Section 9.2
Volume II

STRUCTURAL CONCRETE PRODUCTION FACILITIES GUIDE

9.2.1 PURPOSE

This guide establishes policies that govern the production of structural concrete used by the Florida Department of Transportation (FDOT), herein after called the Department. The guide also provides the Structural Concrete Production Facility (Plant) with information related to the methods and the minimum requirements for Quality Control (QC) Plan, and criteria by which the Department will review the QC Plan for acceptance.

9.2.2 AUTHORITY

Sections 20.23(3)(a), 334.044(2), 334.044(10)(a), and 334.048(3) Florida Statutes.

9.2.3 SCOPE

The principal user of this document is a structural concrete Plant.

9.2.4 REFERENCES

Code of Federal Regulations (CFR), Federal-Aid Policy Guide (FAPG), Subchapter G – Engineering and Traffic Operations, Part 637 – Construction Inspection and Approval, Subpart B – Quality Assurance Procedures for Construction

American Society for Testing and Materials (ASTM) Standard Test Methods and Specifications, Philadelphia, Pennsylvania.

American Association of State Highway and Transportation Officials (AASHTO), Part II Tests, Washington, D.C.

American Concrete Institute (ACI), Farmington Hills, Michigan. Reports of the Technical Committees 211, 214, 301 and 318.

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

Florida Department of Transportation Approved Products List (APL).

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

9.2.5 GENERAL INFORMATION

Plants that supply concrete to Department projects must have a Producer QC Plan accepted by the Department in accordance with ***Specifications Section 105***. Complete the Structural Concrete Production Facility Quality Control Plan Review Checklist (Appendix B03) and submit it with the QC Plan. The checklist can be found at the following link.

https://www.fdot.gov/materials/quality/programs/qualitycontrol/checklists/index.shtm
Immediately notify the District Materials and Research Office (DMRO) in writing of any changes to the QC Plan. In case of change(s), revise the QC Plan annually in the form of addenda or complete revision of the entire document. Submit the revised QC Plan, if there were addenda throughout the year, to the DMRO annually. Any revisions to an accepted QC Plan shall be submitted and accepted by the DMRO prior to the implementation of the changes. The Department will maintain a list of Plants with accepted QC Plans that meet the requirements of this guide.

When the concrete producer has multiple Plants located in the same physical address:

a. Each Plant is required to have a separate QC Plan and Plant Number, provided that concrete mixers are fed by independent processing lines, including aggregates and cementitious materials silos, set of scales, and conveyors.

b. The Plants may have separate or combined batch house and control center.

c. The same Concrete Batch Plant Operator can simultaneously control multiple Plants.

Concrete produced in accordance with ***Specifications Section 346*** and this guide will be accepted based on the proper certification, QC testing and verification of project compressive strength acceptance criteria.

Perform materials sampling and testing in accordance with the ***Specifications Section 6***.

The Department will inspect the Plants actively producing concrete the for the Department at least once every three months. Plants actively producing

concrete include those that have produced concrete for Department projects within the last year or expected to produce within the next three months. At a minimum, actively producing Plants will be inspected in-person at least once every year. Remote audits may be conducted at the discretion of the District Materials and Research Engineer (DMRE) given the following requirements are met.

a. An on-site inspection has been conducted within the last year.
b. The Plant QC Manager must participate in the remote inspection and the preparation of all support materials.
c. The Plant QC Manager must provide inquiry responses and supporting documentation by the requested date. Documentation must be in a suitable electronic format.
d. No concrete performance issues related to plant production have been observed since the last inspection.
e. The Plant QC plan has not been suspended within the last year.
f. No batch ticket discrepancies or production related issues have been observed at the delivery site since the last inspection.

The Plants may request a reduced scheduling frequency for the Plant inspections from the DMRE. The reduced inspection scheduling frequency will be based on the requirements of ***Appendix "B"***.

Upon meeting all criteria in ***Appendix "B"***, the Plant's inspection frequency may be changed to a reduced inspection frequency if approved by the DMRE. The inspection frequency shall be a minimum of once every six (6) months or less. These inspections will assist in ensuring that the Plant continues to produce material in accordance with the Plant's accepted QC Plan, ***Specifications*** and other ***Contract Documents***.

9.2.6 CONCRETE PLANT ROLES AND RESPONSIBILITIES

9.2.6.1 Material Requirements

Meet the requirements of ***Specifications Section 346***.

9.2.6.1.1 Cementitious Materials

Acceptance of the cementitious materials at the Plant shall be based on the delivery ticket and mill certificate.

Store each cementitious material in a separate weatherproof storage container. Clearly label each storage container with the material contained within.

Measure the mass of the cementitious materials within an accuracy of 1 percent of the required total amount. For concrete batches of 3 cubic yards or less, an accuracy of 2 percent is allowed. Weigh the cementitious materials separately from other materials. When weighing the cementitious materials in a cumulative weigh hopper, weigh the cement first.

If bagged highly reactive pozzolans (silica fume, metakaolin, ultra-fine fly ash) or other cementitious materials are permitted, proportion the batch to use only whole bags. Store the highly reactive pozzolans in accordance with the manufacturer's recommendation.

9.2.6.1.2 Aggregates

Aggregates used in Department projects must meet the requirements of ***Florida Administrative Code Rule 14-103***. A list of approved sources will be maintained by the Department and made available from the State Materials Office (SMO).

Coarse aggregates size No. 8, and size No. 89 used alone in concrete mix designs are project specific.

Lightweight Fine Aggregates used for internal curing shall meet the requirements of ***ASTM C1761***.

As a minimum, provide suitable bins, stockpiles, or silos to store and identify aggregates without mixing, segregating, degradation or contamination of the different sources or grades. Each source must be properly marked and identified. Department designated, approved source number and aggregate grade shall be included in the identification.

Aggregates shall be measured by mass or volume within an accuracy of 1 percent of the required amount.

The concrete Plant is responsible for handling the aggregates by minimizing their segregation and obtaining them from the stockpile for use in the mix so it will remain within the requirement of the Specification limits. Stockpiles shall be maintained in a well-drained condition to minimize their free water contents and algae/fungal growth. Quantities of aggregates necessary for sampling and testing shall be obtained from the recovery side of the stockpile, where feasible, to ensure compliance with the ***Specifications*** and other ***Contract Documents***.

9.2.6.1.2.1 Wetting Coarse Aggregate Stockpiles, Storage Bins and Silos

For a period of 24 hours immediately preceding introduction into concrete, the coarse aggregate shall be continuously and uniformly sprinkled with water, meeting the requirements of ***Specifications Section 923***. Address in the Plant's QC Plan any request for deviations from the 24-hour sprinkling requirement including aggregates for structural lightweight concrete.

9.2.6.1.2.2 Wetting Lightweight Fine Aggregates

Lightweight Fine Aggregates used for internal curing shall be saturated according to ***ASTM C1761***.

9.2.6.1.3 Admixtures

Use only admixtures approved by the Department in the concrete mixes. A certification from the admixture supplier that the admixture meets the requirements of ***Specifications Section 924*** is required. The admixture dosage rate of the product to be used should be within the range of the admixture manufacturer's technical data sheet. Dosage rates outside of this range may only be used with written recommendation from the admixture producer's technical representative.

(1) The use of air entrainment admixtures is optional in all concrete mixes. Do not use it in counterweight and dry cast concrete.

(2) When a highly reactive pozzolan is incorporated into concrete, use a high range water-reducing admixture Type I, II, F or G.

(3) When a corrosion inhibitor admixture is incorporated into concrete, use a water-reducing and retarding admixture, Type D, or a high range water-reducing and retarding admixture, Type G, to normalize the setting time of concrete.

(4) Use non-chloride accelerating admixtures, Type C or accelerating and water-reducing, Type E, only in the manufacturing of precast drainage and incidental concrete products.

Measure the admixtures by mass or volume. Use measuring equipment that has accuracy (under all operating conditions) within 3 percent of the quantity of admixture required for the batch. Measure each admixture separately and add it to the batch in accordance with the admixture manufacturer's recommendation.

Store the admixtures in accordance with the admixture manufacturer's recommendation.

9.2.6.2 Scales, Meters, and other Weighing or Measuring Devices

9.2.6.2.1 General Requirements

Check the accuracy of all scales, meters, and other weighing or measuring devices, excluding admixture dispensers, prior to the production of concrete and, at a minimum, once every three months thereafter.

Ensure that a qualified representative of a scale company registered with the Bureau of Weights and Measures, under the Division of Standards of the Florida Department of Agriculture and Consumer Services, checks the accuracy of the above listed equipment. The Department reserves the right to be present during all equipment accuracy checks.

Ensure that the report provided by the qualified company performing the check includes the date of inspection, signature of the company representative, observed deviations for each quantity checked and a statement that the device conforms to the ***Specifications*** and other ***Contract Documents***. Maintain a copy of the report corresponding with the current certificate of inspection at the Plant.

Affix a certificate of inspection bearing the date of the certification showing signature of the company representative to each weighing or measuring device.

9.2.6.2.2 Scales

Maintain scales to an accuracy of 0.5 percent of the maximum load normally handled.

9.2.6.2.3 Water Measuring Devices

The check for accuracy will be by weight or volume. Whichever method is used, ensure that the accuracy of measurement is not affected by variations in pressure in the water supply line. Use a meter or weighing device capable of being set to deliver the required quantity and automatically cut off the flow when the required quantity has been discharged. Ensure that the measuring equipment has accuracy, under all operating conditions, within 1 percent of the quantity of water required as total mixing water for the batch. Ensure that the total mixing water shall include water added to the batch, ice added to the batch, free water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures.

Use of flow meters mounted in series is acceptable provided that the accuracy of the flow meters is traceable to the National Institute of Standards and Technology.

9.2.6.2.4 Admixture Measuring Dispensers

Ensure that the admixture supplier completes the annual certification of admixture measuring dispenser accuracy. Calibrate the dispensing equipment for calcium nitrite quarterly.

9.2.6.2.5 Recorders

Plants equipped with recording mechanisms must provide records that are clear, complete, and with permanent indications of the Plant's performance. Recorder information may be supplemented by the batcher during the batching operation. Allow Department inspectors to review the recorder history at any time.

9.2.6.2.6 Concrete Equipment

Use equipment that has no detrimental effect on the plastic concrete for handling of concrete mix ingredients; and mixing, handling, transporting, and depositing of the mixed concrete. Do not use equipment with aluminum surfaces in physical contact with the mixed product. As an exception, aluminum chutes, not longer than 20 feet, may be used for ready mixed concrete trucks.

9.2.6.3 Batching Accuracy

The failure to maintain batching operations of the plastic concrete within the tolerance for each component material requires immediate investigation and corrective action by the Plant. A failure to immediately investigate and implement corrective measures may be cause for suspension of the Plant's QC Plan.

9.2.6.3.1 Batch Adjustments for Materials

Permissible adjustments to previously approved mix designs that may be made without a new mix design request are as follows:

(1) Allowable variation of Coarse or Fine Aggregate: The variation for each aggregate can be ±75 pounds per cubic yard of concrete.

(2) Admixtures' dosage should be within the admixture manufacturer's technical data sheet range. Dosage rates outside of this range may be used only after obtaining written recommendation from the admixture manufacturer's technical representative.

(3) 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 DMRE of any adjustments made to the concrete mix design. Do not use batch adjustments for batch tolerances of aggregate and cementitious materials. Note the adjustments on the concrete delivery tickets.

At the Producer's option, submit the adjusted mix design for approval based on satisfactory field demonstration of at least 4 lots of production. Provide documentation of batch adjustments and field performance data.

9.2.6.3.2 Batch Adjustments for Moisture

Determine the free moisture of coarse and fine aggregates within two hours prior to each day's batching, unless moisture meters are used. Determine the free moisture content of aggregates at 4-hour intervals during continuous batching operations, and at any time a change in moisture content becomes apparent. Adjust batch proportions using these values.

Use the following methods to determine aggregate free moisture:

(1) Use moisture meter readings, speedy moisture tester or Chapman flask for fine aggregate moisture. The moisture meter readings may be used for coarse or fine aggregate moistures. Verify the accuracy of the moisture meter at least weekly by the moisture meter manufacturer's recommended method and by method (2) below. Verify the accuracy of the Chapman flask and speedy moisture tester at least weekly by method (2) below.

(2) Calculate the coarse and fine aggregate free moisture based upon dry sample weights and adjusting for absorption per ***AASHTO T 255***. Use the following minimum sample sizes in lieu of the sample sizes required in ***AASHTO T 255*** Table 1.

Fine Aggregate – 500 grams
Coarse Aggregate – 1500 grams

(3) Towel dry coarse aggregate to calculate free moisture on saturated surface dry aggregate. The accuracy of towel drying shall be verified weekly by method (2) above.

(4) The comparison criteria between any of these methods must be no more than 0.5 percent.

9.2.7 MIX DESIGNS

9.2.7.1 General

Concrete mix designs shall meet the requirements of ***Specification Section 346***. Plants may follow ACI 301 Section 4, and ACI 211 as guidelines to design concrete mixes.

When the Engineer determines that unsatisfactory results are obtained during production, the mix design approval will be rescinded.

Design a concrete mix to provide a required compressive strength (***f'cr***) that exceeds the specified minimum compressive strength (***f'c***) by the overdesign value.

$$\boldsymbol{f'cr = f'c + Overdesign}$$

Proceed as follows to select the overdesign value in concrete mixes:

(1) For a class of concrete, submit compressive strength field test data for the past 24 months and spanning no less than 45 calendar days, to determine the standard deviation. The ***f'c*** is required to be within 1,000 psi. The strength test data represents either a group of at least 30 consecutive tests or a statistical average for two groups totaling 30 or more tests. Determine the overdesign as follow:

a. When ***f'c*** is equal to or less than 5,000 psi.

$$\boldsymbol{Overdesign = 2.33\ x\ Standard\ Deviation - 500\ psi}$$

b. When ***f'c*** is greater than 5,000 psi.

$$\boldsymbol{Overdesign = 2.33\ x\ Standard\ Deviation - 0.10 x f'c}$$

(2) Use Table 1 at the concrete producer's option, or when the concrete producer has no records of field strength tests performed within the past 24 months and spanning no less than 45 calendar days for a class of concrete within 1,000 psi of that ***f'c***.

Design a concrete mix with a paste volume not exceeding requirements when specified. Paste Volume definitions, equations and examples are provided in "Appendix C".

TABLE 1 – Overdesign requirements for establishing ***f'cr*** when data is not available at 28-day or 56-day whichever is applicable					
Class of Concrete	***f'c*** (psi)	Overdesign (psi)	***f'cr*** (psi)	Paste Volume (1)	Drying Shrinkage (2) (3)
I Seal	3,000	1,200	4,200	Not Specified	
I Pavement	3,000	1,200	4,200	≤ 25%	≤ 400 με
II	3,400	1,200	4,600	Not Specified	
II Bridge Deck	4,500	1,200	5,700	≤ 28%	≤ 400 με
III	5,000	1,200	6,200	Not Specified	
IV	5,500	1,250	6,750	Not Specified	
IV Drilled Shaft	4,000	1,200	5,200	Not Specified	
V	6,500	1,350	7,850	Not Specified	
VI	8,500	1,550	10,050	Not Specified	
VII	10,000	1,700	11,700	Not Specified	

(1) Meet shrinkage requirements if paste volume requirement is exceeded
(2) Measure drying shrinkage in accordance with AASHTO T160. Moist cure specimens in lime-saturated water for 7 days, obtain the initial reading, then dry store at 50% RH and 73°F for 21 days prior to the final reading.
(3) Mix designs exceeding this threshold may be accepted at the discretion of the SMO Concrete Materials Engineer.

Design a concrete mix for a class of concrete specified in ***Specifications Section 346***. When the concrete mix meets the overdesign requirements of a higher class, classify the mix design as per Table 1. When a higher class is substituted for Class I Pavement or Class II Bridge Deck, the substituted mix design must satisfy the paste volume and drying shrinkage limits applicable to the specified class. The Engineer may waive the paste volume and drying shrinkage requirements for the substituted mix when project-specific conditions such as the need for accelerated strength gain justify the use of a higher class mix.

9.2.7.2 Lightweight concrete

Submit the fresh (unit weight) and hardened concrete density. Determine the hardened density (equilibrium density) in accordance with ***ASTM C567***. Ensure that the hardened density of the mix design is within ± 2 lb/ft^3 of the hardened density specified in the ***Contract Documents***. The hardened density may be calculated as the approximate equilibrium density, using the measured oven-dry density. Correlate the hardened density for the mix design with the fresh density measured in accordance with ASTM C138.

During production, the freshly mixed concrete density must be within ± 3 lb/ft^3 of the approved mix design fresh density.

9.2.7.3 Surface Resistivity Test

For all concrete mixes, cast three – 4 by 8 in. cylinders from the laboratory trial batch or from the field trial batch of at least 3 cubic yards. Test the cylinders at 28-day, or 56-day, whichever is applicable, by an accredited laboratory in accordance with ***AASHTO T 358***. Submit the results to the Department for mix design approval.

9.2.7.4 Acceptance of concrete at 56 days

The Department may approve specific mix designs for acceptance at 56 days in accordance with Table 1. The mix design shall meet the durability requirements at 56 days when specified in the ***Contract Documents***. Submit the strength development plot (concrete cylinder compressive strength versus concrete age) for test cylinder ages of 3, 7, 28 and 56 days. Mix designs meeting the overdesign requirements at 28-day will not be approved.

9.2.7.5 Concrete mixes with reduced total cementitious materials content

The Department may approve Class I (Seal) and I (Pavement) mix designs with the amount of total cementitious materials content below the minimum required in ***Specification Section 346***. Ensure that the mix meets the compressive strength (***f'cr***) requirement of Table 1.

9.2.7.6 Flowing Concrete and Self-Consolidating Concrete (SCC)

Perform the test method listed in Table 2 and determine the slump/slump flow loss test in accordance with 9.2.7.5.1 for mix design approval.

When the mix design is approved, perform the field demonstration mockup as follows:

(1) For cast-in-place concrete applications, the mockup shall be performed by the Contractor at the job site meeting the requirements of ***Specification Section 346***.

(2) For precast/prestressed concrete applications, the mockup shall be performed at the precast/prestressed plant in accordance with the applicable ***Materials Manual 8.4*** or ***Materials Manual 8.6***.

TABLE 2 – Test Methods for Flowing Concrete and SCC				
Properties	Concrete Classification	Test	Standard Method	Acceptance Criteria
Filling Ability	Flowing	Slump	ASTM C143	Target = 9.0 in
	SCC	Slump Flow	ASTM C1611	Minimum Target = 22.5 in
		Relative Viscosity (T_{50})	ASTM C1611	2 sec ≤ T_{50} ≤ 7 sec
Passing Ability	SCC	J-Ring (Δ Flow)	ASTM C1621	Δ Flow ≤ 2.0 in
Static Segregation	SCC	Rapid Assessment of Static Segregation (Pd)	ASTM C1712	Pd ≤ 25 mm
		Visual Stability Index (VSI)	ASTM C1611	VSI ≤ 1
	Flowing and SCC	Column Segregation (S)	ASTM C1610	S ≤ 15%
		Hardened Visual Stability Index (HVSI)	AASHTO R 81	HVSI ≤ 1
Compressive Strength	Flowing and SCC	Compressive Strength	ASTM C39	Depends on the Class of Concrete
Assessment of Durability	Flowing and SCC	Surface Resistivity	AASHTO T 358	Depends on the Contract Documents

9.2.7.6.1 Slump/Slump Flow Loss Test

For concrete production the time between batching and depositing of each load of concrete is the cutoff time of the mix design and it does not exceed the allowable time limit specified in FDOT ***Specifications Section 346***.

Determine the mix design cutoff time as follows:

(1) Prepare three concrete batches with a minimum volume of 3 cubic yards.

(2) Determine the workability of the three concrete batches by performing the slump/slump flow tests at 15-minute intervals from each batch. The time for each batch is counted from the time that the concrete is batched at the concrete production facility.

(3) Continue sampling and testing each batch until the slump/slump flow measures the proposed target minus 1.5 for flowing concrete or 2.5 inches for SCC, or a minimum of three slump/slump flow data points are obtained.

(4) For each batch of concrete, plot the slump/slump flow versus time to determine the individual cutoff time.

(5) The mix design cutoff time is the average of the three individual batch time determinations.

9.2.7.7 Mix Design Submittal

Submit the mix design verification requests directly to the DMRO in the District where the mix design will be verified. If a mix design is to be verified

at a location that is out-of-state, submit the mix design verification request to the DMRO closest to that location.

Ensure that the preparation and testing of the laboratory trial batch mixes are performed by a laboratory that is inspected and meets the requirements of ***ASTM C1077***. Personnel performing plastic or hardened concrete testing shall be qualified as described in ***Specifications Section 105***.

Slab replacement mixes do not require hot weather verification for mix design approval. Use only mix designs approved by the SMO for Department projects.

Ensure that the compressive strength at 28-day or 56-day whichever is applicable, of all trial laboratory batch mixes meet the requirements of Table 1.

At the discretion of the SMO Concrete Materials Engineer, the mix design may be tentatively approved at an earlier date (e.g. 14-day). If the 28-day or 56-day compressive strength whichever is applicable, does not meet the requirements of Table 1, the mix design will be rescinded.

Submit the proposed mix designs in MAC. For Class I (Pavement) mix designs, submit as Spec Version 350 in MAC.

Proportion the raw materials intended to be combined to produce 27 ± 0.02 cubic foot theoretical yield.

Attach the following supporting documentation with each new mix design submittal:

(1) A current material certificate (less than one-year from submittal date) for all cementitious materials, including their specific gravity.

(2) A current material certificate (less than one-year old from submittal date) for all aggregate materials, including their SSD specific gravity, gradation, absorption and fineness modulus (for fine aggregates).

(3) A certification statement from the admixture manufacturer’s technical representative that the proposed admixture is compatible with all other admixtures to be included in the concrete mix design.

(4) Laboratory trial batch and testing documentation including constituents, batch weights, trial batch size, date batched, time batched, time sampled, plastic properties, hardened properties, chloride contents and written recommendations for admixture dosage.

(5) For mix designs meeting Special Provisions, Technical Special Provisions, Developmental Specifications, Plan Notes or Supplemental Agreements, a copy of the contract documents that specifies the concrete mix design requirements.

(6) Laboratory slump/slump flow loss test data.if performed, for drilled shaft mixes with an elapsed time of 5 hours or less as described in ***Specification Section 455***, and 30 cubic yards of concrete or less.

For material substitutions, attach the following supporting documentation with each submittal:

(1) A current material certificate (less than one-year old from submittal) for all cementitious material, to include specific gravity.

(2) A current (less than one-year old from submittal) material certificate for all aggregate materials, to include SSD specific gravity, gradation, absorption and fineness modules (for fine aggregates).

9.2.7.7.1 Substitution of Materials

Obtain the Department's approval for portland cement, aggregates, and supplementary cementitious materials substitutions before placing concrete.

At the discretion of the SMO Concrete Materials Engineer, concrete materials substitutions may be considered to prevent concrete placement delays on ongoing construction projects. The Department may take up to five working days to review any material substitution request. Ensure that the concrete producer submits the proposed material substitution to the appropriate DMRO for verification. The concrete producer assumes all risks involved for ensuring that concrete plastic and hardened properties comply with the specifications at the time of placement.

Ensure that the substituted mix meets the theoretical yield requirements, does not exceed the maximum allowable water to cementitious materials ratio, and the cementitious materials content of the mix is equal to the approved base mix design. The theoretical unit weight of the proposed mix design shall be within 2.0 pounds per cubic foot of the originally approved theoretical mix design unit weight. The substitution of materials does not require chloride testing for mix design approval.

The Department may require a single 3.0 cubic yards minimum test batch at the Plant to demonstrate that the properties of the adjusted mix design are within the tolerances provided in ***Specifications Section 346***. When

the Department determines that unsatisfactory results are obtained during production, the mix design approval will be rescinded.

9.2.7.7.2 Aggregates

Aggregate sources may be substituted within an approved base mix design provided that the aggregates are the same geological type, same size, and are from an approved source. The new aggregate must have a saturated surface dry (SSD) specific gravity within 0.08 of the SSD specific gravity of the original aggregate source.

To prevent concrete placement delays on ongoing construction projects, aggregate source substitution approvals may be accelerated if all the following conditions are met:

(1) The proposed aggregate source substitution meets the requirements of ***Specifications Section 346.***

(2) The revised mix design is derived from an approved mix design (base mix design).

(3) The revised mix design is adjusted to meet theoretical yield requirements of the base mix design.

Follow the process outlined below to request an accelerated aggregate source substitution approval.

(1) Submit the written request to the Construction Engineer, the District Materials Office, and the State Materials Office. State the intended use and environmental classification for the placement of the revised mix design. Include the proposed revised mix design and a summary of the changes.

(2) The Construction Engineer may provide written preliminary approval of the revised mix design if the requirements of this section are met.

(3) The State Materials Office will review the revised mix design and provide a new mix design number within two business days.

(4) After the new mix design number is issued, the producer quality control plan shall be updated accordingly.

9.2.7.7.3 Portland & Blended Cement

Cement sources may be substituted within an approved mix design. The DMRO will ensure the replacement mix contains the same amount and type of cement as the replaced mix and only cement substitution is permitted.

9.2.7.7.4 Supplementary Cementitious Materials

Coal Ash and Slag from an approved source may be substituted within an approved base mix design. The DMRO will ensure the replacement mix contains the same amount and class, type or grade of SCM as the replaced mix.

Highly reactive pozzolans from an approved source may be substituted, provided that:

(1) The substitute material is the same material type as the product listed in MAC (e.g., silica fume, metakaolin, UFFA, calcined clay),

(2) Supporting test data demonstrates a Strength Activity Index equal to or greater than that of the listed product, and

(3) Any mix design incorporating the substitute material shall demonstrate compliance with the surface resistivity requirements prior to use.

9.2.7.7.5 Optimized Aggregate Gradation

Determine the optimized aggregate gradation in accordance with ***FM 5-621***.

9.2.7.8 Standard Concrete Trial Batch Mix (mix temperature between 68°F and 86°F)

(1) Ensure that preparation and testing of the trial mix is performed in accordance with ***ASTM C192***. Perform water to cementitious materials ratio calculations in accordance with ***FM 5-501***.

(2) On completion of the mixing period, ensure that the trial batch mix concrete has a slump/slump flow within ±0.50 inch of the target value (±1.0 inch for mixes utilizing a High Range Water-Reducing admixture), and an air content less than or equal to 6.0 percent.

9.2.7.9 Hot Weather Concrete Trial Batch Mix (mix temperature of 94°F or higher)

(1) Ensure that preparation and testing of the trial batch mixes is performed in accordance with ***ASTM C192***, with the following exceptions:

(2) Perform initial mixing in accordance with ***ASTM C192***, except concrete materials shall be brought to a temperature that will ensure the mix temperature is not less than 94ºF at any time.

(3) Hold the trial batch mix in the mixer for 90 minutes after completion of initial mixing. During the extended mixing period, turn the drum intermittently for 30 seconds every five minutes. Cover the drum with wet burlap or an impermeable cover material during the rest periods. At the end of the 90-minute period, remix the trial batch mix for a minimum of one minute and make a slump/slump flow test to verify that the concrete is within the specified range for slump/slump flow. Ensure that the mix temperature is not less than 94ºF at any time.

(4) On completion of the extended mixing period, ensure that the trial batch mix concrete has a slump/slump flow within ±0.75 inch of the target value (±1.0 inch for mixes utilizing a High Range Water-Reducing admixture), and an air content less than or equal to 6.0 percent. If below the target range, the Plant may adjust the slump/slump flow by adding water. After the water addition, remix the concrete for a minimum of two minutes and perform slump/slump flow and air content tests.

(5) The total water used in initial mixing and the final slump/slump flow adjustment constitutes the mix design water content. Perform water to cementitious materials ratio calculations in accordance with ***FM 5-501***. Ensure that the total water to cementitious materials ratio does not exceed the specified water to cementitious materials ratio in the ***Specifications Section 346***, for the respective class of concrete.

9.2.7.10 Hot Weather concrete trial mix for extended transit time mixes

Ensure that preparation and testing of the trial mixes are performed in accordance with the hot weather procedure, with the following additional requirements.

Upon completion of the hot weather procedure, do not add additional water to the batch. Hold the trial mix in the mixer for the additional time required after completion of the 90-minute mixing period. During the extended mixing period, turn the drum intermittently for 30 seconds every five minutes. Cover

the drum with wet burlap or an impermeable cover material during the rest periods. At the end of the required additional time extension period, remix the trial mix for a minimum of one minute and perform a slump/slump flow test to verify that the concrete is within the specified range for slump/slump flow. Ensure that the mix temperature is not less than 94ºF at any time.

9.2.7.11 Concrete trial batch mix for Specifications Section 353 (slab replacement):

Ensure that preparation and testing of the trial batch mix is performed in accordance with ***ASTM C192***. Perform water to cementitious materials ratio calculations in accordance with ***FM 5-501***.

On completion of the mixing period, ensure that the trial batch mix concrete has a slump/slump flow within ±0.50 inch of the target value (±1.0 inch for mixes utilizing a High Range Water-Reducing admixture), an air content less than or equal to 6.0 percent.

Hold the trial batch mix in the mixer for 60 minutes after completion of initial mixing. During the extended mixing period, turn the drum intermittently for 30 seconds every five minutes. Cover the drum with wet burlap or an impermeable cover material during the rest periods. Forty-five (45) minutes after completion of initial mixing add the required accelerator and cast the compressive strength test specimens.

9.2.7.12 Mix Design Review

Every five years, approved mix designs will be reviewed for compliance with current ***Specifications***. The SMO will track through MAC the concrete mix designs field data and may reclassify the mixes when:

(1) The compressive strength results exceed the required compressive strength (***f'cr***), and the concrete meets the overdesign requirements of a higher class.

(2) The result of the statistical evaluation of the concrete according to 9.2.5, indicate at least a good quality control as specified in ***ACI 214R*** Tables 4.3 and 4.4).

The mix design may be disapproved, reapproved or reclassified.

9.2.8 DRILLED SHAFT CONCRETE

Provide drilled shaft concrete meeting the requirements of ***Specifications Section 346***, including the slump/slump flow loss test data. When concrete is placed in any shaft, provide concrete in accordance with the following specified slump/slump flow loss requirements.

Ensure that the slump/slump flow loss is gradual as evidenced by slump/slump flow loss tests described below. The concrete elapsed time is defined in ***Specifications Section 455***.

Provide slump/slump flow loss tests before drilled shaft concreting operations begin, demonstrating that the drilled shaft concrete maintains a slump/slump flow of at least 5 inches throughout the concrete elapsed time. Obtain all other slump/slump flow loss test results in the field. The slump/slump flow loss test is performed at an ambient temperature consistent with the summer condition (85°F or higher) or the normal condition (below 85°F).

Inform the DMRE at least 48 hours before performing such tests. Perform slump/slump flow loss testing of the drilled shaft mix using qualified personnel as defined by this section.

Perform the following procedures for the field slump/slump flow loss tests, summer condition:

(1) Begin all elapsed times when water is initially introduced into the mixer.

(2) During field slump/slump flow loss testing for summer condition, the concrete temperature must exceed an average of 90°F.

(3) Ensure that the mix is at least 3 cubic yards and is mixed in a truck mixer with a valid mixer identification card.

(4) After initial mixing, determine the slump/slump flow, ambient and concrete temperatures and air content. Ensure that the concrete properties are within the required limits as specified in ***Specifications Section 346***.

(5) Verify the water to cementitious materials ratio and other delivery ticket data meet mix design requirements.

(6) When concrete is not being mixed, agitate the mixer at the midrange of the mixer manufacturer's recommended agitating speed. Remix

the batch for one minute at the mixing speed of the mixer before determining slump/slump flow, ambient and concrete temperatures.

(7) Determine slump/slump flow, ambient and concrete temperatures at 30-minute intervals until the slump/slump flow is 5 inches or less.

Perform the following procedures for the field slump/slump flow loss tests, normal condition:

(1) Begin all elapsed times when water is initially introduced into the mixer.

(2) During field slump/slump flow loss testing for normal condition, the concrete temperature does not exceed an average of 85°F.

(3) Ensure that the mix is at least 3 cubic yards and is mixed in a truck mixer with a valid mixer identification card.

(4) After initial mixing, determine the slump/slump flow, ambient and concrete temperatures and air content. Ensure that the concrete properties are within the required limits as specified in ***Specifications Section 346***.

(5) Verify the water to cementitious materials ratio and other delivery ticket data meet mix design requirements.

(6) When concrete is not being mixed, agitate the mixer at the midrange of the mixer manufacturer's recommended agitating speed. Remix the batch for one minute at the mixing speed of the mixer before determining slump/slump flow, ambient and concrete temperatures.

(7) Determine slump/slump flow, ambient and concrete temperatures at 30-minute intervals until the slump/slump flow is 5 inches or less.

During laboratory slump/slump flow loss testing for summer condition, the concrete temperature shall meet the requirements for hot weather trial batching (94°F).

(1) Begin all elapsed times when water is initially introduced into the mixer.

(2) Follow the procedure for Concrete Trial Mix Temperature of 94°F (hot weather mixes).

(3) At the end of the Concrete Trial Mix Temperature of 94°F (hot weather mixes). Turn the drum intermittently for 30 seconds every

five minutes. Cover the drum with wet burlap or an impermeable cover material during the rest periods.

(4) After initial mixing, determine the slump/slump flow, ambient and concrete temperatures and air content. Ensure that the concrete properties are within the required limits as specified in ***Specifications Section 346***.

(5) Remix the batch for one minute before determining slump/slump flow, ambient and concrete temperatures at 15-minute intervals until the slump/slump flow is 5 inches or less.

During laboratory slump/slump flow loss testing for normal condition, the concrete temperature shall be in the range of 68°F to 86°F.

(1) Begin all elapsed times when water is initially introduced into the mixer.

(2) Ensure that preparation and testing of the trial mix is performed in accordance with ***ASTM C192***.

(3) At the end of the mix procedure, turn the drum intermittently for 30 seconds every five minutes. Cover the drum with wet burlap or an impermeable cover material during the rest periods.

(4) After initial mixing, determine the slump/slump flow, ambient and concrete temperatures and air content. Ensure that the concrete properties are within the required limits as specified in ***Specifications Section 346***.

(5) Remix the batch for one minute before determining slump/slump flow, ambient and concrete temperatures at 15-minute intervals until the slump/slump flow is 5 inches or less.

Submit slump/slump flow loss test results to the DMRO for obtaining the approval in terms of elapsed time before concrete placement.

Mix designs approved based on aggregate substitution shall not require a new slump/slump flow loss test. However, drilled shaft mix designs with cement or SCM substitutions will require a new slump/slump flow loss test to be performed.

9.2.9 PLANT BATCHING REQUIREMENTS

9.2.9.1 Bins

Provide bins of adequate capacity for the required concrete production. Support the bins upon a rigid framework founded upon a stable foundation capable of holding them in a safe and secure position. Design each compartment to discharge efficiently and freely into the weigh hopper. Provide positive means of control so that as the quantity desired in the weigh hopper is approached, the material can be added slowly, and the addition of further material can be stopped precisely. Use a discharging mechanism that prevents loss of material when it is closed. Construct aggregate storage bins sufficiently tight to prevent leakage of material, and divide them into at least one compartment for the fine aggregate and one compartment for each size of coarse aggregate to be used.

Provide compartment partitions that are sufficiently tight and high enough to prevent intermingling of the different materials. Construct leak-proof and moisture-proof cementitious bins, and provide them with vibrators or other means to aid the flow of cement from the bin.

9.2.9.2 Weigh Hoppers

Provide weigh hoppers consisting of suitable containers freely suspended from scales and protected from the elements so that accuracy is not adversely affected. Equip the hoppers with a discharge mechanism that prevents leakage or loss of material when closed. Vent hoppers to permit air to escape and equip them with vibrators or other equipment that ensures complete and efficient discharge of materials.

9.2.9.3 Scales

Provide either beam type or springless dial type scales, or electronic devices such as load cells. Where using beam type scales, provide suitable means to hold poises securely in position after they are set. Keep scales clean and in good operating condition. Provide the scale operator with an unobstructed view of all indicating devices and convenient access to all controls. Use graduated weigh beam or dials to permit reading to 0.1 percent of the capacity of the scales. Check scales up to at least the maximum load normally handled on each respective scale.

9.2.10 MIXERS

9.2.10.1 General Requirements

Provide mixers that can combine the components of the concrete into a thoroughly mixed and uniform mass, free from balls or lumps, and which can discharge the concrete with a satisfactory degree of uniformity.

Inspect all mixers at least once each week.

9.2.10.2 Design

Use inclined axis revolving drum type truck mixers, or concrete Plant central mixers of the non-tilting, tilting, vertical or horizontal shaft types.

Make always available at the Plant a copy of the mixer manufacturer's design, showing dimensions and arrangement of blades. The concrete Plant may use mixers that have been altered from such design in respect to blade design and arrangement, or to drum volume, when authorized by the mixer manufacturer and approved by the DMRE. For initial design changes, provide uniformity test data, based on ***ASTM C94*** testing.

The metal rating plates must be attached to each mixer to specify its mixing speed, agitating speed, rated capacity and unit serial number. The unit serial number represents the entire mixing system. The metal rating plate may be located on the inside of the driver’s door. Mixer drum identification numbers or part numbers may or may not compare with the serial number on the rating plate. Should a drum be replaced, documentation from the mixer manufacturer must identify any deviations from the rating plate.

9.2.10.3 Truck Mixers Description

Use truck mixers with a drum that is actuated by a power source independent of the truck engine or by a suitable power take-off. Either system must provide control of the rotation of the drum within the limits specified on the mixer manufacturer's rating plate, regardless of the speed of the truck. Use truck mixers that are equipped with a hatch in the periphery of the drum shell which permits access to the inside of the drum for inspection, cleaning and repair of the blades.

Use truck mixers equipped with revolution counters and mounting, by which the number of revolutions of the drum may be readily verified.

Ensure that the water supply system mounted on truck mixers is equipped with a volumetric water gauge or a water meter in operating condition. Annually calibrate water measuring devices on truck mixers or other water sources used for concrete water adjustments.

Ensure truck mixers equipped with a volumetric water gauge are parked in a level condition during on-site water adjustments and for calibration. Ensure that the water measuring equipment has an accuracy of within 3 percent of the indicated quantity.

Truck mixers meeting these requirements shall be issued a mixer identification card by the DMRE upon request from the Plant. Failure to present the identification card upon request shall be cause for rejection of the delivered concrete. The Contractor shall remove the identification cards when a truck mixer is discovered to be in noncompliance and the deficiency cannot be repaired immediately.

When the identification card is removed for noncompliance, the Contractor shall note the deficiency on the identification card and forward the identification card to the DMRE in the District with QC Plan acceptance authority.

The concrete Plant shall inspect all truck mixers at least once each week for changes due to accumulation of hardened concrete or to wear of blades or chutes. The blades or chutes shall be repaired or replaced as necessary to meet these requirements. Any appreciable accumulation of hardened concrete shall be removed before any mixer may be used.

Copies of the most recent water measuring equipment calibration shall be kept in the truck cab and made available upon request.

9.2.10.4 Automated Slump Monitoring System

Proposed automated slump monitoring system include the following items:

(1) Slump is measured by the ready-mixed concrete truck.

(2) Slump is adjusted and controlled by the ready-mixed concrete truck.

(3) All water additions and slump adjustments are recorded.

The Plant’s QC Plan shall include:

(1) Automated slump monitoring system information.

(2) Provisions for training on the proposed automated slump monitoring systems. As a minimum, the Plant shall provide training on the automated slump monitoring system for drivers, QC personnel, and verification inspection personnel.

(3) Calibration procedures.

Calibration of the automated slump monitoring system shall be done on an annual basis, or when a truck is rejected in accordance with ***Specifications Section 346***. All system records including calibration records shall be made available at the Plant to the Department upon request.

Mix concrete at speeds and number of revolutions as recommended by the mixer manufacturer, when water is added enroute to the project site. Automatic introduction of water will be disabled when entering the project site or when the maximum water to cementitious materials ratio for the mix design is reached.

If the system adds water in transit, the concrete shall be re-mixed at mixing speed upon arrival to the project for an additional 30 revolutions. Water shall not be added during the discharge of the batch.

9.2.10.5 Central Mixers

Use stationary type mixers equipped with a timing device which will automatically lock the discharge lever when the drum is charged and release it at the end of the mixing period. In the event of failure of the timing device, the Department may allow operations to continue during the day that failure was noticed for the first time. Do not extend such operations beyond the end of that working day. Operate the mixer at the speed recommended by the central mixer manufacturer.

9.2.10.6 Mixer Cleaning and Maintenance

Repair or replace mixer blades of revolving drum type mixers when the radial height of the blade at the point of maximum drum diameter is less than 90 percent of the design radial height. Repair or adjust mixers of other designs per mixer manufacturer's instructions. Resolve questions of performance by performing mixer uniformity tests as described in ***ASTM C94***.

9.2.11 MIXING AND DELIVERING CONCRETE

9.2.11.1 General Requirements

Operate all Plant mixers at speeds per the mixer manufacturer's design or recommendation. Do not allow the volume of mixed batch material to exceed the mixer manufacturer's rated mixing capacity. Mix concrete

containing highly reactive pozzolans in accordance with the supplier's recommendations.

Wash-out water left in the drum prior to batching and account for all water entering the drum as batch water.

When necessary, during cold weather conditions, heat either the mix water, the aggregates or both prior to batching. Apply the heat uniformly in a manner which is not detrimental to the mix. Do not heat the aggregates directly by gas or oil flame or on sheet metal over fire. Do not heat the aggregates or water to a temperature of over 150° F. If either component is heated to over 100° F, mix them together prior to the addition of the cement.

The cement must not be in contact with the materials at temperatures exceeding 100° F. Include in the Plant's QC Plan measures to maintain free moisture in a well-drained condition when heating aggregates.

9.2.11.2 Central Mixing

After all materials are in the mixer, mix the concrete a minimum of two minutes or the central mixer manufacturer's recommended minimum mixing time, whichever is longer.

9.2.11.3 Transit Mixing

Initially mix each batch between 70 and 100 revolutions of the drum at mixing speed. The number of initial mixing revolutions may be modified when using specialty ingredients (highly reactive pozzolans, corrosion inhibitors calcium nitrite, accelerators, high range water reducers, etc.), as recommended by the specialty ingredients supplier.

Do not haul concrete in mixer trucks loaded with more than the rated capacity shown on their attached plates.

The water storage tanks on the truck shall be filled after reporting all water used and the delivery ticket is printed, before leaving for the project site. Water missing from the water storage tanks upon arrival at the project site shall be included in the jobsite water added.

9.2.11.4 Charging the Mixer

Charge each batch into the drum so that some water enters both in advance of and after the cementitious material and aggregates. If using coal ash

(other than ultra-fine fly ash) in the mix, charge it into the drum over approximately the same interval as the cement. Other time intervals introducing materials into the mix may be used after demonstrating uniformity of the concrete mix using the test requirements specified in ***ASTM C94***.

For concrete mixes containing specialty ingredients, charge the batch materials into the mixer in a sequence recommended by the mixer manufacturer of the specialty ingredients. Adjust the weight of mixing water for a concrete mix containing a corrosion inhibitor and/or accelerator admixture. Account for water in the corrosion inhibitor and/or accelerator as described in the admixture manufacturer's technical data sheet.

9.2.12 QUALITY CONTROL PROGRAM

The QC Plan of any concrete Plant shall meet the requirements of ***Specifications Sections 105***. The Plant's QC Plan shall also address the following items:

(1) Describe how the concrete Plant will maintain the properties of concrete to the point of discharge at the project site.

(2) Describe how the water to cementitious materials ratio and the plastic properties tests of concrete will be controlled to meet ***Specification*** requirements.

(3) Describe the action that will be taken when batching high slump/slump flow concrete to prevent lumps and balls shall also be addressed.

(4) Describe personnel qualification, source of materials, and equipment used to produce concrete shall be addressed in the Plant's QC Plan.

(5) Describe the action that will be taken when there is a concern with a material or product at the Plant which may be in violation of the ***Contract Documents*** and notify the DMRO.

When more than two trucks from a Plant delivering high slump concrete (6" slump or higher) is found to contain lumps and balls, the Department will notify the Plant that the Department will not accept high slump concrete from the Plant on any Department projects. To resume production of high slump concrete, the Plant must demonstrate the ability to batch a full-size load as defined by the Plant's QC Plan of high slump concrete free of lumps and balls. In addition, the Plant must revise that portion of its QC Plan that addresses batching of high slump concrete to reflect QC improvements made.

The Plant shall be on the Department's Production Facility Listing prior to production of concrete for Department projects. The accepted Plant's QC Plan shall be the minimum required control of concrete on all Department projects.

9.2.13 PERSONNEL

Plants supplying concrete to Department projects shall have adequate qualified personnel. Concrete Batch Plant Operator, qualified technicians and Plant Manager of QC are required positions for a Plant.

The Plant QC personnel shall meet the Structural Concrete Production Facility QC Personnel requirements of ***Specification Section 105***.

9.2.13.1 Concrete Batch Plant Operator

The duties and responsibilities of the Concrete Batch Plant Operators include but are not limited to the following:

(1) Sign concrete certification/delivery tickets.

(2) Must be present during concrete batching operations.

9.2.13.2 Qualified Technicians

The duties and responsibilities of the Qualified Technicians include but are not limited to the following:

(1) The ACI Concrete Field Testing Technician - Grade 1 performs concrete plastic properties test, such as slump, temperature, air content, making and curing concrete cylinders, and calculating the water to cementitious materials ratio.

(2) The ACI Concrete Strength Testing Technician performs tests on hardened properties of concrete.

(3) The ACI Self-Consolidating Concrete Testing Technician performs the self-consolidating concrete tests.

9.2.13.3 Plant Manager of Quality Control

Personnel who perform the duties of managing the QC of the Plant shall have the duties, responsibilities, and be qualified as follows:

Duties and responsibilities:

(1) Implement policies and procedures of the Plant’s QC Plan.

(2) Maintain liaison with the Department on all activities related to QC.

(3) Supervise the activities of all QC technicians, ensuring sufficient manpower is available in all areas related to QC testing and inspection.

(4) Review all QC procedures to ensure compliance with the ***Specifications*** and other ***Contract Documents***.

(5) Ensure all QC records are properly prepared and reviewed.

(6) Ensure that QC activities are performed in accordance with documented instructions and procedures.

(7) Develop and maintain a filing, storage, and retrieval system for QC records.

(8) QC Plant Manager or his/her qualified designee must be daily on-site at the Plant or always available on-site upon a four-hours' notice.

9.2.13.4 Concrete Mix Designer

The Concrete Mix Designer is responsible for the QC functions of designing the required concrete mixes.

9.2.14 RECORDS

All records shall be kept on file and made available at each Plant upon request by the Department. The following updated information shall be available at each Plant:

(1) Accepted concrete Plant QC Plan.

(2) Approved concrete mix designs.

(3) Materials source/specification compliance (delivery tickets, certifications, miscellaneous test reports).

(4) Concrete chloride test data.

(5) Aggregate moisture control records including date and time of test.

(6) Manufacturer's mixer information.

(7) Federal Highway Administration poster shall be posted to be visible to all employees.

(8) A copy of the scale company's report corresponding with the current certificate of inspection, showing the date of inspection, signature of the scale company representative, and the observed scale deviations for the loads checked.

(9) Certification documents for admixture weighing and measuring dispensers.

(10) Weekly mixer inspection reports.

(11) A daily record of all concrete batched for delivery to Department projects, including respective mix design numbers and quantities of batched concrete.

9.2.15 SAMPLING AND TESTING OF MATERIALS

9.2.15.1 General

Sampling and testing of materials and concrete for QC purposes is the responsibility of the concrete Plant. The frequency of sampling must be designed to provide adequate data to operate within the Plant's QC Plan for each mix design. ***Table 2*** designates the minimum sampling and testing frequencies that shall be performed in a well-controlled Plant. The Plant's QC Plan shall indicate an increased sampling rate when any of the Plant's testing results of the QC Plan items reach their maximum allowable limits.

All sampling and testing shall be conducted in accordance with the Department's current ***Florida Sampling and Testing Methods***, ***AASHTO***, or ***ASTM*** sampling and testing methods. Obtain SSD specific gravity and absorption values for both coarse and fine aggregate.

The Plant shall submit a corrective action plan to prevent the recurrence of the problem when evidence shows that the Plant has failed to sample within the required frequencies.

TABLE 2 – Concrete Material Components Sampling and Testing	
Material and Required Tests	Minimum Sampling Frequency for Each Source and Grade
Coarse Aggregate Gradation (**AASHTO T 27**) Total Minus 200-mesh (**FM 1-T011**)	Certification
Fine Aggregate Gradation (**FM 1-T 027**) Total Minus 200-mesh (**FM 1-T011**)	Certification
Cementitious Materials	Delivery Ticket and Mill Certificate

TABLE 2 – Concrete Material Components Sampling and Testing	
Material and Required Tests	Minimum Sampling Frequency for Each Source and Grade
Admixtures	Certification
Water (1)	As required in ***Specification Section 923***
Chlorides (**FM 5-516**)	1 every 30 days or in accordance with this guide
(1) The corrective action plan requires that open bodies of water and recycled water shall be tested every 15 days during production. Well and other sources of water shall be tested every 45 days during production, until approval to return to the normal sampling frequency is given by the DMRE for the District which has Plant QC Plan acceptance responsibility. Failure to comply with the sampling frequency shall be cause for suspension of the Plant's QC Plan.	

9.2.15.2 Chloride Testing

It is the responsibility of the Plant to make sure chloride content of concrete produced for the Department does not exceed the maximum allowable limits indicated in ***Specifications Section 346***. The Plant shall use a qualified laboratory, from the Department's Qualified Labs Report, for all chloride testing. The laboratory shall meet the requirements of ***Specifications Section 105-7***.

Determine the chloride content of each mix design produced every calendar month at the Plant. When more than one mix design uses the same material sources, the Plant has the option to test for chlorides on the mix design with the highest cementitious content to represent all such mixes. The chloride test report shall clearly indicate all mix designs covered by the test. When the source of any component material, including admixtures, for the concrete is changed, sampling for chloride determination shall restart the first day of production of the mix with the new component material.

Obtain the chloride test report. Enter the test results and attach the chloride test report in MAC within 15 business days of sampling. Failure to comply with the time frame for data entry may result in suspension of the Plant's QC Plan.

An increased sampling frequency shall be implemented when evidence shows the concrete Plant has failed to sample for chlorides content within the required frequency or failure of the chloride limit. The increased sampling frequency requires that the concrete for chloride testing shall be sampled once per week during production, until approval to return to the normal sampling frequency is given by the DMRE of the District that has Plant QC Plan acceptance responsibility. Failure to comply with the sampling frequency shall result in suspension of the Plant's QC Plan.

If chloride test results exceed the limits shown in ***Specifications Section 346***, within 0.10 lb/yd^3, submit the following documentation to the DMRE and SMO:

(1) A Corrective Action Report (CAR)

(2) The ***FM 5-516*** Chloride test results.

(3) Date(s) of production represented by failing test results.

(4) Mix design(s) represented by failing test results.

(5) Contract and Financial Project number(s).

If chloride test results exceed the limits shown in ***Specifications Section 346***, by more than 0.10 lb/yd^3, submit the above documentation and suspend concrete production immediately for every mix design represented by the failing chloride test results until corrective measures are made.

In addition to the testing frequency required in ***Table 2***, the DMRO will collect the chloride split samples from the Plant once per year for testing at SMO. The DMRO will compare the test results as follows:

(1) If the average chloride test results are within 0.092 lb/yd^3 of concrete, and at least one test passes, no further action is necessary.

(2) If the average chloride test results are within 0.092 lb/yd^3 of concrete, and both results fail, resolve as per ***Specifications Section 346***.

(3) If the average chloride test results are not within 0.092 lb/yd^3 of concrete, DMRO will notify SMO and the SMO will send the sample to third-party laboratory for resolution.

If third-party laboratory agrees with Plant results, no further action is required. If third-party laboratory agrees with SMO results, resolve as per ***Specifications Section 346***.

9.2.16 DELIVERY TICKET/CERTIFICATION

The following information is required information for each concrete delivery and must be furnished with each load. The information contained within ***Specifications Section 346*** is required information on each delivery ticket/certification. The original signature on the delivery ticket shall certify to the accuracy of the recorded information and compliance with the approved mix design. A sample of a delivery ticket is provided in ***Appendix "A".*** Use this form or a similar form containing the same information:

(1) Serial number of delivery ticket.

(2) The Plant number as assigned by the Department.

(3) Date of batching.

(4) Contractor's name.

(5) FDOT Financial Project Number.

(6) Truck number making the concrete delivery shall match the truck number on the delivery ticket.

(7) Class of concrete.

(8) Mix design number.

(9) Time all materials are introduced into mixer.

(10) Cubic yards in this load.

(11) Cumulative total cubic yards batched for job on date of delivery.

(12) Maximum allowable water addition at the job site. Unit of measure must be indicated.

(13) Number of revolutions at mixing speed before leaving for job site.

(14) Amount of mixing time for central mixer.

(15) Coarse and fine aggregate sources (Department assigned Source No.).

(16) Actual amount of coarse and fine aggregates batched in pounds.

(17) Percent of free moisture in coarse and fine aggregates.

(18) Cement producer’s name and type of cement.

(19) Total amount of cement batched in pounds.

(20) Producer’s name, brand name and class (whichever might apply) of supplementary cementitious material used.

(21) Total amount of each supplementary cementitious material batched in pounds.

(22) Admixture manufacturer, type and total amount of each admixture used.

(23) Total amount of water batched and added after the truck leaves the Plant in gallons or pounds before leaving for the job site. Unit of measure must be indicated.

(24) Statement of compliance with the ***Contract Documents.***

(25) Original signature of Batch Plant Operator and technician identification number.

Notes:
- Items 12 and 13 do not apply to non-agitating concrete transporting vehicles.
- Items 1, 2, 4, 6, and 9 through 13 do not apply to precast operations with onsite Plants.

9.2.17 TRAINING

Training will be in accordance with ***Specifications Section 105***.

9.2.18 FORMS

Example Concrete Delivery Ticket – Appendix A, ***Materials Manual Volume II, Section 9.2***

APPENDIX "A"
Sample Delivery Ticket for Structural Concrete

Financial Project No.: _____ Serial No.: _____

Plant No.: _____ Date: _____

Concrete Plant: _____ Delivered to: _____

Phone Number: _____ Phone Number: _____

Address: _____ Address: _____

Truck No.	DOT Class	DOT Mix No.	Cubic Yards This Load
Allowable Jobsite Water Addition (gal. or lb.)	Time Loaded	Mixing revolutions or time	Cubic Yards Total Today

Cement Source / Type / Amount	Coal Ash: Source / Grade / Amount Slag: Source / Class / Amount
Coarse Agg. Source Num. / Moisture (%) / Amount	Air Entrainment Admixture Source / Brand / Type / Amount
Fine Agg. Source Num. / Moisture (%) / Amount	Admixture Source / Brand / Type / Amount
Batch Water (gals. or lb.) Amount	Admixture Source / Brand / Type / Amount

Issuance of this ticket constitutes certification that the batched concrete was produced and is in compliance with the ***Contract Document*** requirements for Structural Concrete.

Technician Identification Number

Signature of Batch Plant Operator

Arrival time at job site		Number of revolutions upon arrival at job site	
Total Water added at job site (gallons)	Admixtures added at the job site (ounces)	Additional mixing revolutions with added water	
Time concrete completely discharged	Time admixture added		
Initial Slump/slump flow	Initial Air	Initial Concrete Temp.	Initial w/cm Ratio
Acceptance Slump/slump flow	Acceptance Air	Acceptance Concrete Temp.	Acceptance w/cm Ratio

Signature on this ticket constitutes certification that the maximum specified water cementitious materials ratio was not exceeded and the batch was delivered and placed in compliance with the ***Contract Document*** requirements.

Technician Identification Number

Signature of Contractor's Representative

APPENDIX "B"

Reduced Scheduling Frequency for the Plant Inspections

At the request of the Producer, the evaluation of the statistical parameters will be performed in accordance with ***ACI 214 Guide to Evaluation of Strength Test Result of Concrete***. The Department Materials Acceptance and Certification system (MAC) will provide a complete report of this information.

Parameters considered to reduce the plant's inspection frequency:

(1) When the specified 28-day or 56-day compressive strength (**f'c**) whichever is applicable is equal to or less than 5,000 psi.

a. The Plant QC standard deviation (**S**) of the compressive strength tests shall be equal to or less than 600 psi.

b. The Plant QC within-batch coefficient of variation ($\mathbf{CV_1}$) shall be equal to or less than 5%.

$\mathrm{CV}_1 = \frac{\mathrm{S}_1}{\overline{\mathrm{X}}}(100\%)$, where:

$\overline{\mathrm{X}}$ = Mean.

S_1 is the within-batch standard deviation.

$$\mathrm{S}_1 = \frac{\overline{\mathrm{R}}}{\mathrm{d}_2}$$

$\overline{\mathrm{R}}$ = Average range of at least 10 same age strength test results.

d_2 = Factor for computing within-batch standard deviation (***ACI 214R*** Table 4.1).

(2) When the specified strength (***f'c***) is greater than 5,000 psi.

a. The Plant QC coefficient of variation (**CV**) shall be equal to or less than 11%.

$\mathrm{CV} = \frac{\mathrm{S}}{\overline{\mathrm{X}}}(100\%)$, where:

S = standard deviation.

$\overline{\mathrm{X}}$ = Mean.

b. The Plant QC within-batch coefficient of variation shall be equal to or less than 5%.

(3) Previous Plant inspections, correction of any deficiencies noted, failing samples attributed to the Plant.

APPENDIX "C"

Paste Volume definitions, equations and examples.

Paste Volume: Paste volume represents the fraction of concrete occupied by cementitious materials, water, and chemical admixtures, expressed as a percentage. It is determined by calculating the absolute volume, in cubic feet, of each constituent per cubic yard of concrete. The sum of these volumes is then divided by 27 (the number of cubic feet in one cubic yard) and multiplied by 100 to express the result as a percentage. Coarse and fine aggregate volumes, as well as entrained and entrapped air, are excluded from this calculation.

Specific gravities for all cementitious constituents shall be determined from mill certificates or technical data sheets submitted with the mix design. Paste volume shall be calculated from the approved mix design proportions in accordance with the following procedure.

Eq. 1 — Paste volume

$$Paste\ volume\ (\%) = \left[\frac{(V_{cement} + V_{SCM} + V_{water} + V_{admix})}{27}\right] \times 100$$

Eq. 2 — Cement volume

$$Vcement = \frac{mass_{cement}}{SG_{cement} \times 62.4}$$

Eq. 3 — SCM volume

$$V_{SCM} = \frac{\Sigma\, mass_i}{SG_i \times 62.4}$$

Eq. 4 — Water volume

$$V_{water} = \frac{mass_{water}}{62.4}$$

Eq. 5 — Admixture volume

$$V_{admix} = \frac{\Sigma\, mass_j}{SG_j \times 62.4}$$

where:

V_{cement} = absolute volume of portland or blended cement, ft³/yd³

V_{SCM} = sum of absolute volumes of all supplementary cementitious materials, ft³/yd³

$Vwater$ = absolute volume of mix water, including free water from aggregates and liquid admixtures, ft³/yd³

$Vadmix$ = absolute volume of chemical admixtures, ft³/yd³

$mass$ = mass of constituent, lb/yd³

SG_i = specific gravity of constituent i, from mill certificate or technical data sheet

62.4 = unit weight of water, lb/ft³

27 = mix theoretical yield, ft³/yd³

An example of a paste volume percentage calculation is provided below:

Worked Example: Paste Volume Calculation

The following example demonstrates the paste volume calculation procedure using a representative concrete mix. Company and product names have been omitted; admixtures are designated generically. Screenshots from MAC are shown below.

Product Components [4]

Create Mix

Order	Product	Brand Name	Quantity	Unit	% of Total	Volume	Specific Gravity
Cementitious Materials							
1	921: Cement - Type II - **Formerly Type II (MH)**		600	Pound(s)		3.05	3.15
2	929: Fly Ash - Class F	Class F Fly Ash	165	Pound(s)	22	1.13	2.34
Cementitious Total							
			765	Pound(s)			

Water

Water (LBS)	Water (GALLONS)	Volume
292	35.0	4.68

Total Water Contributed (LBS)
45.14

Total (LBS)
337.14

APL Components [5]

Order	Name	Manufacturer	Quantity	Unit	Volume
1	Admixture for Concrete Air-Entraining]		2	FL OZ	0.00
2	Admixture for Concrete Type D Water-Reducing and Retarding]		38.3	FL OZ	0.00
3	Admixture for Concrete Type F High Range Water Reducing]		45.9	FL OZ	0.00
4	- Admixture for Concrete - Corrosion Inhibiting]		576	FL OZ	0.60
5	Admixture for Concrete Type S Shrinkage Reducing]		192	FL OZ	0.20

Step-by-Step Calculation

Step 1 — Cement absolute volume (Eq. 2):

$$V_{cement} = \frac{600}{3.15 \times 62.4} = \mathbf{3.05\ ft^3/yd^3}$$

Step 2 — Fly Ash absolute volume (Eq. 3):

$$V_{SCM} = \frac{165}{2.34 \times 62.4} = \mathbf{1.13\ ft^3/yd^3}$$

Step 3 — Mix water absolute volume (Eq. 4):

$$V_{water} = \frac{292}{62.4} = \mathbf{4.68\ ft^3/yd^3}$$

Step 4 — Chemical admixtures total absolute volume (see note 1) (Eq. 5):

Admixture 4: $\frac{\frac{576}{128}\times 8.34}{62.4} = 0.60\ ft^3/yd^3$

Admixture 5: $\frac{\frac{192}{128}\times 8.34}{62.4} = 0.20\ ft^3/yd^3$

$$V_{admix} = \mathbf{0.80\ ft^3/yd^3}$$

Step 5 — Sum paste volumes:

$$3.05 + 1.13 + 4.68 + 0.80 = 9.66\ ft^3/yd^3$$

Step 6 — Paste volume percentage (Eq. 1):

$$Paste\ volume = \left[\frac{9.66}{27}\right] \times 100 = \mathbf{36\%}$$

Notes:

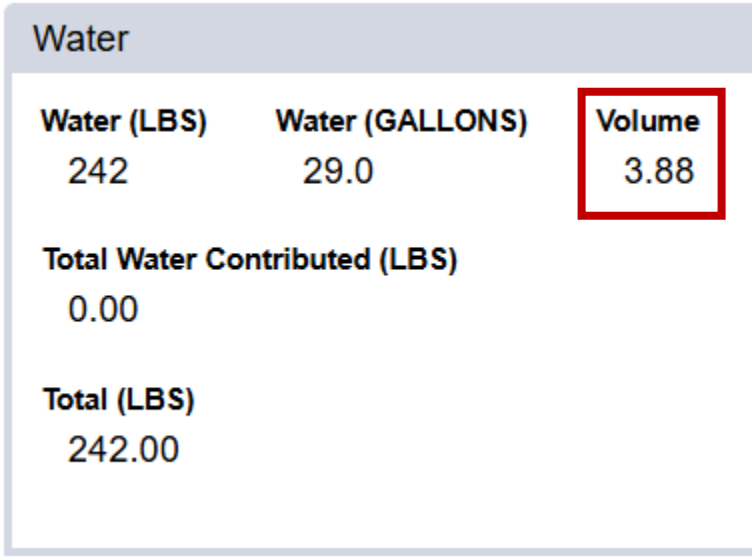
(1) Chemical admixtures dosed at one gallon per cubic yard (128 fl oz/yd³) or greater shall be included in V_{admix}. Admixtures with dosage rates below this threshold may be considered negligible and excluded from the calculation

(2) Aggregate volumes and air are excluded per specification requirements

Example #2:

Product Components [4]

Order	Product	Quantity	Unit	% of Total	Volume
Cementitious Materials					
1	921: Cement - Type II - **Formerly Type II (MH)**	155	Pound(s)	32	0.79
2	929: Slag	328	Pound(s)	68	1.81
Cementitious Total					
		483	Pound(s)		



Water

Water (LBS)	Water (GALLONS)	Volume
242	29.0	3.88

Total Water Contributed (LBS)

0.00

Total (LBS)

242.00

APL Components [2]

Order	Name	Quantity	Unit	Volume
1	Admixture for Concrete Air-Entraining]	0.6	FL OZ	0.00
2	Admixture for Concrete Type D Water-Reducing and Retarding]	18.6	FL OZ	0.00

$$Paste\ Volume = \frac{0.79 + 1.81 + 3.88}{27} * 100 = 24\%$$

Note: Admixture volume was not considered given the quantities are below 1 gallon (128 FL OZ)