



# Florida Department of Transportation

**CHARLIE CRIST**  
GOVERNOR

605 Suwannee Street  
Tallahassee, FL 32399-0450

**STEPHANIE KOPELOUSOS**  
SECRETARY

January 29, 2010

Monica Gourdine  
Program Operations Engineer  
Federal Highway Administration  
545 John Knox Road, Suite 200  
Tallahassee, Florida 32303

Re: Office of Design, Specifications  
Section 346  
Proposed Specification: **3460301 Portland Cement Concrete**

Dear Ms. Gourdine:

We are **resubmitting** the above referenced Supplemental Specification for your approval.

Additional changes were made to address comments received. These changes are highlighted in yellow below. The comments with responses were forwarded to Rafiq Darji on January 29, 2010 via email.

Sincerely,

Rudy Powell, Jr., P.E.  
State Specifications Engineer

RP/rp

Attachment

cc: Gregory Jones, Chief Civil Litigation  
Florida Transportation Builders' Assoc.  
State Construction Engineer

**PORTLAND CEMENT CONCRETE.**(REV ~~198-2931531-1009~~)

SUBARTICLE 346-3.1 (Pages 320 – 321) is deleted and the following substituted:

**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. Strength, slump, and air content of each class are specified in Table 2.

Substitution of a higher class concrete in lieu of a lower class concrete may be allowed, if approved by the Engineer. When the compressive strength acceptance data is less than the minimum compressive strength of the higher design mix, notify the Engineer. Acceptance is based on the requirements in Table 2 for the lower class concrete.

TABLE 2			
Class of Concrete	Specified Minimum Strength (28-day) (psi)	Target Slump <i>Value</i> (inches) (c)	Air Content Range (%)
<b>STRUCTURAL CONCRETE</b>			
I (a)	3,000	3 (b)	1.0 to 6.0
I (Pavement)	3,000	2	1.0 to 6.0
II (a)	3,400	3 (b)	1.0 to 6.0
II (Bridge Deck)	4,500	3 (b)	1.0 to 6.0
III (e)	5,000	3 (b)	1.0 to 6.0
III (Seal)	3,000	8	1.0 to 6.0
IV	5,500	3 (b) (d)	1.0 to 6.0
IV (Drilled Shaft)	4,000	8.5	0.0 to 6.0
V (Special)	6,000	3 (b) (d)	1.0 to 5.0
V	6,500	3 (b) (d)	1.0 to 5.0
VI	8,500	3 (b) (d)	1.0 to 5.0

(a) ~~For precast drainage systems that are manufactured at the precast plant, apply the chloride content limits specified in 346-4.2 to all box culverts. For precast elements of the following type; three sided box culverts, and precast drainage structures~~ *box culverts, endwalls, inlets, manholes and junction boxes,* -the target *slump value and* air content will not apply. ~~and target slump will not apply. and~~ *The maximum allowable slump is* shall be 6 inches, *except as noted in (b).* The Contractor is permitted to use concrete meeting the requirements of ASTM C 478 4,000 psi in lieu of Class I or Class II concrete for precast ~~drainage systems~~ *endwalls, inlets, manholes and junction boxes.*

(b) The Engineer may allow *a* higher target slump, ~~not to exceed 7 inches,~~ when a Type F, G, I or II admixture is used, *except when flowing concrete is used. The maximum target slump shall be 7 inches.*

(c) ~~The Engineer may approve~~ *For* a reduction in the target slump for slip-form operations, *submit a revision to the mix design to the Engineer Department.*

(d) When the use of silica fume, ultrafine fly ash, or metakaolin is required as a pozzolan in Class IV, Class V, Class V (Special) or Class VI concrete, ensure that the concrete exceeds a resistivity of 29 KOhm-cm at 28 days, when tested in accordance with FM 5-578. Submit three 4 x 8 inch cylindrical test specimens to the Engineer for resistivity testing before mix design approval. Take the resistivity test specimens from the concrete of the laboratory trial batch or from the field trial batch of at least 3 yd<sup>3</sup>. Verify the mix proportioning of the design 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 resistivity test specimens at least 7 days prior to the scheduled 28 day test. The average resistivity of the three cylinders, eight readings per cylinder, is an indicator of the permeability of the concrete mix.

(e) When ~~the precast elements of the following type:~~ *three-sided culverts, box culverts, endwalls, inlets, manholes or junction boxes,* or precast drainage products require a Class III concrete, the minimum cementitious materials ~~is~~ *will be 470 lb/yd<sup>3</sup>. Do not apply t* The air content range and target slump will not apply. *and tThe maximum target slump shall be- shall be 6 inches, except as allowed in (b).*

SUBARTICLE 346-3.2.1 (Page 322) is deleted and the following substituted:

**346-3.2.1 Slump Loss Test Requirements:** Provide slump loss tests before drilled shaft concrete operations begin, demonstrating that the drilled shaft concrete maintains a slump of at least 5 inches throughout the concrete elapsed time. Inform the Engineer at least 48 hours before performing such tests. Perform slump loss testing of the drilled shaft mix using personnel meeting the requirements of Section 105. *The Engineer may require a new slump loss test in the event that the temperature changes more than plus or minus 15 °F, the environmental conditions change or change in the volume increases change.*

Perform the following procedures for slump loss tests:

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

(2) The slump loss test is performed at a temperature consistent with the highest ambient and concrete temperatures expected during actual concrete placement. *This test may be used for lower temperature placements without any admixture adjustments.*

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

(4) After initial mixing, determine the slump, ambient and concrete temperatures, and air content. Ensure that the concrete properties are within the required ~~specification target range~~ *limits as specified in 346-3.1, Table 2.*

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

(6) Mix the concrete intermittently for 30 seconds every 5 minutes, *at a speed greater than or equal to  $\geq$  at the midrange of the manufacturer's recommended mixing speed. (When concrete is not being mixed, aAgitate the mixer when concrete is not being mixed at the midrange of the manufacturer's recommended agitating speed).*

(7) Determine slump, ambient and concrete temperatures at 30 minute intervals until the slump is 5 inches or less. Remix the mix for one minute at the mixing speed of the mixer before these tests are run.

(8) Ensure that the concrete maintains a slump of at least 5 inches for the anticipated elapsed time.

(9) Cast cylinders to determine when 500 psi compressive strength is obtained for the purpose of transporting field samples to the laboratory.

(10) Obtain the Engineer's approval of slump loss test results in terms of elapsed time before concrete placements.

SUBARTICLE 346-4.2.2 (Page 326) is deleted and the following substituted:

**346-4.2.2 Certification:** ~~Certify for each mix design from the first day of production and every 30 calendar days or less thereafter to the Department that all concrete produced for the Department meets the requirements of this Section. Include in the certification all pertinent~~ *If any chloride test data exceeds the limits in Table 4, identify the exception on the Construction Compliance with Specifications and Plans monthly certification form.* ~~The Department will require properly executed certifications showing the chloride content within the required limits for acceptance of all concrete produced. Include all the chloride certificates that apply with the monthly certification of compliance as required in Section 105.~~

SUBARTICLE 346-6.1 (Page 328) is deleted and the following substituted:

**346-6.1 General:** Develop a Quality Control Plan (QCP) as specified in Section 105. Meet the requirements of the approved QCP and Contract Documents. Ensure the QCP includes the necessary requirements to control the quality of the concrete.

Perform QC activities to ensure materials, methods, techniques, personnel, procedures and processes utilized during production meet the specified requirements. For precast/prestressed operations, ensure that the QC testing is performed by the producer.

Accept the responsibility for QC inspections on all phases of work. Ensure all materials and workmanship incorporated into the project meet the requirements of the Contract Documents.

When concrete plastic properties (slump, air content and temperature) could be significantly affected by handling between the point of delivery and the point of final placement, including the use of pumps, conveyor belts, troughs, chutes, barge transport or other means, include provisions in the QCP to sample the plastic concrete for all testing at the point of final placement.

Ensure the QCP includes any anticipated requirements for adjusting the concrete at the placement site. Include the testing procedures that will be implemented to control the quality of the concrete and ensure that concrete placed is within the ~~target~~ *tolerance* range. Also, include provisions for the addition of water to concrete delivered to the placement site at designated level areas, to ensure the allowable amount of water stated on the concrete delivery ticket or the maximum water to cementitious materials ratio on the approved design mix are not exceeded. Ensure the anticipated ranges of jobsite water additions are described and the proposed methods of measuring water for concrete adjustments are included.

Failure to meet the requirements of this Specification or the QCP will automatically void the concrete portion of the QCP. To obtain QCP re-approval, implement corrective actions as approved by the Engineer. The Engineer may allow the Contractor to continue any ongoing concrete placement but the Engineer will not accept concrete for any new placement until the QCP re-approval is given by the Engineer.

SUBARTICLE 346-6.3(Page 329) is deleted and the following substituted:

**346-6.3 Delivery Certification:** Ensure that an electronic delivery ticket is furnished with each batch of concrete before unloading at the placement site. The delivery ticket may be proprietary software or in the form of an electronic spreadsheet, but shall be printed. Ensure that the materials and quantities incorporated into the batch of concrete are printed on the delivery ticket. Include the following information on the Delivery Ticket:

- (1) Arrival time at jobsite,
- (2) Time that concrete mix has been completely discharged~~discharged~~placed,
- (3) Number of revolutions upon arrival at the jobsite,
- (4) Total gallons of water added at the jobsite,
- (5) Additional mixing revolutions when water is added,
- (6) Total number of revolutions at mixing and agitating speed.

Items 3 through 6 do not apply to non-agitating concrete transporting vehicles.

Ensure the batcher responsible for production of the batch of concrete signs the delivery ticket, certifying the batch of concrete was produced in accordance with the Contract Documents.

*Verify that the chloride test results on the delivery ticket meet the requirements of Table 4.*

Sign the delivery ticket certifying that the design mix maximum specified water to cementitious materials ratio was not exceeded due to any jobsite adjustments to the batch of concrete, and that the batch of concrete was delivered and placed in accordance with the Contract Documents.

SUBARTICLE 346-6.4 (Pages 329 – 330) is deleted and the following substituted:

**346-6.4 Plastic Property Tolerances:** *Do not place concrete with a slump more than plus or minus  $\pm 1.5$  inches from the target slump value specified in Table 2.* Meet the following tolerances from target values for plastic concrete properties specified in 346-3.1.

TABLE 6		
Property	Target Range	Tolerance
Slump (Non-Drilled Shaft Concrete without HRWR)	$\pm 0.75$ inch	$\pm 1.5$ inch
Slump (Non-Drilled Shaft Concrete with HRWR)	$\pm 1.0$ inch	$\pm 1.5$ inch
Slump (Drilled Shaft Concrete)	$\pm 1.0$ inch	$\pm 1.5$ inch
Air Content	As shown in the range in Table 2	

Reject concrete with slump or air content ~~exceeding~~ *that does not fall within the above-specified tolerances and immediately notify the concrete production facility that an adjustment of the concrete mixture is required so that it will fall within specified tolerances. If a load does not fall within the tolerances, test each subsequent load and the first adjusted load. If adjustments are not implemented by the next load of concrete, reject the concrete and terminate further production until adjustments are implemented. Test the plastic properties of the first adjusted load and every load that arrives at the project site prior to first adjusted load. If failing concrete is not rejected or adjustments are not implemented, the Contractor does not reject the failing concrete or does not implement adjustments, the Engineer may reject the concrete and terminate further production until the Contractor makes corrections are implemented. The Engineer may authorize placement of concrete that would otherwise have been rejected because the permanent structure will be adversely affected.*

Do not allow concrete to remain in a transporting vehicle to reduce slump. Water may be added only upon arrival of the concrete to the jobsite and not thereafter.

~~If the slump varies from the target range as described in Table 6, immediately adjust the concrete mixture to correct the slump of succeeding batches. The Engineer will allow a reasonable time for adjustment. Test each load to ensure only concrete meeting the specification is placed. The Engineer will take into consideration trucks already in route from the concrete production facility after the facility has been notified. If the Contractor does not implement adjustments at the earliest possible time, the Engineer may reject the concrete and terminate further production until the Contractor makes corrections.~~

SUBARTICLE 346-7.4 (Page 330) is deleted and the following substituted:

**346-7.4 Concreting in Cold Weather:** Do not mix concrete when the air temperature is below 45°F and falling. ~~The Contractor may mix~~ *Mix* and place concrete when the air temperature in the shade, and away from artificial heat, is 40°F and rising. Protect the fresh concrete from freezing until the concrete reaches a minimum compressive strength of 1,500 psi unless the concrete is to be heat cured. The requirements of concreting in cold weather are not applicable to precast concrete placement operations occurring in a temperature controlled environment.

SUBARTICLE 346-7.6 (Page 331) is deleted and the following substituted:

**346-7.6 Transit Time:** Ensure compliance with the following maximum allowable time between the initial introduction of water into the mix and depositing the concrete in place:

Non-Agitator Trucks	Agitator Trucks
45 minutes	60 minutes
75 minutes*	90 minutes*

\*When a water-reducing and retarding admixture (Type D, Type G or Type II) is used.

SUBARTICLE 346-7.7 (Page 331) is deleted and the following substituted:

**346-7.7 Adding Water to Concrete at the Placement Site:** Perform an initial slump *test* before the addition of water at the jobsite. If the slump, ~~is as delivered, within~~ *is outside* the ~~target~~ *tolerance* range, ~~no water will be added to~~ *reject* the load. If the slump is ~~outside the target range but is within the tolerance range~~, that load may be adjusted *by adding water provided the addition of water does not exceed the water to cementitious materials ratio as defined by the mix design*. After adjusting the slump, perform a *slump* test to confirm ~~that the slump of the concrete is within the slump tolerance target range as defined in Table 6. Perform~~ *Confirm with another a slump test on that the next load to ensure the concrete is within the target slump tolerance range. Maintain the slump within the target tolerance range on successive loads. Repeated incidents of concrete being placed outside the target range may result in revocation of that portion of the QCP. Do not place concrete represented by slump test results outside of the tolerance range.*

ARTICLE 346-8 (Page 331) is deleted and the following substituted:

### **346-8 Plastic Concrete Sampling and Testing.**

QC tests include air content, temperature, slump, and preparing compressive strength cylinders for testing at later dates. In addition, calculate the water to cementitious materials ratio in accordance with FM 5-501 for compliance to the approved mix design.

Ensure that each truck has a valid mixer identification card issued by the Department, the revolution counter on the mixer is working properly, and calibration of the water dispenser has been performed within the last twelve months and verify batch weights within required limits of the mix design. Reject any concrete batches that are delivered in trucks that do not have mixer identification cards. The Contractor may remove the mixer identification cards when a truck mixer is discovered to be in noncompliance. When the mixer identification card is removed for noncompliance, forward the card to the District Materials Engineer in the District where the plant is located.

Perform plastic concrete tests on the initial delivery of each concrete design mix each day. Ensure QC technicians meeting the requirements of Section 105 are present and performing tests throughout the placement operation. Ensure one technician is present and performing tests throughout the placement operation at each placement site. If a placement site has multiple concrete trucks, identify the number of technicians in the Quality Control Plan. If a placement site has multiple trucks placing concrete, then have at least two technicians present at that site. Ensure that the equipment used for delivery, placement and finishing meets the requirements of this Specification. Do not proceed with the placement operation until QC tests confirm that the delivered concrete complies with the plastic properties specified. When a truck designated for QC testing arrives at the site of discharge, subsequent trucks may not discharge until QC testing results are known. Reject non-complying loads at the jobsite. Ensure that corrections are made on subsequent loads.

Furnish sufficient concrete of each design mix as required by the Engineer for verification testing. When the Engineer's verification test results do not compare with the QC plastic properties test results, within the limits defined by the Independent Assurance (IA) checklist comparison criteria, located in Materials Manual Chapter 5, disposition of the concrete will be at the option of the Contractor.

*On concrete placements consisting of only one load of concrete, perform initial sampling and testing in accordance with this Section. The acceptance sample and plastic properties tests may be taken from the initial portion of the load.*

If any of the QC plastic properties tests fail, reject the remainder of that load, terminate the LOT and notify the Engineer. Make cylinders representing that LOT from the same sample of concrete.

Following termination of a LOT, obtain samples from a new load, and perform plastic properties tests until such time as the water to cementitious materials ratio, air content, temperature and slump comply with the Specification requirements. Initiate a new LOT once the testing indicates compliance with Specification requirements.

Suspend production when three ~~consecutive~~ LOTs, or when any five LOTs in two days of production of the same design mix are outside the specified tolerances. Make the necessary revisions to concrete operations and increase the frequency of QC testing in the QCP to bring the concrete within allowable tolerances. Obtain the Engineer's approval of the revisions before resuming production. After production resumes, obtain the Engineer's approval before returning to the normal frequency of QC testing.

If concrete placement stops for more than 90 minutes, perform initial plastic properties testing on the next batch and continue the LOT. Cylinders cast for that LOT will represent the entire LOT.

~~—The Department may perform Independent Verification testing to verify compliance with specification requirements.~~

When the Department performs Independent Verification, the Contractor may perform the same tests on the concrete at the same time. The Department will compare results based on the Independent Assurance Checklist tolerances.

When the Department's Independent Verification test results do not meet the requirements of this Section, the Engineer may require the Contractor to revise the QCP.

SUBARTICLE 346-9.1 (Pages 333 – 334) is deleted and the following substituted:

**346-9.1 General:** Perform plastic properties tests in accordance with 346-8 and cast a set of three QC cylinders (either 4 inch by 8 inch or 6 inch by 12 inch cylinders are acceptable), for all structural concrete incorporated into the project. Take these acceptance samples randomly as determined by a random number generator (acceptable to the Department). The Department will independently perform verification plastic properties tests and cast a set of verification cylinders. The verification cylinders will be the same size cylinder selected by the Contractor, from a separate sample from the same load of concrete as the Contractor's QC sample.

The Department may perform inspections in lieu of plastic properties tests of the precast plants producing Class I and II concrete.

For each set of QC cylinders verified by the Department, cast one additional cylinder from the same sample, and identify it as the QC "hold" cylinder. The Department will also cast one additional "hold" cylinder from each Verification sample. Provide curing facilities that have the capacity to store all QC, Verification, "hold" and Independent Verification cylinders simultaneously for the initial curing. All cylinders will be clearly identified *as outlined in the Sample/Lot Numbering System instructions located on the State Materials Office website*. Deliver the QC samples, including the QC "hold" cylinder to the final curing facility in

accordance with ASTM C 31. At this same time, the Department will deliver the Verification samples, including the Verification “hold” cylinder, to their final curing facility.

Test the QC laboratory cured samples for compressive strength at the age of 28 days, or any other specified age, in a laboratory meeting and maintaining at all times the qualification requirements listed in Section 105.

The QC testing laboratory will input the compressive strength test results into the Department’s sample tracking database within 24 hours. When the QC testing laboratory cannot input the compressive strength test results into the Department’s sample tracking database within 24 hours, the QC testing laboratory will notify the Verification testing laboratory within 24 hours of testing the cylinder and provide the Verification testing laboratory the compressive strength test results. Ensure the compressive strength results are input into the Department’s sample tracking database within 72 hours of determining the compressive strength of the cylinders.

The Department will average the QC compressive strength test data, average the Verification compressive strength test data, and compare the averages. In the event that one set of compressive strength data for a set of cylinders falls outside the range of the other set of cylinders, use the lower Range of Average Compressive Strength to determine the comparison criteria. Based on this comparison, the Department will determine if the Comparison Criteria as shown in Table 8-7 has been met. When the difference between QC and Verification are less than or equal to the Comparison Criteria, the QC data is verified. When the difference between QC and Verification data exceeds the Comparison Criteria, the Engineer will initiate the resolution procedure.

Range of Average Compressive Strength	Comparison Criteria
Less than 3500 psi	420 psi
3,501 – 4,500 psi	590 psi
4,501 – 6,500 psi	910 psi
6,501 – 8,500 psi	1,275 psi
Greater than 8,500 psi	1,360 psi

SUBARTICLE 346-9.2 (Pages 334 – 335) is deleted and the following substituted:

**346-9.2 Sampling Frequency for Quality Control Tests:**

As a minimum, sample and test concrete of each design mix for water to cementitious materials ratio, air content, temperature, slump and compressive strength once per LOT as defined by Table 9-8. When more than one concrete production facility is used for the same mix design, describe the method of sampling, testing and LOT numbering in the QC Plan. The Engineer will randomly verify one of every four consecutive LOTs of each design mix based on a random number generator. ~~and may perform additional Independent Verification tests.~~ *The Department may perform Independent Verification testing to verify compliance with specification requirements.* All QC activities, calculations, and inspections will be randomly confirmed by the Department.

TABLE 9-8

Class Concrete	Maximum LOT Size
I	one day's production
I (Pavement)	250 lane ft, or one day's production, whichever is less
II, II (Bridge Deck), III, IV, V (Special), V, VI	50 yd <sup>3</sup> , or one day's production, whichever is less
IV (Drilled Shaft)	50 yd <sup>3</sup> , or two hours between placements, whichever is less
III (Seal)	Each Seal placement

SUBARTICLE 346-9.4 (Pages 335 – 336) is deleted and the following substituted:

**346-9.4 Acceptance of Hardened Concrete:**

*Accept or reject concrete on the basis of plastic property results in accordance with 346-6.4.*

*Ensure that the ~~Hardened~~ hardened concrete will be accepted or rejected on the basis of strength test results ~~are obtained~~ as defined in ~~accordance with~~ 346-9.3 ~~the Specifications~~. Do not discard a cylinder strength test result based on low strength (strength below the specified minimum strength as per the provisions of ~~this Section~~ 346-3 and 346-9). When QC strength test results are verified, the Engineer will accept the concrete based on QC test results. The Engineer will accept at full pay only LOTS of concrete represented by strength test results which equal or exceed the respective specified minimum strength.*

When one of the three QC cylinders from a LOT is lost, damaged or destroyed, determination of compressive strength will be made by averaging the remaining two cylinders. If more than one QC cylinder from a LOT is lost, damaged or destroyed, the Contractor will core the structure at no additional expense to the Department to determine the compressive strength. Acceptance of LOT may be based on verification data at the discretion of the Engineer. Obtain the approval of the Engineer to core, and of the core location prior to coring.

For each QC cylinder that is lost, damaged or destroyed, payment for that LOT will be reduced by \$750.00 per 1,000 psi of the specified design strength [Example: loss of two Class IV (Drill Shaft) QC cylinders that has no verification data will require the element to be cored and a penalty will be assessed (4,000 psi / 1,000 psi) x \$750 x 2 = \$6,000. This reduction will be in addition to any pay adjustment for low strength.

When QC compressive strength test results are not verified, the resolution procedure will be used to accept or reject the concrete. Maintain the "hold" cylinders until the verification of the compressive strength test results.

*When QC test results are verified, the Engineer will accept the concrete based on QC test results. The Engineer will accept at full pay only LOTS of concrete represented by plastic property results which meet the requirements of the approved mix design and strength test results which equal or exceed the respective specified minimum strength.*

SUBARTICLE 346-9.6 (Page 337) is deleted and the following substituted:

**346-9.6 Small Quantities of Concrete:** When a project has a total plan quantity of less than 50 yd<sup>3</sup>, that concrete will be accepted based on the satisfactory compressive strength of the QC cylinders. Provide certification to the Engineer that the concrete was batched and placed in accordance with the Contract Documents. Submit a quality control plan for the concrete placement operation in accordance with Section 105. In addition, the Engineer may conduct Independent Verification (IV) testing as identified in 346-9. Evaluate the concrete in accordance with 346-10 at the discretion of the Engineer. ~~On concrete placements consisting of only one load of concrete, perform initial sampling and testing in accordance with this Section. The acceptance sample and plastic properties tests may be taken from the initial portion of the load.~~

SECTION 346 (Pages 317 – 340) is expanded by the following new Article:

***346-12 Pay Reduction Adjustments for Plastic Properties***

*If concrete is placed even when the result of plastic properties testing requires its rejection, the payment for concrete represented by the plastic property tests will be reduced by a pay adjustment of twice the invoice price per cubic yard for all concrete in the load that is placed. ~~of the placed concrete will be assessed for all the concrete in the load that is placed. If the Engineer authorizes placement of the concrete in accordance with 346-6.4, there will no be no pay reduction. adjustment will be assessed.~~*

**PORTLAND CEMENT CONCRETE.**

**(REV 1-29-10)**

SUBARTICLE 346-3.1 (Pages 320 – 321) is deleted and the following substituted:

**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. Strength, slump, and air content of each class are specified in Table 2.

Substitution of a higher class concrete in lieu of a lower class concrete may be allowed, if approved by the Engineer. When the compressive strength acceptance data is less than the minimum compressive strength of the higher design mix, notify the Engineer. Acceptance is based on the requirements in Table 2 for the lower class concrete.

TABLE 2			
Class of Concrete	Specified Minimum Strength (28-day) (psi)	Target Slump Value (inches) (c)	Air Content Range (%)
<b>STRUCTURAL CONCRETE</b>			
I (a)	3,000	3 (b)	1.0 to 6.0
I (Pavement)	3,000	2	1.0 to 6.0
II (a)	3,400	3 (b)	1.0 to 6.0
II (Bridge Deck)	4,500	3 (b)	1.0 to 6.0
III (e)	5,000	3 (b)	1.0 to 6.0
III (Seal)	3,000	8	1.0 to 6.0
IV	5,500	3 (b) (d)	1.0 to 6.0
IV (Drilled Shaft)	4,000	8.5	0.0 to 6.0
V (Special)	6,000	3 (b) (d)	1.0 to 5.0
V	6,500	3 (b) (d)	1.0 to 5.0
VI	8,500	3 (b) (d)	1.0 to 5.0

(a) For precast three sided culverts, box culverts, endwalls, inlets, manholes and junction boxes, the target slump value and air content will not apply. The maximum allowable slump is 6 inches, except as noted in (b). The Contractor is permitted to use concrete meeting the requirements of ASTM C 478 4,000 psi in lieu of Class I or Class II concrete for precast endwalls, inlets, manholes and junction boxes.

(b) The Engineer may allow a higher target slump when a Type F, G, I or II admixture is used, except when flowing concrete is used. The maximum target slump shall be 7 inches.

(c) For a reduction in the target slump for slip-form operations, submit a revision to the mix design to the Engineer.

(d) When the use of silica fume, ultrafine fly ash, or metakaolin is required as a pozzolan in Class IV, Class V, Class V (Special) or Class VI concrete, ensure that the

concrete exceeds a resistivity of 29 KOhm-cm at 28 days, when tested in accordance with FM 5-578. Submit three 4 x 8 inch cylindrical test specimens to the Engineer for resistivity testing before mix design approval. Take the resistivity test specimens from the concrete of the laboratory trial batch or from the field trial batch of at least 3 yd<sup>3</sup>. Verify the mix proportioning of the design 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 resistivity test specimens at least 7 days prior to the scheduled 28 day test. The average resistivity of the three cylinders, eight readings per cylinder, is an indicator of the permeability of the concrete mix.

(e) When precast three-sided culverts, box culverts, endwalls, inlets, manholes or junction boxes require a Class III concrete, the minimum cementitious materials is 470 lb/yd<sup>3</sup>. Do not apply the air content range and the maximum target slump shall be 6 inches, except as allowed in (b).

SUBARTICLE 346-3.2.1 (Page 322) is deleted and the following substituted:

**346-3.2.1 Slump Loss Test Requirements:** Provide slump loss tests before drilled shaft concrete operations begin, demonstrating that the drilled shaft concrete maintains a slump of at least 5 inches throughout the concrete elapsed time. Inform the Engineer at least 48 hours before performing such tests. Perform slump loss testing of the drilled shaft mix using personnel meeting the requirements of Section 105. The Engineer may require a new slump loss test in the event that the temperature changes more than plus or minus 15°F, the environmental conditions change or the volume increases.

Perform the following procedures for slump loss tests:

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

(2) The slump loss test is performed at a temperature consistent with the highest ambient and concrete temperatures expected during actual concrete placement. This test may be used for lower temperature placements without any admixture adjustments.

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

(4) After initial mixing, determine the slump, ambient and concrete temperatures and air content. Ensure that the concrete properties are within the required limits as specified in 346-3.1, Table 2.

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

(6) Mix the concrete intermittently for 30 seconds every 5 minutes, at a speed greater than or equal to the midrange of the manufacturer's recommended mixing speed. When concrete is not being mixed, agitate the mixer at the midrange of the manufacturer's recommended agitating speed.

(7) Determine slump, ambient and concrete temperatures at 30 minute intervals until the slump is 5 inches or less. Remix the mix for one minute at the mixing speed of the mixer before these tests are run.

(8) Ensure that the concrete maintains a slump of at least 5 inches for the anticipated elapsed time.

(9) Cast cylinders to determine when 500 psi compressive strength is obtained for the purpose of transporting field samples to the laboratory.

(10) Obtain the Engineer's approval of slump loss test results in terms of elapsed time before concrete placements.

SUBARTICLE 346-4.2.2 (Page 326) is deleted and the following substituted:

**346-4.2.2 Certification:** If any chloride test data exceeds the limits in Table 4, identify the exception on the Construction Compliance with Specifications and Plans form.

SUBARTICLE 346-6.1 (Page 328) is deleted and the following substituted:

**346-6.1 General:** Develop a Quality Control Plan (QCP) as specified in Section 105. Meet the requirements of the approved QCP and Contract Documents. Ensure the QCP includes the necessary requirements to control the quality of the concrete.

Perform QC activities to ensure materials, methods, techniques, personnel, procedures and processes utilized during production meet the specified requirements. For precast/prestressed operations, ensure that the QC testing is performed by the producer.

Accept the responsibility for QC inspections on all phases of work. Ensure all materials and workmanship incorporated into the project meet the requirements of the Contract Documents.

When concrete plastic properties (slump, air content and temperature) could be significantly affected by handling between the point of delivery and the point of final placement, including the use of pumps, conveyor belts, troughs, chutes, barge transport or other means, include provisions in the QCP to sample the plastic concrete for all testing at the point of final placement.

Ensure the QCP includes any anticipated requirements for adjusting the concrete at the placement site. Include the testing procedures that will be implemented to control the quality of the concrete and ensure that concrete placed is within the tolerance range. Also, include provisions for the addition of water to concrete delivered to the placement site at designated level areas, to ensure the allowable amount of water stated on the concrete delivery ticket or the maximum water to cementitious materials ratio on the approved design mix are not exceeded. Ensure the anticipated ranges of jobsite water additions are described and the proposed methods of measuring water for concrete adjustments are included.

Failure to meet the requirements of this Specification or the QCP will automatically void the concrete portion of the QCP. To obtain QCP re-approval, implement corrective actions as approved by the Engineer. The Engineer may allow the Contractor to continue any ongoing concrete placement but the Engineer will not accept concrete for any new placement until the QCP re-approval is given by the Engineer.

SUBARTICLE 346-6.3(Page 329) is deleted and the following substituted:

**346-6.3 Delivery Certification:** Ensure that an electronic delivery ticket is furnished with each batch of concrete before unloading at the placement site. The delivery ticket may be

proprietary software or in the form of an electronic spreadsheet, but shall be printed. Ensure that the materials and quantities incorporated into the batch of concrete are printed on the delivery ticket. Include the following information on the Delivery Ticket:

- (1) Arrival time at jobsite,
- (2) Time that concrete mix has been completely placed,
- (3) Number of revolutions upon arrival at the jobsite,
- (4) Total gallons of water added at the jobsite,
- (5) Additional mixing revolutions when water is added,
- (6) Total number of revolutions at mixing and agitating speed.

Items 3 through 6 do not apply to non-agitating concrete transporting vehicles.

Ensure the batcher responsible for production of the batch of concrete signs the delivery ticket, certifying the batch of concrete was produced in accordance with the Contract Documents.

Verify that the chloride test results on the delivery ticket meet the requirements of Table 4.

Sign the delivery ticket certifying that the design mix maximum specified water to cementitious materials ratio was not exceeded due to any jobsite adjustments to the batch of concrete, and that the batch of concrete was delivered and placed in accordance with the Contract Documents.

SUBARTICLE 346-6.4 (Pages 329 – 330) is deleted and the following substituted:

**346-6.4 Plastic Property Tolerances:** Do not place concrete with a slump more than plus or minus 1.5 inches from the target slump value specified in Table 2.

Reject concrete with slump or air content that does not fall within the specified tolerances and immediately notify the concrete production facility that an adjustment of the concrete mixture is required so that it will fall within specified tolerances. If a load does not fall within the tolerances, test each subsequent load and the first adjusted load. If failing concrete is not rejected or adjustments are not implemented, the Engineer may reject the concrete and terminate further production until the corrections are implemented.

Do not allow concrete to remain in a transporting vehicle to reduce slump. Water may be added only upon arrival of the concrete to the jobsite and not thereafter.

SUBARTICLE 346-7.4 (Page 330) is deleted and the following substituted:

**346-7.4 Concreting in Cold Weather:** Do not mix concrete when the air temperature is below 45°F and falling. Mix and place concrete when the air temperature in the shade, and away from artificial heat, is 40°F and rising. Protect the fresh concrete from freezing until the concrete reaches a minimum compressive strength of 1,500 psi unless the concrete is to be heat cured. The requirements of concreting in cold weather are not applicable to precast concrete placement operations occurring in a temperature controlled environment.

SUBARTICLE 346-7.6 (Page 331) is deleted and the following substituted:

**346-7.6 Transit Time:** Ensure compliance with the following maximum allowable time between the initial introduction of water into the mix and depositing the concrete in place:

TABLE 6	
Non-Agitator Trucks	Agitator Trucks
45 minutes	60 minutes
75 minutes*	90 minutes*
*When a water-reducing and retarding admixture (Type D, Type G or Type II) is used.	

SUBARTICLE 346-7.7 (Page 331) is deleted and the following substituted:

**346-7.7 Adding Water to Concrete at the Placement Site:** Perform an initial slump test before the addition of water at the jobsite. If the slump, as delivered, is outside the tolerance range, reject the load. If the slump is within the tolerance range, that load may be adjusted by adding water provided the addition of water does not exceed the water to cementitious materials ratio as defined by the mix design. After adjusting the slump, perform a slump test to confirm the concrete is within the slump tolerance range. Perform a slump test on the next load to ensure the concrete is within the slump tolerance range. Do not place concrete represented by slump test results outside of the tolerance range.

ARTICLE 346-8 (Page 331) is deleted and the following substituted:

### **346-8 Plastic Concrete Sampling and Testing.**

QC tests include air content, temperature, slump, and preparing compressive strength cylinders for testing at later dates. In addition, calculate the water to cementitious materials ratio in accordance with FM 5-501 for compliance to the approved mix design.

Ensure that each truck has a valid mixer identification card issued by the Department, the revolution counter on the mixer is working properly, and calibration of the water dispenser has been performed within the last twelve months and verify batch weights within required limits of the mix design. Reject any concrete batches that are delivered in trucks that do not have mixer identification cards. The Contractor may remove the mixer identification cards when a truck mixer is discovered to be in noncompliance. When the mixer identification card is removed for noncompliance, forward the card to the District Materials Engineer in the District where the plant is located.

Perform plastic concrete tests on the initial delivery of each concrete design mix each day. Ensure QC technicians meeting the requirements of Section 105 are present and performing tests throughout the placement operation. Ensure one technician is present and performing tests throughout the placement operation at each placement site. If a placement site has multiple concrete trucks, identify the number of technicians in the Quality Control Plan. If a placement site has multiple trucks placing concrete, then have at least two technicians present at that site. Ensure that the equipment used for delivery, placement and finishing meets the requirements of this Specification. Do not proceed with the placement operation until QC tests confirm that the delivered concrete complies with the plastic properties specified. When a truck designated for

QC testing arrives at the site of discharge, subsequent trucks may not discharge until QC testing results are known. Reject non-complying loads at the jobsite. Ensure that corrections are made on subsequent loads.

Furnish sufficient concrete of each design mix as required by the Engineer for verification testing. When the Engineer's verification test results do not compare with the QC plastic properties test results, within the limits defined by the Independent Assurance (IA) checklist comparison criteria, located in Materials Manual Chapter 5, disposition of the concrete will be at the option of the Contractor.

On concrete placements consisting of only one load of concrete, perform initial sampling and testing in accordance with this Section. The acceptance sample and plastic properties tests may be taken from the initial portion of the load. If any of the QC plastic properties tests fail, reject the remainder of that load, terminate the LOT and notify the Engineer. Make cylinders representing that LOT from the same sample of concrete.

Following termination of a LOT, obtain samples from a new load, and perform plastic properties tests until such time as the water to cementitious materials ratio, air content, temperature and slump comply with the Specification requirements. Initiate a new LOT once the testing indicates compliance with Specification requirements.

Suspend production when three LOTs, or when any five LOTs in two days of production of the same design mix are outside the specified tolerances. Make the necessary revisions to concrete operations and increase the frequency of QC testing in the QCP to bring the concrete within allowable tolerances. Obtain the Engineer's approval of the revisions before resuming production. After production resumes, obtain the Engineer's approval before returning to the normal frequency of QC testing.

If concrete placement stops for more than 90 minutes, perform initial plastic properties testing on the next batch and continue the LOT. Cylinders cast for that LOT will represent the entire LOT.

When the Department performs Independent Verification, the Contractor may perform the same tests on the concrete at the same time. The Department will compare results based on the Independent Assurance Checklist tolerances.

When the Department's Independent Verification test results do not meet the requirements of this Section, the Engineer may require the Contractor to revise the QCP.

SUBARTICLE 346-9.1 (Pages 333 – 334) is deleted and the following substituted:

**346-9.1 General:** Perform plastic properties tests in accordance with 346-8 and cast a set of three QC cylinders (either 4 inch by 8 inch or 6 inch by 12 inch cylinders are acceptable), for all structural concrete incorporated into the project. Take these acceptance samples randomly as determined by a random number generator (acceptable to the Department). The Department will independently perform verification plastic properties tests and cast a set of verification cylinders. The verification cylinders will be the same size cylinder selected by the Contractor, from a separate sample from the same load of concrete as the Contractor's QC sample.

The Department may perform inspections in lieu of plastic properties tests of the precast plants producing Class I and II concrete.

For each set of QC cylinders verified by the Department, cast one additional cylinder from the same sample, and identify it as the QC "hold" cylinder. The Department will also cast one additional "hold" cylinder from each Verification sample. Provide curing facilities

that have the capacity to store all QC, Verification, “hold” and Independent Verification cylinders simultaneously for the initial curing. All cylinders will be clearly identified as outlined in the Sample/Lot Numbering System instructions located on the State Materials Office website. Deliver the QC samples, including the QC “hold” cylinder to the final curing facility in accordance with ASTM C 31. At this same time, the Department will deliver the Verification samples, including the Verification “hold” cylinder, to their final curing facility.

Test the QC laboratory cured samples for compressive strength at the age of 28 days, or any other specified age, in a laboratory meeting and maintaining at all times the qualification requirements listed in Section 105.

The QC testing laboratory will input the compressive strength test results into the Department’s sample tracking database within 24 hours. When the QC testing laboratory cannot input the compressive strength test results into the Department’s sample tracking database within 24 hours, the QC testing laboratory will notify the Verification testing laboratory within 24 hours of testing the cylinder and provide the Verification testing laboratory the compressive strength test results. Ensure the compressive strength results are input into the Department’s sample tracking database within 72 hours of determining the compressive strength of the cylinders.

The Department will average the QC compressive strength test data, average the Verification compressive strength test data, and compare the averages. In the event that one set of compressive strength data for a set of cylinders falls outside the range of the other set of cylinders, use the lower Range of Average Compressive Strength to determine the comparison criteria. Based on this comparison, the Department will determine if the Comparison Criteria as shown in Table 7 has been met. When the difference between QC and Verification are less than or equal to the Comparison Criteria, the QC data is verified. When the difference between QC and Verification data exceeds the Comparison Criteria, the Engineer will initiate the resolution procedure.

Range of Average Compressive Strength	Comparison Criteria
Less than 3500 psi	420 psi
3,501 – 4,500 psi	590 psi
4,501 – 6,500 psi	910 psi
6,501 – 8,500 psi	1,275 psi
Greater than 8,500 psi	1,360 psi

SUBARTICLE 346-9.2 (Pages 334 – 335) is deleted and the following substituted:

**346-9.2 Sampling Frequency:**

As a minimum, sample and test concrete of each design mix for water to cementitious materials ratio, air content, temperature, slump and compressive strength once per LOT as defined by Table 8. When more than one concrete production facility is used for the same mix design, describe the method of sampling, testing and LOT numbering in the QC Plan. The Engineer will randomly verify one of every four consecutive LOTs of each design mix based on a random number generator. The Department may perform Independent Verification

testing to verify compliance with specification requirements. All QC activities, calculations, and inspections will be randomly confirmed by the Department.

TABLE 8	
Class Concrete	Maximum LOT Size
I	one day's production
I (Pavement)	250 lane ft, or one day's production, whichever is less
II, II (Bridge Deck), III, IV, V (Special), V, VI	50 yd <sup>3</sup> , or one day's production, whichever is less
IV (Drilled Shaft)	50 yd <sup>3</sup> , or two hours between placements, whichever is less
III (Seal)	Each Seal placement

SUBARTICLE 346-9.4 (Pages 335 – 336) is deleted and the following substituted:

**346-9.4 Acceptance of Concrete:**

Accept or reject concrete on the basis of plastic property results in accordance with 346-6.4.

Ensure that the hardened concrete strength test results are obtained in accordance with 346-9.3. Do not discard a cylinder strength test result based on low strength (strength below the specified minimum strength as per the provisions of this Section).

When one of the three QC cylinders from a LOT is lost, damaged or destroyed, determination of compressive strength will be made by averaging the remaining two cylinders. If more than one QC cylinder from a LOT is lost, damaged or destroyed, the Contractor will core the structure at no additional expense to the Department to determine the compressive strength. Acceptance of LOT may be based on verification data at the discretion of the Engineer. Obtain the approval of the Engineer to core, and of the core location prior to coring.

For each QC cylinder that is lost, damaged or destroyed, payment for that LOT will be reduced by \$750.00 per 1,000 psi of the specified design strength [Example: loss of two Class IV (Drill Shaft) QC cylinders that has no verification data will require the element to be cored and a penalty will be assessed (4,000 psi / 1,000 psi) x \$750 x 2 = \$6,000. This reduction will be in addition to any pay adjustment for low strength.

When QC compressive strength test results are not verified, the resolution procedure will be used to accept or reject the concrete. Maintain the "hold" cylinders until the verification of the compressive strength test results.

When QC test results are verified, the Engineer will accept the concrete based on QC test results. The Engineer will accept at full pay only LOTs of concrete represented by plastic property results which meet the requirements of the approved mix design and strength test results which equal or exceed the respective specified minimum strength.

SUBARTICLE 346-9.6 (Page 337) is deleted and the following substituted:

**346-9.6 Small Quantities of Concrete:** When a project has a total plan quantity of less than 50 yd<sup>3</sup>, that concrete will be accepted based on the satisfactory compressive strength of the QC cylinders. Provide certification to the Engineer that the concrete was batched and placed in accordance with the Contract Documents. Submit a quality control plan for the concrete placement operation in accordance with Section 105. In addition, the Engineer may conduct Independent Verification (IV) testing as identified in 346-9. Evaluate the concrete in accordance with 346-10 at the discretion of the Engineer.

SECTION 346 (Pages 317 – 340) is expanded by the following new Article:

**346-12 Pay Reduction for Plastic Properties**

If concrete is placed even when the result of plastic properties testing requires its rejection, the payment for concrete represented by the plastic property tests will be reduced by twice the invoice price per cubic yard for all concrete in the load that is placed. If the Engineer authorizes placement of the concrete, there will be no pay reduction.