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USACE / CESAJ

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DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS

CESAJ 03301 (May 2002)

Coordinated with
UFGS-03301A (March 1994)

JACKSONVILLE DISTRICT LOCAL MASTER GUIDE SPECIFICATION

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SECTION 03301

CAST-IN-PLACE STRUCTURAL CONCRETE
04/03

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NOTE: THIS CESAJ MASTER IS TO BE USED FOR PROJECTS THAT ARE LOCATED IN FLORIDA.

This guide specification covers the requirements for furnishing all plant, labor, material, and equipment and performing all operations required for furnishing, hauling, and placing the cast-in-place structural concrete within Floridacomplete, as specified herein and shown on the contract drawings.

The characteristics that distinguish this specification from CEGS-03700, "Mass Concrete", are:

1. Concrete strengths and maximum permitted water-cement ratios are specified.

2. The proportioning of concrete mixtures is the responsibility of the Contractor.

3. Measurement of concrete is on the basis of the actual volume of concrete within pay lines of the structure as indicated on the drawings. Payment is made at contract prices per cubic meter (yard) for various items on the schedule. As an option payment may be by lump sum for various items on the schedule.

4. For large complex projects, this specification may be used in conjunction with CEGS-03700, "Mass Concrete". If so used, the portions of the project to be constructed under the respective specifications must be clearly called out in the contract documents.

The content of this specification is such that guidance given in EM 1110-2-2000, "Standard Practice for Concrete", is applicable.

Comments and suggestions on this guide specification

are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Use of electronic communication is encouraged.
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PART 1 GENERAL

1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest change (Notice) to this guide specification.
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The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 117/117R	(1990; Errata) Standard Tolerances for Concrete Construction and Materials
ACI 211.1	(1991; R 1997) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214	(1977; R 1997) Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 301	(1999) Specifications for Structural Concrete
ACI 303.1	(1997) Guide to Cast-in-Place Architectural Concrete Practice
ACI 304R	(2000) Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R	(1999) Hot Weather Concreting
ACI 318/318R	(2002) Building Code Requirements for Structural Concrete and Commentary

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31/C 31M	(2000) Making and Curing Concrete Test Specimens in the Field
ASTM C 39/C 39M	(1999) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42/C 42M	(1999) Obtaining and Testing Drilled Cores

	and Sawed Beams of Concrete
ASTM C 94/C 94M	(2000) Ready-Mixed Concrete
ASTM C 143/C 143M	(2000) Slump of Hydraulic Cement Concrete
ASTM C 150	(1999a) Portland Cement
ASTM C 171	(1997a) Sheet Materials for Curing Concrete
ASTM C 172	(1999) Sampling Freshly Mixed Concrete
ASTM C 173	(1994a) Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 192/C 192M	(2000) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 260	(2000) Air-Entraining Admixtures for Concrete
ASTM C 309	(1998a) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 494/C 494M	(1999a) Chemical Admixtures for Concrete
ASTM C 597	(1983; R 1997) Pulse Velocity Through Concrete
ASTM C 618	(2000) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 803/C 803M	(1997e1) Penetration Resistance of Hardened Concrete
ASTM C 805	(1997) Rebound Number of Hardened Concrete
ASTM C 881	(1999) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 989	(1999) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM C 1059	(1999) Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C 1064/C 1064M	(1999) Temperature of Freshly Mixed Portland Cement Concrete
ASTM C 1077	(1998) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1107	(1999) Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C 1240	(2000) Silica Fume for Use as a Mineral

	Admixture in Hydraulic-Cement Concrete, Mortar and Grout

FLORIDA DEPARTMENT OF TRANSPORTATION (FDOT)

FDOT	(2000) Standard Specifications for Road and Bridge Construction

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(1997) NIST Handbook 44: Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(1996) Concrete Plant Standards

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 94	(1995) Surface Retarders
COE CRD-C 143	(1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregate
COE CRD-C 318	(1979) Cloth, Burlap, Jute (or Kenaf)
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete

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NOTE: Measurement and Payment paragraphs are located in Section 01270 MEASUREMENT AND PAYMENT.

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1.2 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item on the project should be one of the primary factors in determining if a submittal for the items should be required.

Indicate submittal classification in the blank space following the name of the item requiring the submittal by using "G" when the submittal requires Government approval. Submittals not classified as "G" will show on the submittal register as "Information Only". For submittals requiring Government approval, a code of up to three characters should be used following the "G" designation to indicate the approving authority.

REFER TO SECTION 01330 SUBMITTAL PROCEDURES FOR DESIGNATION ABBREVIATIONS.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

[Lift Drawings

NOTE: Use for Pumping Stations. Select if appropriate.

A lift drawing and bill of materials shall be furnished for each lift of concrete. (Only one lift shall be shown on a drawing.) These drawings shall be to scale and shall show all embedded items in sufficient detail for the proper installation and prosecution of the work. All embedded electrical and/or mechanical items shall be identified. The drawings shall not be less than 11 by 17 inches in size and the scale used shall be sufficiently large to clearly show all details of the structure covered by these drawings. A note shall be included on each lift drawing indicating all contract drawings from which the lift drawing was prepared.]

[Concrete Construction Drawings; G|[COR][ED]

NOTE: For use on large complex structures, such as locks, dams, or multi-monolith spillways, or other jobs that have unique features such as access and land area restrictions. Select if appropriate.

Submit six (6) copies each of Concrete Construction Drawings for approval at least 20 calendar days before work on the applicable feature is commenced. Prepare these construction drawings in accordance with the paragraph SUBMITTAL PROCEDURES of Section 01330 SUBMITTAL PROCEDURES. The drawings shall be submitted showing the outline dimensions of each concrete block or pour of a monolith section. Each monolith section shall be numbered for identification. Include schedule and sequence of placing concrete for each monolith section.]

SD-03 Product Data

Concrete Mixture Proportioning

NOTE: Delete the bracketed information if requirements for thermal development analysis and thermal protection plan IS NOT APPLICABLE.

Submit concrete mixture proportions for compliance with the requirements in paragraph CONCRETE MIXTURE PROPORTIONING. The concrete mixture quantities of all ingredients per cubic yard and nominal maximum coarse aggregate size that will be used in the manufacture of each quality of concrete shall be stated. Proportions shall indicate the weight of cement, fly ash and ground granulated blast-furnace (GGBF) slag, and water; the weights of aggregates in a saturated surface-dry condition; and the quantities of admixtures. The submission shall be accompanied by test reports from a laboratory complying with ASTM C 1077 which show that proportions thus selected will produce concrete of the qualities indicated. No substitution shall be made in the source or type of materials used in the work without additional tests to show that the quality of the new materials and concrete are satisfactory. [Submit the concrete mix designs, thermal development analysis, and the thermal protection plan concurrently.]

[Thermal Developments]

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NOTE: Delete submittal requirement in its entirety if thermal development analysis, thermal protection plan, and temperature monitoring if heat of hydration (for mass concrete placements) is not a concern.
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[Submit an analysis of the anticipated thermal developments for compliance with the requirements in paragraph THERMAL DEVELOPMENTS. Submit the concrete mix designs, thermal development analysis, and the thermal protection plan concurrently.]

Batch Plant

Submit batch plant data for conformance with applicable specifications.

Concrete Mixers

Submit concrete mixer data which includes the make, type, and capacity of concrete mixers proposed for mixing concrete.

Conveying Equipment

Submit the conveying equipment and methods for transporting, handling, and depositing the concrete for conformance with paragraphs CAPACITY and CONVEYING EQUIPMENT.

Placing Equipment and Methods

Submit all placing equipment and methods for conformance with paragraph CAPACITY and other applicable specifications.

Testing Technicians
Concrete Transportation Construction Inspector (CTCI)

Submit statements that the concrete testing technicians and the concrete inspectors meet the specified requirements.

Construction Joint Treatment; G|[COR][ED]

Submit the method and equipment proposed for joint cleanup and waste disposal for conformance with paragraph CONSTRUCTION JOINT TREATMENT.

Curing and Protection; G|[COR][ED]

Submit the curing medium and methods to be used for conformance with paragraph [CURING AND PROTECTION] [CURING, PROTECTION, AND TEMPERATURE MONITORING].

Cold-Weather Placing; G|[COR][ED]

Submit the proposed materials and methods meeting the requirements of paragraph COLD-WEATHER PLACING.

Hot-Weather Placing; G|[COR][ED]

Submit the proposed materials and methods meeting the requirements of paragraph HOT-WEATHER PLACING.

[Thermal Protection; G|[COR][ED]

Describe the measures and procedures intended for use to monitor and control a temperature differential for conformance with paragraphs TEMPERATURE MONITORING DEVICES and TEMPERATURE MONITORING. Submit the concrete mix designs, thermal development analysis, and the thermal protection plan concurrently.]

Level I Quality Control Plan; G|[COR][ED]

Submit the quality control plan for compliance with the requirements in paragraph BATCH PLANT. The Concrete Producer shall develop and implement plan to maintain the properties of concrete from the point of production to the point of delivery within the required limits. The plan shall show what testing the Producer intends to do to monitor concrete plastic properties (slump, air and temperature), and how he intends to implement the controls necessary to meet specification requirements. The plan shall require certified personnel and assurances that materials, plant, equipment and transporting operations comply with specifications.

[Underwater Concrete Methods and Equipment]; G|[COR][ED]

Include traffic control plan for concrete trucks, both onsite and access to site. Consider areas for turning around, area for QC/QA, area for washing concrete trucks, area for pump trucks with space for two concrete trucks per pump truck, and an area for the air-lifts/water pump/crane; this plan should be coordinated with the concrete supplier and the pumpers. Include lighting plan if operations begin before sunrise. Include inspection plan detailing sounding locations and frequency of soundings.]

SD-04 Samples

Curing Compound; G|[COR][ED]

Samples of materials for government testing and approval shall be submitted as required in paragraph PRECONSTRUCTION SAMPLING AND TESTING.

SD-06 Test Reports

Mixer Uniformity

Submit the results of the initial mixer uniformity tests at least 5 days prior to the initiation of placing.

Tests and Inspections

Submit test results and inspection reports daily and weekly as required in paragraph REPORTS.

SD-07 Certificates

Cement

Acceptance of cement will be based on manufacturer's certified mill analysis of test results meeting the specification limits of the ASTM Designation for the particular type. Certification of these test values shall be submitted and corresponding samples for independent assurance shall be furnished upon request.

Fly Ash

Acceptance of fly ash will be based on certified test reports meeting the specification limits of the ASTM Designation for the particular type. These tests shall be made for each lot, not to exceed 400 tons per lot.

The certified test reports shall be from an approved laboratory certifying that the fly ash conforms to FDOT Specification Section 929 and was obtained from the residue of an electric generating plant using only ground or powdered coal. The fly ash supplier shall utilize a Quality Control Plan previously approved by the (Florida) State Materials Office. The approved laboratory shall have been inspected by (Florida) Cement and Concrete Reference Laboratory as a fly ash testing laboratory and shall have corrected any deficiencies noted at the time of inspection. The laboratory shall authorize the Cement and Concrete Reference Laboratory to send a copy of the inspection report to the Contracting Officer.

Ground Granulated Blast-Furnished Slag

Acceptance of slag will be based on certified test reports meeting the specification limits of the ASTM Designation for the particular type. Certification of these tests shall be submitted at the time of shipment and corresponding samples for independent assurance test shall be furnished upon request. The test results shall be from samples of the material taken during production or transfer. The slag manufacturer shall also state in writing the nature, amount and identity of any processing or other additions

made to the slag.

Aggregates

Acceptance of aggregates will be based on the requirements of paragraph AGGREGATES.

Chemical Admixtures

Acceptance of chemical admixtures will be based on the requirements of paragraph CHEMICAL ADMIXTURES.

Impervious-Sheet Curing Materials

Impervious-Sheet Curing Materials shall be certified for compliance with all specification requirements.

Epoxy Resin
Latex Bonding Compound

Epoxy Resin and Latex Bonding Compound shall be certified for compliance with all specification requirements.

Nonshrink Grout

Descriptive literature of the Nonshrink Grout proposed for use shall be furnished together with a certificate from the manufacturer stating that it is suitable for the application or exposure for which it is being considered.

1.3 GOVERNMENT TESTING AND SAMPLING

The Government will sample and test curing compound and concrete to determine compliance with the specifications. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples.

1.3.1 Preconstruction Sampling and Testing

Curing compound samples will be obtained as specified in ASTM C 309. Filled containers, represented by the sample(s) will be sealed and marked for later identification and correlation. Each sample will be at least one quart. At least one sample representing each 40 drums (2200 gallons), or fraction thereof, will be taken for testing if shipment is by drum. At least three samples representing 6000 gallons, or fraction thereof, will be taken for testing if shipment is by bulk.

Samples of curing compound will be tested by and at the expense of the Government for compliance with subparagraph "Membrane-Forming Curing Compound" of paragraph [CURING AND PROTECTION][CURING, PROTECTION, AND TEMPERATURE MONITORING]. If the sample fails to meet specification requirements, new samples shall be provided and the cost of retesting will be deducted from payments due the Contractor at a rate of $1,200 per sample.

1.3.2 Construction Testing

Concrete shall be sampled in accordance with ASTM C 172. Compressive strength test specimens will be made by the Government and cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39/C

39M. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 500 psi. A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test.

1.4 DESIGN REQUIREMENTS

1.4.1 Concrete Strength

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NOTE: Consult the Structural Design Engineer and the appropriate DM to fill in the blanks.
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Specified compressive strength f'c shall be as follows:

COMPRESSIVE STRENGTH (PSI)	STRUCTURE OR PORTION OF STRUCTURE
[4,000 @ 28 days	Maximum cross-sectional dimension is less than 2-1/2 feet]
[4,000 @ 56 days	Minimum cross-sectional dimension is 2-1/2 feet or greater [,except the mass concrete substructure]]
[2,500 @ 90 days	Mass concrete substructure]
[_____ @ __ days	_____]

1.4.2 Maximum Water-Cement (W/C) Ratio

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NOTE: Consult EM 1110-2-2000 and the appropriate DM to fill in the blanks and to select the appropriate W/C. When cementitious materials other than portland cement are used, see paragraph CONCRETE PROPORTIONING, for definitions of W/C. Drawings shall label and dimension portions of structure.
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Maximum W/C shall be as follows:

WATER-CEMENT RATIO, BY WEIGHT	STRUCTURE OR PORTION OF STRUCTURE
[_____]	[_____]
[0.45	Underwater concrete]
[0.45	Stilling basin]
[0.55	Everything except for _____]
[0.60	Mass concrete substructure]

These W/C's may cause higher strengths than that required by paragraph CONCRETE STRENGTH.

1.4.3 [Thermal Developments

Analysis of anticipated thermal developments in elements with minimum cross-sectional dimension of 2-1/2 feet or greater for all expected project temperature ranges using the proposed mix designs, placement procedures, and materials shall be the responsibility of the Contractor. A temperature

differential of 35 F degrees or less between the interior and exterior portions of the elements shall be maintained during curing.]

1.5 CONSTRUCTION TOLERANCES

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NOTE: Edit accordingly.
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Construction tolerances shall be in accordance with ACI 117/117R. [However, Section 10 - Tolerances for Monolithic Siphons and Culverts, which shall be applicable for the formed suction intake and discharge conduits, shall be changed to 1/2-inch for Lateral Alignment, Centerline Alignment; to 1/2-inch for Level Alignment, Profile Grade; and to minus 0-inch for Cross-Sectional Dimensions, Cross Section at Any Point, Decrease Thickness.] Use Section 11 - Tolerances for Cast-in-Place Bridges for erosion-protection and small hydraulic structures. Use straightedge method for measuring floor finish tolerances; the maximum gap under a freestanding straightedge shall be 5/16-inch.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Cementitious materials shall be portland cement in combination with fly ash pozzolan or GGBF slag [or silica fume] and shall conform to appropriate specifications listed below. Use of cementitious materials in architectural concrete shall be restricted to one color, one source, and one type.

2.1.1.1 Portland Cement

ASTM C 150, Type I or II, except that the maximum amount of C3A in Type I cement shall be 15 percent. [The Heat of Hydration Requirements in the Optional Physical Requirements shall apply for Type II cement used in mass concrete.]

2.1.1.2 [High-Early-Strength Portland Cement

ASTM C 150, Type III, [with C3A limited to [5][8] percent][low alkali when used with aggregates listed at the end of this section which require it][used only when specifically approved in writing]].

2.1.1.3 Fly Ash

Fly ash shall conform to ASTM C 618, Class F, including the Supplementary Optional Chemical Requirement. When the loss of ignition exceeds 5 percent, the Uniformity Requirements in the Supplementary Optional Physical Requirements shall apply.

2.1.1.4 Ground Granulated Blast-Furnace Slag

Ground Granulated Blast-Furnace Slag shall conform to ASTM C 989, Grade 100. Reference Cement used for determination of Slag Activity shall met the requirements of ASTM C 989.

2.1.1.5 [Silica Fume

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Optional Table 2 in ASTM C 1240 shall be included when used with aggregates listed to require low-alkali cement. Other requirements in Table 4 may be specified if necessary. Refer to EM 1110-2-2000 for guidance.
****

Silica fume may be furnished as a dry, densified material or as a slurry. Silica fume, unprocessed, or before processing into a slurry or a densified material, shall conform to ASTM C 1240 with [Table 2 and] the Specific Surface Area and Uniformity Requirements in Table 4 invoked.

The Contractor shall provide at his expense the services of a manufacturer's technical representative, experienced in mixture proportioning, placement procedures, and curing of concrete containing silica fume. The manufacturer's representative shall be available for consultation by both the Contractor and the Government during mixture proportioning, planning, and production of silica-fume concrete and shall be onsite immediately prior to and during at least the first placement of concrete containing silica fume, and at other times if directed.]

2.1.2 Aggregates

Aggregates shall be produced under the FDOT-approved Producer Quality Control Program (QC) that is in accordance with the FDOT's requirements and procedures for obtaining and maintaining FDOT approval of developed and operational mineral aggregate sources (mines and redistribution terminals), and with FDOT's Mineral Aggregate Manual. An individual certification shall be furnished with each haul unit load of materials shipped, attesting that those specific materials were produced under a FDOT-approved QC and that they meet the requirements of either FDOT Specification Sections 901 or 902. The nominal maximum size shall be as listed in paragraph NOMINAL MAXIMUM-SIZE AGGREGATE (NMSA).

2.1.3 Chemical Admixtures

2.1.3.1 Qualified Products List

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NOTE: Confirm Internet address.
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The FDOT maintains a list of qualified admixtures for air-entraining, water-reducing, and water reducing and retarding which have previously been determined as meeting requirements for use on FDOT projects. Admixtures included on this list, as specified in FDOT Specification Section 6-1, will be permitted without further testing. The Qualified Products List Internet address is: http://www11.myflorida.com/specificationsoffice/product.htm. The inclusion of any specific product on the Qualified Products List, as specified in FDOT Specification Section 6-1, indicates that the product has been given contingent approval, as evidence by previous tests and apparent effectiveness under field conditions. Except as specified in FDOT Specification Section 346, no further testing will be required for any product on the Qualified Products List unless there is indication in actual field use of inadequate or unreliable results

2.1.3.2 Certification

Manufacturers of admixtures not included on FDOT's Qualified Products List shall provide certified test results from an independent laboratory inspected by FDOT's Cement and Concrete Reference Laboratory on a regular basis, with all deficiencies corrected. Test results shall indicate compliance with test requirements as modified herein of ASTM C 260 for air-entraining, ASTM C 494/C 494M for water-reducing (Type A) or water-reducing and retarding (Type D), and High Range Water Reducer (Type F or Type G).

a. For Air-Entraining: Air-entraining admixtures not on FDOT's Qualified Products List shall meet the requirements of ASTM C 260, except for the following modifications and exceptions:

(1) The coarse aggregate shall be Size No. 57 meeting the requirements of FDOT Specification Section 901.

(2) The fine aggregate shall meet the requirements of FDOT Specification Section 902.

(3) The cement shall meet the requirements of FDOT Specification Section 921.

(4) The flexural strength, resistance to freezing and thawing, and length change are waived.

b. For Type A (Water-Reducing) and Type D (Water-Reducing and Retarding): Water-reducing and water-reducing and retarding admixtures not on FDOT's Qualified Products List shall meet the requirements of ASTM C 494/C 494M for Type A and D, respectively, except for the following modifications and exceptions:

(1) The coarse aggregate shall be Size No. 57 meeting the requirements of FDOT Specification Section 901.

(2) The fine aggregate shall meet the requirements of FDOT Specification Section 902.

(3) The cement shall meet the requirements of FDOT Specification Section 921.

(4) The flexural strengths in Table I (ASTM C 494/C 494M) and compressive strength at 6 months and 1 year are waived.

c. For Type F or Type G (High Range Water Reducer): High range water reducers shall meet the requirements of ASTM C 494/C 494M and all the additional requirements in FDOT Specification Section 346-2.5.3.

2.1.3.3 Contingency of Continued Approval

The continued approval of admixtures allowed for use, as based on the above specification requirements, will also be subjected to the contingencies specified in subparagraph "Qualified Products List" of paragraph MATERIALS.

2.1.3.4 Performance Test on Air-Entraining Admixtures, For Effect on Strength of Concrete

a. Condition Under Which Test is Required: For any air-entraining

admixture selected for use, the Contracting Officer may call for a performance test (either prior to or at any time during construction) for determining its effect on the strength of the concrete. In general, this check-list will be required only when there is indication that such admixture is giving erratic results or is unduly reducing the strength of the concrete. Testing shall be in accordance with subparagraphs "Permissible Reduction in Strength of the Concrete" and "Method of Test for Strength Reduction" below.

b. Permissible Reduction in Strength of the Concrete: For concrete composed of the same cement and aggregates (and in the same proportions) to be used in the work, and containing the admixture under test, in an amount sufficient to produce between 3 percent and 5 percent entrained air in the plastic concrete, the compressive strength at 7 days shall be at least 90 percent of the strength of the same concrete without the admixture.

c. Method of Test for Strength Reduction: The percentage reduction in strength shall be calculated from the average strength of at least three standard 6 inch by 12 inch cylinders of each class of concrete. Specimens shall be made and cured in the laboratory in accordance with ASTM C 192/C 192M, and shall be determined in accordance with ASTM C 173.

2.1.3.5 Retesting

Approved water-reducing and water-reducing and retarding admixtures, due to indication of giving erratic results, shall be retested for comparison between infrared spectrophotometry, pH value and solids content. Any marked variation from the original curve, pH value or solids content will be considered sufficient evidence that the chemistry of the original material has been changed; therefore, the use of this material will be rejected.

2.1.4 Curing Materials

2.1.4.1 Impervious-Sheet Curing Materials

Impervious-sheet curing materials shall conform to ASTM C 171, type optional, except polyethylene film shall not be used.

2.1.4.2 Membrane-Forming Curing Compound

The membrane-forming curing compound shall conform to ASTM C 309, Type 1-D or 2, except a styrene acrylate or chlorinated rubber compound meeting Class B requirements shall be used for surfaces that are to be painted or are to receive bituminous roofing, or waterproofing, or floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, coating, or flooring specified. Nonpigmented compound shall contain a fugitive dye and shall have the reflective requirements in ASTM C 309 waived.

2.1.4.3 Burlap

Burlap used for curing shall conform to COE CRD-C 318.

2.1.5 Water

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that nonpotable

water may be used if it meets the requirements of COE CRD-C 400.

2.1.6 Nonshrink Grout

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NOTE: The requirements for grout in ASTM C 1107 is not satisfactory for grouting under pumping equipment. Designer needs to research and specify appropriate grout.
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Nonshrink grout shall conform to ASTM C 1107 and shall be a commercial formulation suitable for the application proposed.

2.1.7 Latex Bonding Compound

Latex bonding compound agents for bonding fresh to hardened concrete shall conform to ASTM C 1059.

2.1.8 Epoxy Resin

Epoxy resin for use in repairs shall conform to ASTM C 881, Type V, Grade I or II.

2.2 CONCRETE MIXTURE PROPORTIONING

2.2.1 Quality of Mixture

For each portion of the structure, mixture proportions shall be selected so that the strength and W/C requirements listed in paragraph DESIGN REQUIREMENTS are met.

2.2.2 Nominal Maximum-Size Aggregate (NMSA)

NMSA (INCHES)	PORTION OF STRUCTURE
1 (ASTM size #57)*	Everything [except for the mass concrete substructure]
[1-1/2 (ASTM size #4)	Mass concrete substructure]

*Except 3/4 inch NMSA shall be used when any of the following conditions exist: the narrowest dimension between side of forms is less than 7-1/2 inches; the depth of the slab is less than 4 inches; the minimum clear spacing between reinforcing is less than 2-1/4 inches; [or, Class A finish on the exterior walls is required].

2.2.3 Air Content

Air content, as delivered to the forms and as determined by ASTM C 173, shall be between the following ranges:

PERCENT	PORTION OF STRUCTURE
1-1/2 to 4-1/2	Everything [except for the mass concrete substructure]
[3-1/2 to 6-1/2	Mass concrete substructure]

2.2.4 Slump

The slump shall be determined in accordance with ASTM C 143/C 143M and shall be within the following ranges:

INCHES	PORTION OF STRUCTURE
3 to 5*	Everything [except for the mass concrete substructure]
[1-1/2 to 3	Mass concrete substructure]

*Where placement by pump is approved, the slump shall not exceed 6 inches. When a Type F or G high range water reducing admixture conforming to ASTM C 494/C 494M is permitted to increase the slump of concrete, the concrete shall have a slump of 2 to 4 inches before the admixture is added and a maximum slump if 8 inches at the point of delivery after the admixture is added.

2.2.5 Use of Fly Ash and Slag

Fly ash or slag shall be used as a cement replacement with the following limitations:

a. Water-Cement Ratios shall be converted to a weight of water to cement plus fly ash or GGBF slag by weight equivalency as described in ACI 211.1. In the case where GGBF slag is used, the weight of the slag shall be included in the equations for the term P, which is used to denote the weight of pozzolan.

b. [Fly Ash in Mass Concrete Substructure: The quantity of cementitious material replaced with fly ash shall be greater than 25 percent and less than 35 percent by weight of the total cementitious content. Fly ash shall only replace Type II cement.]

c. [For all other concrete uses not covered in subparagraph b. above,] the quantity of cementitious material replaced with fly ash shall be greater than 18 percent and less than 22 percent of the weight of the total cementitious content.

d. [GGBF Slag in Mass Concrete Substructure: The quantity of cementitious material replaced with GGBF slag shall be greater than 70 percent by weight of the total cementitious content. The heat of hydration of the concrete mixture using Type I cement and slag shall be less than 60 cal/g at 7 days. Slag shall only replace Type I cement.]

e. [For all other concrete uses not covered in subparagraph d. above,] the quantity of cementitious material replaced with GGBF slag shall be greater than 25 percent and less than 70 percent of the weight of the total cementitious content.]

2.2.6 Concrete Proportioning

Trial design batches, mixtures proportioning studies, and testing requirements for various classes and types of concrete specified shall be the responsibility of the Contractor. Samples of the materials used in mixture proportioning studies shall be representative of those proposed for the project and shall be accompanied by the manufacturer's or producer's test reports indicating compliance with applicable specified requirements. Trial mixtures having proportions, consistencies, and air content suitable

for the work shall be made based on methodology described in ACI 211.1. The trial mixture shall use at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required on the project. Trial mixtures shall be proportioned for maximum permitted slump and air content with due consideration to the approved conveying and placement method. The effects of fly ash or GGBF slag on the air content of concrete shall be evaluated during the ready-mix concrete company's laboratory mixture proportioning study. The temperature of concrete in each trial batch shall be reported. For each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance with ASTM C 192/C 192M. They shall be tested at 7 and 28 days and at the design age specified in paragraph DESIGN REQUIREMENTS in accordance with ASTM C 39/C 39M. From these test results, plot a curve showing the relationship between water-cement ratio and strength; in addition, plot a curve showing the relationship between 7 and 28 days and at the design age specified in paragraph DESIGN REQUIREMENTS.

2.2.7 Hot-Weather Concreting Conditions

For design mixes developed for use under hot-weather concreting condition (from FDOT Specification paragraph 346-6.2(5)):

a. Hold the trial mix prepared at a minimum temperature of 94 degrees F in the mixture for 90 minutes after completion of initial mixing. Extended mixing for precast/prestressed concrete will not be required when centrally mixed at the placement site.

On completion of the extended mixing period, ensure that the trial mix concrete has a slump within plus or minus 0.75 inch of the target value (plus or minus 1 inch for mixes utilizing HRWR), and an air content between 2 percent and 5 percent. Ensure that the mix temperature at the end of the extended mixing period is not less than 94 degrees F.

During the extended mixing period, turn the drum intermittently for 30 seconds every 5 minutes. Cover the drum with wet burlap or an impermeable mover material during the rest periods.

At the end of the 90-minute period, remix the trial mix for a minimum of 1 minute and make a slump test to verify that the concrete is within the specified range for slump. If below the target range, the Contractor may adjust the slump by a water addition. After the water addition, remix the concrete for a minimum of 2 minutes. The total water used in initial mixing and the final slump adjusting constitutes the design mix water content. Ensure that the total water content does not exceed the maximum water cement ratio of the respective class of concrete.

b. Ensure that the heat of hydration of the cement does not exceed 80 cal/g at 7 days measured as the average of three samples, and that no individual measurement exceeds 90 cal/g.

Where fly ash is 18 percent or greater or slag is 50 percent or greater of the total cementitious material, ensure that the heat of hydration of the cement does not exceed 88 cal/g at 7 days measured as the average of three samples, and ensure that no individual measurement exceeds 96 cal/g.

2.2.8 Required Average Compressive Strength

In meeting the strength requirements specified in paragraph CONCRETE STRENGTH, the selected mixture proportion shall produce a required average compressive strength f'cr exceeding the specified strength f'c by the amount indicated below.

2.2.8.1 Average Compressive Strength from Test Records

Where a concrete production facility has test records, a standard deviation shall be established in accordance with the applicable provisions of ACI 214. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified strength or strengths (f'c) within 1,000 psi of that specified for proposed work, and shall consist of at least 30 consecutive tests. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days or at another test age designated for determination of f'c.

Required average compressive strength f'cr used as the basis for selection of concrete proportins shall be the larger of the equations that follow using the standard deviation as determined above:

$$f'cr = f'c + 1.34S$$
$$f'cr = f'c + 2.33S - 500$$

Where S = standard deviation

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS* less than 15	MODIFICATION FACTOR FOR STANDARD DEVIATION
15	1.16
20	1.09
25	1.03
30 or more	1.00

*Interpolate for intermediate numbers of tests.

2.2.8.2 Average Compressive Strength without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength f'cr shall be determined as follows:

a. If the specified compressive strength f'c is less than 3,000 psi:

$$f'cr = f'c = 1,000$$

b. If the specified compressive strength f'c is 3,000 to 5,000 psi:

$$f'cr = f'c + 1,200$$

[c. If the specified compressive strength f'c is over 5,000 psi:

f'cr = f'c + 1,400]

PART 3 EXECUTION

3.1 EQUIPMENT

3.1.1 Capacity

****
NOTE: Refer to the appropriate DM for the capacity. Guidance is also found in EM 1110-2-2000. (Pump Station 319 used 70 cubic yards.)
****

The batching, mixing, conveying, and placing equipment shall have a capacity of at least [_____] cubic yards per hour.

[If underwater concrete is being placed, the equipment shall have a capacity of at least 100 cubic yards per hour per concrete pump truck or tremie.]

3.1.2 Batch Plant

****
NOTE: Confirm Internet address.
****

Batch plant shall exercise concrete quality control in accordance with Level I Quality Control Plan requirements in the FDOT Materials Manual Chapter 9 - Concrete Production. The FDOT Materials Manual Internet address is: http://www11.myflorida.com/statematerialsoffice/QualitySystems/materialsmanual/MaterialsManualHome.htm. Batch plant shall conform to the requirements of NRMCA CPMB 100 and as specified; however, rating plates attached to batch plant equipment are not required. A batch plant with a FDOT "fully approved plant status" or a "conditional approved status" will be an acceptable alternative; this plant shall be reinspected every two months in accordance with the FDOT's Standard Operating Procedures for Quality Control of Concrete. Costs associated with the inspections by FDOT will be the Contractor's responsibility.

3.1.2.1 Batching Equipment

The batching controls shall be automatic. The batching system shall be equipped with an accurate recorder or recorders that meet the requirements of NRMCA CPMB 100. Separate bins or compartments shall be provided for each size group of aggregate and cement, pozzolan, and GGBF slag. Aggregates shall be weighed either in separate weigh batchers with individual scales or cumulatively in one weigh batcher on one scale. Aggregate shall not be weighed in the same batcher with cement, pozzolan, or GGBF slag. If both cement and pozzolan or GGBF slag are used, they may be batched cumulatively provided that the portland cement is batched first. If measured by weight, water shall not be weighed cumulatively with another ingredient. Water batcher filling and discharging valves shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. An accurate mechanical device for measuring and

dispensing each admixture shall be provided. Each dispenser shall be interlocked with the batching and discharging operation of the water so that each admixture is separately batched and discharged automatically in a manner to obtain uniform distribution throughout the batch in the specified mixing period. Admixtures shall not be combined prior to introduction in water. The plant shall be arranged so as to facilitate the inspection of all operations at all times. Suitable facilities shall be provided for obtaining representative samples of aggregates from each bin or compartment. All filling ports for cementitious materials bins or silos shall be clearly marked with a permanent sign stating the contents. Furnish mandatory batch ticket information for each load of ready-mix concrete.

3.1.2.2 Scales

The weighing equipment shall conform to the applicable requirements of NIST HB 44, except that the accuracy shall be plus or minus 0.2 percent of scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring devices. Tests shall be made at the frequency required in paragraph TESTS AND INSPECTIONS, and in the presence of a government inspector.

3.1.2.3 Batching Tolerances

a. Weighing Tolerances

MATERIAL	PERCENT OF REQUIRED WEIGHT
Cementitious materials	plus or minus 1
Aggregate	plus or minus 2
Water	plus or minus 1
Chemical admixture	plus or minus 3

b. Volumetric Tolerances - For volumetric batching equipment, the following tolerances shall apply to the required volume of material being batched:

Water: ..... Plus or minus 1 percent.
Chemical admixtures: ..... Zero to plus 3 percent.

3.1.2.4 Moisture Control

The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched. [An electric moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measuring moisture in the fine aggregate. The sensing element shall be arranged so that the measurement is made near the batcher charging gate of the sand bin or in the sand batcher.]

3.1.3 Concrete Mixers

The concrete mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Should any mixer at any time produce

unsatisfactory results, its use shall be promptly discontinued until it is repaired.

3.1.3.1 Stationary Mixers

Concrete plant mixers shall be tilting, nontilting, horizontal-shaft, vertical-shaft, or pugmill and shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. The mixing time and uniformity shall conform to all the requirements in ASTM C 94/C 94M applicable to central-mixed concrete.

3.1.3.2 Truck Mixers

Truck mixers, the mixing of concrete therein, and concrete uniformity shall conform to the requirements of ASTM C 94/C 94M. A truck mixer may be used either for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Each truck shall be equipped with two counters from which it will be possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed.

3.1.4 Conveying Equipment

The conveying equipment shall conform to the following requirements.

3.1.4.1 Buckets

The interior hopper slope shall be not less than 58 degrees from the horizontal, the minimum dimension of the clear gate opening shall be at least five times the nominal maximum-size aggregate, and the area of the gate opening shall not be less than 2 square feet. The maximum dimension of the gate opening shall not be greater than twice the minimum dimension. The bucket gates shall be essentially grout tight when closed and may be manually, pneumatically, or hydraulically operated except that buckets larger than 2 cubic yards shall not be manually operated. The design of the bucket shall provide means for positive regulation of the amount and rate of deposit of concrete in each dumping position.

3.1.4.2 Transfer Hoppers

Concrete may be charged into nonagitating hoppers for transfer to other conveying devices. Transfer hoppers shall be capable of receiving concrete directly from delivery vehicles and have conical-shaped discharge features. The transfer hopper shall be equipped with a hydraulically operated gate and with a means of external vibration to effect complete discharge. Concrete shall not be held in nonagitating transfer hoppers more than 30 minutes.

3.1.4.3 Trucks

Truck mixers operating at agitating speed or truck agitators used for transporting plant-mixed concrete shall conform to the requirements of ASTM C 94/C 94M. Nonagitating equipment may be used for transporting plant-mixed concrete over a smooth road when the hauling time is less than 15 minutes. Bodies of nonagitating equipment shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

3.1.4.4 Chutes

When concrete can be placed directly from a truck mixer, agitator, or nonagitating equipment, the chutes attached to this equipment by the manufacturer may be used. A discharge deflector shall be used when required by the Contracting Officer. Separate chutes and other similar equipment will not be permitted for conveying concrete. Aluminum or aluminum alloy chutes shall not be used.

3.1.4.5 Belt Conveyors

Belt conveyors shall be designed and operated to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients or loss of mortar and shall be provided with positive means for preventing segregation of the concrete at the transfer points and the point of placing. Belt conveyors shall be constructed such that the idler spacing shall not exceed 36 inches. The belt speed shall be a minimum of 300 feet per minute and a maximum of 750 feet per minute. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the conveyor shall discharge concrete into a pipe or elephant trunk that is long enough to extend through the reinforcing bars.

3.1.4.6 Concrete Pumps

Concrete may be conveyed by positive displacement pump when approved. The pumping equipment shall be piston or squeeze pressure. The pipeline shall be rigid steel pipe or heavy-duty flexible hose. The inside diameter of the pipe shall be at least three times the nominal maximum-size coarse aggregate in the concrete mixture to be pumped but not less than 4 inches. Aluminum or aluminum alloy pipe shall not be used.

3.1.5 Vibrators

Vibrators of the proper size, frequency, and amplitude shall be used for the type of work being performed in conformance with the following requirements:

APPLICATION	HEAD DIAMETER INCHES	FREQUENCY VPM	AMPLITUDE INCHES
Thin walls, beams, etc.	1-1/4 to 2-1/2	9,000 to 13,500	0.02 to 0.04
General construction	2 to 3-1/2	8,000 to 12,000	0.025 to 0.05

The frequency and amplitude shall be determined in accordance with COE CRD-C 521.

3.2 PREPARATION FOR PLACING

3.2.1 Embedded Items

3.2.1.1 General

Before placement of concrete, care shall be taken to determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Embedded items shall be free of oil and other foreign matter such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable materials to prevent the entry

of concrete into voids. Welding, including tack welding, will not be permitted on embedded metals within 2 feet of the surface of the concrete.

3.2.1.2 Temperature Monitoring Devices

Provide approved temperature monitoring devices to record temperature development between the interior and exterior portions of the elements with minimum cross-sectional dimension of 2-1/2 feet or greater at approved points.

3.2.2 Concrete on Earth Foundations

Earth surfaces upon which concrete is to be placed shall be clean, damp, and free from debris and standing or running water. Prior to placement of concrete, the earth foundation shall have been satisfactorily compacted in accordance with Section [_____] [_____].

3.2.3 Concrete on Rock Foundations

Rock surfaces upon which concrete is to be placed shall be clean, free from oil, standing or running water, mud, drummy rock, coating, debris, and loose, semidetached, or unsound fragments. Joints in rock shall be cleaned to a satisfactory depth, as determined by the Contracting Officer, and to firm rock on the sides. Immediately before the concrete is placed, all rock surfaces shall be cleaned thoroughly by the use of air-water jets or sandblasting as described in paragraph CONSTRUCTION JOINT TREATMENT. All rock surfaces shall be kept continuously wet for at least 24 hours immediately prior to placing concrete thereon. All approximately horizontal surfaces shall be covered, immediately before the concrete is placed, with a layer of mortar proportioned similar to that in the concrete mixture. The mortar shall be covered with concrete before the time of initial setting of the mortar.

3.2.4 Construction Joint Treatment

Construction joint treatment shall conform to the following requirements.

3.2.4.1 Joint Preparation

Concrete surfaces to which additional concrete is to be bonded shall be prepared for receiving the next lift or adjacent concrete by cleaning with either air-water cutting, sandblasting, high-pressure water jet, or other approved method. Air-water cutting will not be permitted on formed surfaces or surfaces congested with reinforcing steel. Regardless of the method used, the resulting surfaces shall be free from all laitance and inferior concrete so that clean, well bonded coarse aggregate is exposed uniformly throughout the lift surface. The edges of the coarse aggregate shall not be undercut. The surface shall be washed clean again as the last operation prior to placing the next lift. There shall be no standing water on the surface upon which concrete is placed.

3.2.4.2 Air-Water Cutting

Air-water cutting of a construction joint shall be performed at the proper time and only on horizontal construction joints. The air pressure used in the jet shall be 90 to 110 psi, and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. When approved by the Contracting Officer, a retarder complying with the requirements of COE CRD-C 94 may be applied to the surface of the lift to

prolong the period of time during which air-water cutting is effective. Prior to receiving approval, the Contractor shall furnish samples of the material to be used and shall demonstrate the method to be used in applications. After cutting, the surface shall be washed and rinsed as long as there is any trace of cloudiness of the wash water. Where necessary to remove accumulated laitance, coatings, stains, debris, and other foreign material, high-pressure water jet or sandblasting will be required as the last operation before placing the next lift.

3.2.4.3 High-Pressure Water Jet

A stream of water under a pressure of not less than 3,000 psi may be used for cleaning. Its use shall be delayed until the concrete is sufficiently hard so that only the surface skin or mortar is removed and there is no undercutting of coarse-aggregate particles. If the water jet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting.

3.2.4.4 Wet Sandblasting

This method may be used when the concrete has reached sufficient strength to prevent undercutting of the coarse aggregate particles. The surface of the concrete shall then be washed thoroughly to remove all loose materials.

3.2.4.5 Waste Disposal

The method used in disposing of waste water employed in cutting, washing, and rinsing of concrete surfaces shall be such that the waste water does not stain, discolor, or affect exposed surfaces of the structures, or damage the environment of the project area. The method of disposal shall be subject to approval.

3.3 PLACING

3.3.1 Placing Procedures

The surfaces of horizontal construction joints shall be kept continuously wet for the first 12 hours during the 24-hour period prior to placing concrete. Surfaces may be dampened immediately before placement if necessary. Concrete placement will not be permitted when, in the opinion of the Contracting Officer, weather conditions prevent proper placement and consolidation. Concrete shall be deposited as close as possible to its final position in the forms and, in so depositing, there shall be no vertical drop greater than 5 feet except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it may be effectively consolidated in horizontal layers 2.0 feet or less in thickness with a minimum of lateral movement. The amount deposited in each location shall be that which can be readily and thoroughly consolidated. Sufficient placing capacity shall be provided so that concrete placement can be kept plastic and free of cold joints while concrete is being placed. Concrete shall be placed by methods that will prevent segregation or loss of ingredients. Any concrete transferred from one conveying device to another shall be passed through a hopper that is conical in shape. The concrete shall not be dropped vertically more than 5 feet, except where a properly designed and sized elephant truck with rigid drop chute bottom section is provided to prevent segregation and where specifically authorized. In no case will concrete be discharged to free-fall through reinforcing bars.

3.3.2 Placement by Pump

When concrete is to be placed by pump, the nominal maximum-size coarse aggregate shall not be reduced to accommodate the pumps. The distance to be pumped shall not exceed limits recommended by the pump manufacturer. The concrete shall be supplied to the concrete pump continuously. When pumping is completed, concrete remaining in the pipeline shall be ejected without contamination of concrete in place. After each operation, equipment shall be thoroughly cleaned, and flushing water shall be wasted outside of the forms. Grout used to lubricate the pumping equipment at the beginning of the placement will not be incorporated into the placement.

3.3.3 Time Interval Between Mixing and Placing

Concrete shall be placed within 45 minutes after discharge into nonagitating equipment. When concrete is truck-mixed or when a truck mixer or agitator is used for transporting concrete mixed by a concrete plant mixer, the concrete shall be delivered to the site of the work, and discharge shall be completed within 60 minutes after introduction of the cement to the aggregates or the introduction of the mixing water to the cement and aggregates. The transit time for non-agitator truck may be increased to 75 minutes and the time for agitator trucks may be increased to 90 minutes when a water reducing and retarding mixture (Type D or Type G) is used. When the concrete cannot be properly placed and consolidated within these time limits, the time limits shall be reduced to those limits that will result in acceptable placement and consolidation.

3.3.4 Cold-Weather Placing

When concrete is likely to be subjected to freezing temperatures before the expiration of the curing period, it shall be placed in accordance with procedures previously submitted in accordance with paragraph SUBMITTALS. The ambient temperature of the space adjacent to the concrete placement and surfaces to receive concrete shall be above 32 degrees F. The placing temperature of the concrete having a minimum dimension less than 12 inches shall be between 55 and 75 degrees F when measured in accordance with ASTM C 1064/C 1064M. The placing temperature of the concrete having a minimum dimension greater than 12 inches shall be between 50 and 70 degrees F.

3.3.5 Hot-Weather Placing

Hot weather concreting is defined as the production, placing, and curing concrete when the concrete temperature at placing exceeds 85 degrees F, but is less than 100 degrees F. Unless the specified hot-weather concreting special measures are in effect, including a design mix, concrete exceeding 85 degrees F at the time of placement will be rejected. Regardless of special measures taken, concrete exceeding 100 degrees F will be rejected. Cooling of the mixing water and aggregates, or both, may be required to obtain an adequate placing temperature. A retarder meeting the requirements of paragraph WATER-REDUCING OR RETARDING ADMIXTURES may be used to facilitate placing and finishing. Steel forms and reinforcement shall be cooled prior to concrete placement when steel temperatures are greater than 120 degrees F. Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature. Predict the concrete temperatures at placement time and implement hot-weather measures to avoid production shutdown.

3.3.6 Consolidation

Immediately after placement, each layer of concrete, including flowing concrete, shall be consolidated by internal vibrating equipment. Vibrators shall not be used to transport concrete within the forms. Hand spading may be required, if necessary, with internal vibrating along formed surfaces permanently exposed to view. Form or surface vibrators shall not be used unless specifically approved. The vibrator shall be inserted vertically at uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator. The vibrator shall penetrate rapidly to the bottom of the layer and at least 6 inches into the preceding unhardened layer if such exists. It shall be held stationary until the concrete is consolidated and then withdrawn slowly.

3.3.7 [Concrete Lifts

The depth of concrete placed in each lift shall be as indicated. Concrete shall be deposited in approximately horizontal layers about 1-1/2 feet in thickness in stepped progression at such a rate that the formation of cold joints is prevented. Each new layer of concrete shall be placed on the oldest exposed layer. Slabs shall be placed in one lift, unless 2-1/2 feet or more deep. The time interval between successive lift placements shall be 7 days to allow each lift to become thermally stable.]

3.3.8 [Placing Concrete in Ogee Section

The unformed portion of the ogee section shall be finished by placing concrete slightly above grade and striking off to grade by accurate screeding. Screeding may be accomplished by semi-mechanical devices or by a mechanical screed that consolidates and screeds the surface in one operation. Ribs embedded in the fresh concrete as guides for screeds will not be permitted.]

3.4 FINISHING

****
NOTE: Consult the appropriate DM for those surfaces to receive a trowel finish, abrasive aggregate finish or broom finish. Be sure those special finishes are shown in the drawings.
****

The ambient temperature of spaces adjacent to surfaces being finished shall be not less than 40 degrees F. In hot weather when the rate of evaporation of surface moisture, as determined by use of Figure 2.1.5 of ACI 305R, may reasonably be expected to exceed 0.2 pounds per square foot per hour. Provisions for windbreaks, shading, fog spraying, or wet covering with a light-colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as finishing operations will allow. All unformed surfaces that are not to be covered by additional concrete or backfill shall have a float finish. Additional finishing shall be as specified below and shall be true to the elevation shown in the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown on the drawings and left true and regular. Exterior surfaces shall be sloped for drainage unless otherwise shown in the drawing or as directed. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Grate tampers or jitterbugs shall not be used.

3.4.1 Unformed Surfaces

3.4.1.1 Float Finish

Surfaces shall be screeded and darbied or bullfloated to bring the surface to the required finish level with no coarse aggregate visible. No water, cement, or mortar shall be added to the surface during the finishing operation. The concrete, while still green but sufficiently hardened to bear a man's weight without deep imprint, shall be floated to a true and even plane. Floating may be performed by use of suitable hand floats or power-driven equipment. Hand floats shall be made of magnesium or aluminum.

3.4.1.2 Trowel Finish

A trowel finish shall be applied to the following surfaces: [interior building floor slab, includes the operating floor and the first and second floors] [_____]. Concrete surfaces shall be finished with a float finish, and after surface moisture has disappeared, the surface shall be troweled to a smooth, even, dense finish free from blemishes including trowel marks.

3.4.1.3 [Abrasive Aggregate Finish

An abrasive aggregate finish shall be applied to the following surfaces: [_____] [_____]. The concrete surface shall be finished with a float finish. Abrasive aggregate shall be uniformly sprinkled over the floated surface at a rate of not less than 1/4 pounds per square foot. The surface shall be troweled to a smooth, even finish that is uniform in texture and appearance and free from blemishes including trowels marks. Immediately after curing, cement coating or laitance covering the abrasive aggregate shall be removed by steel brushing, rubbing with abrasive stone, or sandblasting to expose the abrasive particles.]

3.4.1.4 [Broom Finish

A broom finish shall be applied to the following surfaces: [_____] [_____]. The concrete surface shall be finished with a float finish. The floated surface shall be broomed with a fiber-bristle brush in a direction transverse to that of the main traffic.]

3.4.1.5 [Bonded Two-Course Floor

****
NOTE: Consult the appropriate DM or the Design Engineer to choose from the optional paragraphs below.
****

A bonded two-course floor shall be constructed by placing a bonded topping on the thoroughly hardened concrete slab left a distance below final grade as shown in the drawings. The floor topping mixture shall have a specified compressive strength of 6,000 psi at 28 days, a 2 inch maximum slump, 1/2 inch maximum-size coarse aggregate and shall be proportioned to obtain required finishability. Materials shall meet the requirements of paragraph MATERIALS. The surface of the base slab shall be thoroughly cleaned by sandblasting or high pressure water jet in accordance with paragraph PREPARATION FOR PLACING. The base slab shall be kept continuously wet for the first 12 hours during the 24-hour period immediately prior to placing the finished floor. After all free water has evaporated or has been

removed from the surface, a grout shall be scrubbed in. The grout shall be a 1:1 mixture of portland cement and sand passing the No. 8 sieve mixed to a creamlike consistency. The grout shall be applied just ahead of the concrete-placing operation. While the grout is still damp, the top course shall be spread and screeded. The surface shall then be floated with a disc power float or equivalent, followed by a minimum of two power trowelings. Trowel marks left by the machine shall be removed by final, hard steel troweling by hand. The finished floor shall be moist cured in accordance with subparagraph "Moist Curing" of paragraph CURING AND PROTECTION.]

3.4.1.6 [Unbonded Two-Course Floor

An unbonded two-course floor shall be constructed by placing a bond-breaker on the thoroughly hardened concrete slab left a distance below final grade as shown in the drawings. The floor topping mixture shall have a specified compressive strength of 6,000 psi 28 days, a 2 inch maximum slump, 1/2 inch nominal maximum-size coarse aggregate, and shall be proportioned to obtain required finishability. Materials shall meet the requirements of paragraph MATERIALS. The base (bottom) course shall be screeded and bull-floated. The bond-breaker shall consist of plastic sheeting, felt paper, a bond-breaking compound or a sand cushion. The topping shall be floated with a disc power float or equivalent, followed by a minimum of two power trowelings. Trowel marks left by the machine shall be removed by final, hard steel troweling by hand. The finished floor shall be moist cured in accordance with subparagraph "Moist Curing" of paragraph CURING AND PROTECTION.]

3.4.2 Formed Surfaces

****

NOTE: Consult the appropriate DM for information on special architectural finishes. These finishes should also be shown in drawings. Contact the Division Office or CECW-EG for additional guidance if the use of architectural finishes is extensive. If any architectural finish is required other than the normal texture imparted by the forms, the optional sample panel in CEGS-03101 FORMWORK FOR CONCRETE shall be required.

****

Unless another finish is specified, surfaces shall be left with the texture imparted by the forms except that defective surfaces shall be repaired as described in paragraph FORMED SURFACE REPAIR. [Other finishes shall be applied to the following structures or portions of structures:]

TYPES OF FINISH	STRUCTURE OR PORTION OF STRUCTURE
[Grout-cleaned	[_____]]
[Textured	[_____]]
[Exposed aggregate	[_____]]
[Sand-blast	[_____]]
[Tooled	[_____]]

Unless painting of surfaces is required, uniform color of the concrete shall be maintained by use of only one mixture without changes in materials or proportions for any structure or portion of structure that is exposed to

view or on which a special finish is required. The form panels used to produce the finish shall be orderly in arrangement, with joints between panels planned in approved relation to openings, building corners, and other architectural features. [The finished surface of sand-blasted, textured, tooled, and exposed aggregate finishes shall duplicate the preapproved sample panel. The sample panel shall be prepared in accordance with Section 03101A FORMWORK FOR CONCRETE.] Forms shall not be reused if there is any evidence of surface wear or defects that would impair the quality of the surface.

3.4.2.1 [Grout-Cleaned Finish

****
NOTE: See the appropriate DM and EM 1110-2-2000 for surfaces to receive a grout-cleaned finish. Be sure this is shown in the drawings.
****

The surfaces of [_____] shall be given a grout-cleaned finish after all required curing, cleaning, and repairs have been completed. Surfaces to be grout-cleaned shall be moist cured for the required period of time before application of the grout-cleaned finish. Grout-cleaning shall be delayed until near the end of construction on all surfaces not to be painted in order to achieve uniformity of appearance and reduce the chance of discoloring caused by subsequent construction operations. The temperature of the air adjacent to the surface shall be not less than 40 degrees F for 24 hours prior to and 72 hours following the application of the finish. The finish for any area shall be completed in the same day, and the limits of a finished area shall be made at natural breaks in the finished surface. The surface to receive grout-cleaned finish shall be thoroughly wetted to prevent absorption of water from the grout but shall have no free water present. The surface shall then be coated with grout. The grout shall be applied as soon as the surface of the concrete approaches surface dryness and shall be vigorously and thoroughly rubbed over the area with clean burlap pads, cork floats or stones, so as to fill all voids. The grout shall be composed of one part portland cement as used on the project, to two parts by volume of well-graded sand passing a No. 30 sieve mixed with water to the consistency of thick paint. White portland cement shall be used for all or part of the cement as approved by the Contracting Officer to give the desired finish color. The applied coating shall be uniform, completely filling all pits, air bubbles, and surface voids. While the grout is still plastic, remove all excess grout by working the surface with a rubber float, burlap pad, or other means. Then, after the surface whitens from drying (about 30 minutes at normal temperature) rub vigorously with clean burlap pads. Immediately after rubbing is completed, the finished surface shall be continuously moist cured for 72 hours. Burlap pads used for this operation shall be burlap stretched tightly around a board to prevent dishing the mortar in the voids.]

3.4.2.2 [Textured Finish

This type of finish shall be applied where specified to conform to details shown in the drawings by use of approved textured form liners. Liner panels shall be secured in the forms by methods recommended by the manufacturer but not by methods that will permit impressions of nail heads, screw heads, washers, or the like to be imparted to the surface of the concrete. Edges of textured panels shall be sealed to each other to prevent grout leakage. The sealant used shall be nonstaining to the surface. The finish shall be similar to and shall closely match the finish

on the sample panel.]

3.4.2.3 [Exposed Coarse-Aggregate Finish

Coarse aggregate shall be exposed by a method preapproved by the Contracting Officer. The finish shall be similar to and shall closely match the finish on the sample panel.]

3.4.2.4 [Sand-Blast Finish

The concrete surface shall be blasted to obtain a [brush] [light] [medium] [heavy] uniform finish prepared in accordance with the descriptive photographs in ACI 303.1. The finish shall be similar to and shall closely match the finish on the sample panel.]

3.4.2.5 [Tooled Finish

The thoroughly cured concrete shall be dressed with electric, air, or hand tools to a uniform texture and shall be given a [hand-tooled] [rough] [or] [fine-pointed] [crandalled] [or] [bush-hammered] surface texture. The finish shall be similar to and shall closely match the finish on the sample panel.]

3.4.3 Formed Surface Repair

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NOTE: Refer to EM 1110-2-2000 for direction on class of finish. Please note that definitions for class of finish have been changed recently. Class of finish shall also be shown in the drawings. The section on formwork presents materials for each class.

****

After removal of forms, all ridges, lips, and bulges on surfaces permanently exposed shall be removed. All repairs shall be completed within 48 hours after form removal.

3.4.3.1 Classes A, AHV, & B Finishes

Surfaces listed in Section 03101A FORMWORK FOR CONCRETE and as shown to have classes A, AHV, and B finishes shall have surface defects repaired as follows: defective areas, voids, and honeycombs smaller than 16 square inches in area and less than 1/2 inch deep and bug holes exceeding 1/2 inch in diameter shall be chipped and filled with dry-packed mortar. Holes left by removal of tie rods shall be reamed and filled with dry-packed mortar as specified in paragraph MATERIAL AND PROCEDURE FOR REPAIRS. Defective and unsound concrete areas larger than described shall be defined by 1/2 inch deep dovetailed saw cuts in a rectangular pattern with lines parallel to the formwork, the defective concrete removed by chipping, and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of paragraph EPOXY RESIN, a latex bonding agent meeting the requirements of paragraph LATEX BONDING COMPOUND, or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with paragraph MATERIAL AND PROCEDURE FOR REPAIRS.

3.4.3.2 Class C Finish

Surfaces listed in Section 03101A FORMWORK FOR CONCRETE and as shown shall have defects repaired as follows: defective areas, voids, and honeycombs smaller than 24 square inches and less than 2 inches deep; bug holes exceeding 1-1/2 inches in diameter shall be chipped and filled with dry-packed mortar; and holes left by removal of the tie rods shall be chipped and filled with dry-packed mortar. Defective and unsound concrete areas larger than 24 square inches and deeper than 1-1/2 inches shall be defined by 1/2 inch deep dovetailed saw cuts in a rectangular pattern, the defective concrete removed by chipping, and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of paragraph EPOXY RESIN, a latex bonding agent meeting the requirements of paragraph LATEX BONDING COMPOUND, or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with paragraph MATERIAL AND PROCEDURE FOR REPAIRS.

3.4.3.3 Class D Finish

Surfaces listed in Section 03101A FORMWORK FOR CONCRETE and as shown to have class D finish shall have surface defects repaired as follows: defective areas, voids, and honeycombs greater than 48 square inches in area or more than 2 inches deep shall be defined by 1/2 inch deep dovetailed saw cuts in a rectangular pattern, the defective concrete removed by chipping and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of paragraph EPOXY RESIN, a latex bonding agent meeting the requirements of paragraph LATEX BONDING COMPOUND, or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with paragraph MATERIAL AND PROCEDURE FOR REPAIRS.

3.4.3.4 Material and Procedure for Repairs

The cement used in the dry-packed mortar or replacement concrete shall be a blend of the cement used for production of project concrete and white portland cement properly proportioned so that the final color of the mortar or concrete will match adjacent concrete. Trial batches shall be used to determine the proportions required to match colors. Dry-packed mortar shall consist of one part cement to two and one-half parts fine aggregate. The fine aggregate shall be that used for production of project concrete. The mortar shall be remixed over a period of at least 30 minutes without addition of water until it obtains the stiffest consistency that will permit placing. Mortar shall be thoroughly compacted into the prepared void by tamping, rodding, ramming, etc. and struck off to match adjacent concrete. Replacement concrete shall be produced using project materials and shall be proportioned by the Contracting Officer. It shall be thoroughly compacted into the prepared void by internal vibration, tamping, rodding, ramming, etc. and shall be struck off and finished to match adjacent concrete. Forms shall be used to confine the concrete. If an expanding agent is used in the repair concrete, the repair shall be thoroughly confined on all sides including the top surface. Metal tools shall not be used to finish permanently exposed surfaces. The repaired areas shall be cured for 7 days. The temperature of the in situ concrete, adjacent air, and replacement mortar or concrete shall be above 40 degrees F during placement, finishing, and curing. Other methods and materials for repair may be used only when approved in writing. Repairs of the so called "plaster-type" will not be permitted.

3.5 [CURING AND PROTECTION] [CURING, PROTECTION, AND TEMPERATURE MONITORING]

3.5.1 General

ACI 301 unless otherwise specified. Materials and equipment needed for curing and protection shall be available and at the placement site prior to the start of concrete placement. Immediately after placement, protect concrete from premature drying, extremes in temperatures, rapid temperature change, and mechanical damage. Maintain minimal moisture loss at a relatively constant temperature from time of placement until the end of the curing period. Avoid damage to concrete from vibration created by blasting, pile driving, movement of equipment in the vicinity, disturbance of formwork or protruding reinforcement, and any other activity resulting in ground vibrations. Protect concrete from injurious action by sun, rain (first 12 hours), flowing water (first 14 days), mechanical injury, tire marks, and oil stains. Prevent fire or excessive heat, including welding, from coming near or in directed contact with concrete or concrete embedments. Do not use membrane-forming curing compound on surfaces where appearance would be objectionable, on any surface to be painted, where coverings are to be bonded to the concrete, or on concrete to which other concrete is to be bonded. If forms are removed prior to the expiration of the curing period, provide curing for the remaining portion of the curing period.

3.5.2 [Temperature Monitoring

Read the monitoring devices and record the readings at not greater than 6-hour intervals, as approved, beginning when placement is complete and continuing until the maximum temperature differential is reached and begins dropping. If monitoring indicates 35 degrees F differential has been exceeded, take immediate action to retard further growth in the temperature differential and make the necessary revisions to the approved plan to maintain the 35 degrees F or less differential on any remaining placements. Obtain approval of revisions to the approved plan prior to implementation.]

3.5.3 Duration

Curing period shall be 7 days for concrete proportioned for a 28-day specified strength. [Curing period shall be 3 days when Type III cement is used.] The curing period shall be a minimum of 14 days for concrete proportioned for a 56- or 90-day specified strength; terminate moisture retention measures when one of the following occurs:

a. Tests are made on at least two additional cylinders kept adjacent to the structure and cured by the same methods as the structure (referred to as control cylinders in paragraph FORM REMOVAL of Section 03101A FORMWORK FOR CONCRETE), and tests indicate 70 percent of the specified compressive strength as determined in accordance with ASTM C 39/C 39M has been attained.

b. Temperature of the concrete is maintained at 50 degrees F or higher for the time required to achieve 85 percent of the specified compressive strength in laboratory-cured cylinders representative of the concrete in place.

3.5.4 Moist Curing

Moist-cured concrete shall be maintained continuously, not periodically,

wet for the entire curing period. If water or curing materials stain or discolor concrete surfaces that are to be permanently exposed, they shall be cleaned by an approved method that does not harm the concrete. Where wooden form sheathing is left in place during curing, the sheathing shall be kept wet at all times. Where steel forms are left in place during curing, the forms shall be carefully broken loose from the hardened concrete and curing water continuously applied into the void so as to continuously saturate the entire concrete surface. Horizontal surfaces may be moist cured by ponding, by covering with a minimum uniform thickness of 2 inches of continuously saturated sand, or by covering with saturated nonstaining burlap or cotton mats. Water for ponding shall be within 20 degrees F of the temperature of the concrete. Horizontal construction joints may be allowed to dry for 12 hours immediately prior to the placing of the following lift. [Silica fume concrete, if used, shall be moist-cured. Curing of silica fume concrete shall start immediately after placement.]

3.5.5 Membrane-Forming Curing Compound

Concrete may be cured with an approved membrane-forming curing compound in lieu of moist curing except that membrane curing will not be permitted on any surface to which a grout-cleaned finish is to be applied or other concrete is to be bonded, on any surface containing protruding steel reinforcement, on an abrasive aggregate finish, or any surface maintained at curing temperature by use of free steam. A styrene acrylate or chlorinated rubber compound may be used for surfaces that are to be painted or are to receive bituminous roofing or waterproofing, or for floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, waterproofing, or flooring specified.

3.5.5.1 Pigmented Curing Compound

A pigmented curing compound meeting the requirements of subparagraph "Membrane-Forming Curing Compound" above may be used on surfaces that will not be exposed to view when the project is completed.

3.5.5.2 Nonpigmented Curing Compound

A nonpigmented curing compound containing a fugitive dye may be used on surfaces that will be exposed to view when the project is completed. Concrete cured with nonpigmented curing compound must be shaded from the sun for the first 3 days when the ambient temperature is 90 degrees F or higher.

3.5.5.3 Application

Seal or cover joint openings prior to application of curing compound. Prevent curing compound from entering the joint. The curing compound shall be applied to formed surfaces immediately after the forms are removed and prior to any patching or other surface treatment except the cleaning of loose sand, mortar, and debris from the surface. The surfaces shall be thoroughly moistened with water, and the curing compound applied as soon as free water disappears. The curing compound shall be applied to unformed surfaces as soon as free water has disappeared and bleeding has stopped. Mechanically agitate curing compound thoroughly during use. The curing compound shall be applied in a two-coat continuous operation by approved motorized power-spraying equipment operating at a minimum pressure of 75 psi, at a uniform coverage of not more than 400 square feet per gallon of

undiluted compound for each coat, and the second coat shall be applied perpendicular to the first coat. The compound shall form a uniform, continuous, coherent film that will not check, crack, or peel. Immediately apply an additional coat of compound to areas where the film is defective. Concrete surfaces that have been subjected to rainfall within 3 hours after curing compound has been applied shall be resprayed by the method and at the coverage specified. All concrete surfaces on which the curing compound has been applied shall be adequately protected for the duration of the entire curing period from pedestrian and vehicular traffic and from any other cause that will disrupt the continuity of the curing membrane. Do not use this method of curing where the use of Figure 2.1.5 in ACI 305R indicates that hot-weather conditions will cause an evaporation rate exceeding 0.2 pound of water per square foot per hour.

3.5.6 Evaporation Retardant

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NOTE: The concrete that may be cured using impervious sheet should be horizontal or near horizontal finished surfaces such as roof slabs, floors, or the first course of two-course floors, or floors that are to be covered with tile or resilient flooring.

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The following concrete surfaces may be cured using sheet material:

a. [_____]
b. [_____]

Sheet curing shall not be used on vertical or near-vertical surfaces. All surfaces shall be thoroughly wetted and be completely covered with waterproof paper or polyethylene-coated burlap having the burlap thoroughly water-saturated before placing. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 12 inches and securely weighted down or shall be lapped not less than 4 inches and taped to form a continuous cover with completely closed joints. Provide sheeting not less than 18 inches wider than the concrete surface to be cured. The sheet shall be weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3.5.7 Cold-Weather Curing and Protection

When the daily outdoor low temperature is less than 32 degrees F, the temperature of the concrete shall be maintained above 40 degrees F for the first 7 days after placing. In addition, during the period of protection removal, the air temperature adjacent to the concrete surfaces shall be controlled so that concrete near the surface will not be subjected to a temperature differential of more than 25 degrees F as determined by observation of ambient and concrete temperatures indicated by suitable temperatures measuring devices furnished by the Government as required and installed adjacent to the concrete surface and 2 inches inside the surface of the concrete. The installation of the thermometers shall be made at such locations as may be directed.

3.5.8 Hot-Weather Curing and Protection

Supplement standard curing practices with additional methods, supplies or equipment that further reduce moisture loss from exposed surfaces during the required curing period. These methods may include but are not limited to the following examples:

a. Continuous or intermittent regular water fogging.

b. Insulated curing blankets.

c. Curing compound applied at a rate of 1.25 times the minimum rate required in subparagraph "Application" of paragraph [CURING AND PROTECTION] [CURING, PROTECTION, AND TEMPERATURE MONITORING].

3.6 [UNDERWATER CONCRETE

The satisfactory performance of the seal in providing a watertight excavation for placing structural concrete shall be the responsibility of the Contractor. Repair, as necessary to perform its required function, any seal concrete which subsequently fails to perform properly. Deposit seal concrete in one continuous pour.

3.6.1 Preparation

Using divers, check the final excavation to determine that all soft material and broken rock is removed prior to placement. Review proposed procedures and equipment and the proposed concrete mixture prior to the start of placement.

3.6.2 Tolerances

The surface of the concrete may have a tolerance of 6 inches below and 0 inches above the top-of-underwater concrete seal elevation (EL ___).

3.6.3 Placing

Place the concrete in the water-filled cofferdam with either tremie or pump placement. The methods and equipment used shall conform to ACI 304R, Chapter 8 - Concrete Placed Under Water, except as specified herein. Use concrete buckets only to deliver concrete to the tremie. Use a steel pipe attached to the pump's rubber trunk line. The tremie shall be watertight and sufficiently large (8" to 12" diameter) to permit a free flow of concrete. Keep the discharge end of the pump line or tremie continuously submerged in the concrete. Effect the underwater seal in a manner that will not produce undue turbulence in the water. Keep the tremie shaft full of concrete to a point well above the water surface. Proceed placement without interruption until the concrete has been brought to the required height. Control placement with qualified personnel observing all phases of concrete production, transportation, placing procedures, and soundings. Keep the tremie pipe stationary (do not move horizontally) during a placing operation. Use a sufficient number of tremies so that the maximum horizontal flow is limited to 15 feet. Maintain tremie placement rate that exceeds 100 cubic yards per hour; maintain pump placement rate that exceeds 100 cubic yards per hour per truck. Use air-lifts or pumps to remove unsuitable material (scum and laitance) in low areas on the surface of the concrete during the placement.

3.6.4 Curing

Allow concrete to cure for 7 days; after the 7 days of curing, dewater the cofferdam.

3.6.5 Finishing

After the cofferdam is dewatered, remove areas of concrete that were placed above EL [_____] by chipping or grinding. Fill zones where the voids below the tolerance are 0.5 cubic feet or larger with concrete.]

3.7 SETTING OF BASE PLATES AND BEARING PLATES

3.7.1 Setting of Plates

After being plumbed and properly positioned, column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates shall be provided with full bearing with nonshrink grout. The space between the top of concrete or masonry-bearing surface and the bottom of the plate shall be approximately 1/24 of the width of the plate, but not less than 1/2 inch for plates less than 12 inches wide. Concrete surfaces shall be rough, clean, and free of oil, grease, and laitance, and they shall be damp. Metal surfaces shall be clean and free of oil, grease, and rust.

3.7.2 Nonshrink Grout Application

Nonshrink grout shall conform to the requirements of paragraph NONSHRINK GROUT. Water content shall be the minimum that will provide a flowable mixture and fill the space to be grouted without segregation, bleeding, or reduction of strength.

3.7.2.1 Mixing and Placing of Nonshrink Grout

Mixing and placing shall be in conformance with the material manufacturer's instructions and as specified. Ingredients shall be thoroughly dry-mixed before adding water. After adding water, the batch shall be mixed for 3 minutes. Batches shall be of size to allow continuous placement of freshly mixed grout. Grout not used within 30 minutes after mixing shall be discarded. The space between the top of the concrete or masonry-bearing surface and the plate shall be filled solid with the grout. Forms shall be of wood or other equally suitable material for retaining the grout and shall be removed after the grout has set. If grade "A" grout as specified in ASTM C 1107 is used, all surfaces shall be formed to provide restraint. The placed grout shall be worked to eliminate voids; however, overworking and breakdown of the initial set shall be avoided. Grout shall not be retempered or subjected to vibration from any source. Where clearances are unusually small, placement shall be under pressure with a grout pump. Temperature of the grout, and of surfaces receiving the grout, shall be maintained at 65 to 85 degrees F until after setting.

3.7.2.2 Treatment of Exposed Surfaces

After the grout has set, those types containing metallic aggregate shall have the exposed surfaces cut back 1 inch and immediately covered with a parge coat of mortar proportioned by weight of one part portland cement, two parts sand, and sufficient water to make the mixture placeable. The parge coat shall have a smooth, dense finish. The exposed surface of other types of nonshrink grout shall have a smooth, dense finish.

3.7.2.3 Curing

Grout and parge coats shall be cured in conformance with paragraph [CURING AND PROTECTION] [CURING, PROTECTION, AND TEMPERATURE MONITORING].

3.8 TESTS AND INSPECTIONS

Tests and inspections shall conform to the following requirements.

3.8.1 General

Perform the inspections and tests described below, and, based upon the results of these inspections and tests, take the action required and submit reports as required. When, in the opinion of the Contracting Officer, the concreting operation is out of control, concrete placement shall cease. The laboratory performing the tests shall conform with ASTM C 1077. The individuals who sample and test concrete or the constituents of concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I. The individuals who perform the inspection of concrete construction shall have demonstrated a knowledge and ability equivalent to the ACI minimum guidelines for certification of Concrete Transportation Construction Inspector (CTCI). The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations and at least once per year thereafter for conformance with ASTM C 1077.

3.8.2 Batch Plant Control

Quality control of the concrete shall be achieved through statistical evaluation of test results. Perform the testing and implementation of controls in accordance with the Level I Quality Control Plan. Maintain records as required by the FDOT's Standard Operating Procedures for Quality Control of Concrete.

3.8.3 Concrete Mixture at Job Site

3.8.3.1 Sampling

Obtain composite samples in accordance with ASTM C 172. Collect at least one composite sample for each 100 cubic yards, or fraction thereof, of each design mixture of concrete placed any one day.

3.8.3.2 Compressive-Strength Specimens

One set of test specimens from each composite sample shall be made. A set of specimens shall consist of four cylinders. Making, handling, and curing of cylinders shall be in accordance with ASTM C 31/C 31M. Additional cylinders shall be made when an error in batching is suspected. Keep the cylinders moist in storage box for the first 24 hours after making. Construct and locate storage box so that its interior air temperature will be between 60 and 80 degrees F. At the end of 48 hours, transport the cylinders to the testing laboratory. Test cylinders in accordance with ASTM C 39/C 39M.

a. [For mass concrete, make tests at 7 days, 28 days, and 90 days. Test one cylinder at 7 days and one cylinder at 28 days for information. Test two cylinders at 90 days for acceptance.]

b. For structural concrete, make tests at 7, 28, and 56 days. Test one cylinder at 7 days and one cylinder at 28 days for information; the information age may be varied to coincide with a construction consideration. Test two cylinders at 56 days for acceptance.

c. Each strength test result shall be the average of the strengths of two test cylinders at 56 [or 90] days. If one cylinder in a set of two shows evidence of low strength due to improper sampling, casting, handling, or curing, the result of the remaining one cylinder shall be used. The average of any three consecutive 56- [or 90-]day strength test results of the cylinders representing each mix design of concrete shall equal or exceed the specified strength. No individual strength test result shall be less than the specified strength by more than 500 pounds per square inch.

d. Certified reports of the test results shall include sufficient information to identify the mix used, the stationing or location of the concrete placement, and the quantity placed. Slump, air content, temperature of concrete and ambient temperature shall be noted. The 56- [or 90-]day strength test results shall be evaluated in accordance with ACI 214. Quality control charts showing field test results shall be included with the test results for each mix design of concrete. Charts shall be prepared in accordance with ACI 214. Quality control charts shall be maintained throughout the entire job and shall be available for inspection at any time.

3.8.3.3 Compressive-Strength Corrective Action

If the 56- [or 90-]day test results fall below the specified compressive strength for the mix design of concrete required for any portion of the work, adjustment in the proportions, water content, or both, shall be made as necessary. Changes and adjustments shall be reported in writing. Additional analysis or testing, including nondestructive testing, taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

a. Investigation of Low-Strength Test Results: When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 500 psi or if tests of field-cured cylinders indicate deficiencies in protection and curing, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. Nondestructive testing in accordance with ASTM C 597, ASTM C 803/C 803M, or ASTM C 805 may be permitted by the Contracting Officer to estimate the relative strengths at various locations in the structure as an aid in evaluating concrete strength in place or for selecting areas to be cored. Such tests shall not be used as a basis for acceptance or rejection.

b. Testing of Cores: When the strength of concrete in place is considered potentially deficient, cores shall be obtained and tested in accordance with ASTM C 42/C 42M. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the performance of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and

if no single core is less than 75 percent of the specified strength requirement.

c. Load Tests: If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Contracting Officer in accordance with the requirements of ACI 318/318R. Concrete work evaluated by structural analysis or by results of a load test shall be corrected in a manner satisfactory to the Contacting Officer. All investigations, testing, load tests, and correction of deficiencies will be performed and approved by the Contracting Officer at the expense of the Contractor, except that if all concrete is in compliance with the plans and specifications, the cost of investigations, testing, and load tests will be at the expense of the Government.

3.8.3.4 Air Content Testing

Determine air content of each composite sample in accordance with ASTM C 173. Test results shall be plotted on quality control charts. Quality control charts shall be maintained throughout the entire job and shall be available for inspection at any time. The Contractor's quality control representatives shall keep copies of the current control charts in the field and shall also plot the results as tests are made. When a single test result reaches either the upper or lower action limit a second test shall immediately be made. The results of the two tests shall be averaged and this average used as the air content of the batch to plot on both the control chart for air content and the control chart for range, and for determining the need for any remedial action. The result of each test, or average as noted in the previous sentence, shall be plotted on a separate chart for each mixture on which an "average line" is set at the midpoint of the specified air content range from subparagraph "Air Content" of paragraph CONCRETE MIXTURE PROPORTIONING. An upper warning limit and a lower warning limit line shall be set 1.0 percentage point above and below the average line, respectively. An upper action limit and a lower action limit line shall be set 1.5 percentage points above and below the average line, respectively. The range between each two consecutive tests shall be plotted on a secondary control chart for range where an upper warning limit is set at 2.0 percentage points and an upper action limit is set at 3.0 percentage points.

3.8.3.5 Air Content Corrective Action

Whenever points on the control chart for percent air reach either warning limit, an adjustment shall immediately be made in the amount of air-entraining admixture batched. As soon as is practical after each adjustment, another test shall be made to verify the result of the adjustment. Whenever a point on the control chart range reaches the warning limit, the admixture dispenser shall be recalibrated to ensure that it is operating accurately and with good reproducibility. Whenever a point on either control chart reaches an action limit line, the air content shall be considered out of control and the concreting operation shall immediately be halted until the air content is under control. Additional air content tests shall be made when concreting is restarted.

3.8.3.6 Slump Testing

Determine slump of each composite sample in accordance with ASTM C 143/C 143M. Test results shall be plotted on quality control charts. Quality control charts shall be maintained throughout the entire job and shall be

available for inspection at any time. The Contractor's quality control representatives shall keep copies of the current control charts in the field and shall also plot the results as tests are made. When a single slump test reaches or goes beyond either the upper or lower action limit, a second test shall immediately be made on the same batch of concrete. The results of the two tests shall be averaged and this average used as the slump of the batch to plot on both the control chart for percent air and the chart for range, and for determining the need for any remedial action. An upper warning limit shall be set at 1/2 inch below the maximum allowable slump on separate control charts for percent air used for each type of mixture as specified in subparagraph "Slump" of paragraph CONCRETE MIXTURE PROPORTIONING. An upper action limit line and lower action limit line shall be set at the maximum and minimum allowable slumps, respectively, as specified in the same paragraph. The range between each consecutive slump test for each type of mixture shall be plotted on a single control chart for range on which an upper action limit is set at 2 inches.

Samples for slump shall be taken at the mixer; however, the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump. If the Contractor's materials or transportation methods cause slump loss between mixer and the placement, correlation samples shall be taken at the placement site and the slump at the mixer controlled as directed.

3.8.3.7 Slump Corrective Action

Whenever points on the control chart for slump reach the upper warning limit, an adjustment shall be immediately made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount allowed by the maximum W/C specified, based upon aggregates which are in a saturated surface-dry condition. When a single slump reaches the upper or lower action limit, no further concrete shall be delivered to the placing site until proper adjustments have been made. Immediately after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever two consecutive slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range at or above the upper action limit, the concreting operation shall immediately be halted and appropriate steps shall be taken to bring the slump under control. Also, additional slump tests shall be made as directed.

3.8.3.8 Temperature

Determine temperature of each composite sample in accordance with ASTM C 1064/C 1064M. The temperature shall be reported along with the compressive strength data.

3.8.4 Inspection Before Placing

Foundation or construction joints, forms, and embedded items shall be inspected for quality in sufficient time prior to each concrete placement to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing.

3.8.5 Placing

3.8.5.1 Placing Inspection

The placing foreman shall supervise all placing operations, shall determine that the correct quality of concrete or grout is placed in each location as directed and shall be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, yardage placed, and method of placement.

3.8.5.2 Placing Corrective Action

The placing foreman shall not permit batching and placing to begin until he has verified that an adequate number of vibrators in working order and with competent operators are available. Placing shall not be continued if any pile of concrete is inadequately consolidated. If any batch of concrete fails to meet the temperature requirements, immediate steps shall be taken to improve temperature controls.

3.8.6 Vibrators

3.8.6.1 Vibrator Testing and Use

The frequency and amplitude of each vibrator shall be determined in accordance with COE CRD-C 521 prior to initial use and at least once a month when concrete is being placed. Additional tests shall be made as directed when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined at the same time the vibrator is operating in concrete with the tachometer held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing.

3.8.6.2 Vibrator Corrective Action

Any vibrator not meeting the requirements of paragraph VIBRATORS shall be immediately removed from service and repaired or replaced.

3.8.7 Curing

3.8.7.1 Moist-Curing Inspections

At least once each shift, and once per day on nonwork days an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

3.8.7.2 Moist-Curing Corrective Action

When a daily inspection report lists an area of inadequate curing, immediate corrective action shall be taken, and the required curing period for such areas shall be extended by one day.

3.8.7.3 Membrane-Curing Inspection

No curing compound shall be applied until the Contractor's authorized

representative has verified that the compound is properly mixed and ready for spraying. At the end of each operation, he shall estimate the quantity of compound used by measurement of the container and the area of concrete surface covered and compute the rate of coverage in square feet per gallon. He shall note whether or not coverage is uniform.

3.8.7.4 Membrane-Curing Corrective Action

When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

3.8.7.5 Sheet-Curing Inspection

At least once each shift and once per day on nonwork days, an inspection shall be made of all areas being cured using material sheets. The condition of the covering and the tightness of the laps and tapes shall be noted and recorded.

3.8.7.6 Sheet-Curing Corrective Action

When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, the tears and holes shall promptly be repaired or the sheets replaced, the joints closed, and the required curing period for those areas shall be extended by one day.

3.8.8 Cold-Weather Protection and Sealed Insulation Curing

At least once each shift and once per day on nonwork days, an inspection shall be made of all areas subject to cold-weather protection. The protection system shall be inspected for holes, tears, unsealed joints, or other deficiencies that could result in damage to the concrete. Special attention shall be taken at edges, corners, and thin sections. Any deficiencies shall be noted, corrected, and reported.

3.8.9 Cold-Weather Protection Corrective Action

When a daily inspection report lists any holes, tears, unsealed joints, or other deficiencies, the deficiency shall be corrected immediately and the period of protection extended 1 day.

3.8.10 Mixer Uniformity

3.8.10.1 Stationary Mixers

Prior to the start of concrete placing and once every 6 months when concrete is being placed, uniformity of concrete mixing shall be determined in accordance with ASTM C 94/C 94M.

3.8.10.2 Truck Mixers

Prior to the start of concrete placing and at least once every 6 months when concrete is being placed, uniformity of concrete shall be determined in accordance with ASTM C 94/C 94M. The truck mixers shall be selected randomly for testing. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of the blades may be regarded as satisfactory.

3.8.10.3 Mixer Uniformity Corrective Action

When a mixer fails to meet mixer uniformity requirements, either the mixer shall be removed from service on the work, the mixing time shall be increased, batching sequence changed, batch size reduced, or adjustments shall be made to the mixer until compliance is achieved.

3.8.11 Reports

3.8.11.1 General

Results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. A weekly report shall be prepared for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all test and inspection records.

3.8.11.2 [Final Laboratory Report

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NOTE: Require Final Laboratory Report if volume of concrete is more than 1,000 cubic yards.
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A final report, prepared by the testing laboratory, shall be provided at the completion of all concreting. This report shall summarize the findings concerning concrete used in the project and provide totals for each mix design of concrete. Final quality control charts for compressive strength rests for each design mixture of concrete specified shall be included. The report shall also include the concrete batch plant's coefficient of variation and standard deviation results for each design mixture of concrete as determined in accordance with ACI 214.]

-- End of Section --