, on the first three consecutive batches to ensure that the concrete properties of the proposed mix design meet the requirements of the **Specifications**.

Take representative samples at the point of final concrete placement and perform the tests prescribed in **Table I** and **Table II** as appropriate. If the Plant is receiving SCC from an off-site ready-mixed concrete facility, perform the field demonstration at the location where the Products will be manufactured. When a previously approved SCC mix design is used at a Plant for the first time, manufacture and evaluate a mockup in accordance with **FM 5-617** at that location.

For SCC, modify the consolidation method of the **ASTM C31**, **ASTM C 138**, **ASTM C173**, and **ASTM C231** test following **ASTM C1758**. Perform the slump flow loss test as described in **Section 8.4.7.3**.

8.4.7.3 SLUMP FLOW LOSS TEST OF THE FIELD DEMONSTRATION CONCRETE

- A. Determine the workability of the three selected demonstration concrete batches by performing the slump flow tests. Take the samples at 15-minute intervals from each batch.
- B. Continue sampling and testing each batch until the slump flow measures the proposed target slump flow minus 2.5 inches, or a minimum of three slump flow data points are obtained.
- C. From the plot of slump flow versus time, determine the time for each batch of concrete to reach its proposed target slump flow minus 2.5 inches.

- D. The average time period determined from three demonstrated batches to reach the proposed target slump flow minus 2.5 inches is considered the cutoff time of the proposed concrete mix design. The time for each batch is counted from the time that the concrete is batched at the concrete production facility.

8.4.7.4 MOCKUP PRODUCT OF THE FIELD DEMONSTRATION CONCRETE

The field demonstration shall include the manufacture and evaluation of a mockup product in accordance with **FM 5-617** if the Plant is utilizing SCC for the first time, and shall meet the following requirements:

- 1) The mockup shall contain reinforcing steel typical of those Products.
- 2) The mockup shall use the proposed mix design.
- 3) The Coarse Aggregate Index (CAI) shall be determined by saw cutting the mockup's entire cross-section.

8.4.7.5 STATIC SEGREGATION OF THE FIELD DEMONSTRATION CONCRETE

The DMRO may exempt the mockup for a particular mix design. In this case, the assessment of static segregation shall be verified following **AASHTO R 81** and at least one of the following conditions shall be met:

- 1) The SCC is centrally batched at the Plant.
- 2) The target slump flow of the previously approved SCC mix design has been increased by less than or equal to 2.5 inches.
- 3) Permissible adjustments to previously approved mix design have been made as referenced below:
 - a) Allowable variation of Coarse or Fine Aggregate: The variation for each aggregate can be ± 75 pounds per cubic yard of concrete.
 - b) Admixtures: Should be within the admixture manufacturer's technical data sheet range. Dosage rates outside of this range may be used with written recommendation from the admixture manufacturer's technical representative. Mixes with adjustments falling outside the technical data sheet range shall be suspended when written recommendation from the admixture manufacturer's technical representative has not been obtained.
 - c) Allowable variation of total Cementitious Materials: ± 6.5 percent per cubic yard but not less than the specified minimum for that class of concrete.

The adjusted mix design must meet the theoretical yield requirements of the approved SCC mix design.

Inform the DMRO of any adjustments to the concrete mix design. Batch adjustments shall not be used for batch tolerances of aggregate and cementitious materials. The adjustments shall be noted on the concrete delivery tickets.

8.4.7.6 POST-PLACEMENT INSPECTION OF THE MOCKUP PRODUCT

Reject the proposed mix design if there is an indication of segregation after performing the aggregate distribution test in accordance with **FM 5-617** or **AASHTO R 81** as appropriate. Determine the cause of the segregation and submit a corrective action plan to prevent the recurrence of the problem during production. The DMRO will review the plan and will require retesting the mix design until the aggregate distribution reaches the required values.

Perform post-placement inspection of the mockup after removal of the forms. Examine the concrete for any signs of honeycombs, cracks, segregation, sedimentation, cold joints, or any other surface defects. Ensure that the hardened concrete is free from these defects.

Perform saw cutting of the mockup when demonstrating the use of SCC for the first time at the Plant. Visually inspect the saw-cut section and examine the distribution of the aggregates within the saw-cut surfaces and around the reinforcing steel and prestressing strands. Verify that the concrete is free from any sign of honeycombs, cracks, segregation, and any other defects.

The DMRO may waive saw cutting of the mockup for routine mix design approvals of SCC. A waiver will only be granted when the Plant has satisfactorily performed saw cutting of previous mockups and has demonstrated that concrete has been placed without any visible sign of defects during approval of previous SCC mix designs.

Dispose of concrete produced for demonstration purposes at no expense to the Department.

8.4.8 SUBMITTAL OF VERIFIED MIX DESIGN AND HISTORICAL PRODUCTION TEST DATA

The concrete production facility may propose the approval of SCC mixes, centrally mixed at the placement site, without the production of field demonstration batches, provided that the proposed mix meets the following criteria:

1. A previously approved SCC mix of the same class has demonstrated satisfactory performance under the proposed job placing conditions with a minimum of fifteen Department-accepted consecutive QC or verification tests, which have met all plastic and hardened concrete test requirements.

2. The cementitious materials and chemical admixtures, used in the proposed mix, are the same materials from the same source used in the previously approved mix. The mix proportions of the proposed mix are similar to the proportions of the previously approved SCC mix.

In any of the previous cases, the slump flow loss test as described in **Section 8.4.7.3** shall be verified.

8.4.9 PRODUCTION BATCH QUALITY CONTROL

1. Check that the forms are stable and leak-proof. Forming materials shall be strong enough to withstand the concrete pressure and prevent any paste or mortar leakage.
2. Ensure that the proposed mix design has been approved prior to the placement of SCC.
3. Ensure that the Plant has a proper plan for the continuous placement of concrete to prevent excessive slump flow loss or cold joints. The plan must provide for actions in case of mechanical failures or other unforeseen incidents.
4. Minimal mechanical vibration (no more than 3 seconds per insertion) is allowed when necessary to consolidate the concrete. The Plant shall have vibrating equipment available to consolidate the concrete, if needed.
5. For continuous placement of more than three batches, perform slump flow tests on at least three batches at the beginning of the placement of SCC to ensure that the delivered concrete meets the requirements of the **Specifications**. In addition to the random sampling and testing, visually check every batch before the concrete is transported to the placement area. Perform additional testing to verify any concrete batch that appears to be out of tolerance, as appropriate.
6. Concrete shall stay plastic and within the slump flow tolerance range during placement.
7. The time between batching and depositing of each load of concrete shall be less than the slump flow loss cutoff time of the mix design unless the load passes the slump flow test.
8. Perform SCC tests at the point of placement or testing station established for that express purpose, provided that a correlation between the plastic properties of the point of placement and testing station has been established.

9. Ensure that the following plastic properties are measured for every LOT of concrete per class as defined in **FDOT Specifications Section 346**:
 - a) Slump Flow
 - b) Relative Viscosity (T_{50})
 - c) Visual Stability Index (VSI)
 - d) Rapid Assessment of Static Segregation Resistance (Pd)
 - e) Air Content
 - f) Temperature
10. Reject any LOT of concrete that does not meet the specified plastic property requirements, with the exceptions described below:
 - a) SCC exceeding the high-end slump flow tolerance should not be rejected if it has passed the rapid assessment of static segregation resistance test (Pd) and all other required tests. Notify the DMRO personnel and take corrective actions if the slump flow is out of the established tolerance of **Table I**.
 - b) At the Plant's risk, when SCC is produced at an off-site ready mixed concrete facility, water may be added at the placement site immediately after completion of the initial slump flow test, either to correct a low slump flow, or to increase the concrete workability, provided the addition of water does not exceed the water to cementitious materials ratio as defined by the mix design. After adding water at the placement site, perform a slump flow and rapid assessment of static segregation resistance test. Reject the load if the slump flow is below the low-end tolerance. As an exception, the Engineer may accept the concrete if the rejection compromises the structural integrity of the element or produces other detrimental effects. Minimum vibration may be needed in accordance with Section 8.4.9 (4).

If an adjustment is made at the concrete production facility, the Plant shall perform a slump flow test on the next load to ensure the concrete test results are within the tolerance ranges.
 - c) SCC shall not be rejected based on visual stability index (VSI) or relative viscosity (T_{50}) if it has satisfactorily passed the rapid assessment of static segregation resistance test (Pd).
 - d) If previous load(s) belonging to the terminated LOT have already been discharged into the Product, the Plant may choose to reject the terminated LOT or re-evaluate it.
 - e) For re-evaluating the terminated LOT based on failing rapid assessment of segregation resistance (Pd), the Plant shall cast two 6x12 inch concrete cylinders for hardened visual stability index (HVSI) evaluation in accordance with **AASHTO R 81**. If the HVSI test results are greater than 1, the SCC is considered segregated and the LOT shall be rejected.

DMRO personnel shall be invited to witness the evaluation. If DMRO cannot attend, the Plant shall take photographs of the saw-cut cylinders and provide to DMRO along with the report. If the Plant and the DMRO disagree over the HVSI value, the report and corresponding photos shall be forwarded to the SMO for final determination.

11. Ensure that the concrete is placed in a continuous and timely manner to maintain its workability and specified slump flow during placement to minimize the possibility of segregation and cold joints.
12. Ensure that the concrete maintains its workability during the entire placement time. If two successive batches are delayed even less than 20 minutes, the surface of the underlying layer might manifest premature stiffness. In such cases, use a rake or a hoe to break the superficial stiffness providing appropriate adhesion between the two layers to avoid any cosmetic issue at the formed surface of the element.
13. Use methods of placement that prevent segregation or other detrimental effects. These methods must be identified in the QC Plan.
14. Do not add water to re-temper the concrete.
15. Perform the finishing of concrete to prevent the occurrence of cracks, honeycombs, voids, and a lack of bonding between the concrete and reinforcing steel.
16. Apply the appropriate curing method in accordance with ***FDOT Specifications Sections 400 or 450.***

8.4.10 SUMMARY OF TEST METHODS

TABLE II			
Test Method	Mix Design	Field Demonstration	Production (Every Lot)
Slump Flow (Spread)	X	X	X
Relative Viscosity (T_{50})	X	X	X
J-Ring (Δ Flow)	X	X	
Column Segregation (S)	X		
Rapid Assessment Static Segregation (Pd)	X	X	X
Visual Stability Index (VSI)	X	X	X
Aggregate Distribution (CAI)		X	
Hardened Visual Stability Index (HVSI)		When required	When required
Compressive Strength	X	X	X
Surface Resistivity	X		
Density (Unit Weight)	X	X	
Air Content	X	X	X
Temperature	X	X	X

8.4.11 TRAINING

Plant personnel performing SCC mix design laboratory trials, field trials, and production SCC testing shall meet the requirements of ***FDOT Specifications Section 105***.

8.4.12 FORMS

None needed.