



**DEVELOPMENTAL SPECIFICATIONS  
FOR  
STRUCTURAL CONCRETE (4500 PSI OR GREATER)**

**Effective Date  
October 17, 2023**

**THE STANDARD SPECIFICATIONS, SERIES 2023, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.**

**23018.01 DESCRIPTION.**

Provide concrete mix design for structural elements designed with a minimum compressive strength of 4500 psi or greater as shown in contract documents. Submit documentation for Class C or HPC mixes meeting strength criteria or submit a new mix design.

[Sections 2403](#) and [2412](#), and Division 41 of the Standard Specifications shall apply with the following modifications.

**23018.02 MATERIALS.**

Material shall meet quality requirements for respective items in Division 41 of the Standard Specifications.

Submit a mix design meeting the minimum 28 day strength requirements noted in the contract documents. Mix design requirements and submittal are as follows:

**A. New Mix Design.**

If Class C or HPC mix design from a concrete production facility cannot meet the strength requirements, a new mix design shall be submitted. Proportions for a new mix design shall be based upon saturated surface dry aggregates and shall produce a workable concrete mixture meeting the following constraints:

**Table DS-23018.02-1: Mix Design Constraints**

Cementitious Content, minimum	560 pounds per cubic yard, (absolute volume 0.106)
Water/Cementitious Ratio	Maximum, 0.45
Target Air Content	6% (absolute volume 0.06)

Submit mix design to the District Materials Engineer for approval at least 60 calendar days prior to placement. Base mix design on a trial batch and mix in the equipment used to batch production concrete.

For a new mix design without previous experience and for which the concrete production facility does not have field data for calculation of the standard deviation, the strength shall be an average of three cylinders and shall meet the following strength requirement at 28 days as shown below.

**Table DS-23018.02-2: Strength Requirements**

Specified minimum compressive strength, $f'_c$ psi	Required average compressive strength, $f'_c$
4500 to 5000	$f'_c + 1200$ psi
Greater than 5000	$1.1 \times f'_c + 700$ psi

where,  $f'_c$  = specified compressive strength in contract documents

If the concrete production facility has test records for calculation of the standard deviation, the required 28 day compressive strength shall be as shown in Article 23018.02, B. Concrete shall represent materials, quality control procedures, conditions, materials and proportions within test records, and the mix design represented shall not have been more restricted than the proposed mix. Strength represented by test records shall be within 1000 psi of the required compressive strength.

**B. Mix Design with History of Strength.**

A Class C mix, or other mixes with satisfactory record of strength, may be submitted in lieu of a new mix design. In accordance with ACI 301, a minimum of 30 tests for 28 day compressive strength shall be required as supporting documentation. The concrete produced for this specification shall be produced in accordance with [Section 2403](#) of the Standard Specifications, representing material sources (fly ash source changes may be included), and shall be batched and mixed in the same equipment used to produce the concrete represented by the performance strength documentation. The standard deviation shall be calculated from the 30 strength tests, except as provided below. The required 28 day compressive strength,  $f'_c$ , shall be the greater of the following

$$f'_c + 1.34 s \text{ or}$$

$$f'_c + 2.33 s - 500 \text{ psi}$$

where:  $f'_c$  = specified compressive strength in contract documents  
 $s$  = standard deviation.

When the concrete production facility has less than 30 tests (15 to 29), the standard deviation shall be increased by the factor included in the following table:

**Table DS-23018.02-3: Standard Deviation Factors**

Number of tests*	Factors for increasing the Standard Deviation
15 to 19	1.16
20 to 24	1.08
25 to 29	1.03

\*Less than 15 tests shall require a new mix design.

Submit modifications to an accepted concrete mix design to the Engineer for review and approval prior to use.

**23018.03 CONSTRUCTION.**

**A. Trial Batch Concrete.**

1. A trial batch will be required for any new mix design or any mix design with a history of strength without past experience on Interstate and primary projects. Approval will be based on trial batch mix properties and submittal of a trial batch report. The District Materials Engineer may waive the trial batch testing and perform testing on initial production placements where lower strengths are required, provided the concrete production facility produces acceptable test records for proposed mix demonstrating mix properties have been achieved through previous trial batches.

2. The District Materials Engineer shall be given notice and mix proportions 7 calendar days prior to this event. The trial batch shall be made at least 30 calendar days prior to planned placement and shall be a minimum of 3 cubic yards in size. Establish batching sequence during trial batch. Transport the concrete a distance comparable to the distance from the ready mix plant to the placement site. Use concrete for testing representative of the entire batch while having a slump within 1 inch of the maximum slump allowed, an intended in place air content of  $6\% \pm 1\%$ , and a w/c ratio that will be typical in the placement. Perform the following tests for each trial batch:

**Table DS-23018.03-1: Trial Batch Tests**

Specific Gravity of Each Individual Aggregate	<a href="#">Materials I.M. 307</a>
Gradation of Each Individual Aggregate	<a href="#">Materials I.M. 302</a>
Unit Weight of Plastic Concrete	<a href="#">Materials I.M. 340</a>
Slump of Plastic Concrete	<a href="#">Materials I.M. 317</a>
Air Content of Plastic Concrete	<a href="#">Materials I.M. 318</a>

3. Submit a trial batch mix design report and include the following:

**Table DS-23018.03-2: Trial Batch Report**

Cover Page	Contractor and Producer Name Project Number Date and Location of Trial Batch Date Submitted Signature of Contractor/Producer Representative
Material Source Information	Brand, Type, and Source
Proportion Information	Specific Gravity Relative % of Each Individual Aggregate Design and As Mixed Batch Weights (SSD) Design and As Mixed w/c Ratios
Mix Properties	Unit Weight of Plastic Concrete Air Content of Plastic Concrete Slump Individual Compressive Strength results at 7 and 28 days

**B. Production Concrete.**

1. Prior to placing production concrete, develop a strength maturity curve in accordance with [Material I.M. 383](#) based on compressive strength. Monitor unit being placed with a minimum of two probes. Forms may be removed and concrete may be subjected to exterior loads once the maturity meets the required design strength for the unit being placed. The Engineer remains responsible for determining if sufficient strength has been achieved. Submit documentation to the Engineer prior to form removal or loading.
2. Perform quality control testing of production concrete for strength to determine if production concrete meets the minimum required design strength. Cast, cure, and handle strength samples according to [Materials I.M. 315](#) using a PCC Level I Concrete Field Testing Technician. At the site ensure cylinders are cured properly with wet burlap and plastic. Do not move cylinders for 16 hours and ensure they remain at the site for a maximum of 1 calendar day before being transported to a certified laboratory for final curing and testing. Cast one random set of three strength samples in 4 inch by 8 inch cylinder molds for each pier, abutment, and deck with required design strength of 4500 psi or higher. Document slump, air content, and w/c ratio (adjusted for all water) of the concrete for the cylinders cast.
3. Test strength samples by a qualified lab in accordance with AASHTO T 22. Test three cylinders for strength at 28 days.

4. Submit test results to the Engineer and the District Materials Engineer no later than 1 working day after testing is completed. Submittal shall clearly indicate the project number, location, Contractor, producer, structural element constructed, slump, air content, w/c ratio (adjusted for all water), date sampled, date tested, break age, individual compressive strengths, and average compressive strengths. Attach plant report for the placement to the submittal.

**C. Failure to Comply.**

According to ACI 318, strength is acceptable if the average compressive strength of three cylinders meets the required compressive strength and no individual test falls below the required compressive strength by more than 500 psi. When the average 28 day compressive strength does not meet or exceed the specified strength, propose evaluation methods to determine the in-place concrete strength. Submit the proposal to the Engineer for approval. Notify the Engineer 48 hours in advance of any sampling and testing and will witness the sampling and testing of the in-place concrete. The Engineer will review the results with the Office of Bridges and Structure and determine corrective action required. The Contractor shall be responsible for the cost of evaluation and any corrective action required.

**23018.04 METHOD OF MEASUREMENT.**

The quantity of Structural Concrete 4500 psi or Greater, As Specified, in cubic yards, will be the quantity shown in the contract documents.

**23018.05 BASIS OF PAYMENT.**

The Contractor will be paid the contract unit price for Structural Concrete 4500 psi or Greater, As Specified per cubic yard. The cost for testing the production concrete shall be included in the contract unit price for Structural Concrete 4500 psi or Greater, As Specified.