Section 8.6
Volume II

FLOWING CONCRETE FOR PRECAST/PRESTRESSED CONCRETE PRODUCTS

8.6.1 PURPOSE

This procedure provides guidance to the precast/prestressed concrete fabrication facilities (Plants) that are involved in the manufacture of products using flowing concrete. The procedure includes requirements related to the Plants' Quality Control (QC) Plans, the submittal of the mix designs, laboratory and field trial batches of the concrete mixes, and inspection and testing of production concrete. Produce flowing concrete using a central mixer at an approved on-site facility, or demonstrate that using an off-site ready-mixed concrete facility with an accepted QC Plan meets the requirements of this Section.

8.6.2 AUTHORITY

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

8.6.3 REFERENCES

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

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

Florida Department of Transportation (FDOT) Materials Manual Volume I, Section 8.6 Quality Assurance Program for The Use of Flowing Concrete in The Fabrication of Precast/Prestressed Concrete Products

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

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

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

8.6.4 SCOPE

This procedure establishes guidelines for Plants that are involved in the utilization of flowing concrete for the manufacturing of the precast/prestressed concrete products (Products). The Plants shall comply with the requirements of the ***Specifications***, except as modified herein.

8.6.5 FLOWING CONCRETE RELATED QC PLAN PROVISIONS

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

A. The mix design qualification process.

B. Routine QC tests.

C. The concrete batching sequence, mixing methods and duration, delivery, placement, finishing, and curing methods.

D. The proposed concrete materials ingredient sources.

E. Concrete delivery and placement times. It is the responsibility of the Plant to utilize the appropriate flowing concrete delivery and placement pattern and methods for the manufacturing of each Product.

F. The preparation of guidelines regarding flowing concrete delivery, placement, finishing, and curing for the training of personnel who are involved in these activities.

G. The proposed inspection and test methods for the laboratory and field trial batches.

H. The test method and frequency of the aggregate moisture content test.

I. The adequacy of the forming strength to support the pressure of the flowing concrete during placement. Provide information about form joint sealing method to prevent mortar leakage.

J. Considering weather conditions, include guidelines in the QC Plan 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.

K. The strand lift loops placement method and capacity to handle the flowing concrete products.

L. The qualifications and familiarity of the personnel performing the required inspection and testing of flowing concrete.

8.6.6 FLOWING CONCRETE MIX DESIGN REQUIREMENTS

Table I

Properties	Test	Standard Method	Acceptance Criteria
Filling Ability	Slump	ASTM C143	Target = 9.0 in Tolerance= ± 1.5 in
Static Segregation	Column Segregation (S)	ASTM C1610	S ≤ 15%
	Aggregate Distribution of Hardened SCC	FM 5-617	C.A.I. ≤ 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 T358	Depends on the application

8.6.6.1 SPECIFIED 346 CLASS CONCRETE

Flowing concrete is allowed for the fabrication of precast/prestressed concrete as a modification of the ***FDOT Specifications Section 346*** class of concrete. The Plant shall submit the proposed mix design with test data and other supporting documents to the Department for review. Upon the Department's approval of the mix design, the use of flowing concrete will be allowed for the fabrication of the precast/prestressed concrete products.

The proposed ***FDOT Specifications Section 346*** classes of flowing concrete mixes 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***, including the following:

A. Concrete mix ingredients are from Department approved sources.

B. The laboratory and field demonstration of the proposed mixes shall meet the requirements of the ***Specifications***, ***Plans***, and ***Materials Manual***.

8.6.6.2 ASTM OR AASHTO CLASS OF CONCRETE

The proposed ASTM or AASHTO class of flowing concrete mix design shall meet the requirements of ***Section 8.6.6.1*** with the exception of the mix design approval process. The DMRO will review and approve 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.

8.6.7 LABORATORY TRIAL BATCH OF THE PROPOSED MIX DESIGN

The requirements of ***ASTM C192*** may be modified to allow the laboratory performance-based batching, mixing time, and sequence that produces the required properties.

In the trial batch process, determine the acceptable batching sequence and the mixing time associated with this batching sequence. During the production of the flowing concrete, use the same batching sequence and adjust the mixing time determined in the trial batch process. Likewise, if the producer uses a different dosage of admixture, the trial batch time is invalid and shall be adjusted.

Following are the steps of the Flowing Concrete Laboratory Trial Batches:

A. Perform the trial batch in accordance with the proposed batching sequence and mixing time that is included in the QC Plan. Note any deviation from the proposed sequence.

B. Obtain a sample of freshly mixed flowing concrete in accordance with test method ***ASTM C172***.

C. Determine the slump of the concrete mix in accordance with ***ASTM C143***.

D. Determine the static segregation of the mix in accordance with ***ASTM C1610***. Vibration shall mimic production practices for the flowing concrete mix.

E. Perform the air content, density, temperature, and any other test that is required for the class of concrete and any other tests that the Plant has proposed to use for the QC of the production concrete.

F. Make and cure concrete test cylinders in accordance with ***ASTM C192***.

8.6.8 FIELD DEMONSTRATION OF FLOWING CONCRETE

Subsequent to a satisfactory laboratory trial batch, perform a field demonstration of the proposed mix design. Perform the field trial batches and cast a partial or full-scale mockup of the proposed Products.

Ensure that the field demonstration concrete is mixed, delivered, placed, consolidated, and cured in accordance with the proposed method and

sequence that are addressed in the QC Plan. Produce the flowing concrete batches at the target slump of 9 inches.

Perform inspection and testing of the field demonstration concrete during batching, delivery, placement, and post placement. Observe the placement sequence and method of the flowing concrete. 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.

8.6.8.1 NUMBER AND QUANTITY OF BATCH SIZES

For the field demonstration, produce and place a total volume of 9 cubic yards in a minimum of three batches of at least 3 cubic yards each. Plants that are producing concrete with batch sizes of less than 3 cubic yards are required to produce the necessary batches to reach the required volume of 9 cubic yards.

8.6.8.2 SAMPLING AND TESTING OF THE FIELD DEMONSTRATION CONCRETE

For each batch, verify the slump, and perform the field demonstration tests in accordance with ***Section 8.6.12 (Table II)***. If more than 3 batches are necessary to reach the required volume, randomly select 3 batches and follow the same procedure.

Take representative samples at the point of final concrete placement and perform the tests prescribed in Table I and Table II as appropriate.

Ensure that the concrete properties are within the required ***Specification*** limits. Perform the slump loss test as described in ***Section 8.6.8.3***.

8.6.8.3 SLUMP LOSS TEST OF THE FIELD DEMONSTRATION CONCRETE

A. Determine the workability of the three selected demonstration concrete batches by performing the slump tests. Take the samples at 15-minute intervals from each batch.

B. Continue sampling and testing each batch until the slump measures 7.5 inches, or a minimum of three data points are obtained.

C. From the plot of slump versus time, determine the time for each batch of concrete to reach a slump value of 7.5 inches.

D. The average time period determined from three demonstrated batches to reach a slump value of 7.5 inches is considered the cutoff time of the proposed concrete mix. The time for each batch is counted from the time that the concrete is batched at the concrete fabrication facility.

E. For production concrete, ensure that the time between the batching and depositing of each load of concrete is less than the cutoff time of the mix

and that it does not exceed the allowable time limit specified in ***FDOT Specifications Section 346***.

8.6.8.4 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 flowing concrete for the first time, and shall meet the following requirements:

1) The mockup shall contain reinforcing steel typical of those Products. If the Plant is introducing a new flowing concrete mix design, but has previously successfully utilized flowing concrete, then the reinforcing steel is optional.
2) The mockup shall use the same mix design.
3) The Coarse Aggregate Index (C.A.I.) shall be determined by saw cutting the Product's entire cross-section.
4) The mockup shall be subject to vibration practices of the same type and frequency as the production method it is representing.

8.6.8.5 STATIC SEGREGATION OF THE FIELD DEMONSTRATION CONCRETE

The mockup product is not required, and the assessment of static segregation shall be verified in accordance with ***AASHTO R 81*** when:

1) The DMRO/SMO determine that the mockup test is not required for a particular mix.
2) 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 producer's technical representative. Mixes with adjustments falling outside the technical data sheet range shall be suspended when written recommendation from the admixture producer'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 must meet the theoretical yield requirements of the approved 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.

8.6.8.6 POST PLACEMENT EVALUATION OF THE AGGREGATE DISTRIBUTION

After performing the aggregate distribution test in accordance with ***FM 5-617***, or ***AASHTO R 81*** as appropriate, if there is an indication of a segregation problem, reject the proposed mix design, 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 until the aggregate distribution reaches the required values.

After the removal of the forms, perform the post-placement inspection of the in-place mockup concrete. Observe for any signs of honeycombs, cracks, aggregate segregation, sedimentation, cold joints, or any other surface defects and ensure that the hardened concrete is free from these deficiencies.

Perform saw cutting of the mockup products when demonstrating the use of flowing concrete for the first time at the Plant. Visually inspect the saw-cut section and observe 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, aggregate segregation, and any other defects.

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

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

8.6.9 SUBMITTAL OF THE VERIFIED MIX DESIGN

Submit the results of the laboratory trial batch tests and field demonstration of verified test data and inspection reports, along with certification, to the DMRO. The certification shall state that the results of the laboratory trial batch tests and field demonstration tests indicate that the proposed concrete mix design meets the requirements of the ***Specifications***. For the proposed mix design, state the anticipated maximum time limit between the batching and when the concrete of each batch is deposited during the production.

Upon satisfactory review and verification of the laboratory trial batch, field demonstration test data, inspection reports, and the Plant's certification statement, the Department will approve the proposed mix design.

8.6.10 SUBMITTAL OF THE PROPOSED LABORATORY VERIFIED MIX DESIGN AND HISTORICAL PRODUCTION TEST DATA

The Plant may propose the approval of the flowing concrete 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 flowing concrete 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 flowing concrete mix.
3. The proposed flowing concrete mix design will be subject to the same type and frequency of vibration as the previously approved mix.

In any of the previous cases, the slump loss test as described in ***Section 8.6.8.3*** shall be verified.

8.6.11 PRODUCTION BATCH VERIFICATION

1. Unless moisture meters are used, for flowing concrete mixes, determine the free moisture content of aggregates within two hours prior to each day's batching operations, at 4-hour intervals during continuous batching operations, and at any time a change in moisture content becomes apparent.
2. Check that the forms are stable and leak proof. Forming materials shall be strong enough to withstand the concrete pressure and prevent any mortar leakage.
3. Ensure that the Plant's proposed flowing concrete mix has been approved prior to the production of concrete.
4. Ensure that the Plant has a proper plan for the continuous mixing, delivery, and placement of concrete to prevent excessive slump loss or cold joints. The plan must provide for actions in case of mechanical failures, or other unforeseen incidents.
5. Ensure that vibrating equipment is available to consolidate the flowing concrete. Continue vibration long enough to achieve proper consolidation of the concrete.
6. 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.

7. Concrete shall stay plastic and within slump tolerance range during placement.
8. Ensure that the flowing concrete is delivered in a continuous and timely manner and within the time limit that is allowed by the ***Specifications*** and field trial batch verification.
9. Perform flowing concrete 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.
10. Ensure that the following plastic properties are measured for every LOT of concrete per class as defined in the ***FDOT Specifications Section 346***.

    a) Slump
    b) Density
    c) Air Content
    d) Temperature

11. Reject any LOT of concrete that does not meet specified plastic property requirements.
12. Place flowing concrete in a continuous and timely manner to maintain its workability and specified slump during placement and to minimize the possibility of segregation and cold joints.
13. Ensure that 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. Vibrate the successive layers as appropriate where required to achieve proper consolidation.
14. Use methods of placement that prevent segregation or other detrimental effects. These methods must be identified in the QC Plan.
15. Do not add water to re-temper the concrete.
16. Apply the appropriate curing method in accordance with ***FDOT Specifications Sections 400 or 450***.
17. Perform the finishing of concrete to prevent the occurrence of cracks, honeycombs, voids, and a lack of bonding between the concrete and reinforcing steel.

8.6.12 SUMMARY OF TEST METHODS

TABLE II			
Test Method	**Mix Design**	**Field Demonstration**	**Production (Every Lot)**
Slump	**X**	**X**	**X**
Column Segregation (S)	**X**		
Aggregate Distribution (C.A.I.)		**X**	
Hardened Visual Stability Index (HVSI)		**X**	
Compressive Strength	**X**	**X**	**X**
Surface Resistivity	**X**		
Density (Unit Weight)	**X**	**X**	**X**
Air Content	**X**	**X**	**X**
Temperature	**X**	**X**	**X**

8.6.13 TRAINING

Ensure that Plant personnel involved in the performance of lab and field trials for flowing concrete have the required qualifications specified in ***FDOT Specifications Section 105.***

8.6.14 FORMS

None needed.