Florida Department of Transportation

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KEVIN J. THIBAULT, P.E.
SECRETARY

January 10 2022

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: **3460200 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 from the State Materials Office to eliminate Class I concrete to reduce the need for excessive mix design laboratory trial batches. Requirements on the number of compressive strength cylinders for a LOT has been clarified and fine aggregate is now required for its use in internal curing. The proposed changes are associated with Section 350, 400 and the Section 9.2 Volume II Materials Manual.

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 (850) 414-4130.

Sincerely,

Signature on file

Daniel Strickland, P.E.
State Specifications Engineer

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

STRUCTURAL PORTLAND CEMENT CONCRETE
(REV 11-8-21)

ARTICLE 346-2 is deleted and the following substituted:

346-2 Materials.

346-2.1 General: Meet the following requirements:

Coarse Aggregate.....Section 901
Fine Aggregate*.....Section 902
Portland Cement and Blended Cement.....Section 921
Water.....Section 923
Admixtures**.....Section 924
Supplementary Cementitious Materials.....Section 929

*Use only silica sand except as provided in 902-~~5.2.3~~.

**Use products listed on the Department's Approved Product List (APL).

Do not use materials containing hard lumps, crusts, or frozen matter, or that is contaminated with materials exceeding the specified limits in the above listed Sections.

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 IT, Type IS, Type II, Type II (MH) or Type III cement in all classes of concrete. Use Type IL, Type IT, 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), Type IT or Ternary Blend
Cast in Place	Type I	Type I, Type IL, Type II, Type IP, or Type IS	Type II (MH), Type IL, Type IT 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, Type IT 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.

346-2.3 Supplementary Cementitious Materials: Supplementary cementitious materials (SCMs) are required to produce binary or ternary concrete mixes in all classes of concrete specified in Table 346-3, except for the following when used in slightly aggressive environments: ~~Class I~~, Class I (Pavement), and Class II.

The quantity of ~~portland cement replaced with supplementary cementitious materials~~ SCMs must be on a~~n equal~~ weight ~~replacement~~percentage basis of the total cementitious materials in accordance with Table 346-2. When using Type IP, IS or IT blended cements, the total quantity of SCMs, including the blended cement added separately at the concrete plant shall meet the requirements of 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~~SCM.

346-2.3.3 Ternary Concrete Mixes: Concrete mixes containing portland cement and any two ~~of supplementary cementitious materials~~SCMs~~, 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			
	30-50		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.

346-2.4 ~~Coarse~~ Aggregate~~s~~ ~~Gradation~~: Produce all concrete using Size No. 57, 67 or 78 coarse aggregate~~s~~.

Use Size No. 8, and Size No. 89 alone, only when approved by the Engineer.

Use Size No. 4 or larger blended with smaller size coarse aggregate as two components.

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, Volume II of the Materials Manual, on the methods used to produce combined aggregate gradation of fine, intermediate, and coarse aggregate sizes for the concrete mixes.

346-2.4.2 Lightweight fine aggregate (LWFA) for internal curing: At the Contractor's option, use LWFA to reduce the early-age concrete cracking by replacing some of normal fine aggregate with saturated LWFA.

346-2.5 Admixtures: Ensure admixtures are used in accordance with the manufacturer's recommendations and meeting the requirements of Section 9.2, Volume II of the Materials Manual.

ARTICLE 346-3 is deleted and the following substituted:

346-3 Classification of Concrete.

346-3.1 General: The classifications of concrete 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 28-day specified minimum compressive strength, maximum water to cementitious materials ratio and target slump of each class are detailed in Table 346-3. The required air content for all classes of concrete is less than or equal to 6.0%.

For purposes of this Specification the concrete is further classified as follows:

1. Conventional Concrete: The target slump is described in Table 346-3 with a tolerance of ± 1.5 inches.

2. Increased Slump Concrete: The maximum target slump is 7 inches with a tolerance of ± 1.5 inches when a Type F, G, I or II admixture is used.

3. Slip-form Concrete: The target slump is 1.5 inches with a tolerance of ± 1.5 inches.

4. Flowing Concrete: Use flowing concrete only in the manufacturing of precast and prestressed products. Request Engineer's authorization to use flowing concrete for cast-in-place applications. The target slump is 9 inches with a tolerance of ± 1.5 inches. Meet the requirements of Section 8.6 Volume II of the Materials Manual.

5. Self-Consolidating Concrete (SCC): Use SCC only in the manufacturing of precast and prestressed products. The minimum target slump flow is 22.5 inches with a tolerance of ± 2.5 inches. Meet the requirements of Section 8.4 Volume II of the Materials Manual.

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 average 28-day compressive strength is less than the 28-day specified minimum compressive strength of the higher class mix design, notify the Engineer. Acceptance is based on the requirements in Table 346-3 for the specified class concrete.

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~~SCMs 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)
~~I (1)~~	~~3,000~~	~~0.53~~	~~3 (2)~~
I (Pavement) (1)	3,000	0.50	1.5 or 3 ~~(3)~~
II (~~1~~3)	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(4)	3 (2)
IV (Drilled Shaft)	4,000	0.41	8.5
V (Special)	6,000	0.37(4)	3 (2)
V	6,500	0.37(4)	3 (2
VI	8,500	0.37(4)	3 (2)
VII	10,000	0.37(4)	3 (2)

Notes:
(1) Meet the requirements of Section 350.
(2) Increased slump and slip form concrete as defined in 346-3.1.
(3~~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) Increased slump and slip form concrete as defined in 346-3.1.~~
~~(3) Meet the requirements of Section 350~~.
(4) 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 Class	Environmental Classification		
	Extremely Aggressive	Moderately Aggressive	Slightly Aggressive
~~I,~~ I (Pavement), II, and III (Seal)	470		
II (Bridge Deck), III (1), IV, IV (Drilled Shaft), V, V(Special), VI and VII	600	550	510

Notes:
(1) When precast three-sided culverts, box culverts, endwalls, inlets, manholes or junction boxes require a Class III concrete, the minimum cementitious materials content may be reduced to 470 pounds per cubic yard.

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

Suspend concrete placement immediately for every mix design if chloride test results exceed the limits of Table 346-5 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.

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~~ According to Section 350
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.

SUBSRTICLE 346-9.2.1 is deleted and the following substituted:

346-9.2.1 Reduced Frequency for Acceptance Tests: Except for Class I (Pavement), ~~T~~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. The reduced testing frequency of Class I (Pavement) is described in the Section 350.

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 346-9.3 is deleted and the following substituted:

346-9.3 Strength Test Definition: The strength test of a LOT is defined as the average compressive strength~~s~~ tests of ~~three~~at least two companion cylinders cast from the same sample of concrete and tested at the same age.

STRUCTURAL PORTLAND CEMENT CONCRETE
(REV 11-8-21)

ARTICLE 346-2 is deleted and the following substituted:

346-2 Materials.

346-2.1 General: Meet the following requirements:

Coarse Aggregate.....Section 901
Fine Aggregate*.....Section 902
Portland Cement and Blended Cement.....Section 921
Water.....Section 923
Admixtures**.....Section 924
Supplementary Cementitious Materials.....Section 929
*Use only silica sand except as provided in 902.
**Use products listed on the Department's Approved Product List (APL).

Do not use materials containing hard lumps, crusts, or frozen matter, or that is contaminated with materials exceeding the specified limits in the above listed Sections.

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 IT, Type IS, Type II, Type II (MH) or Type III cement in all classes of concrete. Use Type IL, Type IT, 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), Type IT or Ternary Blend
Cast in Place	Type I	Type I, Type IL, Type II, Type IP, or Type IS	Type II (MH), Type IL, Type IT 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, Type IT 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.

346-2.3 Supplementary Cementitious Materials: Supplementary cementitious materials (SCMs) are required to produce binary or ternary concrete mixes in all classes of concrete specified in Table 346-3, except for the following when used in slightly aggressive environments:, Class I (Pavement), and Class II.

The quantity of SCMs must be on a weight percentage basis of the total cementitious materials in accordance with Table 346-2. When using Type IP, IS or IT blended cements, the total quantity of SCMs, including the blended cement added separately at the concrete plant shall meet the requirements of 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 SCM.

346-2.3.3 Ternary Concrete Mixes: Concrete mixes containing portland cement and any two SCMs.

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			
	30-50		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.

346-2.4 Aggregates: Produce all concrete using Size No. 57, 67 or 78 coarse aggregates.

Use Size No. 8, and Size No. 89 alone, only when approved by the Engineer.

Use Size No. 4 or larger blended with smaller size coarse aggregate as two components.

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, Volume II of the Materials Manual, on the methods used to produce combined aggregate gradation of fine, intermediate, and coarse aggregate sizes for the concrete mixes.

346-2.4.2 Lightweight fine aggregate (LWFA) for internal curing: At the Contractor's option, use LWFA to reduce the early-age concrete cracking by replacing some of normal fine aggregate with saturated LWFA.

346-2.5 Admixtures: Ensure admixtures are used in accordance with the manufacturer's recommendations and meeting the requirements of Section 9.2, Volume II of the Materials Manual.

ARTICLE 346-3 is deleted and the following substituted:

346-3 Classification of Concrete.

346-3.1 General: The classifications of concrete are designated as 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 28-day specified minimum compressive strength, maximum water to cementitious materials ratio and target slump of each class are detailed in Table 346-3. The required air content for all classes of concrete is less than or equal to 6.0%.

For purposes of this Specification the concrete is further classified as follows:

1. Conventional Concrete: The target slump is described in Table 346-3 with a tolerance of ± 1.5 inches.

2. Increased Slump Concrete: The maximum target slump is 7 inches with a tolerance of ± 1.5 inches when a Type F, G, I or II admixture is used.

3. Slip-form Concrete: The target slump is 1.5 inches with a tolerance of ± 1.5 inches.

4. Flowing Concrete: Use flowing concrete only in the manufacturing of precast and prestressed products. Request Engineer's authorization to use flowing concrete for cast-in-place applications. The target slump is 9 inches with a tolerance of ± 1.5 inches. Meet the requirements of Section 8.6 Volume II of the Materials Manual.

5. Self-Consolidating Concrete (SCC): Use SCC only in the manufacturing of precast and prestressed products. The minimum target slump flow is 22.5 inches with a tolerance of ± 2.5 inches. Meet the requirements of Section 8.4 Volume II of the Materials Manual.

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 average 28-day compressive strength is less than the 28-day specified minimum compressive strength of the higher class mix design, notify the Engineer. Acceptance is based on the requirements in Table 346-3 for the specified class concrete.

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 SCMs 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)
I (Pavement) (1)	3,000	0.50	1.5 or 3
II (3)	3,400	0.53	3 (2)
II (Bridge Deck)	4,500	0.44	3 (2)
III	5,000	0.44	3 (2)
III (Seal)	3,000	0.53	8
IV	5,500	0.41(4)	3 (2)
IV (Drilled Shaft)	4,000	0.41	8.5
V (Special)	6,000	0.37(4)	3 (2)
V	6,500	0.37(4)	3 (2
VI	8,500	0.37(4)	3 (2)
VII	10,000	0.37(4)	3 (2)

Notes:
(1) Meet the requirements of Section 350.
(2) Increased slump and slip form concrete as defined in 346-3.1.
(3) 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 II concrete for precast endwalls, inlets, manholes and junction boxes.
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(4) 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 Class	Environmental Classification		
	Extremely Aggressive	Moderately Aggressive	Slightly Aggressive
I (Pavement), II, and III (Seal)	470		
II (Bridge Deck), III (1), IV, IV (Drilled Shaft), V, V(Special), VI and VII	600	550	510

Notes:
(1) When precast three-sided culverts, box culverts, endwalls, inlets, manholes or junction boxes require a Class III concrete, the minimum cementitious materials content may be reduced to 470 pounds per cubic yard.

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

Suspend concrete placement immediately for every mix design if chloride test results exceed the limits of Table 346-5 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.

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 (Pavement)	According to Section 350
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.

SUBSRTICLE 346-9.2.1 is deleted and the following substituted:

346-9.2.1 Reduced Frequency for Acceptance Tests: Except for Class I (Pavement), 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. The reduced testing frequency of Class I (Pavement) is described in the Section 350.

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 346-9.3 is deleted and the following substituted:

346-9.3 Strength Test Definition: The strength test of a LOT is defined as the average compressive strength tests of at least two companion cylinders cast from the same sample of concrete and tested at the same age.