Florida Department of Transportation

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SECRETARY

July 29, 2020

Khoa Nguyen
Director, Office of Technical Services
Federal Highway Administration
3500 Financial Plaza, Suite 400
Tallahassee, Florida 32312

Re: State Specifications Office
Section: **346**
Proposed Specification: **3460202 STRUCTURAL PORTLAND CEMENT CONCRETE.**

Dear Mr. Nguyen:

We are submitting, for your approval, two copies of the above referenced Supplemental Specification.

The changes are proposed by Jose Armenteros add the optimized aggregate gradation requirements, delete the repeated flowing concrete language, clarify the minimum amount of total cementitious materials content, and update the reduced frequency for acceptance concrete testing to the Standard Specification..

Please review and transmit your comments, if any, within two weeks. Comments should be sent via email to daniel.strickland@dot.state.fl.us.

If you have any questions relating to this specification change, please call me at 414-4130.

Sincerely,

Signature on file

Daniel Strickland, P.E.
State Specifications Engineer

DS/dh
Attachment
cc: Florida Transportation Builders' Assoc.
State Construction Engineer

STRUCTURAL PORTLAND CEMENT CONCRETE
(REV 7-15-20)

SUBARTICLE 346-2.2 is deleted and the following substituted:

346-2 Materials.

346-2.2 Types of Cement: Unless a specific type of cement is designated in the Contract Documents, use Type I, Type IL, Type IP, Type IS, Type II, Type II (MH) or Type III cement in all classes of concrete. Use Type IL or Type II (MH) for all mass concrete elements.

. Use only the types of cements designated for each environmental classification in structural concrete as shown in Table 346-1. A mix design for a more aggressive environment may be used in a less aggressive environmental condition.

~~TABLE~~ Table 346-1
Cement Use by Environmental Classification

Component	Slightly Aggressive Environment	Moderately Aggressive Environment	Extremely Aggressive Environment(1)
Bridge Superstructures			
Precast Superstructure and Prestressed Elements	Type I or Type III	Type I, Type IL, Type II, Type III, Type IP, or Type IS	Type II (MH), Type IL, Type III(2) or Ternary Blend
Cast In Place	Type I	Type I, Type IL, Type II, Type IP, or Type IS	Type II (MH), Type IL, or Ternary Blend
Bridge Substructures, Drainage Structures and other Structures			
All Elements	Type I or Type III	Type I, Type IL, Type II, Type IP, or Type IS	Type II (MH), Type IL, or Ternary Blend

Notes:
(1)~~.~~ Cements used in a more aggressive environment may also be used in a less aggressive environment.
(2)~~.~~ Type III cement may be used in an Extremely Aggressive Environment for precast superstructure and prestressed elements when the ambient temperature at the time of concrete placement is 60°F and below.

SUBARTICLE 346-2.3 is deleted and the following substituted:

346-2.3 Supplementary Cementitious Materials: Supplementary cementitious materials are required to produce binary or ternary concrete mixes in all classes of concrete except for the following when used in slightly aggressive environments: Class I 3,000 psi, Class I 3,000 psi (Pavement), and Class II 3,400 psi. The quantity of portland cement replaced with supplemental cementitious materials must be on an equal weight replacement basis of the total cementitious materials with the limitations, shown in Table 346-2.

346-2.3.1 Highly Reactive Pozzolans: Materials that have a very high degree of pozzolanic reactivity due to their very fine particle sizes, including silica fume, metakaolin and ultrafine fly ash.

346-2.3.2 Binary Concrete Mixes: Concrete mixes containing portland cement and one supplementary cementitious material.

346-2.3.3 Ternary Concrete Mixes: Concrete mixes containing portland cement and any two of supplementary cementitious materials, either fly ash, slag, or highly reactive pozzolans.

Table 346-2
Cementitious Materials Concrete Mix Proportions (%)
(Environmental classification is extremely aggressive, unless otherwise noted.)

Application	Portland Cement	Fly Ash Type F	Slag	Highly Reactive Pozzolans[4]		
				Silica Fume	Metakaolin	Ultra-Fine Fly Ash
General Use	70-82	18-30				
	66-78	15-25		7-9		
	66-78	15-25			8-12	
	66-78	15-25				8-12
	30-40	10-20	50-60			
	30-75[1]		25-70[1]			
	30-50		50-70			
	36-43		50-55	7-9		
	33-42		50-55		8-12	
	33-42		50-55			8-12
Precast / Prestressed	70-85[1]	15-30[1]				
	70-82	18-30				
	66-78	15-25		7-9		
	66-78	15-25			8-12	
	66-78	15-25				8-12
	30-40	10-20	50-60			
	30-50		50-70			
	36-43		50-55	7-9		
	33-42		50-55		8-12	
	33-42		50-55			8-12
Drilled Shaft	63-67	33-37				
	38-42		58-62			
	30-40	10-20	50-60			
Mass Concrete	50-82[2]	18-50[2]				
	50-65[3]	35-50[3]				
	66-78	15-25		7-9		
	66-78	15-25			8-12	
	66-78	15-25				8-12
	30-40	10-20	50-60			
	30-50		50-70			
	36-43		50-55	7-9		
	33-42		50-55		8-12	
	33-42		50-55			8-12

Notes:
(1) Slightly Aggressive and Moderately Aggressive environments.
(2) For Concrete with Core Temperature T≤165°F.
(3) For Concrete with Core Temperature T≥165°F.
(4) Highly reactive pozzolans may be used below the specified ranges to enhance strength and workability. ~~Testing in accordance with AASHTO T358 is not required.~~

SUBARTICLE 346-2.4~~.1~~ is expanded by the following~~deleted and the following substituted~~:

346-2.4.1 Optimized Aggregate Gradation: Improve the aggregate packing density at the Contractor's option, by adding an intermediate-size coarse aggregate. Meet the requirements of Section 9.2 of the Materials Manual, on the methods used to produce combined aggregate gradation of fine, intermediate and coarse aggregate sizes for the concrete mixes.

ARTICLE 346-3 is deleted and the following substituted:

346-3 Classification of Concrete~~, Strength, Slump and Air Content~~.

346-3.1 General: The classifications of concrete covered by this Section are designated as Class I, Class I Pavement, Class II, Class II Bridge Deck, Class III, Class III Seal, Class IV, Class IV Drilled Shaft, Class V, Class V Special, Class VI, and Class VII. The specified s~~S~~trength, maximum water to cementitious materials ratio and slump of each class are specified in Table 346-3. The required air content for all classes of concrete is less than or equal to 6.0%.

346-3.2 Concrete Class Substitutions: The Engineer may allow the s~~S~~ubstitution of a higher class concrete in lieu of the specified~~a lower~~ class concrete ~~may be allowed~~ when the substituted concrete mixes are included as part of the QC Plan, or for precast concrete, the Precast Concrete Producer QC Plan. The substituted higher class concrete must meet or exceed the requirements of the specified~~lower~~ class concrete ~~and both classes must contain the same types of mix ingredients~~.

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 346-3 for the specified~~lower~~ class concrete. Do not place concrete with a slump more than plus or minus 1.5 inches from the target slump value specified in Table 346-3.

346-3.3 Master Proportion Table: Proportion the materials used to produce the various classes of concrete in accordance with Table 346-3.

The calculation of the water to cementitious materials ratio (w/cm) is based on the total cementitious materials including portland cement and any supplementary cementitious materials used in the mix.

TABLE Table 346-3
Structural Concrete Class, Compressive Strength, Water to Cementitious Materials Ratio and Slump Master Proportion Table

Class of Concrete	28-day Specified Minimum Compressive Strength (f_c') (psi)	Maximum Water to Cementitious Materials Ratio (pounds per pounds)	Target Slump Value (inches) (c3)
I (a1)	3,000	0.53	3 (2b)
I (Pavement)	3,000	0.50	1.5 or 3 (5)2
II (a1)	3,400	0.53	3 (2b)
II (Bridge Deck)	4,500	0.44	3 (2b)
III (d4)	5,000	0.44	3 (2b)
III (Seal)	3,000	0.53	8
IV	5,500	0.41(6)	3 (2b)
IV (Drilled Shaft)	4,000	0.41	8.5
V (Special)	6,000	0.37(6)	3 (2b)
V	6,500	0.37(6)	3 (2b)
VI	8,500	0.37(6)	3 (2b)
VII	10,000	0.37(6)	3 (2b)

Notes:
(1a) 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 (b2). The Contractor is permitted to use concrete meeting the requirements of ASTM C478 (4,000 psi) in lieu of the specified Class I or Class II concrete for precast endwalls, inlets, manholes and junction boxes.
(2b) The Engineer may allow a maximum target slump of 7 inches when a Type F, G, I or II admixture is used. When flowing concrete is used, meet the requirements of Section 8.6 of the Materials Manual the target slump is 9 inches.
(3c) For a reduction in the target slump for slip-form operations, submit a revision to the mix design to the Engineer. The target slump for slip-form mix is 1.50 inches.
(4d) When precast three-sided culverts, box culverts, endwalls, inlets, manholes or junction boxes require a Class III concrete, the minimum cementitious materials content is 470 pounds per cubic yard. Do not apply the air content range and the maximum target slump shall be 6 inches, except as allowed in (2b).
(5) Meet the requirements of Section 350.
(6) When silica fume or metakaolin is required, the maximum water to cementitious material ratio will be 0.35. When ultrafine fly ash is used, the maximum water to cementitious material ratio will be 0.30.

346-3.44.2 Durability for Concrete Construction:

346-3.4.1 Minimum Cementitious Materials Content: Ensure that the produced concrete meets the minimum amount of cementitious materials content in Table 346-4.

Table 346-4
Minimum Amount of Total Cementitious Materials Content
(pounds per cubic yard of concrete)

Concrete Application	Environmental Classification		
	Extremely Aggressive	Moderately Aggressive	Slightly Aggressive
Reinforced Concrete (1)	600	550	510
Non-reinforced Concrete	470		

Notes:
(1) The Engineer may allow a lower total amount of cementitious materials content in concrete Class I, Class I (Pavement), Class II and Class III.

346-3.4.2~~4.2.1~~ Chloride Content Limits: Use the following maximum allowable chloride content limits for the concrete application and/or exposure environment shown:

~~TABLE~~ Table 346-5
Chloride Content Limits for Concrete Construction

Application/Exposure Environment		Maximum Allowable Chloride Content, (pounds per cubic yard of concrete)
Non-Reinforced Concrete		No Test Needed
Reinforced Concrete	Slightly Aggressive Environment	0.70
	Moderately or Extremely Aggressive Environment	0.40
Prestressed Concrete		0.40

If chloride test results exceed the limits of Table 346-5, suspend concrete placement immediately for every mix design represented by the failing test results, until corrective measures are made. Submit an Engineering Analysis Scope in accordance with 6-4 by a Specialty Engineer knowledgeable in the areas of corrosion and corrosion control, to determine if the material meets the intended service life of the structure on all concrete produced from the mix design failing chloride test results to the previous passing test results.

346-3.4.3~~4.2.2~~ Surface Resistivity Test: Ensure that the Class II (Bridge Deck), Class IV, Class V, Class V (Special), Class VI, or Class VII concrete in extremely aggressive environments meets or exceeds a resistivity of 29 kOhm-cm at 28 days, when a highly reactive pozzolan is used~~, or a ternary blend is used in Class IV, Class V, Class V (Special), Class VI, or Class VII concrete~~.

ARTICLE 346-4 is deleted and the following substituted:

346-4 Special Types of Concrete.

346-4.1~~3.2~~ Drilled Shaft Concrete: Notify the Engineer at least 48 hours before placing drilled shaft concrete. Obtain slump loss tests results demonstrating that the drilled shaft concrete maintains a slump of at least 5 inches throughout the concrete elapsed time before drilled shaft concrete operations begin.

Perform the slump loss test at the anticipated ambient temperature for drilled shaft placements greater than 30 cubic yards and an elapsed time of greater than five hours.

Obtain slump loss test results from an approved laboratory or from a field demonstration. Slump loss test results for drilled shafts requiring 30 cubic yards of concrete or less and a maximum elapsed time of five hours or less may be done in a laboratory. Obtain all other slump loss test results in the field.

The concrete elapsed time is defined in Section 455. Obtain the Engineer's approval for use of slump loss test results including elapsed time before concrete placement begins.

Test each load of concrete for slump to ensure the slump is within the limits of this Section. Initially cure acceptance cylinders for 48 hours before transporting them to the laboratory.

If the elapsed time during placement exceeds the slump loss test data, submit an Engineering Analysis Scope in accordance with 6-4 by a Specialty Engineer knowledgeable in

the area of concrete foundations, to determine if the shaft is structurally sound and free from voids. At the direction of the Engineer, excavate the drilled shaft for inspection. Obtain approval from the Engineer before placing any additional shafts.

346-4.2~~3.3~~ Mass Concrete: When the Contract Documents designate any structure as mass concrete, use a Specialty Engineer to develop and administer a Mass Concrete Control Plan (MCCP). Develop the MCCP in accordance with ACI Publications 207.1R Guide to Mass Concrete, 207.2R Report on Thermal and Volume Change Effects on Cracking of Mass Concrete, and 224R Control of Cracking in Concrete Structures. Ensure that the concrete core temperatures for any mass concrete element do not exceed the maximum allowable temperature of 180°F and that the differential temperatures between the element core and surface do not exceed the maximum allowable temperature differential of 35°F. Submit the MCCP to the Engineer for approval at least 14 calendar days prior to the first anticipated mass concrete placement. Ensure the MCCP includes and fully describes the following:

1. The Financial Project Identification Number (FPID).
2. Contact names and numbers.
3. Names and qualifications of all designees who will inspect the installation of and record the output of temperature measuring devices, and who will implement temperature control measures.
4. The number, type, and dimensions of each mass concrete element to be constructed.
5. A sequential ID number assigned to each element indicating bridge number, element type, element size, and element location.
6. The mix design number of the concrete used to construct each element.
7. Indicate which mass concrete elements will be monitored.
8. Casting procedures,
9. Insulating systems,
10. Type and placement of temperature measuring and recording devices, as well as any remote monitoring devices and software.
11. For each concrete mix design and concrete element, provide information included in ~~a~~ Ttable 346-6~~formatted as shown below~~, listing the maximum allowable concrete placement temperature for each ambient temperature range at time of placement, in 10°F increments from 40°F and 99°F.

Table 346-6
Maximum Allowable Concrete Placement Temperature Data Sheet

Mix Design No.	Maximum Allowable Concrete Placement Temperature (°F)	
Ambient Temperature at Time of Placement	Footer Dimensions(1) W by L by H (ft)	Column Dimensions(1) D by H(ft)
40° - 49°F		
50° - 59°F		
~~Mix Design No.~~	~~Maximum Allowable Concrete Placement Temperature (°F)~~	
~~Ambient Temperature at Time of Placement~~	~~Footer W by L by H (ft)~~	~~Column D by H (ft)~~
60° - 69°F		
70° - 79°F		
80° - 89°F		

90° - 99°F		
Notes: (1) W = Width, L = Length, H = Height and D = Diameter		

12. Measures to prevent thermal shock.
13. Active cooling measures, if used.

Do not place concrete until the proposed MCCP has ~~been~~is approved~~received written approval~~, and fully complies~~y~~ with its requirements. Any modifications must be submitted as addenda to the original MCCP and must be approved in writing by the Engineer. Ensure that, prior to the first concrete placement of each concrete element the Specialty Engineer or approved designee personally inspects the installation of the temperature measuring devices and verifies that the temperature data acquisition equipment is properly functioning ~~properly~~. The temperature data acquisition equipment must record temperature readings at least once per hour, beginning at the completion of concrete placement and continuing until the core temperature is within 50°F of the ambient temperature. The Specialty Engineer shall be available for immediate consultation during the monitoring period of any mass concrete element. Monitor temperature readings at least once every six hours. Within three workings days of the completion of temperature recording for each concrete element, submit an electronic spreadsheet file, editable report to the Engineer that includes the element identification, date and time of any changes to the temperature control measures, all original temperature readings and curing notes. Also submit data logger summaries and graphs, and results of the visual inspection of each element.

If the first element of a group of elements with the same dimensions is placed in accordance with the approved MCCP, without exceeding either the maximum temperature or maximum temperature differential of the concrete, reduced monitoring of the remaining elements may be allowed with written approval from the Engineer. Request approval from the Engineer at least 14 calendar days prior to the anticipated date of reduced monitoring. If approved, temperature monitoring is required only for the initial element of a group of concrete elements meeting all of the following requirements:

1. All elements have the same dimensions.
2. All elements have the same concrete mix design.
3. All elements have the same insulation R value and active cooling measures (if used).
4. Ambient temperatures during concrete placement for all elements are within minus 10°F of the ambient temperature during placement of the initial element.
5. Use the same temperature control measures used for the initial monitored element and keep in place for at least the same length of time as for the initial element. The Contractor and Engineer each have the option to have the temperature monitored to ensure the core temperature is within 50°F of ambient temperature prior to termination of temperature control measures.

Install temperature measuring and recording devices for all mass concrete elements. Position the temperature sensors 2.00± 0.25 inches inside the concrete surface for surface temperature measurements and at the expected location of the maximum temperature for core temperature measurements. Place the ambient temperature sensor in a location that protects it from direct exposure to rain, sun, or sources of radiated heat, such as concrete or asphalt pavement surfaces. Temperatures shall be continuously recorded starting at the end of concrete placement and continuing until the core has cooled to within 50°F of the ambient temperature. Resume monitoring of the temperatures for all elements if directed by the Engineer.

Instrumentation and temperature monitoring are not required for drilled shafts supporting sign, signal, lighting or intelligent transportation (ITS) structures that meet all of the following requirements:

1. The diameter is six feet or less.

2. The total cementitious materials content of the concrete mix design is less than or equal to 750 pounds per cubic yard.

Temperature monitoring may be omitted at the Contractor's option, for any mass concrete substructure element meeting all of the following requirements:

1. The minimum cross-sectional dimension of the element is six feet or less.

2. Insulation with an R-value of at least 2.5 must be provided for at least 72 hours following the completion of concrete placement.

3. The environmental classification of the concrete element is slightly aggressive or moderately aggressive.

4. The concrete mix design meets the mass concrete proportioning requirements of 346-2.3.

5. The total cementitious material content of the concrete mix design is less than or equal to 750 pounds per cubic yard.

6. Temperature of the concrete is 95°F or less at placement.

Implement immediate corrective action as directed by the Specialty Engineer when either the core temperature or the temperature differential of any mass concrete element exceeds its maximum allowable value. The approval of the MCCP shall be revoked. Do not place any mass concrete elements until a revised MCCP has been approved in writing by the Engineer. Submit an Engineering Analysis Scope in accordance with 6-4 for approval, which addresses the structural integrity and durability of any mass concrete element that is not cast in compliance with the approved MCCP or which exceeds the allowable core temperature or temperature differential. Submit all analyses and test results requested by the Engineer for any noncompliant mass concrete element to the satisfaction of the Engineer. The Department will make no compensation for additional costs or loss of time due to additional analyses, tests, or other impacts on production caused by the use of reduced monitoring or the Contractor's option.

~~**346-3.4 Flowing Concrete for Precast/Prestressed Concrete:** Produce flowing concrete mix with target slump of 9 inches.~~

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

~~Determine the workability of the demonstration concrete batches by performing the slump tests on the samples taken at 15 minute intervals from each batch. Continue sampling and testing until the slump measures 6 inches or less. From the plot of slump versus time, determine the time for each batch when the slump is at 7.5 inches. The shortest time period~~

determined from three consecutive batches, at 7.5 inches slump, is considered the cutoff time of the proposed concrete mix. For production concrete, ensure that the time between the batching and depositing of each load of concrete is less than the cutoff time of the mix and also does not exceed the allowable time limit specified in this Section.

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

Perform inspection of the demonstration concrete during batching, delivery, placement and post placement. During placement, ensure that the concrete batches meet all plastic property requirements of the Specifications and maintain their cohesive nature without excessive bleeding, segregation, or abnormal retardation.

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

After removal of the forms, perform the post-placement inspection of the in-place concrete. Observe for any signs of honeycombs, cracks, aggregate segregation or any other surface defects and ensure that the hardened concrete is free from these deficiencies. The Engineer may require saw cutting of the mock-up products to verify the uniform distribution of the aggregates within the saw-cut surfaces and around the reinforcing steel and prestressing strands. The Engineer will require saw cutting of the demonstration mock-up products for plants that are demonstrating the use of the flowing concrete for the first time. Obtain core samples in accordance with FM 5-617, section 7 to inspect the aggregate distribution.

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

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

The Department may approve proposed flowing concrete mixes, centrally mixed at the placement site, without the production of demonstration batches, provided that the proposed mix meets the following two criteria:

1. A previously approved flowing concrete mix of the same class has demonstrated satisfactory performance under the proposed job placing conditions with a minimum of fifteen consecutive Department acceptance tests, which met all plastic and hardened concrete test requirements.

2. The cementitious materials and chemical admixtures, including the flowing concrete high range water reducing admixture, used in the proposed mix are the same materials from the same source used in the previously approved mix, (1) above.

Do not produce or place concrete until the design mixes have been approved.

346-4 Composition of Concrete.

346-4.1 Master Proportion Table: Proportion the materials used to produce the various classes of concrete in accordance with Table 4:

TABLE 4 Concrete Master Proportions		
Class of Concrete	Minimum Total Cementitious Materials Content pounds per cubic yard *	Maximum Water to Cementitious Materials Ratio pounds per pounds**
I	470	0.53
I (Pavement)	470	0.50
II	470	0.53
II (Bridge Deck)	611	0.44
III	611	0.44
III (Seal)	611	0.53
IV	658	0.41***
IV (Drilled Shaft)	658	0.41
V (Special)	752	0.37***
V	752	0.37***
VI	752	0.37***
VII	752	0.37***

* A lower total cementitious materials content may be used provided the plastic, hardened, and durability properties meet the requirements of this Section.
** The calculation of the water to cementitious materials ratio (w/cm) is based on the total cementitious material including cement and any supplementary cementitious materials that are used in the mix.
*** When silica fume or metakaolin is used, the maximum water to cementitious material ratio will be 0.35. When ultrafine fly ash is used, the maximum water to cementitious material ratio will be 0.30.

346-4.2 Durability for Concrete Construction:

346-4.2.1 Chloride Content Limits: Use the following maximum chloride content limits for the concrete application and/or exposure environment shown:

TABLE 5 Chloride Content Limits for Concrete Construction		
Application/Exposure Environment		Maximum Allowable Chloride Content, pounds per cubic yard
Non-Reinforced Concrete		No Test Needed
Reinforced Concrete	Slightly Aggressive Environment	0.70
	Moderately or Extremely Aggressive Environment	0.40
Prestressed Concrete		0.40

If chloride test results exceed the limits of Table 5, suspend concrete placement immediately for every mix design represented by the failing test results, until corrective measures are made. Submit an Engineering Analysis Scope in accordance with 6-4 by a Specialty Engineer knowledgeable in the areas of corrosion and corrosion control, to determine if the material meets the intended service life of the structure on all concrete produced from the mix design failing chloride test results to the previous passing test results.

346-4.2.2 Surface Resistivity Test: Ensure that the concrete meets or exceeds a resistivity of 29 kOhm-cm at 28 days, when a highly reactive pozzolan, or a ternary blend is used in Class IV, Class V, Class V (Special), Class VI, or Class VII concrete.

ARTICLE 346-5 is deleted and the following substituted:

346-5 Sampling and Testing Methods.

Perform concrete sampling and testing in accordance with the following methods:

~~TABLE 6~~Table 346-7
Concrete Sampling and Testing Methods

Description	Method
Slump of Hydraulic Cement Concrete	ASTM C143
Air Content of Freshly Mixed Concrete by the Pressure Method (1)*	ASTM C231
Air Content of Freshly Mixed Concrete by the Volumetric Method (1)*	ASTM C173
Making and Curing Test Specimens in the Field (2)**	ASTM C31
Compressive Strength of Cylindrical Concrete Specimens	ASTM C39
Obtaining and Testing Drilled Core and Sawed Beams of Concrete	ASTM C42
Initial Sampling of Concrete from Revolving Drum Truck Mixers or Agitators	FM 5-501
Low Levels of Chloride in Concrete and Raw Materials	FM 5-516
Density (Unit Weight), Yield and Air Content (Gravimetric) of Concrete	ASTM C138
Temperature of Freshly Mixed Portland Cement Concrete	ASTM C1064
Sampling Freshly Mixed Concrete (3)***	ASTM C172
Static Segregation of Self-Consolidating Concrete using Column Techniques	ASTM C1610
Slump Flow of Self-Consolidating Concrete	ASTM C1611
Relative Viscosity of Self-Consolidating Concrete	ASTM C1611
Visual Stability Index of Self-Consolidating Concrete	ASTM C1611
Passing Ability of Self-Consolidating Concrete by J-Ring	ASTM C1621
Rapid Assessment of Static Segregation Resistance of Self-Consolidating Concrete Using Penetration Test	ASTM C1712
Aggregate Distribution of Hardened Self-Consolidating Concrete	FM 5-617
Hardened Visual Stability Index of Self-Consolidating Concrete	AASHTO R81
Fabricating Test Specimens with Self-Consolidating Concrete	ASTM C1758
Concrete Resistivity as an Electrical Indicator of its Permeability	AASHTO T358

(1) *The Department will use the same type of meter for Verification testing as used for QC testing. When using pressure type meters, use an aggregate correction factor determined by the concrete producer for each mix design to be tested. Record and certify test results for correction factors for each type of aggregate at the concrete production facility.
(2) ** Provide curing facilities that have the capacity to store all QC, Verification, and Resolution cylinders simultaneously for the initial curing. Cylinders will be delivered to the testing laboratory in their molds. The laboratory will remove the specimens from the molds and begin final curing.
(3)*** Take the test sample from the middle portion of the batch in lieu of collecting and compositing samples from two or more portions, as described in ASTM C172.

SUBARTICLE 346-6.2 is deleted and the following substituted:

346-6.2 Concrete ~~Design~~ Mix Design: Provide concrete that has been produced in accordance with a Department approved mix design ~~mix~~, in a uniform mass free from balls and lumps.

For slump target values in excess of 6 inches, including flowing and self consolidating concrete, utilize a grate over the conveyance equipment to capture any lumps or balls that may be present in the mix. The grate must cover the entire opening of the conveyance

equipment and have an opening that is a maximum of 2-1/2 inches in any one direction. Remove the lumps and ~~or~~ balls from the grate and discard them. Discharge the concrete in a manner satisfactory to the Engineer. Perform demonstration batches to ensure complete and thorough placements in complex elements, when requested by the Engineer.

Do not place concretes of different compositions such that the plastic concretes may combine, except where the Plans require concrete with a surface resistivity value of 29 kOhm-cm or below and one with higher than 29 kOhm-cm values in a continuous placement. Produce these concretes using separate mix designs. For example, designate the mix with calcium nitrite as the original mix and the mix without calcium nitrite as the redesigned mix. Ensure that both mixes contain the same cement, fly ash or slag, coarse and fine aggregates and admixtures. Submit both mixes for approval as separate mix designs, both meeting all requirements of this Section. Ensure that the redesigned mix exhibits plastic and hardened qualities which are additionally approved by the Engineer as suitable for placement with the original mix. The Engineer will approve the redesigned mix for commingling with the original mix and for a specific project application only. Alternately, place a construction joint at the location of the change in concretes as approved by the Engineer.

SUBARTICLE 346-7.2.1 is deleted and the following substituted:

346-7.2.1 Transit Time: Ensure compliance with Table 346-8~~7~~ between the initial introduction of water into the mix and completely discharging all the concrete from the truck. Reject concrete exceeding the maximum transit time. For critical placements, with the Engineer's approval, the transit time may be extended to the allowable mixing time shown in the mix design.

~~TABLE~~ Table 346-~~7~~8	
Maximum Allowable Transit Time	
Non-Agitator Trucks	Agitator Trucks
45 minutes	60 minutes
75 minutes(1)*	90 minutes(1)*

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

ARTICLE 346-8 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 rating plate and a valid mixer identification card issued by the Department. Ensure that the revolution counter on the mixer is working properly, and calibration of the water dispenser has been performed within the last twelve months. Reject any concrete batches that are delivered in trucks that do not have mixer identification cards. Remove the mixer identification card when a truck mixer is discovered to be in noncompliance and the mixer deficiencies cannot be repaired immediately. When the mixer identification card is removed for noncompliance, make note of the deficiency or deficiencies found, and forward the

card to the District Materials and Research Engineer who has Producer QC Plan acceptance authority.

Perform plastic concrete tests on the initial delivery from each plant 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 a~~one~~ technician is present and performing tests throughout the placement operation at each placement site. If a project has multiple concrete placements at the same time, identify the technicians in the QC Plan to ensure minimum sampling and testing frequencies are met. Ensure that the equipment used for delivery, placement and finishing meets the requirements of this Specification.

When a truck designated for QC testing arrives at the discharge site, a subsequent truck may also discharge once a representative sample has been collected from the QC truck and while awaiting the results of QC testing. Reject non-complying loads at the jobsite. Ensure that corrections are made on subsequent loads. Immediately cease concrete discharge of all trucks if the QC truck has failing test. Perform plastic properties tests of concrete on all trucks prior to the first corrected truck and the corrected truck. When more than one truck is discharging into a pump simultaneously, only the truck designated for QC testing may discharge into the pump to obtain a representative sample of concrete from the QC truck only.

Furnish sufficient concrete of each design mix as required by the Engineer for verification (VT) testing. When the Engineer's VT 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, and any other loads that have begun discharging, 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 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 any five loads in two days of production of the same design mix are outside the specified tolerances. Increase the frequency of QC testing to one per load to bring the concrete within allowable tolerances. 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 (IV), the Contractor may perform the same tests on the concrete at the same time. The Department will compare results based on the Independent Assurance (IA) Checklist tolerances.

SUBARTICLE 346-9.2 is deleted and the following substituted:

346-9.2 Sampling Frequency: As a minimum, sample and test concrete of each mix design ~~mix~~ for water to cementitious materials ratio, air content, temperature, slump and

compressive strength once per LOT as defined by Table 346-89. The Engineer will randomly verify one of every four consecutive LOTs of each mix design mix based on a random number generator. The Department may perform Independent Verification (IV) testing to verify compliance with specification requirements. All QC activities, calculations, and inspections will be randomly confirmed by the Department.

TABLE Table 346-89
Sampling Frequency

Class Concrete(1)*	LOT Size
I	one day's production
I (Pavement)	2,000 square yards, or one day's production, whichever is less
II, II (Bridge Deck), III, IV, V (Special), V, VI, VII	50 cubic yards, or one day's production, whichever is less
IV (Drilled Shaft)	50 cubic yards, or one day's production, whichever is less(2)**
III (Seal)	Each Seal placement

(1)* For any class of concrete used for roadway concrete barrier, the lot size is defined as 100 cubic yards, or one day's production, whichever is less.
(2)** Start a new LOT when there is a gap of more than two hours between the end of one drilled shaft placement and the beginning of the next drilled shaft placement.

346-9.2.1 Reduced Frequency for Acceptance Tests: The LOT size may represent 100 cubic yards when produced with the same mix design at the same concrete production facility for the same prime Contractor and subcontractor on a given Contract. As an exception, the requirements for the precast/prestressed production facility will only include the same mix design at the same concrete production facility.

Submit strength test results indicating that the two following criteria are met:

1. The average of the acceptance compressive strengths is equal to or greater than the specified minimum compressive strength (f_c') plus 2.33 standard deviations minus:

a. 500 psi, if f_c' is 5,000 psi or less. above the specified minimum compressive strength for that class of concrete.

b. 0.10 f_c', if f_c' is greater than 5,000 psi.

2. Every average of three consecutive strength test equals or exceeds the f_c'specified minimum compressive strength plus 1.34 standard deviations.

Base calculations on a minimum of ten consecutive strength test results for a Class IV or higher; or a minimum of five consecutive strength results for a Class III or lower.

The average of the consecutive compressive strength test results, based on the class of concrete, can be established using historical data from a previous Department project. The tests from the previous Department project must be within the last calendar year or may also be established by a succession of samples on the current project. Only one sample can be taken from each LOT. Test data must be from a laboratory meeting the requirements of Section 105. Obtain Department approval before beginning reduced frequency LOTs.

If at any time a strength test is not verified or the average strength of the previous ten or five consecutive samples based on the class of concrete from the same mix design and the same production facility does not conform to the above conditions, return to the

frequency represented by the LOT as defined in Table 346-89. Notify the Engineer that the initial frequency is reinstated. In order to reinitiate reduced frequency, submit a new set of strength test results.

SUBARTICLE 346-9.4 is deleted and the following substituted:

346-9.4 Acceptance of Concrete: The Engineer will accept the concrete of a given LOT when it meets the minimum specified compressive strength requirement of Table 346-3. Ensure that the hardened concrete strength test results are obtained in accordance with 346-9.3.

The process of concrete compressive strength acceptance consists of the following steps:

1. Verification of QC and VT data.
2. Resolution of QR and VR data.
3. Structural Adequacy determination.

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, missing, 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, missing, 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 VT 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 and each QR cylinder that is lost, missing, 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 VT data will require the element to be cored and a pay reduction 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.

SUBARTICLE 346-10.1 is deleted and the following substituted:

346-10 Investigation of Low Strength Concrete and Structural Adequacy.

346-10.1 General: The following applies for concrete that does not meet the minimum specified compressive strength of Table 346-3.

For standard molded and cured strength cylinders, the compressive strength of concrete is satisfactory provided that the two following criteria are met:

1. The average compressive strength does not fall below the specified minimum compressive strength by more than:

a. 500 psi if the specified minimum compressive strength is equal to or less than 5,000 psi.

b. 10% of the specified minimum compressive strength if the specified minimum compressive strength is greater than 5,000 psi.

2. The average compressive strength with the previous two LOTs is equal to or exceeds the specified minimum compressive strength. This condition only applies if there are two or more previous LOTs to calculate the average.

The Engineer will consider the concrete for a given LOT as structurally adequate and coring will not be allowed when a concrete compressive strength test result falls below the specified minimum strength but has met the above conditions.

When a concrete compressive strength test result falls below the specified minimum strength, and does not meet the above conditions, perform one of the following options:

1. Submit an Engineering Analysis Scope in accordance with 6-4 to establish structural and durability adequacy. When the scope is approved by the Engineer, submit an Engineering Analysis Report (EAR) in accordance with 6-4 that includes a full structural analysis. If the results of the structural analysis indicate adequate strength to serve its intended purpose with adequate durability, and is approved by the Engineer, the Contractor may leave the concrete in place subject to the requirements of 346-11, otherwise, remove and replace the LOT of concrete in question at no additional expense to the Department.

2. At the Engineer's discretion, obtain drilled core samples as specified in this Section to determine the in-place strength of the LOT of concrete in question, at no additional expense to the Department. The Engineer will determine whether to allow coring of the in-place concrete or require an engineering analysis based on the compressive strength of the test cylinders.

SUBARTICLE 346-10.2 is deleted and the following substituted:

346-10.2 Coring for Determination of Structural Adequacy: Core strength test results obtained from the structure will be accepted by both the Contractor and the Department as the in-place strength of the LOT of concrete in question. The core strength test results will be used in lieu of the cylinder strength test results for determination of structural adequacy. The Department will calculate the strength value to be the average of the compressive strengths of the three individual cores. This will be accepted as the actual measured value.

Obtain the Engineer's written approval before taking any concrete core samples. Notify the Engineer 48 hours prior to taking core samples. Obtain and test the cores in accordance with ASTM C42. Report the test results to the Engineer within seven calendar days of the Engineer's written approval. The Engineer will select the size and location of the drilled cores so that the structure is not impaired and does not sustain permanent damage after repairing the core holes. Sample three undamaged cores taken from the same approximate location where the questionable concrete is represented by the low strength concrete test cylinders. Repair core holes after samples are taken with a product in compliance with Section 930 or 934 and meeting the approval of the Engineer.

The Engineer with input from the District Materials Office, will consider the concrete as structurally adequate, in area represented by core tests at the actual test age, if the average compressive strength of cores does not fall below the specified minimum compressive strength by more than:

a. 500 psi when the specified minimum compressive strength is equal to or less than 5,000 psi.

b. 10% of the specified minimum compressive strength when the specified minimum compressive strength is greater than 5,000 psi.

The Engineer may also require the Contractor to perform additional testing as necessary to determine structural adequacy of the concrete.

SUBARTICLE 346-11.2 is deleted and the following substituted:

346-11.2 Basis for Pay Adjustments: The Engineer will determine payment reductions based on the 28 day compressive strength, represented by either acceptance compressive strength or correlated cores strength test results based on the following criteria:

1. When the acceptance compressive strength test result falls below the specified minimum compressive strength, but no more than the limits established in 346-10.1 below the specified minimum strength, do not core hardened concrete for determining pay adjustments. Use the acceptance compressive strength test results.

2. When the acceptance compressive strength test result falls below the specified minimum compressive strength by more than the limits established in 346-10.1, the structure may be cored for determination of structural adequacy as directed by the Engineer. Use the result of the 28 day correlated core compressive strength or the acceptance compressive strength test, whichever is less.

A price adjustment will be applied to the certified invoice price the Contractor paid for the concrete or the precast product.

The Engineer will relate the strength at the actual test age to the 28 day strength for the design mix represented by the cores using appropriate strength time correlation equations.

In precast concrete operations, excluding prestressed concrete, ensure that the producer submits acceptable core sample test results to the Engineer. The producer may elect to use the products in accordance with this Section. Otherwise, replace the concrete in question at no additional cost to the Department. For prestressed concrete, core sample testing is not allowed for pay adjustment. The results of the cylinder strength tests will be used to determine material acceptance and pay adjustment.

STRUCTURAL PORTLAND CEMENT CONCRETE
(REV 7-15-20)

SUBARTICLE 346-2.2 is deleted and the following substituted:

346-2 Materials.

346-2.2 Types of Cement: Unless a specific type of cement is designated in the Contract Documents, use Type I, Type IL, Type IP, Type IS, Type II, Type II (MH) or Type III cement in all classes of concrete. Use Type IL or Type II (MH) for all mass concrete elements.

. Use only the types of cements designated for each environmental classification in structural concrete as shown in Table 346-1. A mix design for a more aggressive environment may be used in a less aggressive environmental condition.

Table 346-1
Cement Use by Environmental Classification

Component	Slightly Aggressive Environment	Moderately Aggressive Environment	Extremely Aggressive Environment(1)
Bridge Superstructures			
Precast Superstructure and Prestressed Elements	Type I or Type III	Type I, Type IL, Type II, Type III, Type IP, or Type IS	Type II (MH), Type IL, Type III(2) or Ternary Blend
Cast In Place	Type I	Type I, Type IL, Type II, Type IP, or Type IS	Type II (MH), Type IL, or Ternary Blend
Bridge Substructures, Drainage Structures and other Structures			
All Elements	Type I or Type III	Type I, Type IL, Type II, Type IP, or Type IS	Type II (MH), Type IL, or Ternary Blend

Notes:
(1) Cements used in a more aggressive environment may also be used in a less aggressive environment.
(2) Type III cement may be used in an Extremely Aggressive Environment for precast superstructure and prestressed elements when the ambient temperature at the time of concrete placement is 60°F and below.

SUBARTICLE 346-2.3 is deleted and the following substituted:

346-2.3 Supplementary Cementitious Materials: Supplementary cementitious materials are required to produce binary or ternary concrete mixes in all classes of concrete except for the following when used in slightly aggressive environments: Class I 3,000 psi, Class I 3,000 psi (Pavement), and Class II 3,400 psi. The quantity of portland cement replaced with supplemental cementitious materials must be on an equal weight replacement basis of the total cementitious materials with the limitations, shown in Table 346-2.

346-2.3.1 Highly Reactive Pozzolans: Materials that have a very high degree of pozzolanic reactivity due to their very fine particle sizes, including silica fume, metakaolin and ultrafine fly ash.

346-2.3.2 Binary Concrete Mixes: Concrete mixes containing portland cement and one supplementary cementitious material.

346-2.3.3 Ternary Concrete Mixes: Concrete mixes containing portland cement and any two of supplementary cementitious materials, either fly ash, slag, or highly reactive pozzolans.

Table 346-2
Cementitious Materials Concrete Mix Proportions (%)
(Environmental classification is extremely aggressive, unless otherwise noted)

Application	Portland Cement	Fly Ash Type F	Slag	Highly Reactive Pozzolans[4]		
				Silica Fume	Metakaolin	Ultra-Fine Fly Ash
General Use	70-82	18-30				
	66-78	15-25		7-9		
	66-78	15-25			8-12	
	66-78	15-25				8-12
	30-40	10-20	50-60			
	30-75[1]		25-70[1]			
	30-50		50-70			
	36-43		50-55	7-9		
	33-42		50-55		8-12	
	33-42		50-55			8-12
Precast / Prestressed	70-85[1]	15-30[1]				
	70-82	18-30				
	66-78	15-25		7-9		
	66-78	15-25			8-12	
	66-78	15-25				8-12
	30-40	10-20	50-60			
	30-50		50-70			
	36-43		50-55	7-9		
	33-42		50-55		8-12	
	33-42		50-55			8-12
Drilled Shaft	63-67	33-37				
	38-42		58-62			
	30-40	10-20	50-60			
Mass Concrete	50-82[2]	18-50[2]				
	50-65[3]	35-50[3]				
	66-78	15-25		7-9		
	66-78	15-25			8-12	
	66-78	15-25				8-12
	30-40	10-20	50-60			
	30-50		50-70			
	36-43		50-55	7-9		
	33-42		50-55		8-12	
	33-42		50-55			8-12

Notes:
(1) Slightly Aggressive and Moderately Aggressive environments.
(2) For Concrete with Core Temperature T≤165°F.
(3) For Concrete with Core Temperature T≥165°F.(4) Highly reactive pozzolans may be used below the specified ranges to enhance strength and workability.

SUBARTICLE 346-2.4 is expanded by the following:

346-2.4.1 Optimized Aggregate Gradation: Improve the aggregate packing density at the Contractor's option, by adding an intermediate-size coarse aggregate. Meet the requirements of Section 9.2 of the Materials Manual, on the methods used to produce combined aggregate gradation of fine, intermediate and coarse aggregate sizes for the concrete mixes.

ARTICLE 346-3 is deleted and the following substituted:

346-3 Classification of Concrete.

346-3.1 General: The classifications of concrete covered by this Section are designated as Class I, Class I Pavement, Class II, Class II Bridge Deck, Class III, Class III Seal, Class IV, Class IV Drilled Shaft, Class V, Class V Special, Class VI, and Class VII. The specified strength, maximum water to cementitious materials ratio and slump of each class are specified in Table 346-3. The required air content for all classes of concrete is less than or equal to 6.0%.

346-3.2 Concrete Class Substitutions: The Engineer may allow the substitution of a higher class concrete in lieu of the specified class concrete when the substituted concrete mixes are included as part of the QC Plan, or for precast concrete, the Precast Concrete Producer QC Plan. The substituted higher class concrete must meet or exceed the requirements of the specified class concrete .

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 346-3 for the specified class concrete. Do not place concrete with a slump more than plus or minus 1.5 inches from the target slump value specified in Table 346-3.

346-3.3 Master Proportion Table: Proportion the materials used to produce the various classes of concrete in accordance with Table 346-3.

The calculation of the water to cementitious materials ratio (w/cm) is based on the total cementitious materials including portland cement and any supplementary cementitious materials used in the mix.

Table 346-3 Master Proportion Table			
Class of Concrete	28-day Specified Minimum Compressive Strength (f_c') (psi)	Maximum Water to Cementitious Materials Ratio (pounds per pounds)	Target Slump Value (inches) (3)
I (1)	3,000	0.53	3 (2)
I (Pavement)	3,000	0.50	1.5 or 3 (5)
II (1)	3,400	0.53	3 (2)
II (Bridge Deck)	4,500	0.44	3 (2)
III (4)	5,000	0.44	3 (2)
III (Seal)	3,000	0.53	8
IV	5,500	0.41(6)	3 (2)
IV (Drilled Shaft)	4,000	0.41	8.5
V (Special)	6,000	0.37(6)	3 (2)
V	6,500	0.37(6)	3 (2
VI	8,500	0.37(6)	3 (2)
VII	10,000	0.37(6)	3 (2)

Notes:
(1) 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 (2). The Contractor is permitted to use concrete meeting the requirements of ASTM C478 (4,000 psi) in lieu of the specified Class I or Class II concrete for precast endwalls, inlets, manholes and junction boxes.
(2) The Engineer may allow a maximum target slump of 7 inches when a Type F, G, I or II admixture is used. When flowing concrete is used, meet the requirements of Section 8.6 of the Materials Manual.
(3) For a reduction in the target slump for slip-form operations, submit a revision to the mix design to the Engineer. The target slump for slip-form mix is 1.50 inches.
(4) When precast three-sided culverts, box culverts, endwalls, inlets, manholes or junction boxes require a Class III concrete, the minimum cementitious materials content is 470 pounds per cubic yard. Do not apply the air content range and the maximum target slump shall be 6 inches, except as allowed in (2).
(5) Meet the requirements of Section 350.
(6) When silica fume or metakaolin is required, the maximum water to cementitious material ratio will be 0.35. When ultrafine fly ash is used, the maximum water to cementitious material ratio will be 0.30.

346-3.4 Durability for Concrete Construction:

346-3.4.1 Minimum Cementitious Materials Content: Ensure that the produced concrete meets the minimum amount of cementitious materials content in Table 346-4.

Table 346-4 Minimum Amount of Total Cementitious Materials Content (pounds per cubic yard of concrete)			
Concrete Application	Environmental Classification		
	Extremely Aggressive	Moderately Aggressive	Slightly Aggressive
Reinforced Concrete (1)	600	550	510
Non-reinforced Concrete	470		

Notes:
(1) The Engineer may allow a lower total amount of cementitious materials content in concrete Class I, Class I (Pavement), Class II and Class III.

346-3.4.2 Chloride Content Limits: Use the following maximum allowable chloride content limits for the concrete application and/or exposure environment shown:

Table 346-5
Chloride Content Limits for Concrete Construction

Application/Exposure Environment		Maximum Allowable Chloride Content, (pounds per cubic yard of concrete)
Non-Reinforced Concrete		No Test Needed
Reinforced Concrete	Slightly Aggressive Environment	0.70
	Moderately or Extremely Aggressive Environment	0.40
Prestressed Concrete		0.40

If chloride test results exceed the limits of Table 346-5, suspend concrete placement immediately for every mix design represented by the failing test results, until corrective measures are made. Submit an Engineering Analysis Scope in accordance with 6-4 by a Specialty Engineer knowledgeable in the areas of corrosion and corrosion control, to determine if the material meets the intended service life of the structure on all concrete produced from the mix design failing chloride test results to the previous passing test results.

346-3.4.3 Surface Resistivity Test: Ensure that the Class II (Bridge Deck), Class IV, Class V, Class V (Special), Class VI, or Class VII concrete in extremely aggressive environments meets or exceeds a resistivity of 29 kOhm-cm at 28 days, when a highly reactive pozzolan is used.

ARTICLE 346-4 is deleted and the following substituted:

346-4 Special Types of Concrete.

346-4.1 Drilled Shaft Concrete: Notify the Engineer at least 48 hours before placing drilled shaft concrete. Obtain slump loss tests results demonstrating that the drilled shaft concrete maintains a slump of at least 5 inches throughout the concrete elapsed time before drilled shaft concrete operations begin.

Perform the slump loss test at the anticipated ambient temperature for drilled shaft placements greater than 30 cubic yards and an elapsed time of greater than five hours.

Obtain slump loss test results from an approved laboratory or from a field demonstration. Slump loss test results for drilled shafts requiring 30 cubic yards of concrete or less and a maximum elapsed time of five hours or less may be done in a laboratory. Obtain all other slump loss test results in the field.

The concrete elapsed time is defined in Section 455. Obtain the Engineer’s approval for use of slump loss test results including elapsed time before concrete placement begins.

Test each load of concrete for slump to ensure the slump is within the limits of this Section. Initially cure acceptance cylinders for 48 hours before transporting them to the laboratory.

If the elapsed time during placement exceeds the slump loss test data, submit an Engineering Analysis Scope in accordance with 6-4 by a Specialty Engineer knowledgeable in the area of concrete foundations, to determine if the shaft is structurally sound and free from

voids. At the direction of the Engineer, excavate the drilled shaft for inspection. Obtain approval from the Engineer before placing any additional shafts.

346-4.2 Mass Concrete: When the Contract Documents designate any structure as mass concrete, use a Specialty Engineer to develop and administer a Mass Concrete Control Plan (MCCP). Develop the MCCP in accordance with ACI Publications 207.1R Guide to Mass Concrete, 207.2R Report on Thermal and Volume Change Effects on Cracking of Mass Concrete, and 224R Control of Cracking in Concrete Structures. Ensure that the concrete core temperatures for any mass concrete element do not exceed the maximum allowable temperature of 180°F and that the differential temperatures between the element core and surface do not exceed the maximum allowable temperature differential of 35°F. Submit the MCCP to the Engineer for approval at least 14 calendar days prior to the first anticipated mass concrete placement. Ensure the MCCP includes and fully describes the following:

1. The Financial Project Identification Number (FPID).
2. Contact names and numbers.
3. Names and qualifications of all designees who will inspect the installation of and record the output of temperature measuring devices, and who will implement temperature control measures.
4. The number, type, and dimensions of each mass concrete element to be constructed.
5. A sequential ID number assigned to each element indicating bridge number, element type, element size, and element location.
6. The mix design number of the concrete used to construct each element.
7. Indicate which mass concrete elements will be monitored.
8. Casting procedures,
9. Insulating systems,
10. Type and placement of temperature measuring and recording devices, as well as any remote monitoring devices and software.
11. For each concrete mix design and concrete element, provide information included in Table 346-6, listing the maximum allowable concrete placement temperature for each ambient temperature range at time of placement, in 10°F increments from 40°F and 99°F.

Table 346-6
Maximum Allowable Concrete Placement Temperature Data Sheet

Mix Design No.	Maximum Allowable Concrete Placement Temperature (°F)	
Ambient Temperature at Time of Placement	Footer Dimensions(1) W by L by H (ft)	Column Dimensions(1) D by H(ft)
40° - 49°F		
50° - 59°F		
60° - 69°F		
70° - 79°F		
80° - 89°F		
90° - 99°F		

Notes:
(1) W = Width, L = Length, H = Height and D = Diameter

12. Measures to prevent thermal shock.
13. Active cooling measures, if used.

Do not place concrete until the proposed MCCP has is approved, and fully complies with its requirements. Any modifications must be submitted as addenda to the original MCCP and must be approved in writing by the Engineer. Ensure that, prior to the first concrete placement of each concrete element the Specialty Engineer or approved designee personally inspects the installation of the temperature measuring devices and verifies that the temperature data acquisition equipment is properly functioning. The temperature data acquisition equipment must record temperature readings at least once per hour, beginning at the completion of concrete placement and continuing until the core temperature is within 50°F of the ambient temperature. The Specialty Engineer shall be available for immediate consultation during the monitoring period of any mass concrete element. Monitor temperature readings at least once every six hours. Within three workings days of the completion of temperature recording for each concrete element, submit an electronic spreadsheet file, editable report to the Engineer that includes the element identification, date and time of any changes to the temperature control measures, all original temperature readings and curing notes. Also submit data logger summaries and graphs, and results of the visual inspection of each element.

If the first element of a group of elements with the same dimensions is placed in accordance with the approved MCCP, without exceeding either the maximum temperature or maximum temperature differential of the concrete, reduced monitoring of the remaining elements may be allowed with written approval from the Engineer. Request approval from the Engineer at least 14 calendar days prior to the anticipated date of reduced monitoring. If approved, temperature monitoring is required only for the initial element of a group of concrete elements meeting all of the following requirements:

1. All elements have the same dimensions.
2. All elements have the same concrete mix design.
3. All elements have the same insulation R value and active cooling measures (if used).
4. Ambient temperatures during concrete placement for all elements are within minus 10°F of the ambient temperature during placement of the initial element.
5. Use the same temperature control measures used for the initial monitored element and keep in place for at least the same length of time as for the initial element. The Contractor and Engineer each have the option to have the temperature monitored to ensure the core temperature is within 50°F of ambient temperature prior to termination of temperature control measures.

Install temperature measuring and recording devices for all mass concrete elements. Position the temperature sensors 2.00± 0.25 inches inside the concrete surface for surface temperature measurements and at the expected location of the maximum temperature for core temperature measurements. Place the ambient temperature sensor in a location that protects it from direct exposure to rain, sun, or sources of radiated heat, such as concrete or asphalt pavement surfaces. Temperatures shall be continuously recorded starting at the end of concrete placement and continuing until the core has cooled to within 50°F of the ambient temperature. Resume monitoring of the temperatures for all elements if directed by the Engineer.

Instrumentation and temperature monitoring are not required for drilled shafts supporting sign, signal, lighting or intelligent transportation (ITS) structures that meet all of the following requirements:

1. The diameter is six feet or less.
2. The total cementitious materials content of the concrete mix design is less than or equal to 750 pounds per cubic yard.

Temperature monitoring may be omitted at the Contractor's option, for any mass concrete substructure element meeting all of the following requirements:

1. The minimum cross-sectional dimension of the element is six feet or less.
2. Insulation with an R-value of at least 2.5 must be provided for at least 72 hours following the completion of concrete placement.
3. The environmental classification of the concrete element is slightly aggressive or moderately aggressive.
4. The concrete mix design meets the mass concrete proportioning requirements of 346-2.3.
5. The total cementitious material content of the concrete mix design is less than or equal to 750 pounds per cubic yard.
6. Temperature of the concrete is 95°F or less at placement.

Implement immediate corrective action as directed by the Specialty Engineer when either the core temperature or the temperature differential of any mass concrete element exceeds its maximum allowable value. The approval of the MCCP shall be revoked. Do not place any mass concrete elements until a revised MCCP has been approved in writing by the Engineer. Submit an Engineering Analysis Scope in accordance with 6-4 for approval, which addresses the structural integrity and durability of any mass concrete element that is not cast in compliance with the approved MCCP or which exceeds the allowable core temperature or temperature differential. Submit all analyses and test results requested by the Engineer for any noncompliant mass concrete element to the satisfaction of the Engineer. The Department will make no compensation for additional costs or loss of time due to additional analyses, tests, or other impacts on production caused by the use of reduced monitoring or the Contractor's option.

ARTICLE 346-5 is deleted and the following substituted:

346-5 Sampling and Testing Methods.

Perform concrete sampling and testing in accordance with the following methods:

Table 346-7 Concrete Sampling and Testing Methods	
Description	Method
Slump of Hydraulic Cement Concrete	ASTM C143
Air Content of Freshly Mixed Concrete by the Pressure Method (1)	ASTM C231
Air Content of Freshly Mixed Concrete by the Volumetric Method (1)	ASTM C173
Making and Curing Test Specimens in the Field (2)	ASTM C31
Compressive Strength of Cylindrical Concrete Specimens	ASTM C39
Obtaining and Testing Drilled Core and Sawed Beams of Concrete	ASTM C42
Initial Sampling of Concrete from Revolving Drum Truck Mixers or Agitators	FM 5-501
Low Levels of Chloride in Concrete and Raw Materials	FM 5-516
Density (Unit Weight), Yield and Air Content (Gravimetric) of Concrete	ASTM C138
Temperature of Freshly Mixed Portland Cement Concrete	ASTM C1064
Sampling Freshly Mixed Concrete (3)	ASTM C172
Static Segregation of Self-Consolidating Concrete using Column Techniques	ASTM C1610
Slump Flow of Self-Consolidating Concrete	ASTM C1611
Relative Viscosity of Self-Consolidating Concrete	ASTM C1611
Visual Stability Index of Self-Consolidating Concrete	ASTM C1611
Passing Ability of Self-Consolidating Concrete by J-Ring	ASTM C1621
Rapid Assessment of Static Segregation Resistance of Self-Consolidating Concrete Using Penetration Test	ASTM C1712
Aggregate Distribution of Hardened Self-Consolidating Concrete	FM 5-617
Hardened Visual Stability Index of Self-Consolidating Concrete	AASHTO R81
Fabricating Test Specimens with Self-Consolidating Concrete	ASTM C1758
Concrete Resistivity as an Electrical Indicator of its Permeability	AASHTO T358

(1) The Department will use the same type of meter for Verification testing as used for QC testing. When using pressure type meters, use an aggregate correction factor determined by the concrete producer for each mix design to be tested. Record and certify test results for correction factors for each type of aggregate at the concrete production facility.
(2) Provide curing facilities that have the capacity to store all QC, Verification, and Resolution cylinders simultaneously for the initial curing. Cylinders will be delivered to the testing laboratory in their molds. The laboratory will remove the specimens from the molds and begin final curing.
(3) Take the test sample from the middle portion of the batch in lieu of collecting and compositing samples from two or more portions, as described in ASTM C172.

SUBARTICLE 346-6.2 is deleted and the following substituted:

346-6.2 Concrete Mix Design: Provide concrete that has been produced in accordance with a Department approved mix design , in a uniform mass free from balls and lumps.

For slump target values in excess of 6 inches, including flowing and self consolidating concrete, utilize a grate over the conveyance equipment to capture any lumps or balls that may be present in the mix. The grate must cover the entire opening of the conveyance equipment and have an opening that is a maximum of 2-1/2 inches in any one direction. Remove the lumps and balls from the grate and discard them. Discharge the concrete in a manner satisfactory to the Engineer. Perform demonstration batches to ensure complete and thorough placements in complex elements, when requested by the Engineer.

Do not place concretes of different compositions such that the plastic concretes may combine, except where the Plans require concrete with a surface resistivity value of

29 kOhm-cm or below and one with higher than 29 kOhm-cm values in a continuous placement. Produce these concretes using separate mix designs. For example, designate the mix with calcium nitrite as the original mix and the mix without calcium nitrite as the redesigned mix. Ensure that both mixes contain the same cement, fly ash or slag, coarse and fine aggregates and admixtures. Submit both mixes for approval as separate mix designs, both meeting all requirements of this Section. Ensure that the redesigned mix exhibits plastic and hardened qualities which are additionally approved by the Engineer as suitable for placement with the original mix. The Engineer will approve the redesigned mix for commingling with the original mix and for a specific project application only. Alternately, place a construction joint at the location of the change in concretes as approved by the Engineer.

SUBARTICLE 346-7.2.1 is deleted and the following substituted:

346-7.2.1 Transit Time: Ensure compliance with Table 346-8 between the initial introduction of water into the mix and completely discharging all the concrete from the truck. Reject concrete exceeding the maximum transit time. For critical placements, with the Engineer's approval, the transit time may be extended to the allowable mixing time shown in the mix design.

Table 346-8	
Maximum Allowable Transit Time	
Non-Agitator Trucks	Agitator Trucks
45 minutes	60 minutes
75 minutes(1)	90 minutes(1)
Note: (1) When a water-reducing and retarding admixture (Type D, Type G, or Type II) is used.	

ARTICLE 346-8 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 rating plate and a valid mixer identification card issued by the Department. Ensure that the revolution counter on the mixer is working properly, and calibration of the water dispenser has been performed within the last twelve months. Reject any concrete batches that are delivered in trucks that do not have mixer identification cards. Remove the mixer identification card when a truck mixer is discovered to be in noncompliance and the mixer deficiencies cannot be repaired immediately. When the mixer identification card is removed for noncompliance, make note of the deficiency or deficiencies found, and forward the card to the District Materials and Research Engineer who has Producer QC Plan acceptance authority.

Perform plastic concrete tests on the initial delivery from each plant 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 a technician is present and performing tests throughout the placement operation at each placement site. If a project has

multiple concrete placements at the same time, identify the technicians in the QC Plan to ensure minimum sampling and testing frequencies are met. Ensure that the equipment used for delivery, placement and finishing meets the requirements of this Specification.

When a truck designated for QC testing arrives at the discharge site, a subsequent truck may also discharge once a representative sample has been collected from the QC truck and while awaiting the results of QC testing. Reject non-complying loads at the jobsite. Ensure that corrections are made on subsequent loads. Immediately cease concrete discharge of all trucks if the QC truck has failing test. Perform plastic properties tests of concrete on all trucks prior to the first corrected truck and the corrected truck. When more than one truck is discharging into a pump simultaneously, only the truck designated for QC testing may discharge into the pump to obtain a representative sample of concrete from the QC truck only.

Furnish sufficient concrete of each design mix as required by the Engineer for verification (VT) testing. When the Engineer's VT 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, and any other loads that have begun discharging, 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 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 any five loads in two days of production of the same design mix are outside the specified tolerances. Increase the frequency of QC testing to one per load to bring the concrete within allowable tolerances. 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 (IV), the Contractor may perform the same tests on the concrete at the same time. The Department will compare results based on the Independent Assurance (IA) Checklist tolerances.

SUBARTICLE 346-9.2 is deleted and the following substituted:

346-9.2 Sampling Frequency: As a minimum, sample and test concrete of each mix design for water to cementitious materials ratio, air content, temperature, slump and compressive strength once per LOT as defined by Table 346-9. The Engineer will randomly verify one of every four consecutive LOTs of each mix design based on a random number generator. The Department may perform Independent Verification (IV) testing to verify compliance with specification requirements. All QC activities, calculations, and inspections will be randomly confirmed by the Department.

Table 346-9 Sampling Frequency	
Class Concrete[1]	LOT Size
I	one day's production
I (Pavement)	2,000 square yards, or one day's production, whichever is less
II, II (Bridge Deck), III, IV, V (Special), V, VI, VII	50 cubic yards, or one day's production, whichever is less
IV (Drilled Shaft)	50 cubic yards, or one day's production, whichever is less[2]
III (Seal)	Each Seal placement

(1) For any class of concrete used for roadway concrete barrier, the lot size is defined as 100 cubic yards, or one day's production, whichever is less.
(2) Start a new LOT when there is a gap of more than two hours between the end of one drilled shaft placement and the beginning of the next drilled shaft placement.

346-9.2.1 Reduced Frequency for Acceptance Tests: The LOT size may represent 100 cubic yards when produced with the same mix design at the same concrete production facility for the same prime Contractor and subcontractor on a given Contract. As an exception, the requirements for the precast/prestressed production facility will only include the same mix design at the same concrete production facility.

Submit strength test results indicating that the two following criteria are met:

1. The average of the acceptance compressive strengths is equal to or greater than the specified minimum compressive strength (f_c') plus 2.33 standard deviations minus:

   a. 500 psi, if f_c' is 5,000 psi or less.
   b. 0.10 f_c', if f_c' is greater than 5,000 psi.

2. Every average of three consecutive strength test equals or exceeds the f_c' plus 1.34 standard deviations.

Base calculations on a minimum of ten consecutive strength test results for a Class IV or higher; or a minimum of five consecutive strength results for a Class III or lower.

The average of the consecutive compressive strength test results, based on the class of concrete, can be established using historical data from a previous Department project. The tests from the previous Department project must be within the last calendar year or may also be established by a succession of samples on the current project. Only one sample can be taken from each LOT. Test data must be from a laboratory meeting the requirements of Section 105. Obtain Department approval before beginning reduced frequency LOTs.

If at any time a strength test is not verified or the average strength of the previous ten or five consecutive samples based on the class of concrete from the same mix design and the same production facility does not conform to the above conditions, return to the frequency represented by the LOT as defined in Table 346-9. Notify the Engineer that the initial frequency is reinstated. In order to reinitiate reduced frequency, submit a new set of strength test results.

SUBARTICLE 346-9.4 is deleted and the following substituted:

346-9.4 Acceptance of Concrete: The Engineer will accept the concrete of a given LOT when it meets the minimum specified compressive strength requirement of Table 346-3. Ensure that the hardened concrete strength test results are obtained in accordance with 346-9.3.

The process of concrete compressive strength acceptance consists of the following steps:

1. Verification of QC and VT data.
2. Resolution of QR and VR data.
3. Structural Adequacy determination.

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, missing, 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, missing, 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 VT 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 and each QR cylinder that is lost, missing, 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 VT data will require the element to be cored and a pay reduction 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.

SUBARTICLE 346-10.1 is deleted and the following substituted:

346-10 Investigation of Low Strength Concrete and Structural Adequacy.

346-10.1 General: The following applies for concrete that does not meet the minimum specified compressive strength of Table 346-3.

For standard molded and cured strength cylinders, the compressive strength of concrete is satisfactory provided that the two following criteria are met:

1. The average compressive strength does not fall below the specified minimum compressive strength by more than:

a. 500 psi if the specified minimum compressive strength is equal to or less than 5,000 psi.

b. 10% of the specified minimum compressive strength if the specified minimum compressive strength is greater than 5,000 psi.

2. The average compressive strength with the previous two LOTs is equal to or exceeds the specified minimum compressive strength. This condition only applies if there are two or more previous LOTs to calculate the average.

The Engineer will consider the concrete for a given LOT as structurally adequate and coring will not be allowed when a concrete compressive strength test result falls below the specified minimum strength but has met the above conditions.

When a concrete compressive strength test result falls below the specified minimum strength, and does not meet the above conditions, perform one of the following options:

1. Submit an Engineering Analysis Scope in accordance with 6-4 to establish structural and durability adequacy. When the scope is approved by the Engineer, submit an Engineering Analysis Report (EAR) in accordance with 6-4 that includes a full structural analysis. If the results of the structural analysis indicate adequate strength to serve its intended purpose with adequate durability, and is approved by the Engineer, the Contractor may leave the concrete in place subject to the requirements of 346-11, otherwise, remove and replace the LOT of concrete in question at no additional expense to the Department.

2. At the Engineer's discretion, obtain drilled core samples as specified in this Section to determine the in-place strength of the LOT of concrete in question, at no additional expense to the Department. The Engineer will determine whether to allow coring of the in-place concrete or require an engineering analysis based on the compressive strength of the test cylinders.

SUBARTICLE 346-10.2 is deleted and the following substituted:

346-10.2 Coring for Determination of Structural Adequacy: Core strength test results obtained from the structure will be accepted by both the Contractor and the Department as the in-place strength of the LOT of concrete in question. The core strength test results will be used in lieu of the cylinder strength test results for determination of structural adequacy. The Department will calculate the strength value to be the average of the compressive strengths of the three individual cores. This will be accepted as the actual measured value.

Obtain the Engineer's written approval before taking any concrete core sample. Notify the Engineer 48 hours prior to taking core samples. Obtain and test the cores in accordance with ASTM C42. Report the test results to the Engineer within seven calendar days of the Engineer's written approval. The Engineer will select the size and location of the drilled cores so that the structure is not impaired and does not sustain permanent damage after repairing the core holes. Sample three undamaged cores taken from the same approximate location where the questionable concrete is represented by the low strength concrete test cylinders. Repair core holes after samples are taken with a product in compliance with Section 930 or 934 and meeting the approval of the Engineer.

The Engineer with input from the District Materials Office, will consider the concrete as structurally adequate, in area represented by core tests at the actual test age, if the average compressive strength of cores does not fall below the specified minimum compressive strength by more than:

a. 500 psi when the specified minimum compressive strength is equal to or less than 5,000 psi.

b. 10% of the specified minimum compressive strength when the specified minimum compressive strength is greater than 5,000 psi.

The Engineer may also require the Contractor to perform additional testing as necessary to determine structural adequacy of the concrete.

SUBARTICLE 346-11.2 is deleted and the following substituted:

346-11.2 Basis for Pay Adjustments: The Engineer will determine payment reductions based on the 28 day compressive strength, represented by either acceptance compressive strength or correlated cores strength test results based on the following criteria:

1. When the acceptance compressive strength test result falls below the specified minimum compressive strength, but no more than the limits established in 346-10.1 below the specified minimum strength, do not core hardened concrete for determining pay adjustments. Use the acceptance compressive strength test results.

2. When the acceptance compressive strength test result falls below the specified minimum compressive strength by more than the limits established in 346-10.1, the structure may be cored for determination of structural adequacy as directed by the Engineer. Use the result of the 28 day correlated core compressive strength or the acceptance compressive strength test, whichever is less.

A price adjustment will be applied to the certified invoice price the Contractor paid for the concrete or the precast product.

The Engineer will relate the strength at the actual test age to the 28 day strength for the design mix represented by the cores using appropriate strength time correlation equations.

In precast concrete operations, excluding prestressed concrete, ensure that the producer submits acceptable core sample test results to the Engineer. The producer may elect to use the products in accordance with this Section. Otherwise, replace the concrete in question at no additional cost to the Department. For prestressed concrete, core sample testing is not allowed for pay adjustment. The results of the cylinder strength tests will be used to determine material acceptance and pay adjustment.