Submittal Review Response

Project Name:	***Hilo WWTP Rehabilitation and Replacement Project Phase 1***
Submittal No.:	***03300-001.0***
Date:	***5/13/2025***

Client:	County of Hawai‘i	**Carollo Project No.:**	203975
Contractor:	Nan, Inc.		
Submittal Name:	Eucobar		
Reviewed By:	Gavin Goo		

SUBMITTAL REVIEW		
Review is for general compliance with contract documents. No responsibility is assumed by Carollo for correctness of quantities, dimensions, and details. No deviation or variation is approved unless specifically addressed in these review comments. Refer to Section 01330 for additional requirements. The Contractor shall assume full responsibility for coordination with all other trades and deviations from contract requirements.		
Approved	☒	No Exceptions
	☐	Make Corrections Noted - See Comments
	☐	Make Corrections Noted - Confirm
Not Approved	☐	Correct and Resubmit
	☐	Rejected - See Remarks
Receipt Acknowledged	☐	Filed for Record
	☐	With Comments - Resubmit

Review Comments:

1. No further comments.

CONTRACTOR SUBMITTAL TRANSMITTAL FORM

Owner:	County of Hawaii	**Date:**	5/6/2025
Contractor:	Nan, Inc.	**Project No.:**	WW-4705R
Project Name:	Hilo WWTP Phase 1	**Submittal Number:**	03300-001.0
Submittal Title:	Product Submittal: Evaporation Retardant		
To:	Engineer		
From:	Nan Inc.		

Specification No. and Subject of Submittal / Equipment Supplier			
Spec ##:	03300	**Subject:**	Product Submittal: Evaporation Retardant
Authored By:	Matthew Chun, QC	**Date Submitted:**	5/6/2025

Submittal Certification

Check Either (A) or (B):

[X] (A) We have verified that the equipment or material contained in this submittal meets all the requirements specified in the project manual or shown on the contract drawings with no exceptions.

[ ] (B) We have verified that the equipment or material contained in this submittal meets all the requirements specified in the project manual or shown on the contract drawings except for the deviations listed.

Certification Statement: By this submittal, I hereby represent that I have determined and verified all field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and I have checked and coordinated each item with other applicable approved shop drawings and all Contract requirements.

General Contractor's Reviewer's Signature: Matthew Chun

Printed Name and Title: Matthew Chun, QC

In the event, Contractor believes the Submittal response does or will cause a change to the requirements of the Contract, Contractor shall immediately give written notice stating that Contractor considers the response to be a Change Order.

Firm: **Signature:** **Date Returned:**

PM/CM Office Use

Date Received GC to PM/CM:

Date Received PM/CM to Reviewer:

Date Received Reviewer to PM/CM:

Date Sent PM/CM to GC:

Nan, Inc

PROJECT: HILO WWTP REHABILITATION AND REPLACEMENT PROJECT - PHASE 1

JOB NO. WW-4705R

THIS SUBMITTAL HAS BEEN CHECKED BY THIS CONTRACTOR. IT IS CERTIFIED CORRECT, COMPLETE, AND IN COMPLIANCE WITH CONTRACT DRAWINGS AND SPECIFICATIONS. ALL AFFECTED CONTRACTORS AND SUPPLIERS ARE AWARE OF, AND WILL INTEGRATE THIS SUBMITTAL (UPON APPROVAL) INTO THEIR OWN WORK.

DATE RECEIVED 5/6/2025
SPECIFICATION SECTION # 3300
SPECIFICATION Cast-In-Place Concrete
PARAGRAPH 1.05.I.(2), 3.09
DRAWING N/A
SUBCONTRACTOR N/A
SUPPLIER N/A
MANUFACTURER N/A

CERTIFIED BY: M. Chun, QC

SECTION 03300

CAST-IN-PLACE-CONCRETE

TABLE OF CONTENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Cast-in-place concrete.

B. The requirements of this Section will require advance planning for preparation and testing of trial batches. Review the mix design and testing requirements carefully, and schedule preparations and testing with sufficient time to complete tests, to obtain Engineer's review of mixes and testing results, and to complete revisions and re-testing if required.

1.02 REFERENCES

A. American Concrete Institute (ACI):
1. 212.3R - Report on Chemical Admixtures for Concrete.
2. 302.1R - Guide to Concrete Floor and Slab Construction.
3. 305R - Guide to Hot Weather Concreting.
4. 318 - Building Code Requirements for Structural Concrete and Commentary.
5. 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
6. Manual of Concrete Practice.

B. ASTM International (ASTM):
1. C29 - Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate.
2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
3. C33 - Standard Specification for Concrete Aggregates.
4. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
5. C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
6. C42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
7. C88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
8. C94 - Standard Specification for Ready-Mixed Concrete.
9. C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
10. C117 - Standard Test Method for Materials Finer that 75-m (No. 200) Sieve in Mineral Aggregates by Washing.
11. C123 - Standard Test Method for Lightweight Particles in Aggregate.
12. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
13. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
14. C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.
15. C142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate.
16. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.

17. C150 - Standard Specification for Portland Cement.
18. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
19. C157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
20. C171 - Standard Specifications for Sheet Materials for Curing Concrete.
21. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
22. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
23. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
24. C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading).
25. C295 - Standard Guide to Petrographic Examination of Aggregates for Concrete.
26. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
27. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
28. C494 - Standard Specification for Chemical Admixtures for Concrete.
29. C595 - Standard Specification for Blended Hydraulic Cements.
30. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
31. C702 - Standard Practice for Reducing Samples of Aggregate to Testing Size.
32. C856 - Standard Practice for Petrographic Examination of Hardened Concrete.
33. C989 - Standard Specification for Slag Cement for Use in Concrete and Mortars.
34. C1017 - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
35. C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
36. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
37. C1240 - Standard Specification for Silica Fume Used in Cementitious Mixtures.
38. C1260 - Standard Test Method of Potential Alkali Reactivity of Aggregates (Mortar Bar Method).
39. C1293 - Standard Test Method for Determination of Length Change of Concrete due to Alkali-Silica Reaction.
40. C1567 - Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
41. C1602 - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
42. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.
43. C1876 - Standard Test Method for Bulk Electrical Resistivity or Bulk Conductivity of Concrete.
44. D29 - Standard Practice for Determining Volatile and Nonvolatile Content of Cellulosics, Emulsions, Resin Solutions, Shellac, and Varnishes.
45. D75 - Standard Practice for Sampling Aggregates.
46. D2103 - Standard Specification for Polyethylene Film and Sheeting.

47. D3665 - Standard Practice for Random Sampling of Construction Materials.
48. D4791 - Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

C. National Ready-Mixed Concrete Association (NRMCA).

1.03 DEFINITIONS

A. Alkali: The sum of sodium oxide and potassium oxide calculated as sodium oxide.

B. Alkali Load: Amount of alkalies contributed by the Portland cement in a concrete mixture, expressed in pounds per cubic yard (lb/yd^3) and calculated by multiplying the Portland cement content of the concrete in lb/yd^3 by the alkali content of the Portland cement, or the Portland cement portion of a blended cement, divided by 100.

C. Architectural Concrete: Concrete surfaces that will be exposed to view in the finished work.
1. For purposes of this Section, includes only those surfaces that receive paint or coatings.
2. Exposed concrete surfaces in open basins, channels, and similar liquid containing structures: Surfaces will be considered exposed to view if located above the water line as defined in Section 03366 - Tool Concrete Finishing.
3. Exterior concrete surfaces with portions above and below grade: Surface will be considered exposed to view of located above the grade line as defined in Section 03366 - Tool Concrete Finishing.

D. Average Daily Temperature: Calculated by summing hourly measurements of air temperature in the shade at the face of the concrete and dividing that sum by 24. In calculating the sum of the temperatures recorded, any measurement less than 50 degrees Fahrenheit shall be recorded as 0 degrees Fahrenheit and included in the sum.

E. Cementitious Materials: Portland cement or blended cement and supplementary cementitious materials.

F. Class of Concrete: Refers to a mix with characteristics, proportions, and constituents (including a specific combination of admixtures) as specified in this Section.
1. Any change in the source or characteristics of constituent materials, in the proportions of materials, or in the admixtures included in a mix shall be considered as creating a new and separate class of concrete.
2. Any mix to be placed by pumping shall be considered as creating a new and separate class of concrete.

G. Green Concrete: Concrete that has not yet achieved 100 percent of the minimum specified compressive strength, f'c, for that mix.

H. Hairline Crack: Crack with a crack width of less than 4 thousandths of an inch (0.004 inches).

I. Hot Weather: Any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.2 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI 305R and in this Section, Attachment A - Menzel Formula and Nomograph.

J. Hot Weather Concreting: Operations for placing, finishing, curing, and protecting concrete during hot weather.

K. Paste Content: The total concrete volume minus the volume of aggregate, expressed as a percentage of total volume. Paste volume includes volume of cementitious materials, water, air, admixtures materials, and any fibers.

L. Supplemental Cementitious Material: inorganic material such as fly ash, natural pozzolans, silica fume, or slag cement that reacts pozzolanically or hydraulically.

1.04 DELEGATED DESIGN

A. Provide Delegated Design for the following Work, based on the requirements of this Section.
   1. Concrete mix designs.

1.05 SUBMITTALS

A. General:
   1. Data for concrete mixes and mix constituents supplied to the Work shall be coordinated through a single supplier.
   2. A maximum of ~~2~~ 4 mix designs will be reviewed by the Engineer for each class of concrete required. (Delete and Replace as per Bid Addendum 6)
      a. Review of additional mix designs shall be at the expense of the Contractor.

B. Product data:
   1. Submit data completely describing products and demonstrating compliance with the requirements of this Section.
   2. Data for all products in the mix for each class of concrete shall be submitted concurrently with that mix design.
   3. Admixtures:
      a. For each admixture included in concrete mixes, submit manufacturer's product data demonstrating compliance with standards specified.
   4. Curing compound: Submit complete data on proposed compound.

C. Design data:
   1. Concrete mix designs:
      a. Submit full details, including mix design calculations and plots, for concrete mixes proposed for use for each class of concrete.
      b. Include mix design calculations of proportions by both weight and volume.
      c. Determine and include the alkali load of the proposed mix.
      d. Include information on correction of batching for varying moisture contents of fine aggregate.

e. Submit source quality test records with mix design submittal.
f. Provide calculations demonstrating that the mixes proposed provide the required average compression strength of concrete (f'cr) based on source quality test records.
g. For each Class A mix design submitted, plot the mix design Attachment B - Coarseness Factor Chart and submit.
h. For each Class A mix design submitted, plot the combined aggregate gradation on the chart Attachment C - Combined Aggregate Gradation Chart and submit.

D. Concrete mixes - Trial batches:
1. Drying shrinkage test results.
a. Submit results of testing.
b. Submit test specimens from drying shrinkage tests for trial batches.
1) Submit all specimens from each mix accepted by Engineer.
2) Using indelible marker, clearly label each specimen with concrete class, trial batch mix designator, and specimen number.
2. Compression strength test results.
a. Submit results of testing. Provide data for each cylinder tested.
b. Submit data indicating trial batch mix designator, slump, and specimen number for each test cylinder.
c. Submit test specimens from compression strength tests for trial batches.
1) Submit 2 cylinders from each mix accepted by Engineer.
2) Using indelible marker, clearly label each cylinder with concrete class, trail batch number, and specimen number.
3. If there is any change in suppliers or in quality of concrete mix constituents, submit new test data.

E. Test reports:
1. Dated not more than 24 months prior to the date of submittal.
2. Aggregate:
a. Submit certified copies of commercial laboratory tests proposed for use in concrete.
b. Sieve analyses:
1) During construction, submit sieve analyses of coarse, intermediate, fine, and combined aggregates used any time there is a change in supplier, or a significant change in the character and/or grading of materials, and when requested by the Engineer.
c. Aggregates - coarse:
1) Physical properties:
a) Sieve analysis.
b) Percentage of particles having flat and/or elongated characteristics.
c) Abrasion loss.
d) Soundness.
2) Deleterious substances:
a) Clay lumps and friable particles content.
b) Materials finer than 200 sieve (percentage).
c) Shale and chert content.
d) Coal and lignite content.

3) Alkali reactivity.
4) Petrographic analysis.

d. Aggregates - Intermediate:
1) Physical properties:
a) Sieve analysis.
b) Percentage of particles having flat and/or elongated characteristics.
c) Abrasion loss.
d) Soundness.
2) Deleterious substances:
a) Clay lumps and friable particles content.
b) Chert and shale content.
c) Coal and lignite content.
d) Materials finer than No. 200 sieve.
3) Alkali reactivity.
4) Petrographic analysis.

e. Aggregates - Fine:
1) Physical properties:
a) Sieve analysis and fineness modulus.
b) Soundness.
2) Deleterious substances:
a) Clay lumps and friable particles (percentage).
b) Materials finer than No. 200 sieve (percentage).
c) Coal and lignite (percentage).
d) Shale and chert.
e) Organic impurities ("Color" as determined by ASTM C40).
3) Alkali reactivity.
4) Petrographic analysis.

f. Aggregates - Combined:
1) Test combined gradation for the following sieve sizes: 1.5 inches, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch, Number 4, Number 8, Number 16, Number 30, Number 100, Number 200.
2) Bulk density in accordance with ASTM C29.
3) Void content in accordance with ASTM C29.
4) Submit at:
a) Initial mixture design submittal,
b) Intervals of not more than 4 weeks,
c) Any time there is a change in character or grading of constituent materials,
d) When requested by the Engineer.

3. Cement:
a. Mill tests, including alkali content measured as equivalent alkalis, for each shipment of cement included in the Work.
1) During construction, submit mill certificates for cement being used at intervals of not more than 90 days, any time there is a change in supplier or a significant change in the character of the materials, and when requested by the Engineer.

4. Supplemental cementitious material:
    a. Fly ash: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C618 and this Section.
        1) Include supplier's report certifying the total alkali content of the material, expressed as equivalent percentage of sodium oxide (Na_2Oe).
    b. Slag cement: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C989 and this Section.
    c. Silica fume: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C1240 and this Section.

F. Certificates:
    1. Current NRMCA certification for all plants and trucks that will be used to supply concrete.

G. Source quality control submittals:
    1. Truck batch tickets for each load of concrete delivered to the site, whether accepted or rejected.
    2. Concrete supplier's quality control plan. Include the following elements, at a minimum:
        a. Names and qualifications of key quality control personnel:
            1) Quality control manager.
            2) Testing and inspection personnel.
        b. Names and qualifications of testing laboratories:
            1) Each laboratory shall hold current accreditation from the AASHTO Accreditation Program, or other accreditation program acceptable to the Engineer, for each test performed.
        c. Example forms for: inspection reports, certificates of compliance, and test results.
        d. Quality control procedures: Method and frequency of performing each procedure, including inspections and materials testing. At a minimum, the plan shall include:
            1) Daily testing of aggregate gradation.
            2) Monthly testing of cement quality.
            3) Monthly testing of fly ash quality.
        e. Procedures to control quality characteristics, including standard procedures to address properties outside the specified operating limits, and example reports to document non-conformances and corrective actions taken. Include procedure for notifying Contractor and Engineer of non-conformances.
        f. Procedures for verifying that:
            1) Materials are properly stored during concrete batching operations.
            2) Batch plants have the ability to maintain concrete consistency during periods of extreme heat and of low temperatures.
            3) Admixtures are dispensed in the correct dosages within the accuracy requirements specified.
            4) Delivery trucks have a valid NRMCA certification card.
        g. Procedures for verifying that weighmaster certificate for each load of concrete shows:
            1) Cement and supplementary materials are from sources designated in the approved submittals.

2) Concrete as-batched complies with the constituent weights designated in the approved submittals.
3) Corrections for aggregate moisture are being correctly applied.
4) Any mix water withheld from the batch.

h. Procedures for visually inspecting concrete during discharge.

H. Field quality control submittals:
1. Contractor's notifications of readiness for concrete placement.
2. Contractor's reports of field quality control testing.
a. Include with each report the concrete batch ticket number and identification numbers for associated cylinders used for compressive strength testing.
b. Testing results for slump, temperature, and unit weight.
c. Testing results for compressive strength at 7 and 28 days, and for any compressive strength tests after 28 days.
d. Note on batch ticket the amount of water that was withheld and the maximum amount that can be added on site as "Max add water." Record on the batch ticket the volume of water actually added at site.
e. Note on the batch ticket the concrete mix classification as defined in Table 3 of this Section.

I. Special procedure submittals:
1. Sequence of concrete placing:
a. Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements. Submittal shall include plans sections and details to address all pours.
2. Hot weather concreting plan.
3. Repair of defective concrete: Submit mix design for repair materials to be used.

1.06 QUALITY ASSURANCE

A. Pre-installation meetings:
1. Schedule and conduct pre-installation meeting at least 10 days prior to batching and placing of concrete.
a. Provide additional meetings if necessary, to discuss specific concrete submittals, mixes, or placing and curing conditions.
b. Notify Engineer of location and time of each conference.
2. Required attendees:
a. Contractor including Contractor's superintendent and key personnel.
b. Concrete supplier.
c. Technical representative(s) of supplier(s) of concrete admixtures.
d. Subcontractor(s) providing pumping, placing, finishing, and curing.
e. Subcontractor(s) providing embedded items (structural embedded plates, electrical conduit).
f. Sampling and testing personnel.
g. Engineer.
h. On-site inspectors representing Engineer.
i. Other persons deemed by the Engineer and the Contractor to be critical to the quality and efficiency of the Work.

3. Agenda:
    a. Review of requirements of Drawings and Specifications.
    b. Project and product safety requirements.
    c. Discussion of points of interface and coordination between various trades or products to be used in the Work.
    d. Contractor's schedule for cast-in-place concrete work.
    e. Mix designs, mix tests, and submittals.
    f. Admixture types, dosing, performance, requirements for monitoring, and limits on dosing or re-dosing at the site.
    g. Placement and consolidation methods, techniques, and equipment and the effects of those methods on form pressures.
    h. Slump and limits on placing time or conditions to maintain placeability.
        1) Field adjustment of slump and air content.
    i. Procedures for finishing, curing, and retention of moisture during these operations.
    j. Procedures and protection for hot weather conditions.
    k. Requirements and coordination for inspections.
        1) Responsibility for test specimen curing and storage.
        2) Distribution of test reports.
    l. Other Specification requirements requiring coordination between parties to the work.
4. Prepare and submit minutes of the pre-installation meeting as specified in Section 01312 - Project Meetings.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
    1. Deliver, store, and handle concrete materials in manner that prevents damage and inclusion of foreign substances.
    2. Deliver and store packaged materials in original containers until ready for use.
    3. Deliver aggregate to mixing site and handle in such manner that variations in moisture content will not interfere with steady production of concrete of specified degree of uniformity and slump.
    4. For Class M concrete:
        a. Store coarse and fine aggregate in covered area. Shade aggregates to prevent heating by direct sunlight.
        b. Store cementitious materials in covered, shaded silos to prevent heating by direct sunlight.

B. Acceptance at site:
    1. Reject material containers or materials showing evidence of water or other damage.
    2. Concrete mixes: Do not accept or incorporate into the Work concrete mixes that do not comply with the specified requirements for water content, slump, temperature, and air content.

1.08 PROJECT CONDITIONS

A. Hot weather concreting: During periods of hot weather as defined in this Section, implement hot weather concreting procedures in this Section.

1.09 SEQUENCING AND SCHEDULING

A. Schedule placing of concrete in a manner that completes all placing operations from one construction, contraction, or expansion joint to another construction, contraction, or expansion joint.

B. Joints at each end of the placement shall be as indicated on the Drawings, or as identified and accepted in advance by the Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. It is the intent of this Section to secure, for every part of the Work, concrete with a homogeneous mixture, that, when hardened, will have required strength, watertightness, and durability.

B. It is the intent of this Section to procure a workable, low-shrinkage concrete mix that maximizes aggregate content and minimizes paste content.

C. Performance requirements:
   1. General:
      a. Except as otherwise specified, provide concrete composed of Portland cement or blended cement, supplemental cementitious materials, aggregate, admixtures and water, proportioned and mixed to produce a plastic, workable mixture in accordance with requirements of this Section, and suitable to specific conditions of placement.
      b. Proportion aggregates to produce an optimized gradation of aggregate that combines fine, intermediate, and coarse aggregate in well-graded proportions that maximizes the aggregate content and minimizes the paste content of the mix. The gradation should maximize long-term durability and strength of the concrete mixture.
      c. Durability requirements will be deemed to be satisfied when:
         1) The mixture is proportioned with a well-graded combined aggregate.
         2) The specified water-cement ratio is satisfied.
         3) The concrete contains the specified range of air content.
         4) The maximum specified paste content is satisfied.
         5) The requirements of ASTM C1778 to reduce the risk of deleterious alkali-aggregate reactions are satisfied. Reduce alkali loading of concrete, provide minimum supplemental cementitious material content, or both as required.
            a) Size and Exposure Conditions (ASTM C1778, Table 2): Concrete exposed to humid air, buried or immersed.
            b) Structure Class (ASTM C 1778, Table 3): Class SC 4.
      d. Proportion materials in a manner that will secure the lowest cement content, water-cementious materials ratio, and paste volume that is consistent with good workability, that provides a plastic and cohesive mixture, and that provides a slump that is within the specified range.

e. Construction and expansion joints have been positioned in structures as indicated on the Drawings, and curing methods have been specified, for purpose of to reduce the number and size of cracks, resulting from normal expansion and contraction expected from the concrete mixes specified.
f. Remove and replace, or repair as specified in this Section, non-conforming work and surfaces with cracks, voids and honeycombs, or surface wetness.

2. Workmanship and methods: Provide concrete work, including detailing of reinforcing, conforming with best standard practices and as set forth in ACI 318, ACI 350, and the ACI Manual of Concrete Practice.

2.02 MATERIALS - GENERAL

A. Water and ice:
1. Water for concrete mixes, for washing aggregate, and for curing concrete: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
2. Non-potable water may be used with the following limits:
a. Chlorides (C 114): 1,000 ppm.
b. Sulfates, as SO4 (C 114): 1,500 ppm.
c. Alkalies, as NA2O + 0.658 K20 (C 114): 300 ppm.
d. Total inorganic solids by mass (C 1603): 5,000 ppm.
e. Organic solids by mass (T 26): 300 ppm.
f. pH (T 26): 4 to 9.
g. Oil (visual): No sheen.
3. Comply with the optional chemical limits of ASTM C1602.
4. Do not use water from concrete production operations, or combined water from concrete production operations as defined in ASTM C1602.

2.03 MATERIALS - CONCRETE MIX CONSTITUENTS

A. Water and ice:
1. As specified in the preceding paragraphs.

B. Cementitious materials:
1. Portland cement:
a. In accordance with ASTM C150.
1) Type II low-alkali cement.
b. Single source: To provide uniformity of appearance, for each structure use only one source, type, and brand of Portland cement for walls and slabs that will be exposed in the finished work.
1) Confirm adequate supply of cement over duration of project before making trial batches or beginning concrete placements.
c. Cement for finishing: Provide cement from same source and of same type as concrete to be finished or repaired.
2. Blended hydraulic cement:
a. In accordance with ASTM C595:
1) Type IL (MS).
b. Single source: To provide uniformity of appearance and quality, for each structure use only 1 source, type, and brand of cement.

c. Confirm adequate supply of cement over duration of project before making trial batches or beginning concrete placements.
d. Cement for finishing: Provide cement from same source and of same type as concrete to be finished or repaired.

C. Supplementary cementitious materials:
1. Fly ash:
a. Class C or Class F fly ash in accordance with the requirements of ASTM C618, except as modified in this Section:
1) Class C, may be used in concrete made with Type II (low-alkali) Portland cement.
2) Class F required if used in concrete mixes containing aggregates classified as potentially reactive based on ASTM C1293 or ASTM C1260.
a) CaO content: Less than 18 percent.
b. Loss on ignition: Not exceeding 3 percent.
c. Replace Portland cement at ratio of 1.0 pound fly ash for each pound of cement, up to minimum and maximum replacement as specified in "Requirements for Mix Proportioning."
2. Slag cement:
a. Grade 80, 100, or 120 in accordance with ASTM C989, except as modified below:
1) Fineness: Amount retained on a No. 325 sieve: 20 percent maximum.
2) Total alkalies Na2O + 0.658 K2O:
a) Minimum: 0.60 percent.
b) Maximum: 0.90 percent.
3. Silica fume:
a. Provide silica fume in accordance with ASTM C1240, except as modified below:
1) Moisture content: 3 percent maximum.
2) Loss on ignition: 6 percent maximum.
3) Reactivity with cement alkalies: 80 percent minimum.
4) Sulfate resistance: maximum 0.05 percent expansion at 1 year.

D. Admixtures:
1. General:
a. Do not include admixtures, other than those specified, unless written acceptance has been obtained from the Engineer during submittal of mix designs.
b. Admixtures shall be compatible with concrete constituents and with other admixtures.
1) All admixtures in a given mix shall be products of the same manufacturer to ensure compatibility.
2) Admixture manufacturers: One of the following, or equal.
a) Master Builders Solutions.
b) Euclid Chemical.
c) GCP Applied Technologies (formerly W.R. Grace).
d) Sika Corp.
c. Do not use admixtures containing chlorides, calculated as chloride ion, in excess of 0.5 percent by weight of cement.

d. Use in accordance with manufacturer's recommendations. Add each admixture to concrete mix separately.
e. Admixtures used shall be the same products used in concrete trial batches, or the same products used in concrete represented by submitted field test records.

2. Corrosion-inhibiting admixture (CIA):
   a. Use admixture where specified.
   b. Manufacturer: One of the following:
      1) Sika Corporation, Sika-CNI, Corrosion-Inhibiting Admixture.
      2) Master Builders, MasterLife CI 30, Corrosion-Inhibiting Admixture.
   c. Meet the requirements of ASTM C1582 and ASTM C494, Type C.
   d. Where specified for use, dosage rates shall be a minimum of 3 gallons per cubic yard of concrete or as recommended by the manufacturer based on chloride content in the concrete.
   e. Where specified for use, other admixture dosage rates shall be adjusted as required to offset any effects that the corrosion-inhibiting admixture introduces. Adjustments shall be determined prior to the casting of the trial batch cylinders.
   f. Where the admixture is anticipated to cause set acceleration, a set retarder that is compatible with all of the admixtures may be used. The set retarding admixture shall be dosed at a rate recommended by the manufacturer.
   g. The mix water at the batch plant may need to be reduced to compensate for the addition of corrosion inhibitor.
3. Water reducing admixture (WRA):
   a. May be used at the Contractor's option.
   b. Conforming to ASTM C494, Type A (water-reducing).
      1) ASTM C494, Type D (water-reducing and retarding) may be used during periods of hot weather with prior acceptance by the Engineer.
   c. Not containing air-entraining agents.
   d. Liquid form before adding to the concrete mix.
4. High range water reducing admixtures ("super-plasticizers") (HRWR):
   a. Not permitted without acceptance by Engineer.
5. Permeability-reducing admixture for concrete exposed to hydrostatic conditions (PRAH):
   a. Portland-cement based, capillary waterproofing admixture that reacts in concrete to form non-soluble crystalline hydration products sufficient to fill capillary pores and micro-cracks in the concrete, and that become a permanent part of the concrete.
      1) Permeability-reducing admixture for hydrostatic conditions (PRAH) as described in ACI 212.3R.
      2) Integral element of hardened concrete that is available within the concrete to react with water and to fill future cracks.
   b. In accordance with ASTM C494, Type S (specific performance).
   c. One of the following, or equal:
      1) Master Builders Solutions: MasterLife 300D. or 300L Added as per Bid Addendum 08
      2) Euclid Chemical: Eucon Vandex AM-10.
      3) GCP Applied Technologies: Penetron Admix.

6. Shrinkage reducing admixture (SRA):
    a. May be used at Contractor's option.
        1) Provide shrinkage reducing admixture in sufficient dosage so as to produce shrinkage within the limits specified.
    b. Not containing expansive agents.
    c. In accordance with ASTM C494, Type S (specific performance).
    d. One of the following, or equal:
        1) Master Builders Solutions: SRA Series.
        2) Euclid Chemical: Eucon SRA Series.
        3) GCP Applied Technologies: Eclipse Series.
7. Alkali-Silica Reaction (ASR) Inhibiting Admixture:
    a. Use admixture where specified.
    b. Meet the requirements of C 494, Type S.
    c. Manufacturer: One of the following:
        1) Master Builders, MasterLife ASR 30.
        2) Sika Corporation, SikaControl ASR.
        3) Euclid Chemical Company, Eucon Integral ARC.
    d. Dosage rates shall be as recommended by the manufacturer.
    e. Where specified for use, other admixture dosage rates shall be adjusted as required to offset any effects that the ASR inhibiting admixture introduces. Adjustments shall be determined prior to the casting of the trial batch cylinders.
    f. Where the admixture is anticipated to cause set acceleration, a set retarder that is compatible with all of the admixtures may be used. The set retarding admixture shall be dosed at a rate recommended by the manufacturer.
    g. The mix water may need to be reduced to compensate for the addition of ASR inhibiting admixture.
8. Set-controlling admixtures:
    a. Shall not be used without prior acceptance from Engineer.
    b. Accelerating admixtures: not permitted.

E. Coloring admixtures (CA):
    1. Conduit encasement coloring agent:
        a. Red color concrete used for encasement of electrical ducts, conduits, and similar type items.
        b. Manufacturers: One of the following or equal:
            1) Davis Co., #100 Utility Red.
            2) I. Reiss Co., Inc., equivalent product.
            3) Euclid Chemical Co., Increte Division, “Colorcrete Brick Red.”
        c. Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.

F. Aggregate:
    1. General:
        a. Provide concrete aggregates that are sound, graded as specified, and free of deleterious material in excess of allowable amounts specified.
        b. Provide aggregates to produce in place concrete with unit weight as follows:
            1) Normal weight concrete: Not less than 140 pounds per cubic foot.

c. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, and other construction materials.
d. Do not use aggregate recycled from fresh concrete returned to the batching facility.

2. Alkali-silica reactivity:
   a. Provide aggregate classified as aggregate-reactivity class of R0 in accordance with ASTM C1778 with expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260, and not greater than 0.04 percent at one year when tested in accordance with ASTM C1293.
   b. Aggregates classified as potentially reactive based on the preceding tests may be permitted, at the discretion of the Engineer, if the following condition is satisfied:
      1) ASTM C1567: Testing with the reactive aggregate, cement, and supplemental cementitious materials demonstrate that expansion is less than 0.10 percent at 14 days. Include ASTM C1260 and ASTM C1293 test results to demonstrate that mitigation of alkali-silica reaction by ASTM C1567 is suitable. See Figure 3 of ASTM C1778 for reactivity of aggregates where ASTM C1567 testing is not recommended.
3. Fine aggregate:
   a. Material graded such that 95 to 100 percent of material passes the No. 4 (4.75 mm) sieve, when sampled in accordance with ASTM D75 and D3665, and tested in accordance with ASTM C136.
   b. Provide fine aggregate consisting of clean, natural sand, or sand prepared from crushed stone or crushed gravel.
   c. In accordance with ASTM C33 requirements for grading, deleterious substances, soundness, and alkali reactivity, except as modified in the following paragraphs.
      1) Grading: For sieve sizes listed in ASTM C33 for fine aggregate, not more than 45 percent passing any sieve and retained on the next consecutive sieve.
      2) Deleterious substances: not in excess of the percentages by weight specified in Table 1 of this Section.

Table 1: Fine Aggregate, Limits on Deleterious Substances		
Item	**Test Method**	**Percent (maximum)**
Materials finer than No. 200 sieve(2)	ASTM C117	3.00(2)
Clay lumps and friable particles	ASTM C142	1.00
Lightweight particles (SG < 2.40)	ASTM C123	1.00
• Chert or shale(1)	ASTM C295	1.00(1)
Coal and lignite	ASTM C123	0.50

Notes:

(1) ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage of lightweight particles (sum of shale, chert, coal and lignite) not greater than 1.00, testing under ASTM C295 will not be required.

(2) For manufactured sand, if material finer than the No. 200 sieve consists of crusher dust and the aggregate is essentially free of clay or shale, maximum percentage may be increased to 5.0 percent.

3) Organic impurities: Free of injurious amounts of organic matter and producing a supernatant liquid with color not darker than “standard color” when tested in accordance with ASTM C40.
4) Soundness: In accordance with requirements of ASTM C33 when tested in accordance with ASTM C88 using sodium sulfite solution.

4. Intermediate aggregate:
   a. Material graded such that 90 to 100 percent of material passes the 3/8 inch sieve, and not more than 5 percent of material passes the No. 50 (300 µm) sieve, when sampled in accordance with ASTM D75 and D3665, and tested in accordance with ASTM C136.
   b. Requirements for maximum percentage of impurities, abrasion loss, and soundness: As specified for coarse aggregate.
5. Coarse aggregate:
   a. Materials graded such that not more than 10 percent of material passes the 3/8-inch sieve, when sampled in accordance with ASTM D75 and D3665, and tested in accordance with ASTM C136.
   b. Consisting of gravel, crushed gravel, crushed stone, or a combination of these materials having clean, hard, durable particles free from calcareous coatings, organic matter, or other deleterious substances.
   c. Conforming to the requirements of ASTM C33, Class 4S for physical properties, deleterious substances, and alkali reactivity, except as modified in the following paragraphs.
      1) Grading:
         a) Size number as specified in ASTM C33, and as indicated in Table 3 of this Section, except as otherwise specified or accepted by the Engineer.
         b) Weights of flat or elongated particles (particles having a length greater than 3 times average width or thickness) not exceeding 15 percent when tested in accordance with ASTM D4791.

2) Deleterious substances: Not in excess of the percentages by weight specified in Table 2 of this Section and having total of all deleterious substances exceeding 2 percent.

Table 2: Coarse Aggregate, Limits on Impurities		
Item	**Test Method**	**Percent (maximum)**
Clay lumps and friable particles	ASTM C142	0.50
Lightweight particles (SG < 2.40)	ASTM C123	1.25
• Chert or shale(1)	ASTM C295	1.00(1)
Materials finer than No. 200 sieve	ASTM C117	0.50(2)
Coal and lignite	ASTM C123	0.25

Notes:

(1) ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage (sum of shale, chert, coal and lignite) not greater than 1.25, testing under ASTM C295 will not be required.

(2) When material finer than No. 200 sieve consists of crusher dust, maximum percentage may be increased to 1.00 percent. When mix design complies with provisions of ASTM C33, Table 4, footnote C, the maximum percentage may be increased in accordance with the equation in footnote C, up to a maximum of 1.5 percent.

3) Abrasion loss: Loss not greater than 45 percent after 500 revolutions when tested in accordance with ASTM C131.

4) Soundness: Loss not greater than 10 percent when tested in accordance with ASTM C88 using sodium sulfate solution.

2.04 MATERIALS FOR PLACING, CURING AND FINISHING

A. General:
   1. Materials shall be compatible with concrete and with other materials.

B. Cement grout:
   1. Use: For spreading over surface of construction and cold joints in concrete before placing additional concrete above those joints.
   2. As specified in Section 03600 - Grouting.

C. Concrete sealer:
   1. As specified in Section 03366 - Tooled Concrete Finishing.
   2. Not for use in water-containment structures.

D. Evaporation retardant:
   1. Use: For mitigating surface moisture evaporation from freshly placed concrete during rapid drying conditions. Placed after screeding.
   2. Waterborne, monomolecular, spray-applied compound, with fugitive dye to indicate coverage.
   3. Manufacturers: One of the following or equal:
      a. Master Builders Solutions, MasterKure ER 50.
      b. Euclid Chemical Co., Eucobar.

E. Nonslip abrasive:
   1. Aluminum oxide abrasive size 8/16, having structure of hard aggregate that is, homogenous, nonglazing, rustproof, and unaffected by freezing, moisture, or cleaning compounds.
   2. Manufacturers: One of the following or equal:
      a. Exolon Co.
      b. Abrasive Materials, Inc.
      c. “Non-Slip Aggregate”, Euclid Chemical Co.

F. Plastic membrane for curing:
   1. Polyethylene film: In accordance with ASTM C171.
   2. Properties:
      a. Color: White.
      b. Thickness: Nominal thickness of polyethylene film shall not be less than 0.0040 inches when measured in accordance with ASTM D2103. Thickness of polyethylene film at any point shall not be less than 0.0030 inches.
      c. Loss of moisture: Not exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.

G. Sprayed membrane curing compound:
   1. Combination curing and sealing products ("cure and seal") will not be permitted.
   2. Properties:
      a. Clear type with fugitive dye conforming with ASTM C309, Type 1D and containing no wax, paraffin, or oils.
      b. For concrete placed or cured during hot weather, curing compound shall be as specified, except that:
         1) It shall include a white, reflective fugitive dye.
         2) Moisture loss during a 72-hour period shall not exceed 9 pounds per cubic yard when tested in accordance with ASTM C156.

H. Surface-applied sealing system:
   1. Manufacturers: One of the following or equal:
      a. Euclid Chemical Co., Vandex Super.
      b. Kryton International, Inc., Krystol T1.
      c. Xypex Chemical Corp., Xypex Concentrate.
   2. Where surface-applied sealing system is placed over concrete containing permeability reducing admixture for concrete exposed to hydrostatic conditions (PRAH), provide products of same manufacturer providing the admixture.

2.05 EQUIPMENT

A. General:
   1. Provide adequate equipment and facilities for accurate measurement and control of materials and for readily changing proportions of material into mixers.

B. Batching equipment, or batch plant.
   1. Capable of controlling delivery of all material to mixer within 1 percent by weight of individual material.

C. Mixing equipment:
   1. Mixers may be of stationary plant, paver, or truck mixer type, as appropriate to the Work.
   2. Capable of combining aggregates, water, and cementitious materials, and admixtures within specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation.
      a. Maintain concrete mixing equipment in good working order, and operate at loads, speeds, and timing recommended by manufacturer or as specified.
      b. Proportion cementitious materials and aggregate by weight.
   3. If bulk cementitious materials are used, weigh them on separate visible scale which will accurately register scale load at any stage of weighing operation from zero to full capacity.
   4. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer ready for complete mixing with all mixing water.
   5. Procedure of mixing cementitious materials with sand or with sand and coarse aggregate for delivery to project site, for final mixing and addition of mixing water will not be permitted.
   6. Retempering of concrete will not be permitted.
   7. Discharge entire batch before recharging.
   8. Volume of mixed material per batch: Not exceed manufacturer's rated capacity of mixer.
   9. Equip each mixer with device for accurately measuring and indicating quantity of water entering concrete, and operating mechanism such that leakage will not occur when valves are closed.
   10. Equip each mixer with device for automatically measuring, indicating, and controlling time required for mixing:
      a. Interlock device to prevent discharge of concrete from mixer before expiration of mixing period.
   11. Transit-mixed concrete:
      a. Mix and deliver in accordance with ASTM C94.
      b. Total elapsed time between addition of water at batch plant and discharging completed mix:
      c. Not to exceed 90 minutes.
      d. ~~Elapsed time at project site shall not exceed 30 minutes.~~ Delete as per Bid Addendum 06
      d. e. Under conditions contributing to quick setting, total elapsed time permitted may be reduced by the Engineer.
      e. f. Equip each truck mixer with device interlocked to prevent discharge of concrete from drum before required number of turns and furnish device that is capable of counting number of revolutions of drum.
   12. Continuously revolve drum after it is once started until it has completely discharged its batch:
      a. Do not add water until drum has started revolving.
      b. Right is reserved to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. The Contractor will not be entitled to additional compensation because of such increase or decrease.

D. Other types of mixers: For other types of mixers, mixing shall be as follows:
   1. Mix concrete until there is uniform distribution of materials, and discharge mixer completely before recharging.
   2. Neither speed nor volume loading of mixer shall exceed manufacturer's recommendations.
   3. Continue mixing for minimum of 1-1/2 minutes after all materials are in drum, and for batches larger than 1 cubic yard increase minimum mixing time 15 seconds for each additional cubic yard or fraction thereof.

2.06 CONCRETE MIXES

A. General:
   1. Contractor shall develop and provide mix design for each Concrete Class listed in Table 3 of this Section.
   2. Select and proportion mixes and document properties using one of the two methods that follow. Procedures and requirements for use of each alternative are specified in subsequent paragraphs of this Section.
      a. Field experience method.
      b. Trial batch method.
   3. Organize and submit mix designs with data on all constituent materials and products for that mix, for Engineer's review.
   4. Do not place concrete until the mix design for that Concrete Class has been accepted by Engineer.
   5. After acceptance, do not modify accepted mixes or provide new mixes without Engineer's prior review and acceptance of the proposed alternative.
      a. Exception: At all times, adjust batching of water to compensate for free moisture content of the fine aggregate used.
      b. For any change to approved mixes, Engineer may require new trial batching and testing program as specified in this Section before acceptance and use.
      c. For any change to approved mixes, make modifications within limits set forth in this Section.
      d. If there is change in source or quality of any constituent of the concrete class or mix, the revised mix will be considered a new class of concrete and shall require full re-submittal of all data describing mix constituents, design, and testing.
   6. Material sampling, mix designs, trial batch preparation and testing, modifications to mix designs, and any re-testing required to satisfy the requirements of this Section or to obtain satisfactory performance shall be at Contractor's expense and shall not be considered cause for delay.

B. Measurements of materials:
   1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
   2. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
   3. Accuracy of weighing devices: Furnish devices that have capability of providing successive quantities of individual material that can be measured to within 1 percent of desired amount of that material.
   4. Measuring or weighing devices: Subject to review by the Engineer. Shall bear valid seal of the Sealer of Weights and Measures having jurisdiction.

5. Weighing cementitious materials:
    a. Weigh cementitious materials separately.
    b. Cement in unbroken standard packages (sacks): Need not be weighed.
    c. Weigh bulk cementitious materials and fractional packages.
6. Measure mixing water by volume or by weight.

C. Requirements for mix proportioning:
1. Develop and provide mixes that:
    a. Can be readily worked into corners and angles of forms and around reinforcement, without excessive vibration, and without permitting materials to segregate or free water to collect on surface.
    b. Prevent unnecessary or haphazard changes in the consistency of the concrete supplied.
2. Constituent materials:
    a. Provide concrete mixes composed of Portland cement or blended cement, blended aggregates, admixtures and water.
        1) Admixtures required for each concrete class are indicated in Table 3 of this Section. Admixtures not specifically required by that table for a specific Concrete Class are optional and may be included at the discretion of the Contractor based on Contractor's planned means and methods of construction.
    b. In no case shall returned fresh concrete or its constituents be incorporated into concrete batched for the Work.
3. Minimum specified compressive strength:
    a. Minimum specified compressive strength is designated at 28 days, unless otherwise indicated in Table 3 of this Section.
    b. For locations where the placed concrete is adequately protected and is not subjected to loads for an extended period during construction, the Contractor may request that the period for achieving the minimum specified compressive strength be extended to 56 days. If accepted by the Engineer, provide mixes that achieve at least 75 percent of their minimum specified compressive strength after 28 days.
4. Proportions and consistency:
    a. Ratio of water to cementitious materials, and cementitious materials content:
        1) Conform to maximum and minimum cementitous material content requirements specified in Table 3 of this Section.
        2) Cementitious materials content: Consisting of Portland cement or blended cement as indicated in Table 3 of this Section, plus supplemental cementitious materials if aggregate testing indicates potentially reactive aggregates:
            a) Fly ash content:
                (1) Minimum: 15 percent of the total weight of cementitious materials.
                (2) Maximum: 25 percent of the total weight of cementitious materials.
                (3) Class M: provide 20 -25 percent by weight of the total cementitious content as Class F fly ash.
            b) Slag cement content:
                (1) Minimum: 20 percent of the total weight of cementitious materials.

(2) Maximum: 30 of the total weight of cementitious materials.

c) Silica fume content:

(1) Minimum: 4 percent of the total weight of cementitious materials.

(2) Maximum: 10 of the total weight of cementitious materials.

b. Aggregate size and content:

1) Blend aggregates to produce an optimized gradation that combines well-graded coarse, intermediate, and fine aggregates in proportions that maximize the aggregate content of the mix, and that minimize the cement paste content of the mix.

a) Percentage of individual fractions of the combined aggregate gradation retained on individual sieve sizes: Within the range shown in Attachment C - Combined Aggregate Gradation Chart ("Tarantula Curve").

b) Sum of the percentages of individual fractions retained on the No. 8, No. 16, and No. 30 sieves: Greater than 20 percent.

c) Sum of the percentages of individual fractions retained on the No. 30, No. 50, No. 100, and No. 200 sieves: Within the range of 25 percent to 40 percent.

c. Determine bulk density and void content of the combined gradation of aggregates in accordance with ASTM C29. Results for combined aggregates shall not be the summation of results of testing of the individual gradations.

1) Sample the combined aggregate from a flowing aggregate stream or conveyor in accordance with ASTM D75. Take care to ensure that the sample is representative of the proportions of the combined aggregate of the proposed mix.

2) Reduce sample of combined aggregate to test sample size in accordance with ASTM C702, Method A - mechanical splitter or Method B - quartering.

3) Perform bulk density test of combined aggregate in accordance with ASTM C29, Procedure A - rodding.

4) Determine void content of the combined aggregate in accordance with ASTM C29, Procedure A - rodding. Specific gravity of the combined aggregate shall be determined in accordance with ASTM C136.

d. Paste content: Limited to the following:

1) Class A mixes without air entrainment: Maximum 28 percent measured by volume.

2) Paste content shall be limited to 175 percent of the void content of the combined aggregate gradation determined by ASTM C29.

e. Total water content:

1) Not exceeding the water to cementitious material ratio specified in Table 3 of this Section.

2) Not exceeding 245 pounds of water per cubic yard of concrete for Class A mix.

f. Coarseness/workability (Shilstone Method):
   1) Proportion mixes to fall into the "Optimal" zone (Zone II) when plotted on the Coarseness Factor Chart ("Coarseness Factor" versus "Workability Factor") included as Attachment B - Coarseness Factor Chart to this Section. Provide plot for each Class A mix to be used in the Work.
   2) Coarseness factor (CF) for each mix shall be calculated as the percent of the combined aggregate gradation retained on the 3/8 inch sieve, divided by the percent of the combined aggregate gradation retained on the Number 8 sieve, multiplied by 100: or:

$$CF = \frac{(\%\ \text{retained on 3/8” sieve})}{(\%\ \text{retained on No. 8 sieve})} \times 100$$

   3) Workability factor (WF) for each mix shall be the percent of the combined aggregate gradation retained on the Number 8 sieve, adjusted for cement content in the mix.
      a) Determine volume of total cementitious material in the mix.
      b) For each 94 pounds of cement content above 564 pounds per cubic yard, increase workability factor by 2.5 units.
      c) For each 94 pounds of cement below 564 pounds per cubic yard, decrease workability factor by 2.5 units.
      d) Proportion adjustment factor by linear interpolation for each fraction of 94 pounds above or below the 564 pound basis.
      e) Example:
         650 pounds per cubic yard = 564 pounds + 86 pounds.
         Adjustment = (86 lb / 94 lb) x 2.5 = + 2.28.

D. Concrete Classes for use in the Work:
   1. Provide concrete classes listed in Table 3 of this Section.
   2. Provide normal weight concrete, having minimum weight of 140 pounds per cubic foot, unless otherwise noted.
   3. Pumped concrete:
      a. Provide pumped concrete that complies with all requirements of this Section.
      b. Mixes placed by pumping shall be considered a sub-class of each concrete class listed in Table 3 of this Section. Prepare and submit a separate mix design for each mix to be placed by pumping.
   4. Class M concrete: In addition to the requirements of Table 3 of this Section, conform to the requirements for Class A concrete.

Table 3: Concrete Classes

Concrete Class[1]	Minimum Specified Compressive Strength at 28 days, f'c [2] (pounds per square inch)	Ratio of water to cementitious materials[3] (minimum - maximum).	Cementitious Materials Content (pounds per cubic yard of concrete by weight)[4]	Cement Type (Low-Alkali)	Maximum Chloride Content (percent by weight of cement)	Maximum Size of Coarse Aggregate (ASTM C33)	Air Entrainment (percent), (n/a: not applicable)	Admixtures required[4,5]	Slump Range (inches)
A	4,500	0.40 to 0.42	535 to 575	C150 or C595[6]	0.10	#57	n/a	WRA, PRAH, CIA	2 to 4
C	4,500	0.40 to 0.42	535 to 575	C150 or C595[6]	0.10	#57	n/a	WRA	2 to 4
CE	4,500	0.40 to 0.42	535 to 575	C150 or C595[6]	0.10	#57	n/a	WRA, CA	2 to 4
M	Same as Class A								

Notes:

(1) Sub classes within major concrete classes are designated as follows:

NA: Without air entrainment.

(2) At locations where concrete will not be subjected to load from other elements of the structure or from Contractor's placing and/or backfilling operations, maximum time period for achievement of specified compressive strength may be extended to 56 days when accepted by the Engineer.

(3) W/C Ratio = Ratio of water to cementitious materials by weight. Include weight of admixtures in the water content of the mix when the quantity of the admixtures exceeds 10 ounces per 100 pounds of cement.

(4) Cementitious material includes Portland cement plus supplemental cementitious materials. If trial batch testing demonstrates that the required strength cannot be met at 28 or 56 days with the specified combined aggregate gradation and the paste content limits, cementitious material content may be increased with Engineer's approval if a shrinkage-reducing admixture (SRA) is included in the mix design.

(5) Admixtures are designated as follows:

SRA: Shrinkage-reducing admixture.
CIA: Corrosion-inhibiting admixture.
CA: Coloring admixture.
WRA: Water-reducing admixture.
ASR: Alkali-silica reaction inhibiting admixture.
PRAH: Permeability-reducing admixture for concrete exposed to hydrostatic conditions.

(6) ASTM C150, Type II or ASTM C595, Type IL(<15)(MS).

E. Install Concrete Classes in accordance with the following requirements unless otherwise indicated on the Drawings.
   1. Class A concrete: Structural concrete.
      a. Use Class A concrete at all locations unless other Classes are specified or indicated on the Drawings.
   2. Class C concrete:
      a. Class C concrete may be used for fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and where indicated on the Drawings.
      b. Use for concrete pavement, cart paths, curbs, gutters, and sidewalks.
   3. Class CE concrete: Use Class CE for electrical conduit encasements.
   4. Class M concrete: Use Class M concrete for mass concrete at placements when the minimum dimension exceeds 36 inches.

F. Concrete mix design documented by field experience:
   1. Mix design:
      a. Prepare preliminary mix design for each Concrete Class. Submit mix design with product and testing data for materials to be used in the mix for Engineer's review.
   2. Historical records for similar mix.
      a. Determinations of similarity of materials and proportions between historical and proposed mixes shall be by the Engineer, and that shall be final.
      b. Historical record - Materials:
         1) Submit with each mix design the following data for a previously-supplied concrete mix similar to that proposed for this Work.
         2) Records demonstrating that the previously supplied mix included similar materials and proportions as those of the proposed mix.
            a) Documentation that the same concrete supplier will provide both mixes.
            b) Documentation that the materials used was from the same suppliers and had essentially the same properties, demonstrated by test data, as those proposed.
            c) Documentation that proportions of materials in the record mix are essentially the same as those proposed and that the specified compressive strength of the record mix is within 1,000 pounds per square inch of that required by this Section.
            d) Concrete supplier's statement describing any changes made to production of the record mix during the time period reported.
            e) Concrete supplier's statement that preparation and quality control procedures for the record mix were essentially the same as those to be employed for this Work.
      c. Historical record - Testing:
         1) Submit with each record mix, corresponding test data for slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.
         2) Only records satisfying the following requirements will be accepted.
            a) All tests were conducted within a period of 1-year preceding the date of the submittal.

b) All tests were conducted over a period including not less than 45 days.
c) The record of compressive strength testing includes at least 30 tests for slump and 28-day compressive strength.
d) The record of compressive strength tests is consecutive. In other words, it includes all tests conducted on the subject mix within the 1-year time period described above (not just selected tests during that period).
e) Submit concrete supplier's sworn statement confirming that all tests for the record mix have been reported.
f) Tests for drying shrinkage are described in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing,"
g) Tests for chloride ion permeability are described in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing.
h) Provide supplementary testing if requested by Engineer.

d. For mixes determined to be similar and to have an acceptable test history, acceptance criteria shall be as follows:
1) Acceptance criteria:
a) Slump: All tests within limits specified for record mix.
b) Compressive strength: Average compression strength for tests, as determined by ACI 318 and ACI 350 not less than minimum required average strength.
c) Drying shrinkage: Within limits stated in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing."

G. Concrete mix design documented by trial batch preparation and testing:
1. Mix design and trial batches:
a. Prepare preliminary mix design for each Concrete Class. Submit mix design with product and testing data for each combination of materials and proportions to be used for Engineer's review.
1) Determine water content of the mix based on curves showing the relation between water-cementitious materials ratio and the 7 and 28 day compressive strength of the concrete.
2) Determine each curve using 4 or more points, each representing the average compressive strength value of at least 3 specimens tested at each age.
b. After materials and proposed mix designs have been accepted by Engineer, have trial batches for each concrete mix design prepared by Contractor's testing laboratory.
1) Prepare trial batches using the cementitious materials, aggregates, and admixtures proposed to be used for the Work.
2) Provide batches of sufficient quantity to determine slump, workability, consistency, setting time, and finishing characteristics, and to provide sufficient specimens for testing.

c. For each trial batch, make and test specimens to determine and report slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.
    1) If trial batches do not produce concrete conforming to the specified requirements for slump, strength, workability, consistency, drying shrinkage, restrained shrinkage, and finishing, change mix proportions and, if necessary, sources of materials.
    2) Make additional trial batches and perform additional tests until a batch that conforms to requirements of this Section is produced.

2. Testing - Slump:
    a. Determine slump in accordance with ASTM C143.
    b. Acceptance criterion: Slump within range specified.
3. Testing - Compressive strength:
    a. Prepare 4 inch diameter by 8 inch long cylinders in accordance with ASTM C31 for tests specified in this Section.
    b. Determine average compressive strength:
        1) Test at least 12 cylinders from each trial batch for compressive strength in accordance with ASTM C39.
        2) Test 4 cylinders at 7 days, another 4 at 28 days, and another 4 at 56 days.
        3) Calculate average compression strength for 7 day tests, for 28 day tests, and for 56 day tests.
        4) Calculate ratios for:
            a) Average 7 day strength to average 28 day strength.
            b) Average 28 day strength to average 56 day strength.
    c. Determine the required average compressive strength for each mix, f'cr, as described in the following paragraphs:
        1) Calculate required average compressive strength (f'cr) based on the minimum specified 28-day compressive strength, f'c, plus a standard deviation determined from the test history available for that mix.
        2) Determine f'cr as specified in ACI 318 and ACI 350, except as modified in the following paragraphs.
            a) Where 15 or more 28-day compressive strength tests are available, calculate standard deviation as described in the preceding paragraphs for "concrete mix design documented by field experience." Add this standard deviation to the specified minimum compressive strength to determine the required average compressive strength (f'cr) for the mix.
            b) Where fewer than 15 compressive strength tests at 28-days are available, determine minimum required compressive strength, (f'cr) from Table 4 of this Section.

Table 4: Required Average Compressive Strength, Fewer than 15 Tests Available

Minimum Specified Compressive Strength, f'c (pounds per square inch)	Required Average Compressive Strength, f'cr (pounds per square inch)
Less than 3,000	f'c + 1,000
3,000 to 5,000	f'c + 1,200
Over 5,000	f'c + 1,400

d. Acceptance criterion: Average compressive strength of the 4 cylinders tested at 28 days, or of the 4 cylinders tested at 56 days when permitted by the Engineer, shall equal or exceed the required average compression strength, f'cr for that concrete mix design.

4. Testing – Chloride content:
   a. Submit test results showing that the concrete mix contains water-soluble chloride ion content contributed from the constituents including water, aggregates, cementitious materials, and admixtures is less than the limit specified in Table 3 of this Section. Test shall be performed in accordance with ASTM C1218 at age between 28 and 42 days.
5. Testing - Drying shrinkage - Prism specimens:
   a. Class A and Class M: From trial batch for each mix, prepare 10 drying shrinkage specimens in accordance with ASTM C157 Divide specimens into 2 groups of 5 specimens each: One group including shrinkage-reducing admixture, and one group without shrinkage-reducing admixture.
   b. Prepare, cure, and test both groups in accordance with ASTM C157, except as modified in the following paragraphs.
      1) Remove drying shrinkage specimens from molds at age of 23 hours plus or minus 1 hour after trial batching.
         a) Immediately place them in lime-saturated water maintained at 73 degrees Fahrenheit plus or minus 3 degrees for at least 30 minutes.
         b) Remove specimens from the water, and wipe with a damp cloth.
         c) Measure to nearest 0.0001 inch to determine original length.
         d) Record measurements and re-submerge specimens in lime-saturated water at 73 degrees Fahrenheit plus or minus 3 degrees for moist curing.
      2) Maintain submerged curing conditions at 73 degrees Fahrenheit plus or minus 3 degrees for 7 days. 7 days after batching, remove specimens from water and repeat measuring procedures.
      3) Immediately store specimens in a humidity controlled room maintained at 73 degrees Fahrenheit plus or minus 3 degrees, and at 50 percent relative humidity plus or minus 4 percent for remainder of the test.
      4) At periods of 14, 21, 28 and 56 days after batching, remove specimens from curing room and repeat measurements.
   c. Drying shrinkage test report:
      1) Report measurements of all specimens at 1, 7, 14, 21, 28, and 56 days after batching.
      2) Using measured length at 7 days as base length for drying shrinkage, calculate the following for each measuring period:
         a) Drying shrinkage of each specimen. Determine as difference between the 7-day base length and measured length for each period.
         b) Average of these differences. If drying shrinkage of any specimen departs from the average of the measurements for each period by more than 0.0004 inch, disregard results obtained from that specimen.
         c) Percentage of drying shrinkage from batching to date of measurement.

d. Drying shrinkage acceptance criteria:
    1) Average shrinkage of trial batch concrete specimen group at 28 days after batching, when measured and cured as indicated, shall not exceed 0.035 percent.
e. Mixes accepted by Engineer:
    1) Retain drying shrinkage test specimens. Bag in re-sealable plastic bags and submit to Engineer.
    2) Indicate trial batch identifier, specimen number, and date of final measurements on each specimen bag.

6. Testing – Resistance to chloride ion penetration:
    a. Submit test results for resistance to chloride ion penetration in accordance with ASTM C1876. Test two samples:
        1) Concrete mix with permeability reducing admixture.
        2) Concrete mix without permeability reducing admixture.
    b. Condition samples after curing for 28-days by soaking in potable water for 14 days.

2.07 SOURCE QUALITY CONTROL

A. Sample and test materials in accordance with the following requirements:
    1. Sampling, testing, and reporting frequency:
        a. In preparation for mix design submittals and trial batch tests.
        b. Whenever there is a change in source of the material, or a significant change in the characteristics or quality of materials from the same source.
        c. For each 10,000 cubic yards of concrete mix produced.
        d. At intervals not exceeding 90 calendar days, unless otherwise specified in the following paragraphs.
    2. Supplemental cementitious materials.
        a. Sample and test fly ash in accordance with ASTM C311.
        b. Sample and test slag cement in accordance with ASTM C989.
        c. Sample and test silica fume in accordance with ASTM C1240.
    3. Aggregate:
        a. Sample combined aggregate in accordance with ASTM D75 and D3665, and test for gradation in accordance with ASTM C136.
        b. At least once every 30 days, and when requested by the Engineer.
        c. Submit test results.
    4. Cementitious materials:
        a. Sample and test Cementitious materials and provide mill certificates demonstrating compliance with ASTM C150 or ASTM C595, and additional requirements of this Section.
            1) Determine alkali content by method set forth in ASTM C114.
        b. At least once every 90 days, and when requested by the Engineer.
        c. Submit test results.

B. Batch materials in accordance with the following requirements:
    1. Concrete batch weights: Control and adjust so as to secure maximum yield, and at all times maintain proportions of concrete mix within specified limits.
    2. Aggregates:
        a. Obtain aggregate from a source capable of providing uniform quality, moisture content, and grading during any single day's operation.

b. Furnish satisfactory means at batching plant for checking moisture content of fine aggregate for each batch.

3. Admixtures:
   a. Batch solutions using mechanical batcher capable of accurate measurement.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare and submit mix designs for each Concrete Class indicated in Table 3 of this Section.

B. Submit proposed sequence of concrete placements. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested by the Contractor and accepted by the Engineer.
   1. Use construction methods and sequence work to allow concrete placement to reach adequate strength and to be constructed with required support to prevent overstress of the concrete structure during construction.

C. Make provisions for monitoring weather conditions:
   1. Install an outdoor weather station capable of measuring and recording ambient temperature, wind speed, and humidity. Furnish instruments accurate to within 2 degrees Fahrenheit, 5 percent relative humidity, and 1 mile per hour wind speed.
   2. Furnish and use sufficient number of maximum and minimum self-recording thermometers to adequately measure temperature adjacent to the concrete as required in the hot-weather concreting and cold-weather concreting plans.
   3. Monitor the weather forecast beginning at least 48 hours prior to any concrete placement and make provisions for hot weather concreting if those conditions exist or are forecast to exist during the period of placement, finishing, and curing.
      a. Record temperature, relative humidity, and wind speeds for each placement beginning at least 24 hours before scheduled delivery of concrete.

D. Place no concrete without Engineer's prior acceptance of conditions.

E. Notify the Engineer in writing that all preparations are complete and ready for placement of concrete. Such notification shall indicate readiness - not just intention - to place concrete for the designated portion of the Work.
   1. Submit notification to Engineer on forms provided by or acceptable to the Engineer and bearing the signature of Contractor's superintendent.
      a. Sample form is included at the end of this Section, see Attachment B - Coarseness Factor Chart.
   2. Submittal of notification will be Contractor's certification that preparations are complete and in accordance with the Contract Drawings and Specifications.
   3. Provide notification for Engineer to make final observations at the locations of concrete placements not less than 24 hours before commencing placement of concrete.

3.02 CONCRETE JOINTS

A. Locations of joints are indicated on the Drawings.
   1. In order to preserve strength and watertightness of structures, make no other joints, except as authorized by the Engineer.
   2. Construct joints where indicated, and as indicated on the Drawings.
   3. Where joint locations are not indicated on the Drawings, submit Contractor's proposed locations for Engineer's review and acceptance. Provide construction joints in slabs and walls at intervals not greater than 35 feet.

B. Time between placements of adjacent concrete separated by joints.
   1. Provide not less than 3 days (72 hours) between placement of adjacent sections for the following:
      a. Slabs.
      b. Walls.
   2. Provide not less than 7 days (168 hours) between placement of the lower and upper pours for the following:
      a. Walls over slabs.
      b. Slabs over walls.

C. Edges of joints:
   1. Provide joints have edges detailed as indicated on the Drawings.
   2. Protect wall and slab surfaces at edges from concrete splatter. Thoroughly clean adjacent surfaces after completion of each placement.

D. Joint construction:
   1. Preparation of forms:
      a. Provide cleanout holes at base of each wall and column for inspection and cleaning.
      b. Wash forms and adjacent joint surfaces of sawdust, chips, and other debris after forms are built, and immediately before concrete or grout placement.
      c. Should formwork confine sawdust, chips, or other loose matter in such manner that it is impossible to remove them by flushing with water, use a vacuum cleaner for their removal, and then flush cleaned surfaces with water.
   2. Before placing concrete against previously placed concrete, thoroughly clean the prior placement of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter by means of pressure washing.
   3. Provide and install waterstops, expansion joint material, and other similar materials as indicated on the Drawings and as specified.
      a. Take special care to ensure that waterstops are secured in proper position.
      b. Take special care to ensure that concrete is well consolidated around and against waterstops during placement.
   4. Horizontal joints:
      a. As initial placement over cold joints, thoroughly spread bed of cement grout as specified in Section 03600 - Grouting.
         1) Thickness: not less than 1/2 inch nor more than 1 inch.

b. For wall placements above planned cold joints, placement of cement grout will not be required for locations where the wall mix includes high-range water-reducing admixture (“superplasticizers”), and the Contractor can demonstrate dense concrete joints without voids or honeycomb after the forms are removed.

3.03 MEASURING AND BATCHING MATERIALS

A. Measurements of materials:
   1. Proportion and measure cementitious materials and aggregates by weight.
      a. Weigh cementitious materials separately.
      b. If bulk cementitious materials are used, weigh them on separate visible scale that will accurately register scale load at any stage of weighing operation from zero to full capacity.
      c. Cement in unbroken standard packages (sacks) need not be weighed.
   2. Mixing water: Measure by volume or by weight.
   3. Other mix constituents: Measure by weight, except as otherwise specified or accepted by the Engineer.
   4. Weighing and measuring devices:
      a. Use equipment designed and constructed specifically for that purpose.
      b. Furnish devices capable of weighing successive quantities of individual material measured to within 1 percent of desired weight of that material.
      c. Bearing valid seal of the department of weights and measures for the authority having jurisdiction over the Work.
   5. Measurements and measuring devices:
      a. Subject to review by the Engineer.

B. Batching:
   1. Admixtures shall be added at the concrete batch plant.
   2. Addition of admixtures in the field is permitted only with prior acceptance by the Engineer, and only when the following conditions are satisfied:
      a. The dosage and mixing is personally overseen by concrete supplier's trained technologist.
      b. Adequate mixing is provided after addition.
      c. The maximum time to placement of concrete remains 90 minutes after water added to mix - not 90 minutes after any field additions/adjustments.
      d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

3.04 MIXING AND TRANSPORTING

A. Machine mixing:
   1. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer and ready for complete mixing with all mixing water.
   2. Procedure of mixing cementitious materials with sand, or with sand and coarse aggregate, for delivery to project site for final mixing and addition of mixing water is not permitted.
   3. Remixing of concrete that has started to take its initial set (“retempering”) is not permitted.
   4. Discharge entire batch before recharging.

5. Volume of mixed material per batch: Not exceeding manufacturer's rated capacity of mixer.

B. Transit-mixed concrete:
   1. Mix and deliver in accordance with ASTM C94, except as modified in this Section.
   2. Total elapsed time between addition of water at batch plant and discharging completed mix:
      a. Not to exceed 90 minutes nor 300 revolutions of the mixing drum.
      b. Under conditions contributing to rapid setting, total elapsed time permitted may be reduced by the Engineer.
   3. Temperature - minimum and maximum allowable during mixing and transporting:
      a. Minimum: 50 degrees Fahrenheit.
      b. Maximum: 90 degrees Fahrenheit.
   4. Continuously revolve drum after it is started until it has completely discharged its batch.
      a. Do not add water until drum has started revolving.
      b. Engineer reserves the right to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.

C. Concrete delivery:
   1. Furnish to the Engineer a delivery ticket for each batch of ready mixed concrete within 24 hours after delivery. Include the following information on each ticket:
      a. Time of day concrete was batched, and time of day that discharge from the truck is complete.
      b. Printed record of the individual weight of each of the following constituents in the batch: fine aggregate, coarse aggregate, cement, pozzolan, and water.
      c. Concrete Class as defined in Table 3 of this Section.
      d. Type, brand, and quantity of each admixture in the batch.
      e. Total volume of water allowed in the mix, volume of mixing water added at the batch plant, volume of mixing water withheld from the mix during batching, and total volume of any water added to the mix after leaving the batch plant.
         1) In no case shall volume of mixing water withheld result in a water/cementitious materials ratio less than the minimum values specified in Table 3 of this Section.
      f. Number of revolutions of transit truck at arrival on site, and total number of revolutions when discharge is complete.
      g. Volume of concrete delivered in the batch.
      h. Numerical sequence of the batch delivered for that placement.
   2. Additional water may be only be added to the mix when the following conditions are fully satisfied:
      a. Batch ticket showing total volume of water already added and maximum volume of water that may be added is available for Engineer’s observation before any additional water is added.

b. Total volume of water in the mix after the addition will be less than the maximum allowable volume of water indicated on the ticket.
c. The full concrete load is still within the truck's mixing drum, and truck has not begun to discharge the load. Under no conditions shall water be added in the field to a partial truckload of concrete.
d. Volume of water added, and time of addition are clearly marked for record on the batch ticket delivered to the Engineer.

3. Addition of admixtures in the field is permitted only with prior approval by the Engineer, and when the following conditions are satisfied:
   a. Dosage and mixing is personally overseen by concrete supplier's trained technologist and admixtures supplier's representative.
   b. Adequate mixing time is provided after addition of admixtures.
   c. The maximum time to placement of concrete remains 90 minutes after water is added to the mix – not 90 minutes after any field additions/adjustments.
   d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

D. Conveying concrete:
1. Convey concrete from mixer to location of final deposit by methods that prevent separation or loss of materials.
2. Use equipment for chutes, pumps, and conveying of concrete of such size and design as to ensure practically continuous flow of concrete, from delivery to the point of placement, without separation of materials.
3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from chute or conveying device.
4. Keep equipment for conveying concrete thoroughly clean by washing and scraping upon completion of any day's placement.

3.05 PLACING AND CONSOLIDATING

A. Preparation:
1. Obtain Engineer’s acceptance of completed preparations before placing concrete.
   a. Notify Engineer in writing that all preparations are complete and ready for placement of concrete. Such indication shall indicate readiness, not just intention, to place concrete for the designated portion of the work.
   b. Submit completed Attachment D - Contractor’s Concrete Placement Checklist Form.
2. Confirm completeness of the following before notification of readiness is given to Engineer:
   a. Place forms, reinforcement, screeds, anchors, ties, and inserts in final position.
   b. Reinforcement is secure and properly fastened in its correct position.
   c. Loose form ties at construction joints have been retightened.
   d. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
   e. Forms have been cleaned of debris and form release agents are applied as specified.

3. Preparation for placement of footings and slabs on grade:
    a. Do not place concrete on ground or compacted fill until subgrade is in moist condition acceptable to the Engineer.
    b. If necessary, sprinkle subgrade with water not less than 6 or more than 20 hours in advance of placing concrete.
    c. If subgrade surface becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
    d. Do not place concrete if subgrade is muddy or soft.
4. Keep sufficient protective coverings on hand at all times for protection of concrete during and after placement.
    a. Protect concrete placed before rain to prevent water from coming in contact with such concrete.
    b. Protect concrete placed before winds to prevent excessive drying or embedment of debris in the finished surfaces.

B. Concrete placement:
1. Do not place concrete:
    a. With slump outside the limits specified in Table 3 of this Section.
    b. In which initial set has occurred, or that has been retempered.
    c. During rainstorms or high velocity winds.
2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
    a. Do not deposit concrete in large quantities in one place, and then work material along forms with vibrator or by other methods.
3. Do not drop concrete freely into place from height greater than 5 feet. Use tremies for placing concrete where drop is over 5 feet.
4. Place concrete on slopes starting from bottom of slope and working upward.
5. Place concrete in horizontal lifts not exceeding 24 inches in depth and bring up evenly in all parts of forms.
6. After concrete placement begins, continue in a continuous operation without significant interruption until the end of the placement. Plan and implement precautions to prevent any delay, between layers or adjacent volumes, from exceeding 20 minutes.
7. If concrete is to be placed over previously placed concrete and more than 20 minutes has elapsed, spread layer of cement grout over surface before placing additional concrete. Provide grout layer thickness of not less than 1/2 inch, nor more than 1 inch.
8. Placement of concrete for slabs, beams, or walkways:
    a. If cast monolithically over walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
    b. Allow set time of not less than 1 hour for shrinkage.
        1) During waiting time, keep top surface of concrete moist, but not wet.
        2) Do not permit water to pond or stand on the surface.
        3) Do not coat surface with evaporation retarders or curing agents.
    c. Start placement above wall or column with layer of cement grout as described in the preceding paragraph.

C. Consolidating concrete:
1. Consolidate concrete with aid of acceptable mechanical vibrators.
2. Thoroughly consolidate concrete around reinforcement, pipes, or other shapes built into the work.

3. Provide sufficiently intense vibration to cause concrete to flow and settle readily into place and to visibly affect concrete over radius of at least 18 inches.
4. Vibrators:
    a. Keep sufficient vibrators on hand at all times to vibrate concrete as placed.
    b. In addition to vibrators in actual use while concrete is being placed, have on hand a minimum of 1 spare vibrator in operable condition.
    c. Do not place concrete until it has been confirmed that all vibrating equipment, including spares, are in operable condition.
5. Place concrete solidly against forms and concrete surfaces, leaving no voids or honeycomb.
6. Make concrete solid, compact, and smooth. If for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the Engineer.
7. Do not over-vibrate so as to produce segregation.

3.06 FINISHING CONCRETE

A. Provide concrete finishes in accordance with Section 03366 - Tooled Concrete Finishing unless otherwise indicated on the Drawings.

B. Liquid evaporation retardant:
1. Under conditions that result in rapid evaporation of moisture from the surface of the concrete, coat the surface of the concrete with a liquid evaporation retardant immediately after screeding.
2. Conditions that result in rapid evaporation of moisture are defined as any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.1 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI 305R, and included as Attachment A - Menzel Formula and Nomograph to this Section.
3. Apply evaporation retardant again after each finishing operation as necessary to prevent drying shrinkage cracks.
4. Do not work evaporation retardant into the surface of the concrete.
5. Do no use evaporation retardant as finishing aid (to rehydrate surface a creamy state for finishing).

C. Concrete sealer:
1. Floors and slabs to receive concrete sealer: See Room Finish Schedule on the Drawings, and Section 03366 - Tooled Concrete Finishing.

3.07 CURING

A. Cure concrete by methods specified in this Section.

B. For placements of Class M concrete, as specified in Section 03703 - Thermal Control of Concrete for additional requirements.

C. Keep concrete continuously moist and at an average daily temperature of at least 50 degrees Fahrenheit for a minimum of 7 days after placement.
   1. Provide at least 350 degree days of curing (350 degrees times 7 days of 24 hours each).
   2. If hourly temperatures at any surface of a concrete placement drop below 50 degrees Fahrenheit during the curing period, count the period below 50 degrees Fahrenheit as zero degrees, and extend the curing time to compensate.

D. Schedule of curing methods:
   1. Cure the following concrete surfaces using water curing, or plastic membrane curing.
      a. Floor surfaces of water containment structures.
      b. Surfaces where additional concrete will be placed over or against the surface, including concrete joints.
      c. Surfaces where grout or other toppings will be placed over the surface.
      d. Slabs scheduled to receive concrete sealer, or other bonded or adhered architectural finishes.
      e. Formed surfaces scheduled to receive coatings, paint, adhered masonry, cementitious materials, or other similar finishes, and where formwork is removed within 7 days after concrete placement.
      f. Horizontal concrete surfaces at tops of walls.
   2. Cure the following concrete surfaces by water curing, plastic membrane curing, or sprayed curing membrane. Selection of methods shall be at the Contractor's option.
      a. Surfaces not listed in the preceding paragraph.

E. Water curing:
   1. Keep surfaces of concrete constantly and visibly wet, day and night, for period of not less than 7 days.
      a. Each day forms remain in place will be counted as 1 day of water curing.
      b. Do not loosen form ties during period when concrete is cured by leaving forms in place. No further curing credit will be allowed for forms remaining in place after contact has been broken between concrete surface and forms.
   2. Begin water curing as soon as concrete attains initial set.
   3. Maintain a wet surface by ponding, continuous sprinkling, covering with saturated burlap, or otherwise saturating the surface by means acceptable to Engineer.
      a. Flood top of walls with water at least 3 times per day and keep surfaces moist at all times during 7 day curing period.
      b. Provide plastic sheet material over surfaces if required to maintain a wet surface during arid or windy conditions. See plastic membrane curing requirements for additional details.
   4. Use water having a temperature within 20 degrees Fahrenheit of the temperature of concrete, and not lower than the minimum temperature allowed for the concrete surface during curing.

F. Plastic membrane curing:
   1. Install plastic membrane as soon as concrete is finished and can support limited pedestrian traffic without damage.

2. Cover entire surface of finished concrete with membrane.
3. Anchor membrane to prevent uplift from wind or air trapped below the sheet.
4. Fully seal joints and edges to provide full seal around perimeter.
5. Keep concrete under plastic membrane moist, regularly monitoring surfaces and adding supplemental moisture if necessary. Add water as specified for water curing.

G. Sprayed membrane curing compound:
   1. Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
      a. If more than 1 hour elapses after removal of forms, do not use membrane curing compound. Instead, provide water curing for not less than 7 days.
      b. Do not remove sprayed membrane curing compound from concrete in less than 7 days after initial application.
      c. When application of curing compound at concrete joints is accepted by Engineer, take care to apply curing compound to all surfaces along full profile of joints.
   2. Apply curing compound by mechanical, power operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
      a. Apply curing compound in at least 2 coats.
      b. Apply each coat in direction turned 90 degrees from application direction of the preceding coat.
      c. Apply curing compound in sufficient quantity so that concrete has uniform appearance and its natural color is effectively and completely concealed immediately after spraying.
      d. Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
   3. Thickness and coverage of curing compound:
      a. Provide curing compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
      b. Contractor is cautioned that method of applying curing compound specified in this Section may require more curing compound than normally suggested by manufacturer of curing compound and is more than is customary in the trade. Apply amounts specified in this Section, regardless of manufacturer's recommendations or customary practice.
   4. If Contractor desires to use a curing compound other than specified product, coat sample areas of concrete wall with proposed curing compound, and also coat similar adjacent area with the specified compound in the manner specified, for comparison:
      a. If proposed sample is not equal or better, in opinion of the Engineer, the proposed substitution will not be allowed.
   5. Removal of curing compound.
      a. After curing period is complete, remove curing compound placed on surfaces that will receive additional concrete, including all concrete joint surfaces, by heavy sandblasting or by other means acceptable to Engineer. Complete removal and cleanup prior to placing any new concrete against the surface.
      b. Where additional finishes will be applied over concrete surfaces, unless otherwise recommended by the manufacturer of the finish to be applied, remove curing compound by sandblasting. Provide blasting as necessary to fully remove curing compound.

6. Prior to final acceptance of the work, remove, by sandblasting or by other method acceptable to the Engineer, any curing compound on surfaces exposed to process water or exposed to view, so that only natural color of finished concrete is visible and uniform over the entire surface.

3.08 PROTECTION

A. General:
   1. Keep forms in place, as specified in the following paragraphs, to provide curing and to protect concrete surfaces and edges from damage.
   2. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified.

B. Form removal:
   1. Do not remove forms from concrete which has been placed when outside ambient air temperature is below 50 degrees Fahrenheit until the following conditions are satisfied:
      a. Concrete has sufficient strength to allow form removal without damage to surfaces.
      b. At least 48 hours have elapsed since the end of concrete placement.
      c. Provisions are in place to maintain moisture for curing concrete, and temperature at or above the required minimum curing temperature specified.
   2. Vertical forms:
      a. Retain in place for a minimum of 24 hours after concrete is placed.
      b. If concrete has sufficient strength and hardness to resist surface or other damage after 24 hours, forms may be removed.
   3. Other forms supporting concrete, and shoring: Retain in place as follows:
      a. Formed sides of footings: 24 hours minimum.
      b. Formed vertical sides of beams, girders, and similar members: 48 hours minimum.
      c. Forms below slabs, beams, and girders: Until concrete strength reaches specified strength f'c or until shoring is installed.
         1) Shoring for slabs, beams, and girders: Shore until concrete strength reaches minimum specified 28-day compressive strength.
   4. Wall bracing: Brace walls until strength of concrete beams and slabs laterally supporting wall reaches minimum specified 28-day compressive strength.

C. Loading of concrete members:
   1. Placement of loads on or against green concrete is not permitted.
   2. Do not place soil against walls, or fill over the top of concrete until conditions designated in the following paragraphs are satisfied:
      a. Walls have been cast to their full height in the structure and have achieved their minimum specified 28-day compressive strength.
      b. Connecting slabs and beams that brace the walls are in place, are complete, and (in the case of concrete) have achieved their minimum specified 28-day compressive strength.

3.09 HOT WEATHER CONCRETING

A. Implement hot weather concrete procedures during periods of hot weather as defined in this Section.
   1. Comply with the recommendations of ACI 305R and this Section.

B. If placements during hot weather are expected, and when requested by the Engineer, prepare a hot weather concreting plan. Maintain at least 1 copy on site. Provide plan for review if requested by the Engineer.
   1. Include procedures for batching, delivery, placement, curing, protection, and monitoring and recording the temperature of the concrete and the surrounding environment.
   2. Describe procedures to be implemented in the event of abrupt changes in weather conditions, or in the event of equipment failure.
   3. Review hot weather concreting plan during pre-construction meeting. Make provisions to address any concerns expressed by Engineer before beginning concrete placements.

C. Preparation:
   1. Do not place concrete against forms, reinforcement, or embedments with a surface temperature greater than 120 degrees Fahrenheit.
      a. If necessary, to maintain maximum concrete temperature during placing, cool forms and reinforcement to temperature below 90 degrees Fahrenheit using water or shades.
      b. Do not allow water to puddle in forms or placement areas.
   2. Moisten forms or subgrade to maintain a saturated surface without standing water or soft spots.
   3. Provide windbreaks, shades, fog spray, sprinkling, wet cover, or other means required to protect concrete from premature loss of moisture and rapid temperature gain.

D. Batching and delivery:
   1. Retarding admixtures will not be permitted.
   2. Temperature of concrete delivered for placement shall not exceed 90 degrees Fahrenheit.
      a. Maintain uniform temperature in the mix below this level during batching, delivery, placing, and consolidation.
      b. Temperature of mix, even if below the maximum allowable temperature specified, shall be maintained at a level to avoid loss of slump, flash setting, or cold joints in placements.
   3. If necessary:
      a. Mix water may be chilled or replaced with ice to maintain mix temperature. Where mix water is replaced with ice, provide replacement at a 1 to 1 ratio by weight.
      b. Shade transit mixed concrete trucks, or cool mixing outside of container with water to control temperature of concrete.

E. Placing and finishing:
   1. Place and finish concrete promptly. Place so that vertical lift lines will not be visible in exposed concrete surfaces.

2. Provide plastic sheeting, fog nozzles, shades or other means to reduce concrete temperature and protect from moisture loss.
3. For placements of Class M concrete, use fog sprayers to reduce ambient air temperature and increase humidity during concrete placement.

F. Protection and curing:
1. Furnish and locate maximum/minimum temperature recording thermometers in sufficient numbers to confirm concrete temperatures over full area and edges of concrete.
2. Flatwork: Protect and cure using water curing methods as specified in this Section.
a. Water curing:
1) Keep concrete continuously wet and make provisions for runoff.
2) For sprinkling or soaker hoses, maintain temperature of water as close as possible to the temperature of the concrete to minimize effects of thermal shock.
3. Formed surfaces: Protect and cure using forms left in place or membrane curing methods as specified in this Section.
a. Cover forms and keep continuously moist for at least 24 hours after placement.
b. Loosen forms as soon as this can be accomplished without damaging the concrete.
c. Maintain continuously moist surfaces by fogging or spraying with water, or by application of curing compound as specified.

3.10 FIELD QUALITY CONTROL BY CONTRACTOR

A. Provide quality control over the Work of this Section as required by Section 01450 - Quality Control.

B. Temperature Monitoring Program:
1. For placements of Class M concrete, execute temperature monitoring program required in Section 03703 - Thermal Control of Concrete.

C. Field tests:
1. During progress of construction, provide testing to determine whether the concrete, as being produced, complies with requirements specified.
2. Sampling and testing shall be performed by Contractor's testing laboratory. See Section 01455 - Regulatory Quality Assurance - Special Tests and Inspections for requirements.
a. Cooperate in testing by allowing free access to the Work for testing laboratory to sample and test materials.
b. Provide full access for Engineer to observe concrete sampling and testing at any time.
c. Contractor is responsible for providing care of and curing conditions for test specimens in accordance with ASTM C31 until specimens are collected by testing laboratory.
d. Provide 4 firmly braced, insulated, heated, closed wooden curing boxes, each sized to hold 10 specimens. Include hot weather temperature control thermostat for initial curing and storage from time of fabrication through shipment to Owner's testing laboratory.

3. Testing shall include:
    a. Sampling of concrete in accordance with ASTM C172.
    b. Temperature of concrete at delivery in accordance with the requirements of ASTM C1064 and as specified in this Section.
    c. Slump of concrete using slump cone in accordance with requirements of ASTM C143. Test slump at the following intervals:
        1) At the beginning of each placement.
        2) As often as necessary to keep slump within the specified range, but not less than every 6th truck.
        3) When requested to do so by the Engineer.
        4) Observe concrete during slump test for signs of segregation.
            a) Observe concrete to see if mortar or moisture flows from slumped concrete.
            b) Reject concrete if mortar or moisture flows out of mix.
    d. Unit weight of concrete in accordance with ASTM C138.
    e. Compressive strength in accordance with ASTM C39. Required number of cylinders is as follows:
        1) Not less than 6 cylinder specimens, 4 inches in diameter by 8 inches long, will be tested for each 150 cubic yards of each class of concrete, with minimum of 6 specimens for each class of concrete placed; not less than 6 specimens for each half day's placement; and not less than 2 sets of 6 specimens for each structure.
        2) 1 cylinder will be broken at 7 days, 1 at 14 days, and 3 at 28 days. The 6th cylinder may be used to evaluate strength after 28 days if requested by the Engineer.
        3) Retain and store "6th cylinders" (tested and untested) at testing laboratory until 56 days. Break “6th cylinder” when directed by the Engineer.
    f. Provide full access for Engineer to observe concrete sampling and testing at any time.

D. Test completed liquid containment structures listed in Section 01759 - Water Leakage Test for Concrete Structures for watertightness.

3.11 FIELD QUALITY CONTROL BY OWNER

A. Provide on-site inspection and field quality assurance for the Work of this Section as specified in Section 01450 - Quality Control.

B. Special tests and inspections: See Section 01455 - Regulatory Quality Assurance except where specified as provided by the Contractor.

C. Field inspections:
1. Required inspections:
    a. Observe construction for conformance to the Contract Documents and the accepted submittals.
2. Records of inspections:
    a. Provide record of each inspection.
    b. Submit copies to Contractor upon request.

D. Field tests:
   1. Engineer may request, at any time, additional testing to confirm that materials being delivered and placed conform to the requirements of the Contract Documents.
      a. If such additional testing shows that the material do not conform to the specified requirements, Contractor shall pay the cost of these tests.
      b. If such additional testing shows that the materials do conform to the specified requirements, Owner will pay the cost of these tests.

3.12 NON-CONFORMING WORK

A. Remove and replace or repair non-conforming and defective work.
   1. Provide repairs having strength equal to or greater than specified concrete for areas involved.
   2. Provide replacement or repair of non-conforming work by means acceptable to the Engineer and at no additional cost to Owner.
   3. Project schedule will not be extended based on work to address non-conforming concrete.

B. Concrete not conforming to the specified requirements for properties of plastic concrete: Remove from the site and replace with conforming materials at no additional cost to Owner.
   1. Temperature: Do not use concrete having a temperature above or below the limits specified in this Section.
   2. Slump: Do not place concrete that does not conform to requirements for slump.

C. Concrete not conforming to the specified requirements for compressive strength:
   1. Concrete is expected to reach a compressive strength equal to or greater than the minimum specified compressive strength f'c in Table 3 of this Section.
   2. Strength of concrete will be considered acceptable if following conditions are satisfied.
      a. Averages of all sets of 3 consecutive strength test results is greater than or equal to the specified compressive strength f'c.
      b. No individual strength test (average of 3 cylinders) falls below the strength specified in Table 6 of this Section.
      c. Where relationships between 7-day and 28-day compressive strength, or between 28-day and 56-day compressive strength, have been provided as part of the mix design submittals:
         1) 7-day strength may be considered as an indication of 28 day strength provided effects of temperature and humidity between 7 day and 28 day are taken into account.

2) 28-day strength may be considered as indication of 56 day strength provided effects of temperature and humidity between 28 days and 56 days are taken into account.

Table 6: Strength Compliance Requirements	
Minimum Specified Compressive Strength, f'c (pounds per square inch)	**Lower Bound of an Individual Compressive Strength Test, (pounds per square inch)**
Less than 5,000	f'c – 500
Over 5,000	f'c – (0.10 x f'c)

3. Non-compliant strength tests:
   a. Mark non-compliant strength test reports to highlight the non-complying results, and immediately forward copies to all parties on the test report distribution list.
   b. Initial treatment may consist of additional curing of affected portion(s) followed by not less than 3 cores at each affected area, taken in accordance with ASTM C42 and ACI 318. Obtain Engineer's acceptance of proposed coring locations before proceeding with that work.
   c. Submit report of compressive strength testing for Engineer's review.
   d. If requested by the Engineer, provide additional cores, and obtain petrographic testing in accordance with ASTM C856. Submit results for Engineer's review.
   e. If additional curing does not bring the average strength of 3 cores taken in affected area to at least specified compressive strength f'c, designate such concrete in affected area will be considered defective.
   f. Engineer may require the Contractor to strengthen defective concrete by means of additional concrete, additional reinforcing steel, or replacement of defective concrete, all at the Contractor's expense.

D. Concrete sections or surfaces with honeycombing and voids:
   1. Provide repairs having surface appearance and finish consistent with that of the surrounding work and acceptable to the Engineer.
   2. Do not patch, repair, or cover defective Work without prior inspection by the Engineer.
   3. Preparation of concrete for repair:
      a. Make no repair until Engineer has accepted methods for preparing surfaces and for making and curing repairs.
      b. Chip out and key-in imperfections in the Work to make them ready for repair.
      c. Coat bonding surfaces and edges of repair area with one of the following bonding agents as accepted by the Engineer.
         1) Epoxy bonding agent as specified in Section 03071 - Epoxies; or
         2) Epoxy resin/Portland cement bonding agent as specified in Section 03072 - Epoxy Resin/Portland Cement Bonding Agent.
   4. Methods of repair:
      a. Dry pack mortar method:
         1) Use for holes having depth nearly equal to or greater than least surface dimension of hole, for cone-bolt holes, and for narrow slots cut for repair.

2) Smooth Holes: Clean and roughen by heavy sandblasting before repair.
3) Install dry-pack mortar as specified in Section 03600 - Grouting.

b. Cement mortar method:
1) Use for holes too wide to dry pack and too shallow for concrete replacement; and for comparatively shallow depressions, large or small, that extend no deeper than nearest surface reinforcement.
2) Install cement mortar as specified in Section 03600 - Grouting.

c. Concrete replacement:
1) Use when holes extend entirely through the concrete section or when holes are more than 1 square foot in area and extend halfway or more through the section.
2) Form, place, consolidate, and cure concrete of same mix as the surrounding work.

E. Leaking construction joints and cracks in concrete walls and slabs:
1. Repair cracks that develop in walls or slabs, and repair cracks that show any signs of leakage until all leakage is stopped.
2. Pressure inject visible cracks in the following areas, other than hairline cracks and crazing, with repair products and methods acceptable to the Engineer.
a. Floors and walls of water bearing structures.
b. Walls and overhead slabs of passageways and occupied spaces where the opposite face of the member is exposed to weather or may be washed down and where the opposite face does not receive a separate waterproofing membrane.
c. Other items not specified to receive separate waterproofing membrane including slabs over water channels, wet wells, reservoirs, and other similar surfaces.
3. Continue pressure injection of cracks as specified until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion or 30 days after date of final repair, whichever occurs later in time.

F. Leaking expansion joints in concrete walls or slabs that include waterstops:
1. Repair any signs of leakage until all leakage is stopped.
2. Pressure inject visible leaks with hydrophilic polyurethane foam resin as specified in Section 03933 - Hydrophilic and Hydrophobic Foam Polyurethane Resin Injection System.
3. Continue pressure injection along joints lines as specified until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion or 30 days after date of final repair, whichever occurs later in time.

G. Walls and slabs at overhead channels that leak or sweat because of porosity or cracks too small for successful pressure injection with epoxy.
    1. Seal on water or weather side by coating using surface-applied sealing system as specified in this Section.
    2. Apply as recommended by manufacturer published instructions. Where concrete continues to sweat or leak, apply additional coats of surface-applied sealing system until the sweating or leaks stop.
    3. Continue application of surface-applied sealing system until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion, or 30 days after date of final repair, whichever occurs later in time.

END OF SECTION

ATTACHMENT A - MENZEL FORMULA AND NOMOGRAPH

MENZEL FORMULA AND NOMOGRAPH

Source: ACI 350R

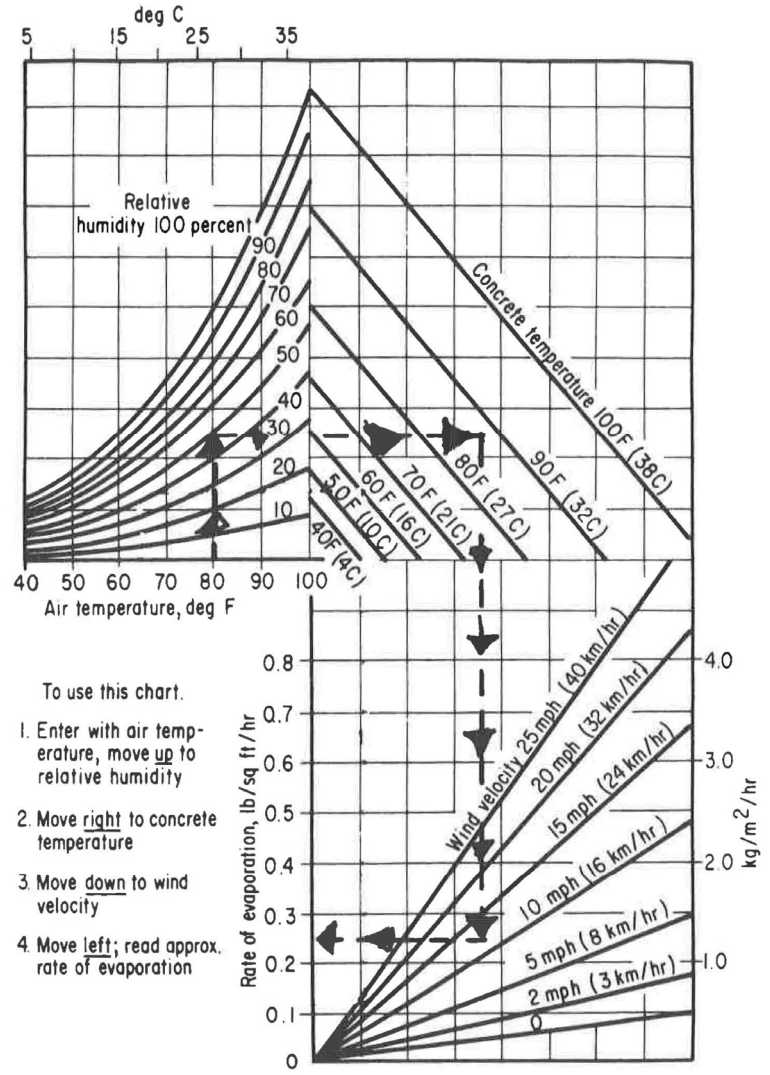


Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind speed on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use this chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/h (1 kg/m²/h), precautions against plastic-shrinkage cracking are necessary (Lerch 1957). Wind speed is the average horizontal air or wind speed in mph (km/h) and should be measured at a level approximately 20 in. (510 mm) higher than the evaporating surface. Air temperature and relative humidity should be measured at a level approximately 4 to 6 ft (1.2 to 1.8 m) higher than the evaporating surface on its windward side shielded from the sun's rays (PCA Journal *1957*).

ATTACHMENT B - COARSENESS FACTOR CHART

COARSENESS FACTOR CHART

Source: ACI 302.1R-15, Figure 8.9.2.2.

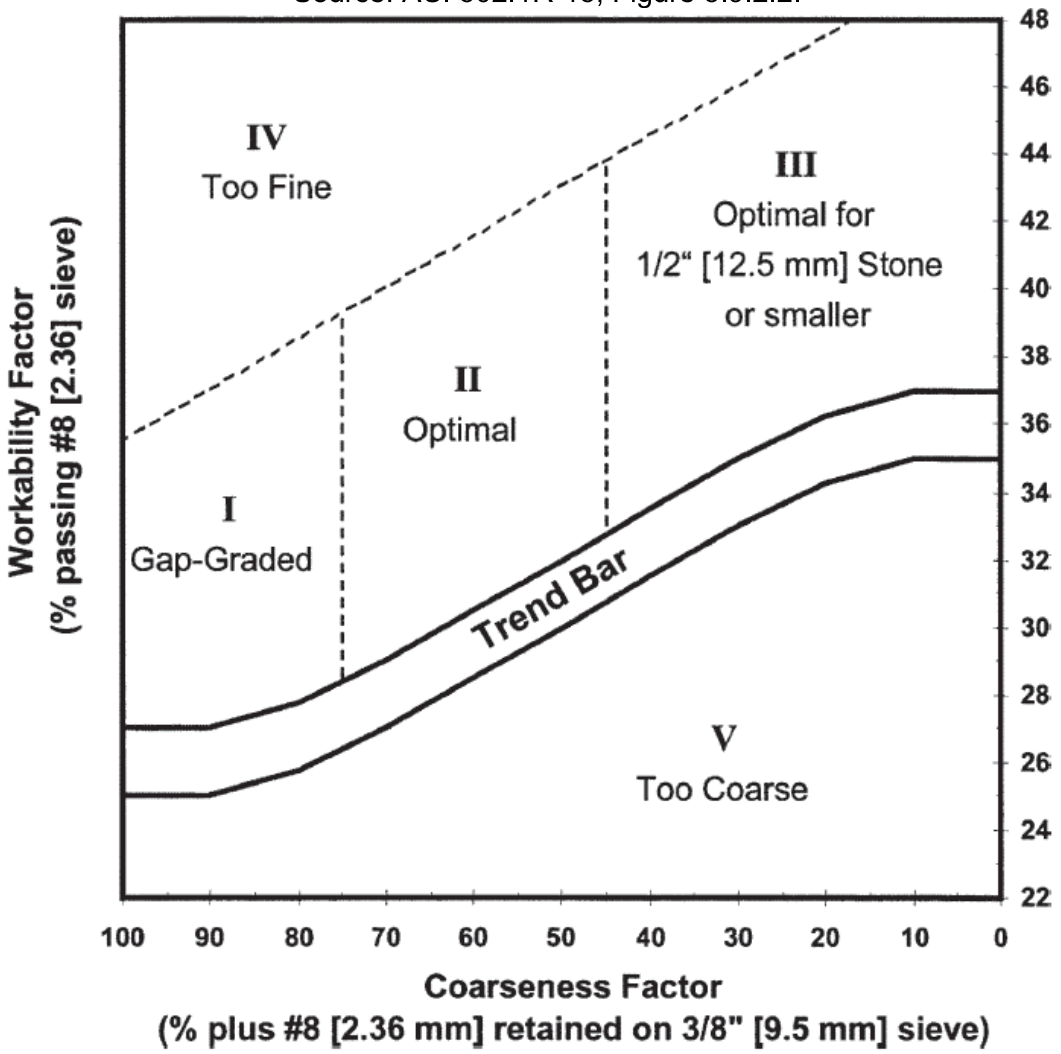
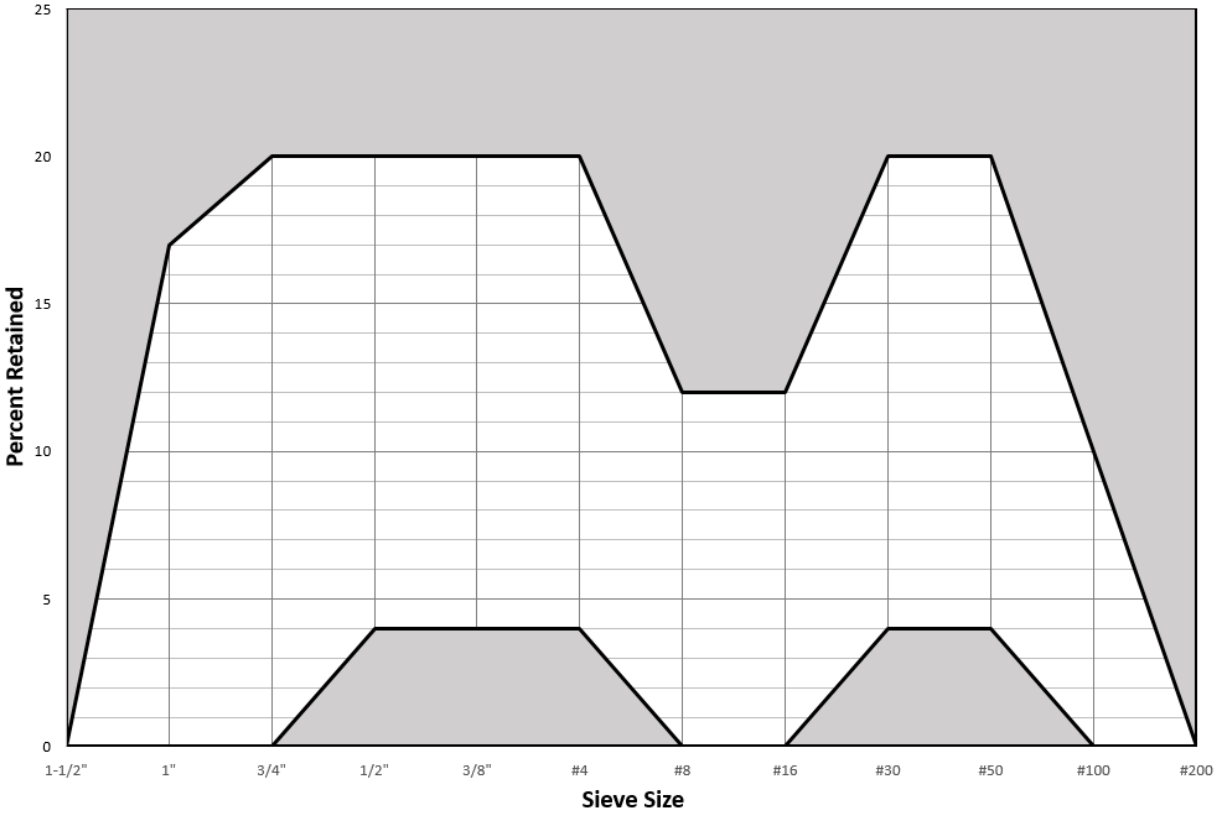


Fig. 8.9.2.2—Coarseness factor chart for evaluating potential performance of mixture.

ATTACHMENT C - COMBINED AGGREGATE GRADATION CHART

COMBINED AGGREGATE GRADATION CHART



ATTACHMENT D - CONCRETE PLACEMENT CHECKLIST

CONCRETE PLACEMENT CHECKLIST

Project: _____ Class of Concrete _____
Project No.: _____Test Cylinders Taken? Yes _____ No _____
Location of Placement _____
The Contractor certifies the above-proposed concrete placement is prepared as indicated and is

Preparation Slab	Contractor	N/A
Compaction Subgrade		
Filter Fabric/Drain Rock-ABC/Separator Fabric		
Drain Rock, Pea Gravel & Void Form		
Starter Wall Forms		
Reinforcing Steel		
Screeds		

Embedded Items	Contractor	N/A
A. Anchor Bolts		
B. Water Stop		
C. Rebar		
D. Electrical		
E. Plumbing Rough-in		
F. Mechanical		
G. HVAC		

Concrete Placement Equip.	Contractor	N/A
A. Crane		
B. Buckets		
C. Hoppers		
D. Vibrators		
E. Elephant trunks		
F. Floodlights		
G. Pump Truck		

Building Department Notification	
Date:	Time:

Prep Wall Concrete	Contractor	N/A
Access To Work		
Ladders Secured		
Clean up and Washed Out		
Reinforcing Steel		

Forms	Contractor	N/A
A. Alignment & Grade		
B. Scaffolding		
C. Sleeves & Wall Castings		
D. Embedded Items		
E. Electrical		
F. Plumbing Rough-in		
G. Piping		

Record of Curing Conditions During Placement		
	Start	Finish
Date		
Time		
Weather		
Temperature		
Comments		

in accord with the Contract Drawings and Specifications. The Contractor requests permission to begin placement of concrete on the date of _____ at _____. The estimated number of yards is: _____. The estimated duration of the placement is _____.

By: _____
Contractor

Released for placement by: _____
Engineer

MISCELLANEOUS

Master Format #: 03 35 00

EUCOBAR

EVAPORATION RETARDANT AND FINISHING AID

EUCLID CHEMICAL

PACKAGING

5 gal (18.9 L) pail
Code: 028 05

55 gal (208 L) drum
Code: 028 55

1 gal (3.8 L) jugs, 6 per case
Code: 028 95

CLEAN UP

Clean spray equipment with soap and water.

SHELF LIFE

2 years in original, unopened package

DESCRIPTION

EUCOBAR is designed to be used as an evaporation retardant and finishing aid on concrete surfaces of all types. When sprayed over fresh concrete, EUCOBAR forms a monomolecular film that prevents rapid moisture loss from the concrete surface. It is easy to use requiring only the addition of water before spray application. EUCOBAR is especially effective when concreting operations must be performed in direct sun, wind, high temperatures, or low relative humidity.

PRODUCT CHARACTERISTICS

FEATURES/BENEFITS

- Holds in surface moisture on concrete floors, slabs, and repairs
- Helps prevent plastic shrinkage cracking
- Easy and economical to use
- Helps eliminate crusting caused by loss of surface moisture
- Water based for total compatibility with fresh concrete
- Can be used on silica fume/ microsilica modified concrete mixes and other mixes containing little to no bleed water.
- Excellent for both interior and exterior concrete projects
- Will not affect adhesion of curing compound or other treatments
- VOC Content: 11 g/L

PRIMARY APPLICATIONS

- Floors
- Pavements
- Concrete toppings
- Vertical/overhead repairs
- Dry shake floors including all SURFLEX and EUCO-PLATE formulations
- Specialty iron toppings
- Parking decks and ramps

APPEARANCE

EUCOBAR is a free flowing pink liquid designed to be mixed with water. The use of EUCOBAR will not affect the color of concrete.

COVERAGE

Dilution Rate: 9:1 (Water:EUCOBAR)

EUCOBAR (after dilution) will cover approximately 200 to 400 ft²/gal (5 to 10 m²/L). Coverage will vary depending on concrete texture and wind conditions. For estimating purposes, 1 gal (3.8 L) of EUCOBAR concentrate will treat 2,000 to 4,000 ft² (186 to 372 m²) of concrete surface area, but is highly dependent upon ambient conditions.

TECHNICAL INFORMATION

EUCOBAR is a water based polymer concentrate that is readily dilutable in water.

Evaporation rate is a function of relative humidity, concrete temperature, air temperature and wind velocity. Plastic shrinkage cracking is a strong possibility when the rate of evaporation exceeds 0.2 lb/ft²/hr (1.0 kg/m²/hr). The chart on the back of this page (Fig. 2.1.5 of ACI 305, Hot Weather Concreting) is useful in determining the evaporation rate under a given set of jobsite conditions. Use EUCOBAR when the above limit is exceeded.

DIRECTIONS FOR USE

Surface Preparation: EUCOBAR is applied directly to the surface of fresh concrete. No surface preparation is necessary.

Mixing: EUCOBAR is supplied as a concentrate and must be diluted with water at a 9:1 (water:EUCOBAR) ratio. Determine capacity of sprayer and divide by 10. Add this amount of EUCOBAR to the sprayer canister followed by 9 times that amount of water. For example, if 1 quart (0.95 L) of EUCOBAR is added, dilute with 9 quarts (8.5 L) of water. Mix or shake until thoroughly blended.

Placement: Apply using a tank type, hand pump sprayer capable of spraying in a fine mist. Use a slotted tip for the best spray. Spray EUCOBAR over the fresh concrete surface as soon as possible after floating. A pink, translucent sheen will appear as the surface is treated. On extreme drying conditions, additional applications may be given as needed. When used on floors with dry shake hardener applications, EUCOBAR may be used on the fresh concrete as well as between each shake application.

Curing & Sealing: Proper curing procedures are important to ensure the durability and quality of concrete. To prevent surface cracking, cure flatwork with a high solids cure and seal or other industry-approved curing method.

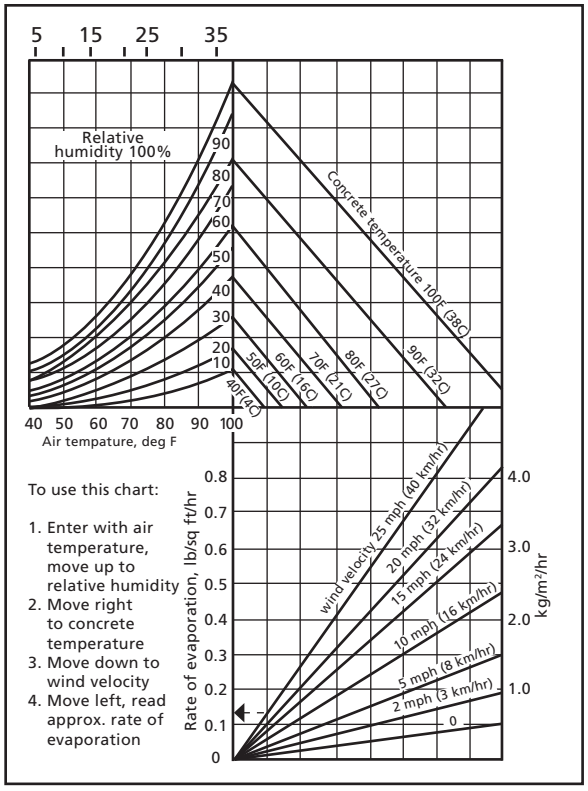


Fig. 2.1.5, ACI 305, Hot Weather Concreting

PRECAUTIONS/LIMITATIONS

- Use with proper dilution rate.
- This product is not a surface retarder for doing exposed aggregate concrete.
- Do not apply Eucobar as a final finishing aid.
- Do not immediately work Eucobar into the surface of concrete or cementitious repair products.
- Do not use as a curing compound.
- Apply only as a fine spray.
- Do not allow to freeze.
- In all cases, consult the Safety Data Sheet before use.

Rev. 08.23