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June 29, 2004

Expired

MATERIALS BULLETIN NO. 04-04
MEMORANDUM NO. 11-04

TO: **DISTRICT MATERIALS ENGINEERS**
DISTRICT CONSTRUCTION ENGINEERS

FROM: Thomas O. Malerk, P.E., Director, State Materials Office
Ananth Prasad, P.E., Director, State Construction Office

COPIES: Florida Transportation Builders' Association, Florida Prestressed Concrete Association, Inc.

SUBJECT: **SELF-CONSOLIDATED CONCRETE**
FLOWING CONCRETE

The precast/prestressed concrete producers may use the Flowing concrete (FC) for the fabrication of the precast/prestressed concrete products. The Flowing concrete shall meet the requirements of the attached supplemental technical special provisions, dated June 29, 2004.

The manufacturers of non-prestressed precast concrete products may use self-consolidated Concrete (SCC) or FC for the fabrication of their products. In the utilization of SCC or FC, the manufacturers are required to use the attached document as a guide for the preparation of their concrete mix design, mixing, delivery, consolidation, curing, inspection and testing. The precast concrete plants shall include the quality control inspection, testing, personnel training and other required processes related to the use of SCC or FC as part of their quality control plan.

The precast concrete plants that are planning to use SCC or FC on the current projects, as replacement for the specified conventional 346 classes of concrete, shall submit their request for change order.

Please contact Ghulam Mujtaba at (352) 955-6685 if there are any questions.

TOM/AP: gm
Attachment

SUPPLEMENTAL TECHNICAL SPECIAL PROVISIONS

FOR

USE

OF

FLOWING CONCRETE

And

SELF-CONSOLIDATING CONCRETE

FOR

MANUFACTURING OF PRECAST/PRESTRESSED CONCRETE PRODUCTS

PREPARED

BY

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FLORIDA DEPARMENT OF TRANSPORTATION
STATE MATERIALAS OFFICE
GAINESVILLE, FLORIDA

June 29, 2004

FLOWING CONCRETE
AND
SELF-CONSOLIDATING CONCRETE
FOR
MANUFACTURING OF PRECAST/PRESTRESSED CONCRETE PRODUCTS

1. SUBARTICLE 346-2.5.3 OF THE SPECIFICATIONS IS DELETED AND THE FOLLOWING SUBSTITUTED:

346-2.5.3 High Range Water Reducing and Viscosity Modifying Admixtures:

346-2.5.3.1 General: The Contractor may propose the use of a Type F or G admixture, meeting the requirements of Section 924, in all classes of concrete, except for concrete used in drilled shafts. The use of High Range Water Reducing (HRWR) admixtures in concrete mixes incorporating silica fume or metakaolin is mandatory.

346-2.5.3.2 Flowing Concrete Admixtures: The Contractor may propose the use of a Type I or Type II admixture, meeting the requirements of Section 924. Produce flowing concrete mix with target slump of 9.0 inches [230 mm]. The use of flowing concrete admixtures is limited to the construction of precast/prestressed concrete products. Add the flowing concrete admixtures at the ready-mixed concrete production batch plant.

Submit the proposed flowing concrete mix design, containing Type I or II admixture, and test data as specified herein and in 346-6.2.

Subsequent to the laboratory trial batch, perform a field demonstration of the proposed mix design by production and placement of at least three batches, 3 yd^3 [2.3 m^3] minimum size each, of concrete containing flowing concrete HRWR admixture. Take representative samples from each batch and perform slump, air content, density (unit weight), and temperature tests on these samples. Cast specimens from each sample for compressive strength tests. Record the ambient air temperature during the test. Ensure that the concrete properties are within the required specification limits. The plants that are producing concrete with batch sizes of less than 3 yd^3 [2.3 m^3] are required to produce and place at least a total amount of 9 yd^3 [6.9 m^3] and perform the aforementioned tests on at least three randomly selected batches.

Determine the workability of the demonstration concrete batches by performing the slump tests on the samples taken at 15-minute intervals from each batch. Continue sampling and testing until the slump measures 6.0 inches [150 mm] or less. From the plot of slump versus time, determine the time for each batch when the slump is at 7.5 inches [190 mm]. The shortest time period determined from three consecutive batches, at 7.5 inches [190 mm] slump is considered the cutoff time of the proposed concrete mix. 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 also does not exceed the allowable time limit specified in 346-7.6.

Ensure that the demonstration concrete is mixed, delivered, placed, consolidated and cured in accordance with the proposed method and sequence. Produce the flowing concrete batches at slumps between 7.5 inches to 10.5 inches [190 mm to 265 mm].

Perform inspection of the demonstration concrete during batching, delivery, placement and post placement. 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.

Dispose of concrete produced for demonstration purposes at no expense to the Department. Subject to the Engineer's approval, the Contractor may incorporate this concrete into non-reinforced concrete items and may be included for payment; provided it meets Contract requirements for slump, entrained air and strength.

After removal of the forms, perform the post-placement inspection of the in-place concrete. Observe for any signs of honeycombs, cracks, aggregate segregation or any other surface defects and ensure that the hardened concrete is free from these deficiencies. The Engineer may require saw cutting of the mock-up products to verify the uniform distribution of the aggregates within the saw cut surfaces and around the reinforcing steel and prestressing strands. The Engineer will require saw cutting of the demonstration mock-up products for plants that are demonstrating the use of the flowing concrete for the first time. Obtain core samples from different locations of mock-up products to inspect the aggregate distribution in each sample and compare it with the aggregate distribution of other core samples. Perform rapid chloride permeability or surface resistivity tests on the core samples or test cylinders.

Submit the results of the laboratory trial batch tests and field demonstration of verified test data and inspection reports to the Engineer, along with certification stating 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 the review and verification of the laboratory trial batch, field demonstration test data, inspection reports and contractor's certification statement, the Department will approve the proposed mix design.

The Department may approve proposed flowing concrete mixes, centrally mixed at the placement site, without the production of demonstration batches, provided that the proposed mix meets the following two 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 consecutive Department acceptance tests, which met all plastic and hardened concrete test requirements.

(2) The cementitious materials and chemical admixtures, including the flowing concrete HRWR admixture, used in the proposed mix are the same materials from the same source used in the previously approved mix, (1) above, and the other materials and mix proportions are approved as similar by the Department.

Do not produce or place concrete for payment under Contract pay items until design mixes have been approved.

346-2.5.3.3 Self-Consolidating Concrete Admixtures: The Engineer may allow the use of a previously approved High Range Water Reducer Admixture, Type I or Type II admixtures meeting the requirements of Section 924, with or without Viscosity Modifying Admixtures (VMA), to produce a Self-Consolidating Concrete (SCC). The maximum allowable target slump flow is 27.0 in [685 mm].

The use of SCC is limited to the manufacturing of non-prestressed precast concrete products. Produce SCC in accordance with Precast/Prestressed Concrete Institute (PCI) publication, TR-6-03, "Interim Guidelines for the Use of Self-Consolidating Concrete in Precast/Prestressed Concrete Institute Member Plants". The requirements of Contract Documents will govern, when there is a discrepancy between TR-6-03 and Contract Documents. The requirements of 2.5.3.2 are also applicable to SCC, except as revised herein:

Slump/Slump Flow: For the SCC, replace the term slump with the slump flow.

Mix Design Proportions: Use maximum allowable fine-to-total aggregate ratios (S/A) of 50.0 percent, by volume. For S/A ratio of less than 45 %, the use of VMA is mandatory. The maximum amount of cementitious materials in the mix is limited to 1.2 times the minimum allowable amount that is specified in the Master Proportion TABLE 346-4.1.

Laboratory Trial Batch: The requirements of ASTM C 192 are modified to allow batching and mixing that produce SCC with the required properties. The allowable tolerance of the slump flow for the laboratory verification is ± 2.5 in [± 63.5 mm]. During the trial batch process, determine the acceptable batching sequence and mixing time associated with batching sequence. During the production of the SCC concrete, use the same batching sequence and proper mixing time that is determined during the, prerequisite, satisfactory laboratory and field demonstration process.

Laboratory Plastic Property tests: Perform the slump flow, including T-50 and Visual Stability Index (VSI) rating, air content, density (Unit weight), temperature, J-ring, and bleed tests. Perform the Column Segregation, V-Funnel, L-Box, and any other tests during the laboratory, if the tests are used for the quality control during the production.

Shrinkage Test Results: Perform shrinkage tests. The results of the 28-day shrinkage of the concrete mix shall be less than 0.04 %.

Field Demonstration of Mockup Products: Perform field demonstration of SCC for the qualification of each mix design.

Perform field demonstration of the proposed mix by production and placement of at least three batches, 3 yd^3 [2.3-m^3] minimum size each, of concrete. Take representative samples from each batch and perform the slump flow, including T-50 and Visual Stability Index (VSI) rating, air content, temperature, density (Unit Weight), J-Ring test, and bleed tests. Perform additional tests such as V-Funnel, Column Segregation, L-Box, and other tests, if it is intended to use them for quality control testing of the production concrete. The plants that are producing concrete with batch sizes of less than 3 yd^3 [2.3 m^3] are required to produce and place at least a total amount of 9 yd^3 [6.9 m^3] and perform the aforementioned tests on at least three randomly selected batches.

Slump Loss tests: Determine the workability of the demonstration concrete batches by measuring the slump flow of concrete samples taken at 15-minute intervals from each batch. Continue sampling and testing until the slump flow measures 20 in [510 mm] or less. From the plot of slump flow versus time, for each batch, determine the time when the minimum allowable designed slump flow is reached. The minimum allowable slump flow is the target designed slump flow minus the maximum allowable tolerance. The shortest time determined from the three consecutive batches, is the cutoff time of the proposed concrete mix. For production concrete, ensure that the time between the batching to the depositing of concrete is less than the cutoff time. Also, total batching to depositing time for each load must remain within the time limit of 346-7.6.

Saw-Cut of Mockup Products: Perform saw cutting of the mockup products and take core samples when demonstrating the use of SCC for the first time in the precast concrete fabrication plant.

SCC Preparation and Placement Guideline: Based on the laboratory trial batch and field demonstration of the mockups, establish the proper mixing, dosage rates, minimum and maximum mixer revolutions for the production concrete, delivery and placement cutoff time, placement and curing methods. Include the guidelines in the SCC part of the quality control plan.

SUBARTICLE 346-3.1 OF THE SPECIFICATION IS DELETED AND THE FOLLOWING SUBSTITUTED:

346-3 Classification, Strength, Slump, Slump Flow, and Air Content

346-3.1 General: The separate classifications of concrete covered by this Section are designated as Class I, Class II, Class III, Class IV, Class V, and Class VI. TABLE 2 specifies the required Strength, slump, slump flow and air content properties of each class:

TABLE 2			
STRUCTURAL CONCRETE			
Class of Concrete	**Specified Minimum**	**Target Slump**	**Air Content Range**

	Strength (28-day) (psi) [(MPa)]	(inches) [(mm)](c)	(%)
I (Pavement)	3,000 [21]	2 [50]	1 to 6
I (Special) (a)	3,000 [21]	3 [75](b)	1 to 6
II (a)	3,400 [23]	3 [75] (b)(f)	1 to 6
II (Bridge Deck)	4,500 [31]	3 [75] (b)	1 to 6
III	5,000 [35]	3 [75] (b)	1 to 6
III (Seal)	3,000 [21]	8 [200]	1 to 6
IV	5,500 [38]	3 [75] (b) (e)(f)	1 to 6
IV (Drilled Shaft)	4,000 [28]	8 [200]	0 to 6
V (Special)	6,000 [41]	3 [75] (b) (d) (e)(f)	1 to 5
V	6,500 [45]	3 [75] (b) (e)(f)	1 to 5
VI	8,500 [59]	3 [75] (b) (e)(f)	1 to 5

(a) For precast concrete drainage products that are manufactured at the precast concrete plant, the Contractor is permitted to use concrete meeting the requirements of ASTM C 478 [ASTM C 478 M] 4,000 psi [30 MPa] in lieu of Class I or Class II concrete. Apply the chloride content limits specified in 346-4.2 to all precast or cast-in-place box culverts.

(b) The Engineer may allow a maximum target slump of 7.0 inches [180 mm], when AASHTO M 194 Type F or G admixture is used.

(c) The Engineer may approve a reduction in the target slump for slip-formed or prestressed elements.

(d) When the use of silica fume or metakaolin is required as a pozzolan in Class V or Class V (Special) concrete, ensure that the concrete does not exceed a permeability of 1,000 coulombs at 28 days, when tested per AASHTO T 277. Submit 2, 4 x 8 inches [102 x 203 mm] cylindrical test specimens to the Engineer for permeability testing before mix design approval. Take the permeability test specimens from the concrete of the laboratory trial batch or from the field trial batch of at least 3 yd^3 [2.3 m^3]. Verify the mix proportioning of the designed mix and take representative samples of trial batch concrete for the required plastic and hardened property tests. Cure the field trial batch specimens similar to the standard laboratory curing methods. Submit the permeability test specimens at least 7 days prior to the scheduled 28 day test. The average permeability of the two tests, one test per cylinder, is considered the rapid chloride permeability of the concrete mix.

In lieu of rapid chloride permeability test, submit three test cylinders to the Engineer for performing of surface resistivity test in accordance with FM 5-578. Ensure that the result of the average 28- day surface resistivity value of the concrete samples remains greater than or equal to 37 KOhm-cm.

(e) The Engineer may allow a target slump of 9.0 inches [230 mm] when

ASTM C 1017 Type I or II admixture is used to produce flowing concrete in construction of precast prestressed concrete beams.

(f) The Engineer may allow a maximum target slump flow of 27.0 [685 mm]. The difference between the slump flow with and without the J-ring shall be less than 2.0 in [50 mm]. The slump flow time T_{50} shall be between 2-7 seconds. The VSI shall not exceed a value of 2.

SECTION 9.2.4.8 of Materials Manual is expanded to read: Unless moisture meters are used, for SCC mixes, determine 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.

SECTION 346-9.2: The first paragraph of Subarticle 346-9.2 is expanded to read: At the beginning of production of SCC, perform slump flow tests on at least three batches, if produced, to ensure that the delivered concrete meets the requirement of the specification. Subsequently, in addition to the randomly sampling and testing, visually check every batch before transportation to the placement area.

SECTION 346-5: TABLE 5 is expanded to include the following tests for SCC.

Bleed Test	**ASTM C 232**
Slump Flow Test and Visual Stability Index (VSI)	**Appendix A2.0 PCI-TR-6-03**
T-50 Test	**Appendix A4.0 PCI-TR-6-0**
V-Funnel Test (Only for Quality control, if used by producer)	**Appendix A7.0 PCI-TR-6-0**
J-Ring	**Appendix A6.0 PCI-TR-6-03**
L-Box (Mix Design Qualification)	**Appendix A8.0 PCI-TR-6-03**
Visual Stability Index (VSI)	**Appendix A13.0 PCI-TR-6-03**
Modulus of Elasticity (Mix Design Qualification - Prestressed Concrete Products)	**ASTM C 469**
Shrinkage (Mix Design Qualification - Prestressed Concrete Products)	**ASTM C 157 PCI-TR-6-03 Page 64**
Split Tensile Strength Test (Mix Design Qualification -Prestressed Concrete Products)	**ASTM C 496 PCI-TR-6-03 Page 64**
Creep (Mix Design Qualification - Prestressed Concrete Products)	**ASTM C 512 PCI-TR-6-03 Page 64**
Surface Resistivity	**FM 5-578**
Rapid Chloride Permeability (Mix Design Qualification -Prestressed	**AASHTO T 277**

Concrete Products)	
Column Segregation	**ASTM (In Development Process)**
Aggregate Distribution (Mix Design Qualification -Prestressed Concrete Products)	**Mujtaba and Bühler, 2003 International Symposium on High performance concrete**
Petrographic Analyses (Mix Design Qualification -Prestressed Concrete Products)	**ASTM C 856**
Strand Bond Confirmation (Mix Design Qualification -Prestressed Concrete Products)	**ASTM C 234 PCI-TR-6-03 Page 66 Moustafa Test 1997 PCI Journal or Bending Test**

For concrete mix design qualification of the prestressed concrete products, perform the modulus of elasticity, shrinkage, and creep to verify the designed values. Perform the saw-cut of the mockup products to verify the aggregate distribution along the saw-cut area and verify if there is any sign of deficiency that impairs the concrete performance, such as segregation, sedimentation, cold joints, and any other visual defects. Take core samples from different locations of the mockup product to verify the aggregate distribution of the product.

A brief outline of the aggregate distribution test is as follows:

(1) Draw a line along the surface of the core sample.
(2) Measure the size of each piece of aggregate along the line, greater than or equal to 0.1 in [2 mm].
(3) Determine the total length of the aggregates along the straight line by adding the measured sizes of all pieces.
(4) Determine the coarse aggregate (C.A.) content along the straight line by calculating the ratio of the total length of aggregates along the line- to- the length of the drawn line.
(5) Draw total of 8 lines, as described in items (1) - (4). Report the average C.A. ratio of 8 lines for each core samples as the C.A. ratio of the core sample

SECTION 346-5: The footnotes of TABLE 5 are expanded to read: For SCC, perform the ASTM C 138, ASTM C 143, ASTM C 173, and ASTM 231 test methods by placing the concrete in the molds in one layer without vibration or tamping.

SECTION 346-6.1: The Subarticle 346-6.1 is expanded to read: For SCC, include the following information in the Quality Control Plan:

(1) Mix design qualification process
(2) Routine Quality Control Tests

(3) Concrete batching sequence, mixing methods and duration, delivery, placement, finishing, and curing methods
(4) Quality Control Personnel familiarity and training related to SCC testing and inspections

SECTION 346-6.4: The TABLE 6 of Subarticle 346-6.4 is expanded to read:

Slump Flow	± 2.5 inch [63.5]
Visual Stability Index (VSI)	Not more than 2
T-50	2-7 Sec, Only for Quality Control Testing at frequency of once per day during production of each mix
J-Ring Test	The difference between the slump flow with and without the J-Ring shall be within 2.0 inch [50 mm].

The first paragraph of Subarticle 346-6.4 is expanded to read: Reject SCC concrete batches that do not meet the Slump flow, VSI, and J-Ring requirements of Table 6.

Subarticle 346-7.7 is deleted and the following substituted:

346-7.7 Adding Water to Concrete at Placement Site: Determine the initial slump/ Slump flow before the addition of water at the job site. After adjusting the slump/slump flow, perform a test to confirm that the slump/slump flow of the concrete is within the target range. If the slump/slump flow exceeds the target range but is within the tolerance range, that load may be accepted, but water added at the site will be reduced to maintain a slump/slump flow within the target range on successive loads. If the slump/slump flow is delivered within the target range, no water will be added to the load. Confirm with another test that the next load is within the target range after the addition of water at the placement site. Repeated incidents of concrete being placed outside the target range will result in revocation of that portion of the QCP. No concrete represented by plastic test results outside of the tolerance range will be accepted for placement.

Subarticle 346-8 Plastic Concrete Sampling and Testing is deleted and the following substituted

In the first and fourth paragraphs change the word "slump" to "slump/slump flow".

Subarticle 346-9.2 Sampling Frequency for Quality Control Tests:

In the first paragraph change the word "slump" to "slump/slump flow".

Subarticle 346-9.2.1 Reduced Frequency for Acceptance Tests:

In the second and third paragraphs change the word "break" to "compressive strength test results".

The sub-article 346-9.2.1 is expanded to read: The requirements of the reduced testing frequency are not applicable to SCC.

Subarticle 400.5.1 Forms General is expanded to read:

For the SCC concrete, include in the quality control plan the methods and procedure of form joint sealing to prevent paste leakage.

Subarticle 400.11 Vibration of Concrete Subarticle 400-7.11.1 General: Quality Control Tests:

Consolidate all concrete by the use of mechanical vibrators, except seal, culvert floors, steel pile jackets, self-consolidating concrete, and concrete for incidental construction.

Subarticle 400-15.1 Finishing Concrete General is expanded to read:

For SCC, considering the weather condition, include guidelines in the QCP regarding the starting time of finishing, application of water fog mist or finishing aid if needed, and finishing methods for each type of product.

Subarticle 450-6.1 Forms General is expanded to read:

For the SCC concrete, include in the quality control plan the methods and procedure of form joint sealing to prevent paste leakage.

Subarticle 450.10.3.2 Requirements for Successive layers:

Expand the first paragraph of 450-3.2 to read as follows:

Place SCC in a continuous and timely manner to maintain its workability and specified slump flow during placement and to minimize the possibility of segregation and cold joints. It is the responsibility of the producer to utilize the appropriate SCC delivery and placement pattern and methods, including selection of the number of layers for the manufacturing of each product. Prepare SCC delivery, placement,

finishing, and curing guidelines for the training of personnel who are involved in these activities. Include the SCC guideline as part of the quality control plan.

Subarticle 450-10.4 Vibration of Concrete is expanded to read:

Ensure that concrete maintains its workability during the entire placement time. Place SCC without any vibration or other consolidation efforts, unless it is determined that minimal vibration efforts result in a better consolidation.

Subarticle 450-10.5.1 Finishing General is expanded to read:

For SCC, considering the weather condition, include guidelines in the QCP regarding the starting time of finishing, application of water fog mist or finishing aid if needed, and finishing methods for each type of product. During the hot weather conditions start early curing process as soon as possible.