SELF-CONSOLIDATING CONCRETE.
(REV 5-11-11)

SUBARTICLE 346-3 is expanded by the following:

346-3.5 Self-Consolidating Concrete Mixture Requirements: Meet the requirements of Table 2. In addition, meet the following requirements:

346-3.5.1 Water-to-Cementitious Materials Ratio: Do not exceed the water-to-cementitious materials ratio requirements of Section 346, Table 3 for the class of concrete or 0.45, whichever is lower.

346-3.5.2 Aggregate Volume Ratio: The volume ratios of fine-to-total aggregates in a mix design must be greater than or equal to 45% unless approved by the Engineer.

346-3.5.3 Slump Flow Target Value and Tolerance Range: In place of Table 2 slump requirements, perform slump flow. The proposed target slump flow value after the addition of all material ingredients, including admixtures, is 27.0 inches. The allowable tolerance range of the slump flow for verification is plus or minus 2.5 inches.

346-3.5.4 Target Visual Stability Index (VSI): The VSI Rating shall not exceed 2.0. Perform a second test when the VSI of the first test exceeds a value of 2.0. Reject the proposed mix if the second VSI test exceeds a value of 2.0. Record the T_{50} (20 inches) for information only.

346-3.5.5 Passing Ability of Self-Consolidating Concrete by J-Ring: Calculate the difference between slump flow and J-Ring flow. The maximum allowable difference is 2 inches.

346-3.5.6 Static Segregation of Self-Consolidating Concrete using Column Technique: The maximum allowable static segregation limit is 15%.

SUBARTICLE 346-6 (Pages 314 - 316) is expanded by the following:

346-6.5 Self-Consolidating Concrete:

346-6.5.1 Producer's Quality Control: Use a concrete production facility with an accepted Quality Control Plan, which was developed in accordance with Section 105. In addition to the requirements for the contents of the Producer Quality Control Plan, include the following information for self-consolidating concrete for review and acceptance by the Department prior to developing a mix design:

1. Describe the mix design qualification process if it is anticipated that the placing temperature will be below 85°F. The mix design qualification process shall be as outlined in Section 105 when the placing temperature will be above 85°F.
2. Concrete batching sequence, mixing methods and duration, and delivery.
3. The proposed sources of concrete materials ingredients.
4. The proposed inspection and test methods for the laboratory trial batches.
5. The frequency and test methods of the aggregate moisture content tests.

6. The qualification and experience of the personnel performing the required mixing, delivery, and testing of the self-consolidating concrete.

346-6.5.2 Laboratory Trial Batch: Perform a trial batch in accordance with the proposed batching sequence and mixing time that are included in the Producer's Quality Control Plan. Note any deviation from the proposed sequence. During the trial batch process, verify the acceptable batching sequence and the mixing time associated with this batching sequence. Ensure that a representative from the admixture manufacturer is present during the laboratory trial batch.

Notify the Engineer three working days prior to the trial batch being performed.

Perform density (unit weight), Visual Stability Index (VSI), T_{50} ,Passing Ability of Self-Consolidating Concrete by J-Ring, and Static Segregation of Self Consolidating Concrete using Column Techniques in addition to the tests required by this Section. In place of slump requirements, perform a slump flow test. Modify the consolidation method of ASTM C 31, ASTM C 138, ASTM C 173, and ASTM 231 by placing the concrete in the molds in one layer without vibration or tamping.

Sample concrete in accordance with ASTM C 31 and submit the test cylinders to the State Materials Office for testing in accordance with FM 5-578. For mixes with silica fume, metakaolin or superfine fly ash, meet the requirements of this Section.

Determine the workability of the concrete by performing a slump flow test every 15 minutes until the slump flow reaches the target slump flow less 5.0 inches. From the slump loss flow curve, determine the cut-off time at the lower tolerance range value. Ensure that the anticipated mixing, transit and placement times do not exceed the allowable cut-off time.

346-6.5.3 Contractor's Quality Control Plan: In addition to the requirements for the contents of the Contractor's Quality Control Plan, include the following for self-consolidating concrete as applicable:

1. Describe the field demonstration batch size, delivery time, placement pattern and methods, including selection of the number of layers for the manufacturing of each mockup.

2. Describe the self-consolidating concrete delivery time, placement pattern and methods.

3. Describe guidelines for training personnel who are involved in self-consolidating concrete placement, finishing and curing activities.

4. Describe guidelines for the finishing and curing processes, including application of water fog mist, evaporation reducer or finishing aids, if needed, for each type of element considering weather conditions.

5. Describe the qualification and experience of the personnel performing the required placement, inspection, and testing of the self-consolidating concrete.

6. Include a stability analysis of the proposed formwork to ensure sufficient strength to support the self-consolidating concrete prior to set, including proposed methods used to prevent leakage of the self-consolidating concrete through joints in the formwork.

346-6.5.4 Field Demonstration: Subsequent to the satisfactory laboratory

trial batch, perform a field demonstration by casting a mockup of the element. Obtain approval for the mockup element from the District Material Research Engineer. The District Materials Research Engineer may waive additional mockups for duplicate placements. Full scale mockups are required for all repairs. Dispose of concrete produced for demonstration purposes at no expense to the Department. Ensure that a representative from the admixture manufacturer is present during the field demonstration.

Ensure that the demonstration concrete is mixed, delivered, placed, consolidated and cured in accordance with the proposed method and sequence that are addressed in the Producer's and Contractor's Quality Control Plans.

Ensure that the concrete batches meet all plastic property requirements and maintain their cohesive nature without bleeding, segregation or abnormal retardation.

Take representative samples from each batch and perform slump flow, air content, J-Ring, density (unit weight), the Static Segregation of Self Consolidating Concrete using Column Techniques and temperature tests on these samples. Cast specimens from each sample for compressive strength tests. Modify the consolidation method of the ASTM C 31, ASTM C 138, ASTM C 173, and ASTM 231 tests by placing the concrete in the molds in one layer without vibration or tamping.

Determine the workability of the concrete by performing a slump flow test every 15 minutes until the slump flow reaches the target slump flow less 5.0 inches. From the slump loss flow curve, determine the cut-off time at the lower tolerance range value. Ensure that the anticipated mixing, transit and placement times do not exceed the allowable cut-off time.

For each field demonstration, record the slump flow, T_{50}, VSI, air content, concrete and ambient air temperatures, density (unit weight), and passing ability of the mix by using the J-Ring test.

Ensure that the concrete batches meet all plastic property requirements in 346-3.5 and 346-6.4. Maintain the batch cohesive nature without bleeding, segregation or abnormal retardation.

After removal of the forms, perform a post-placement inspection. Observe for any signs of honeycombs, cracks, aggregate segregation, sedimentation, cold joints, or any other surface defects.

Perform an aggregate distribution test in accordance with the Mujtaba Bühler test method, as modified herein. Saw-cut the mockup and select six locations along the cross-section view. Measure the aggregate content of the concrete directly at each of the selected areas of the mockup. An alternate option is to obtain core samples from six locations of these selected areas of the mockup. The core samples may be taken from the saw-cut section or uncut areas. The aggregate content of each location of the mockup will be determined and compared with the aggregate content of other locations.

Perform the aggregate distribution test of the saw cut surface as follows:

1. Select six locations along the saw cut surface of the mockup and designate them as A, B, C, D, E, and F. Locate A and B on the upper part, C and D at the middle, and E and F at the bottom part of the elevation view of the mockup.
2. For each test location, select an area of about 8 in x 8 in.

3. For location A, draw a vertical or horizontal line along the surface of the selected saw cut area, A-1.

4. By placing the ruler on the line A-1, measure the size of each piece of aggregate along the line, greater than or equal to 0.1 inch.

5. Determine the total length of the aggregates along the straight line A-1 by adding the measured sized of all pieces.

6. Determine the coarse aggregate content of A-1 along the straight line by calculating the ratio of the total length of aggregates along the line to the length of the drawn line.

7. Draw a total of seven more parallel lines for A-2 to A-8 as described in items 3 through 6. Report the average coarse aggregate ratio of the location A by adding the results of the coarse aggregate content of A-1 through A-8 lines and dividing the summation of the results by eight.

8. Follow the same procedure as described in item numbers 3 – 7 for locations B through F.

9. Calculate the average coarse aggregate content of the mockup by adding the average coarse aggregate contents of locations A through F and dividing the summation of the average coarse aggregate content of all locations by six.

10. Report the coarse aggregate contents of the selected locations and their average values in the percentages of total volume of the concrete to the nearest whole percent. The absolute value of the difference between the average coarse aggregate content of each location and average coarse aggregate content of all samples should not exceed 15%. Also, the difference, between the average coarse aggregate content of the mockup and the calculated values of the mix design should not differ by more than 15%. There is an indication of the segregation problem at any location where the difference between the coarse aggregate content of that location and the average coarse aggregate content of the mockup exceeds 15%.

11. Determine the cause of the problem and submit a corrective action plan to prevent the recurrence of the problem during the production. The District Materials Office will review the plan and decide if the demonstration trial batch should be repeated or the approval process should be continued as submitted.

Perform the aggregate distribution test on the core samples as follows:

1. For Coarse aggregate content of the core samples, follow the same procedure as it is described for the location of the elevation view of the saw cut surfaces. The core samples shall be taken from the selected areas. Draw eight parallel lines along the longitudinal axis of the surface area of the core sample and measure its coarse aggregate content. The coarse aggregate content of each core represents the coarse aggregate content of the selected area.

2. Report the coarse aggregate contents of the selected locations and their average values in percentages of total volume of the concrete to the nearest whole percent. The absolute value of the difference between the average coarse aggregate content of each location and average coarse aggregate content of all samples should not exceed 15%. Also, the difference between the average coarse aggregate content of the mockup and the calculated values of the mix design should not differ by more than 15%. There is an indication of the segregation problem, at any location where

the difference between the coarse aggregate content of that location and the average coarse aggregate content of the mockup exceeds 15%.

3. Determine the cause of the problem and submit a corrective action plan to prevent the recurrence of the problem during the production to the Engineer.

346-6.5 Submittals: Submit the laboratory trial data, field demonstration test results and inspection reports, along with a certification stating the proposed concrete mix design meets the requirements of this Section to the Engineer. State the anticipated maximum time limit between the batching and when the concrete of each batch is deposited during the production for the mix design. Any concrete with results exceeding the tolerances in 346-3.5 or if the density (unit weight) is not within plus or minus 2 lb/ft^3 from the value obtained in the laboratory trial batch or within 15% of the Mujtaba Bühler test method, will result in rejection of the concrete mix design.

ARTICLE 346-7 (Pages 316 - 317) is expanded by the following:

346-7.9 Self-Consolidating Concrete: During the production of the self-consolidating concrete, use the same batching sequence and mixing time determined during the laboratory and field demonstrations. Ensure that a representative from the admixture manufacturer is present during the first placement of self-consolidating concrete.

Notify the Engineer prior to the first placement of each element.

Ensure that all forms are watertight and that the corners are sealed to prevent leakage.

Place the self-consolidating concrete in a continuous and timely manner so that it stays plastic and within slump-flow tolerance range during placement.

Consolidation is typically not necessary for self-consolidating concrete; however, have internal vibrators on site. Obtain prior approval by the Engineer for consolidation.

ARTICLE 346-8 (Pages 318 - 319) is expanded by the following:

346-8.1 Plastic Properties for Self-Consolidating Concrete: For self-consolidating concrete, perform the density (unit weight), Visual Stability Index (VSI), and Passing Ability of Self-Consolidating Concrete by J-Ring in addition to the tests required by this Section.

In place of slump requirements, perform a slump flow test. Follow the same procedure for the slump flow test throughout the project.

Modify the consolidation method of ASTM C 31, ASTM C 138, ASTM C 173, and ASTM 231 by placing the concrete in the molds in one layer without vibration or tamping.

Reject concrete with any results exceeding the tolerances in 346-3.5 or if the density (unit weight) is not within plus or minus 2 lb/ft^3 from the value obtained in the laboratory trial batch.