

BOGUE BROOK RESERVOIR DAM REHABILITATION

SECTION 03300 CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION

- A. The work of this section includes furnishing and placing normal-weight and lightweight cement concrete composed of specified proportions of cement, aggregates, and water mixed to form a homogeneous composition and consolidated in the work as indicated without segregation, under the Engineering Consultant's observation. The Contractor's proposed concrete mix design shall demonstrate the required compressive strengths and densities and be submitted to the Owner and its Engineering Consultant.

Concrete elements shall be reinforced as per the requirements specified herein and as shown on the Contract Drawings.

- B. The work of this section includes furnishing and placement of lightweight cellular cement concrete to be used for infill between buttresses to limits and elevations shown on the Contract Drawings.
- C. The work of this section includes all formwork, bracing, and temporary construction required to build cast-in-place concrete structures (e.g. upstream apron, training walls, splash pad, buttress infill, structural facing, and concrete pads) as shown on the Contract Drawings. Also included in the work of this section is all work required to properly finish, protect, and cure cast-in-place concrete.
- D. The work of this section also include the engagement by the Contractor of an independent testing agency to provide field and laboratory testing services and reports in regard to quality control for cast-in-place concrete. The cost of these services shall be included in the bid price for all cast-in-place concrete. The Contractor shall provide the Owner and its Engineering Consultant with a minimum of 48 hours advance notice of each day of concrete placement operations. Refer to Section 01451 for additional requirements.

1.02 SPECIAL CONDITIONS

- A. The Contractor shall sequence construction and cofferdam/associated by-pass pipe configuration so work at the dam may proceed in the dry. Refer to Section 01565 – Temporary Dewatering and Water Control and the Contract Drawings for additional information and requirements.

1.03 QUALITY CONTROL

The responsibility of the Engineering Consultant includes the inspection of the test results provided by an independent testing agency for the following factors controlling the mix and inspecting the reinforcing steel. The Contractor shall be required to engage, at his own expense, an independent testing agency to perform all quality control tests and inspections. The independent testing agency is subject to approval by the Owner.

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A. Minimum Cement Content and Minimum Strength

The cement proportion is subject to adjustment and approval by the Owner in order to insure compliance with minimum strength requirements. Standard field test specimens conforming to ASTM C31 shall be taken on the job and the Contractor shall be required to add cement as directed by the Owner if test specimens fail to meet the minimum strength requirements.

No claims will be allowed for extra cement or extra concrete due to variations in materials, proportioning, dimensions, shrinkage, waste and similar causes. The Contractor is advised to anticipate a normal loss in yield of at least 1 or 2 percent due to the foregoing causes.

B. Consistency

The Contractor shall uniformly regulate the consistency of the mix to the slump test as directed by the Owner. The Engineering Consultant will reject all batches not conforming to this requirement, and the Contractor shall receive no compensation therefore.

The following general requirements in regard to consistency are given for the Contractor's information; for concrete 3 to 5 inch slump according to placing conditions. The Engineering Consultant will approve the lowest slump with which it is practicable to place and consolidate the mix properly within the forms. Note fiber reinforced concrete may require the use of plasticizer to achieve a workable mix.

C. Air Content

The amount of air in the concrete shall be uniformly regulated to conform to the limiting percentages specified in ASTM C260 and as specified below.

D. Steel Beam

Compliance with the steel beam shown on the Contract Drawings.

1.04 TEST REQUIREMENTS

ASTM C 31	Making and Curing Concrete Test Specimens in the Field
ASTM C 39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C 143	Test for Slump of Portland Cement Concrete
ASTM C 172	Sampling Fresh Concrete
ASTM C 231	Test for Air Content of Freshly Mixed Concrete by the Pressure Method

1.05 MATERIAL REQUIREMENTS

ASTM C 33	Specification for Concrete Aggregates
ASTM C 94	Specification for Ready-Mixed Concrete
ASTM C 150	Specification for Portland Cement
ASTM C 171	Specification for Sheet Materials for Curing Concrete
ASTM C 260	Specification for Air-Entraining Admixtures for Concrete
ASTM C 494	Specification for Chemical Admixtures for Concrete

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1.06 RELATED SECTIONS

A. The following is a list of related work items that shall be performed or furnished under other sections of these specifications as indicated:

1. Independent Testing Services - See Section 01451.
2. Sedimentation and Erosion Control - See Section 01560.
3. Temporary Dewatering and Water Control – See Section 01565
4. Demolition, Removal, and Disposal – See Section 02065.
5. Temporary Cofferdams – See Section 02170
6. Earthwork - See Section 02200.

1.07 SUBMITTALS

The Contractor shall submit, to the Owner and Engineering Consultant the following information for both normal-weight concrete and lightweight cellular concrete:

A. Concrete

1. Name and address of Contractor's testing laboratory firm. Accreditation and a brief description of prior work, which is similar to that proposed for this project. Provide prior work owner's full name, address and telephone number. ASTM E329 will also be used as one of the bases for evaluating the testing laboratory firm.
2. Concrete mix design, material test results, and results of strength tests from the trial concrete mixes by the Concrete supplier.
3. Manufacturer's cement mill test reports for each shipment of cement, regardless of quantity, prior to incorporation into the work.
4. Product data for proprietary materials and items, including forming accessories, admixtures, curing compounds, non-shrink non-metallic grout and others requested by the Owner.
5. Field Test Results from Contractor's Independent Testing Consultant
6. Independent Laboratory Test Results for 7 Day and 28 Day breaks of concrete samples cylinders made at the site by the Contractor's Independent Testing Consultant. Test results from other frequency breaks (i.e. 14 day, 56 day, etc.) may be required.

B. General Procedures

1. Within five (5) days of Notice to Proceed, the Contractor shall submit a schedule of labor, equipment and methods of concrete placement, curing and protection for approval. As part of this submittal include means and methods of delivering concrete to placement areas.
2. Within five (5) days of Notice to Proceed, the Contractor shall submit the name and qualifications of the independent testing company engaged to perform field and laboratory testing of the concrete.

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3. Within five (5) days of the Notice to Proceed, the Contractor shall submit the proposed concrete mix design to both the Owner and Engineering Consultant.

1.08 QUALITY ASSURANCE

A. Concrete

1. Perform Work in accordance with ACI 301.
2. Maintain one copy of document on site.
3. Acquire cement and aggregate from one source for Work.
4. Materials and installed work may require testing and retesting at any time during progress of work. Retesting of rejected materials for installed work shall be done at the Contractor's expense.
5. Do not use admixtures which will cause accelerated setting of the cement in concrete. Use of calcium chloride will not be permitted.
6. Employ an independent accredited testing laboratory, acceptable to the Owner.
7. Acceptance of completed concrete work requires conformance with dimensional tolerances, appearance, and strength as specified and indicated.

PART 2 - PRODUCTS

2.01 NORMAL-WEIGHT CONCRETE

- A. Ready-mixed, air-entrained, low-permeability concrete secured from a batch or mixing plant concrete in accordance with ASTM C94. Minimum 28-day compressive strength of concrete shall be as specified on the Drawings or 4,000 pounds per square inch (psi), whichever is greater. Minimum 7-day compressive strength shall be 3,000 psi.
- B. Cement concrete mix design shall be submitted for review.
- C. The low-permeability cement concrete shall be proportioned per ACI 211.1. The low-permeability cement concrete shall conform to the following requirements of ACI 350R as part of the mix design:

Minimum 28-day compressive strength	4,000 psi
Maximum water/cement ratio	0.45
Maximum aggregate size	¾ inch

The following table of minimum cement contents for various minimum 28-day compressive strengths (6"x12" Cylinders) are based on air entrained and water reduced mixtures. The use of approved additives other than air entraining and water reducing admixtures shall not affect the minimum cement content.

The Contractor shall submit to the Owner, for approval, his/her proposed concrete supplier, source, and type of materials, with current ASTM C-33 aggregate test data, and concrete mix designs by an approved laboratory complete with trial mix data. Trial mixtures will be designed and tested at the maximum slump and air content for each designated class of concrete.

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Minimum 28-Day Compressive Strength	Minimum Cement Pounds per C.Y. Maximum Size Coarse Aggregate			In place Slump (inches)
	1 ½"	¾"	3/8"	
<u>PSI</u>				
2000	376	423	470	3-5
2500	423	470	517	3-5
3000	470	517	564	3-5
3500	517	564	611	3-5
4000	564	611	658	3-5
4500	611	658	705	3-5
5000	658	705	752	3-5
Percent Air Content	5.0	6.0	7.5 (all air content ±1 percent)	

- D. Cement shall be Type II or Type I/II normal Portland cement and admixtures. The cement shall conform to the requirements of ASTM C150 for Portland cement, and shall be either Type II or Type I/II for general use or Type III when high early strength is required. High early strength may also be obtained by use of a non-chloride set accelerating admixture as approved by the Owner. The use of type III Portland cement will not be allowed in concrete exposed to seawater, sewerage, or soils containing chlorides. However, only one type of cement shall be used in a single placement. Cement shall be fresh, sieved, and free of lumps.

Cement shall not exhibit a flash set or cause an abnormal initial rise of temperature upon engaging with water, and it shall maintain its full plasticity and fluidity during the period required for placing the concrete.

Cement having a uniform color shall be used in all exposed concrete.

- E. **Fly Ash – Class F may be substituted for cement up to a maximum of 15% by weight of the design cement content.** Fly ash – Class F or equivalent cementitious produce shall conform to the requirements of AASHTO M 295 or ASTM C618 – Type F. Fly ash may be used to mitigate Alkali-Silica Reactivity (ASR), however fly ash shall replace no more than 15% by weight of the design cement content and any additional fly ash will be considered fine aggregate. Slag (GGBFS) meeting ASTM C989 may be used to replace no more than 20% by weight of the design cement content. Either fly ash or slag may be used, not both.
- F. Cement grout and admixtures for use to fill minor depressions below concrete structures (dental concrete) shall be proposed by the Contractor and will be subject to the Owner’s review and comment prior to approval for use in the work.
- G. Water shall not exhibit any deleterious effects to the required properties of the concrete. Water shall be clean, clear and free from deleterious amounts of oil, acid, alkali, salts and organic matter and conform to ASTM C94, as well as the following requirements:

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1. Acidity 0.1 Normal NaOH 2 c.c. max.*
2. Alkalinity 0.1 Normal HCl 10 c.c. max.*
*(to neutralize 200 c.c. sample)
3. Total Solids:
 - a. Organic 0.01% max.
 - b. Inorganic 0.10% max.
 - c. Sulphate 0.05% max.

Testing of the water by the Contractor shall be in accordance with AASHTO T26 and the test results shall be submitted to the Owner for approval.

H. Aggregates:

1. Fine Aggregate: Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof, conforming to the requirements of ASTM C33, Specifications for "Concrete Aggregates", latest edition. The finess modulus of the fine aggregate shall be 2.80 plus or minus 0.20 and the percent passing the #200 sieve shall not exceed 2 percent by dry sieving and 3 percent by wet sieving.
2. Coarse Aggregate: Coarse Aggregate shall consist of washed gravel, crushed gravel, crushed stone, or a combination thereof conforming to ASTM C33, Specifications for "Concrete Aggregates" latest edition. Aggregates for lightweight concrete shall conform to ASTM C330, Specifications for "Lightweight Aggregates for Structural Concrete."

Select aggregate which is not considered susceptible to Alkali-Silica Reactivity (ASR), in accordance with ASTM C295.

- I. Admixtures: Air entraining and water reducing admixtures will be used in all concrete as specified. They shall be used in strict accordance with the manufacturer's recommendations and added at the batch plant. Admixtures shall be ready-to-use liquid material, and contain no calcium chloride. Set retarding admixtures will be used at the discretion of the Owner when concrete temperatures exceed 80 degrees. The use of high range water reducing admixtures will be allowed only with prior approval of the Owner when circumstances dictate its necessity to facilitate placement .

Air Entraining Admixtures: Shall conform to ASTM C260 Specifications for "Air Entraining Admixtures for Concrete." Testing for air entrainment shall be as per ASTM C231.

Water Reducing, Retarding, Set Accelerating and High Range Admixtures: Shall conform to ASTM C494 Specifications for "Chemical Admixtures for Concrete."

Curing Compounds shall conform to ASTM C309

2.02 LIGHTWEIGHT CELLULAR CONCRETE

- A. Lightweight foamed concrete fill shall be GeoFill LD Hybrid, Aerix Industries, Allied Foam Tech., or equal. The fill shall use Type I/II cement in accordance with ASTM C150. The

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foaming agent shall be non-pervious and comply with ASTM C869. The lightweight foamed concrete fill shall have a wet cast unit weight of 100 pounds per cubic foot (pcf) plus or minus 3 percent. Sand used for aggregate material shall conform to ASTM C33.

- B. Lightweight foamed concrete fill shall have a minimum compressive strength of 1,250 pounds per square inch (psi).
- C. Foam generating equipment shall be used to produce a predetermined quantity of pre-formed foam which shall be mixed and blended with cementitious slurry. Equipment shall be calibrated to produce consistent foam that shall retain its stability until the cement sets to form a uniform cellular structure.

2.03 ACCESSORIES

- A. Bonding Agent. Two component modified epoxy resin.
- B. Epoxy Adhesive. Two component epoxy equivalent to HILTI HY150 or equal. Fast setting adhesive shall NOT be used without express permission.
- C. Cloth, Burlap, Jute or Kenaf. CCC-C-476C
- D. Non-Shrink, Non-Metallic Grout. Premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; capable of developing minimum compressive strength of 5000 psi in 48 hours, with zero percent volume change for plastic state in accordance with ASTM C827, such as Five Star Grout by Five Star Products, Upcon 262 by Emhart Chemical Group or approved equivalent.
- E. Surface Finishing/Patching Cement. Premixed fast setting non shrink patching cement with integral bonding agent, such are ConproSet or approved equivalent.

2.04 FORM MATERIALS AND ACCESSORIES

- A. Plywood Forms:
 - 1. Material: Material shall not be reactive with concrete and shall provide a finish equivalent in smoothness and appearance to plywood conforming to PS-1, Exterior Type Grade B-B. Each panel shall be labeled with grade trademark of APA/EWA.
 - 2. Provide forms which will not deflect beyond finish specified tolerances or indicated on the drawings.
- B. Prefabricated Forms
 - 1. Preformed Steel Forms: Matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces.
 - 2. Form Liners: Smooth, durable, grainless and non-staining hardboard, unless otherwise shown on Drawings.
 - 3. Framing, Studding and Bracing: Stud or No. 3 structural light framing grade.

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C. Accessories

1. Form Ties: Provide ties fitted with devices that will form cone shape holes in the concrete surface not less than 3/8 inch interior diameter or more than 1 1/4 inch exterior surface diameter and at least 1 1/2 inches deep such that the portion of the concrete tie remaining in the concrete will be at least 1 1/2 inches back from the concrete surface.
2. Spreaders: Standard, non-corrosive metal form clamp assembly, of type acting as spreaders and leaving no metal within 1 inch of concrete face. Wire ties, wood spreaders or through bolts are not permitted.
3. Form Anchors and Hangers: Do not use anchors and hangers exposed concrete leaving exposed metal at concrete surface. Symmetrically arrange hangers supporting forms from structural steel members to minimize twisting or rotation of member. Penetration of structural steel members is not permitted.
4. Form Release Agent: Colorless mineral oil which will not stain concrete, or absorb moisture.
5. Corners: 3/4 inch x 3/4 inch triangular fillet type, milled clear straight-grain pine, surfaced each side, or extruded vinyl type, with or without nail flange to form all exposed concrete wall edges
6. Nails, Spikes, Lag Bolts, Through Bolts, Anchorages: Size, strength and character to maintain formwork in place while placing concrete.

2.05 WATERSTOPS

- A. Water stops between existing and new concrete shall be ribbed PVC with a fastening system for mechanically attaching to existing concrete to provide a water tight seal between existing and new concrete. Epoxy or other adhesive/sealant shall be used between water stop and existing concrete. Water stops between existing and new concrete shall be Greenstreak type 655 PVC water stop, or approved equivalent.
- B. For waterstops where new concrete is to adjoin existing (i.e. recently poured) concrete at corners, masonry, or other material, waterstops shall consist of bentonite-free preformed swellable waterstops such as Hydrotite CJ product (or approved equal).
- C. Other types of waterstops shall be as noted on the drawings.

PART 3 - EXECUTION

3.01 METHODS OF PREPARATION AND DELIVERY OF NORMAL-WEIGHT CONCRETE

See ASTM C94 - Standard Specification for Ready-Mixed Concrete

3.02 LIGHTWEIGHT CELLULAR CONCRETE

- A. Foam generating equipment shall be used to produce a predetermined quantity of pre-formed foam which shall be mixed and blended with cementitious slurry. Equipment shall be calibrated to produce consistent foam that shall retain its stability until the cement sets to form a uniform cellular structure.

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- B. Pre-formed foam shall not be added or blended with cementitious slurry in a transit mixer.
- C. Lightweight cellular concrete shall be produced utilizing specialized proportioning, mixing, and foam producing equipment, as approved by the manufacturer, which is capable of meeting the specified properties.
- D. Avoid excessive handling of the material. After sufficient mixing of the foam with slurry, the material shall be conveyed promptly in its final location.
- E. All equipment used to furnish this material shall be approved by the foam manufacturer.
- F. Any items to be encased in lightweight cellular concrete shall be set in place and secured prior to installation of material.
- G. Place lightweight cellular concrete in such a manner so that minimal consolidation of material occurs during or after placement and excessive heat of hydration does not occur. Placement depth of lightweight cellular concrete shall not exceed 6 feet per day.
- H. Final surface of lightweight cellular concrete shall be within +/- 0.2 feet of the plan elevations.
- I. Field Quality Control:
 - 1. Workers, including the contractor's superintendent and/or foreman, shall be fully qualified to perform the work and have had previous experience under similar conditions.
 - 2. Testing shall be performed by the Contractor.
 - 3. Lightweight cellular concrete shall be tested at any age (after 3 days) for compressive strength in accordance with ASTM C-495. At least two (2) specimens from each set should be tested at 28 days.
 - 4. Contractor shall record and measure wet cast densities at the point of placement hourly. Recordings shall be submitted to the Engineer for review. The contractor shall adjust the mix as required to obtain the specified cast density at the point of placement.

3.03 CONSTRUCTION METHODS

A. General

- 1. Concrete elements shall be constructed to the dimensions and design indicated on the Drawing Details, to the lines and grade shown and as directed by the Engineering Consultant, with reinforcement as required, and where necessary, at the direction of the Engineering Consultant.
- 2. The work under this section includes setting all inserts furnished under this specification section to be embedded in cement concrete including all water-stops

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and dowels, plates and guides. The concrete after setting and finishing shall be true to required dimensions and shall be of high quality and exhibit an approved finish and workmanship.

3. The Contractor shall present mix designs for the specified class of concrete. Each of the laboratory design mixes shall be varied as directed by the Owner until a mix has been produced that meets the requirements of these Specifications and which receives the written approval of the Owner. The approved mix design shall not be varied for the remainder of the job unless such change is directed by the Owner.
4. No concrete shall be formed or placed until all sediment control, water control, and reinforcing steel installation work has been completed. These tasks are covered herein and under other sections of the Specifications.
5. The Contractor shall provide and maintain all necessary equipment for the control of surface, groundwater and seepage within the limits of new concrete areas in order to permit assembly of reinforcement (and related appurtenances), and placement of concrete to be conducted in the dry.

B. Forms

Approved centers and forms shall be provided by the Contractor. No extra compensation for false work will be allowed, such work being considered a part of the form work. False work shall be set to give the structural sizes indicated on the Plans or as specified, plus allowance for shrinkage or settlement. Forms, except as hereinafter specified, shall be made of planed lumber or form plywood and shall conform to the design of the work.

Inserts, anchors and support systems shall be installed by the Contractor, including reinforcing steel, water-stops, and dowels and such similar items that are required to be incorporated into the concrete construction. It is the responsibility of the Contractor to insure that all inserts are accurately installed and securely held in place immediately prior to placing the concrete, and to insure that these devices are inspected and approved by the Engineering Consultant at least 24 hours before placing concrete. Concrete placed without such approval of the Engineering Consultant may be rejected and removed at no additional cost to the Owner.

All forms shall be cleaned and repaired as required and oiled prior to each placement. Defective forms with unplugged holes or other defects shall not be used.

The sheathing shall be joined tightly to prevent leakage from the mix and it shall be of sufficient strength to hold the concrete without bulging between supports. Forms shall be properly braced and tied so as to maintain correct dimensions. Bolts, rods or approved form ties shall be used for internal ties. Wire ties will not be permitted except when directed or where concrete is not exposed to view.

Prior to placing concrete in the forms all foreign matter, lumber and wire ends shall be removed.

The forms shall be true to the lines, satisfactorily supported and firmly secured. They shall remain in place as long as directed and shall be replaced by new forms if they lose their proper dimensions or shape.

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All forms shall be treated with non-staining mineral oil or other approved release agent before placing the concrete. The release agent shall be applied before the reinforcing steel is placed. Any material which will adhere to or discolor the concrete shall not be used.

Use steel, plywood or lined board forms as forms for "Smooth Finish" Concrete. Use clean and smooth plywood and form liners, uniform in size, and free from surface and edge damage capable of affecting resulting concrete finish. Install form lining with close-fitting square joints between separate sheets without springing into place. Use full size sheets of form lines and plywood wherever possible. Tape joints to prevent protrusions in concrete. Use care in forming and stripping wood forms to protect corners and edges. Level and continue horizontal joints. Keep wood forms wet until stripped.

Provide removable cleanout sections or access panels at bottoms of forms to permit inspection and effective cleaning of loose dirt, debris and waste material. Clean forms and surfaces against which concrete is to be placed. Remove chips, saw dust and other debris. Thoroughly blow out forms with compressed air just before concrete is placed.

C. Handling and Placing Concrete

Within five (5) days from Notice to Proceed, the Contractor shall submit a schedule of labor, equipment and methods of concrete placement, curing and protection for approval. As part of this submittal include means and methods of delivering concrete to placement areas. Failure to submit aforementioned schedule or demonstrate operation of equipment at the Engineering Consultant's request may be just cause for cancellation of the schedule placement.

Aluminum shall not be used in any equipment where it would be in permanent or abrasive contact with fresh concrete.

Whenever possible, place concrete during normal working hours. When concrete placement schedules require concrete placement at times other than normal working hours, notify the Owner and its Engineering Consultant of special conditions at least 48 hours in advance of placement. Notify Engineering Consultant minimum 48 hours prior to commencement of concrete placement operations. Include within this notification, the quantity of concrete, method and placement location, frequency of trucks, ordered slump and time of initial delivery.

Provide a delivery batch ticket to the Engineering Consultant, written in ink or computer printed, with each batch delivered to the discharge location, and as specified in ASTM C94 and in addition, state the following:

1. Load number, truck number and driver's name
2. Volume of Concrete (Cubic Yards)
3. Mix designation number
4. Actual batch weights of cement, fine and coarse aggregate, admixtures, and water
5. Time batched
6. Signature of ready-mix representative

Failure to provide this information at delivery will be considered cause for rejection of

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the load.

Additional information which may be required at the discretion of the Engineering Consultant is as follows:

1. Compression strength of concrete
2. Reading of revolution counter at first addition of water
3. Type, brand and amount of cement
4. Type, brand and amount of admixture
5. Information necessary to calculate total mixing water
6. Maximum size of aggregate

1. Transportation

Order concrete from batching plant so that trucks arrive at discharge locations when the concrete is required. Avoid excessive mixing of concrete or delays in placing successive layers of concrete in forms. The concrete supplier shall deliver concrete to discharge locations in watertight agitator or mixer trucks without altering the specified properties of water-cement ratio, slump, air-entrainment, temperature and homogeneity. Deliver concrete in order that the contractor can accept delivery within 90 minutes after batching or earlier during hot weather concreting as specified. Do not add retempering water, nor exceed the specified water-cement ratio. The Contractor or Engineering Consultant shall reject concrete not conforming to specification, unsuitable for placement, exceeding time limitation restraints, and not having a complete delivery batch ticket.

The concrete shall be transported from the mixer and placed in the forms by a method which will permit handling concrete of the slump required without segregation. Buggies and wheelbarrows used for this purpose shall be equipped with pneumatic tires. Chutes shall be metal or metal lined, inclined so as to have a slope of between 2 and 3 horizontally to 1 vertically. Long chutes shall be provided with reversed flow or re-mixing hoppers in order to correct for segregation.

Transportation of concrete by pumping is considered a suitable means for delivering concrete. The equipment shall be suitable in kind and adequate in capacity for the work. The equipment and operation shall conform to the requirements of the latest American Concrete Institute (ACI) Specifications for Masonry, Placing Concrete by Pumping. The operation shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pump-line, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.

At the conclusion of placement, the entire equipment shall be thoroughly cleaned and all waste and debris shall be legally disposed of off the site in accordance with Federal, State and Local laws, regulations and ordinances. The number and lengths of flexible lines used for pumping concrete shall be kept to the minimum required for proper distribution. Transition sections for reducing the diameter of the lines shall be of slick-line material and shall be as long as possible.

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2. Placing Concrete

Place concrete in accordance with ACI 301. Deposit concrete at its final position in formwork, to preserve slump, air content, and homogeneity in accordance with ACI 304, and as specified herein. Clean out forms of all soil and debris prior to placement. Wet forms and existing concrete but remove standing water. Concrete shall be properly distributed in the forms by shoveling. The forms shall be filled in horizontal layers 1½ to 2 feet thick maximum, with each layer extending completely across the forms. Do not allow concrete to fall freely in forms to cause segregation. Do not move concrete horizontally more than four feet from the point of discharge. Space points of deposit not more than eight feet apart. Care shall be taken to avoid splashing the forms and reinforcing above the level of the mix. Do not interrupt successive placement; do not permit cold joints to occur. Do not deposit partially hardened concrete in forms. Retempering of partially hardened concrete is prohibited. Remove all partially hardened concrete from site at no additional compensation.

3. Consolidation

Consolidate concrete in accordance with ACI 309. Each layer shall be thoroughly consolidated by vibration. The face of the forms shall be carefully spaded to bring a dense mortar to the face, and produce a good finish.

All concrete, unless otherwise directed, shall be compacted by means of approved mechanical vibrators operated within the mass of the concrete. The Contractor shall provide approved methods of vibration to fully consolidate the mix. Vibrators shall be of internal type, of standard make and approved capacity, and shall be capable of transmitting vibrations to the concrete at frequencies of not less than 4500 impulses per minute.

Vibration of forms or reinforcing steel shall not be permitted except where internal vibration is not practical and then only with approval of the Engineering Consultant for each specific application.

The vibrator shall be applied directly to the mass at the point and time of deposit and move throughout the mass continuously from point to point in the mix using care to avoid hitting the forms, over-vibration, causing segregation, over-finished surface and excess water gain.

Vibrators of sufficient number and size shall be provided to obtain proper placing in accordance with the rate of deposit. At least one spare of each type vibrator required shall be on hand at all times.

Extreme care shall be taken to prevent penetrating or disturbing previously placed concrete which has become partially set.

D. Joints

1. Construction Joints

Concrete in structures shall be placed in such a manner that all construction joints

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shall be exactly horizontal or vertical, as the case may be, except as otherwise specified, and that they shall be straight and as inconspicuous as possible.

When construction joints are indicated, all concrete between consecutive joints shall be placed in a continuous operation.

In order to allow for shrinkage, concrete shall not be placed against the second side of the construction joints for at least 12 hours after that on the first side has been placed.

Approval from the Owner in writing must be secured before the placing of any construction joints not indicated in the plans.

Unless otherwise indicated, interlocking or keying at construction joints shall be provided by use of keyways and/or dowels in a manner approved by the Owner.

Concrete shall be placed in the order of the sequence of construction. All longitudinal and transverse construction joints shall be formed as described herein and as indicated.

2. Bonding to Concrete Already Set

In all locations where new concrete is going to be placed on or adjacent to existing masonry, existing concrete, and/or newly placed mass concrete, the surface of the said masonry or concrete shall be thoroughly cleaned of all dust, particles and otherwise deleterious material via high-pressure air or water jetting.

No reinforced concrete shall be placed until preparation of all contact surfaces has approved by the Engineering Consultant.

E. Protection

Suitable precautions shall be taken to thoroughly protect the concrete from any damage by weather conditions or otherwise during and after placing.

1. Warm and Dry Weather. During warm or dry weather, and as directed all curing concrete shall be water-cured throughout the curing period.
2. Rainy Weather. During rainy weather all curing concrete shall be properly covered, as may be necessary to prevent damage. Sufficient approved material for covering shall be available at the site of the work for immediate use as may be needed.
3. Cold Weather. During cold weather all curing concrete shall be fully protected, by methods approved by the Owner, until properly set and hardened to prevent damage.

F. Finishing

1. Formed Surfaces not exposed to view shall be finished to produce a surface within Class B tolerance throughout. Form ties shall be cut back from the face of the concrete and all voids and cavities shall be filled with a stiff mortar mix compatible

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with the bulk concrete.

2. Formed Surfaces exposed to view shall be finished to produce a surface within Class A tolerance throughout. Form ties shall be cut back from the face of the concrete and all voids and cavities shall be filled with a stiff patching / finishing mortar mix compatible with the bulk concrete and of the same color. All irregularities shall be removed to produce a smooth and uniform surface. Additional finishing may be done by rubbing with a No. 10 carborundum brick or other abrasive of equal quality. All finishing of concrete walls shall take place immediately after removal of formwork.
3. Horizontal Surfaces shall be finished as follows:
 - a. Floated Finish: After the concrete has been placed, consolidated, struck off and leveled, do not work the concrete further until ready for floating. Begin floating when the water sheen has disappeared and when the surface has stiffened sufficiently to permit the operation. During or after the first floating, check planeness of surface with a 10-ft straightedge applied at not less than two different angles. Cut down all high spots and fill all low spots during this procedure to produce a surface within Class B tolerance throughout. Immediately refloat the slab to a uniform sandy texture.
 - b. Troweled Finish: First float-finish the surface as specified above, then power-trowel, and finally hand-trowel. With the first troweling after power floating, produce a smooth surface which is relatively free of defects but which may still show some trowel marks. Perform the final troweling when a ringing sound is produced as the trowel is moved over the surface. Thoroughly consolidate the surface by the hand troweling operations. Produce a finished surface which is essentially free of trowel marks, uniform in texture and appearance, and plane to a Class A tolerance.
 - c. Roughen Finish: At horizontal surfaces where concrete is placed on top of other concrete to create a monolithic structure, a roughened surface shall be provided by brooming or otherwise scarifying the surface following floating.

G. Curing

All concrete shall be cured according to the latest ACI Specifications (ACI 308 Standard Practice for curing concrete; ACI 301, ACI 305 or ACI 306 as applicable). Notify the Owner of curing method and period prior to concrete placement.

All concrete shall be kept fully saturated and protected against any drying action and rapid change in temperature, by the curing method specified herein only, for not less than 14 days after placing cement concrete.

Curing shall be accomplished by the method of water curing only. Membrane curing compounds shall not be used except in limited areas as approved by the Owner.

No vehicular traffic shall be permitted on the concrete during curing.

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H. Removal of Forms

If necessary, the forms for any portion of the structure shall not be removed until the concrete is strong enough, as determined by the Engineering Consultant, to avoid possible injury from such removal. Forms shall not be removed or disturbed without the prior approval of the Engineering Consultant. Form supports shall be removed in such a manner as to permit the concrete to take the stresses due to its own weight uniformly and gradually.

The minimum compressive strength for the type of concrete prior to removing forms or loading the structure shall be not less than eighty-five (85) percent of the design strength. In no event shall forms be removed from concrete less than 24 hours following placement.

Any defective work discovered after the forms have been removed shall be immediately removed and replaced. If the surface of the concrete is bulged, uneven or shown excessive voids or form joint marks which cannot be repaired satisfactorily, the entire section shall be removed and replaced. All repairs and renewals due to defective work shall be done at the expense of the Contractor.

I. Loading of Concrete Structures

All concrete structures (footings, slabs, tank walls, elevated slabs, roofs, foundations, etc.) shall not be loaded until the concrete has obtained sufficient strength to resist the loads imposed. Further, concrete structures or segments thereof shall not be loaded until the concrete obtains the following design strength.

Loading	Required Strength
Concrete loads from above	75%
Earth filled, backfilling	100%
Equipment Loads	100%

J. Concrete Construction During Cold Weather

Cold weather is defined as any time during the concrete placement or curing period the ambient temperature at the work site drops below 40°F or when the temperature may reasonable be expected to drop below 35°F within 24 hours. **Concrete shall not be placed during cold weather, except with written approval by the Owner, which will not be granted until satisfactory provisions have been made to protect the work.** Cold weather concreting shall conform to ACI 306R. Any concrete placed during cold weather shall be placed at the Contractor's risk and any damage or unsatisfactory concrete shall be removed and replaced at the Contractor's expense. When cold weather is reasonably expected or has occurred within 7 days of anticipated concrete placement, the Contractor shall submit detailed procedures for the production, transporting, placing, protecting, curing, and temperature monitoring of concrete during cold weather. All material and equipment required for cold weather placement and curing protection shall be available at the project site before commencing concrete placement. All snow, ice, and frost shall be removed from the surfaces, including reinforcement and subgrade, against which the concrete is to be placed. The temperature of any surface that will come into contact with fresh concrete shall be at least 35°F and shall be maintained at a temperature of 35°F or above during the placement of concrete.

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The minimum concrete surface temperature requirements indicated in the Table below shall be continuously maintained for a curing period of at least 7 days. The 7 day minimum curing period of time will be extended when necessary to develop satisfactory strength in the concrete. Any day during which the minimum concrete surface temperature requirement is not continuously maintained shall not count as a day contributing to the curing period.

Cold Weather Concrete Surface Temperature Requirements				
	Minimum Section Size Dimension			
	Under 1 foot	1-3 feet	Over 3 ft. up to 6 ft	Over 6 feet
Minimum temperature of concrete during curing period	14°C (57°F)	12°C (54°F)	10°C (50°F)	10°C (50°F)
Maximum allowable temperature drop in any 24-hour period after end of curing	28°C (50°F)	22°C (40°F)	16°C (30°F)	11°C (20°F)

As much as possible, any enclosure for protection shall be in place before depositing of any concrete and the remainder shall be installed as rapidly as possible in order to reduce heat losses to a minimum. Heating within the enclosure shall be attained by such means of artificial heat as will maintain the temperatures specified continuously and with a reasonable degree of uniformity in all parts of the enclosures. All exposed surfaces of concrete within the enclosure shall be kept sufficiently moist to prevent any drying of the surface concrete with possible resulting damage to the concrete in place. Heating appliances shall not be placed in such a manner as to endanger the enclosure, forms or supports, or expose any area of concrete to drying out or other injury due to excessive temperatures.

K. Concrete Construction During Hot and Dry Weather

During hot dry weather, and as directed, all new concrete shall be kept shaded from the sun, shielded from the wind and kept wet with water, or protected by other approved methods to retain the moisture in the concrete throughout the curing period. During concrete placement operations in hot weather, appropriate measures shall be taken to reduce the hazards of increased rate of cement hydration, flash set, loss of water due to evaporation, high concrete ingredient temperatures, and the increased difficulty of concrete placing and finishing. The following requirements shall be met during concrete placement operations in hot weather:

1. Concrete Temperature. The temperature of the concrete at the point of discharge shall not exceed 26.7°C (80°F). Concrete shall not be placed when the internal temperature of the concrete is 80°F or above.

2. Cooling Materials. The Contractor may reduce the temperature of the concrete by cooling one or more of several ingredients. The aggregates may be cooled by fogging, or other suitable means that will not result in a high variation of moisture content within the stockpile. Chipped or crushed ice may be used in the mix as a portion of the mixing water on a pound for pound basis, provided such measure is determined at the time it is placed

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in the mix. If used, all ice shall be melted before the batch is discharged from the mixing unit. Ice shall be added with the approval of and/or as directed by the Owner. Water may also be cooled by refrigeration or other means that provide a uniform mixing water temperature.

3. Concrete Placing. Immediately before the concrete is placed, the forms and reinforcement steel shall be cooled by spraying with water. In no case shall there be any standing water in the concrete forms as a result of the spraying procedures. The Contractor shall have sufficient skilled men and adequate equipment to place the concrete without delays which may cause excessive slump loss and evaporation due to over-mixing or exposure before it is placed.

Conform to ACI 305R when concreting during hot weather. Alternatively, when concrete temperatures exceed 80°F, a set retarding admixture conforming to ASTM C494 type B or D may be added to the concrete mix as directed by the Owner.

4. Finishing. To prevent shrinkage cracking resulting from moisture loss, the Contractor may be required to furnish windscreens, to use water fogging, or other approved means of supplying moisture. If the use of windscreens is required, the windscreens shall consist of canvas barriers of suitable height erected on the windward side of the concrete placement. Finishing operations shall follow as closely as practicable behind the placing operation so that curing may begin as soon as possible.

L. Waterproofing

An approved waterproofing compound shall be applied where indicated. The waterproofing compound shall be applied as per the manufacturer's specifications. When, indicated, all joints shall also be treated with the waterproofing compound as per the manufacturer's instructions.

3.04 FIELD QUALITY CONTROL AND TESTING

- A. Testing Agency: The Contractor shall engage a qualified independent testing and inspecting agency to inspect the steel beam placement and formwork, sample materials, perform tests, and submit test reports during concrete placement. Sampling and testing for quality control may include those specified in this Article.
- B. Testing Services: The Contractor shall be responsible for coordinating with the Testing and Inspection Agency during the placement of concrete. Test results for field tests shall be immediately reported to the Owner and its Engineering Consultant. Unless the need for testing is waived by the Engineering Consultant, testing of composite samples of fresh concrete obtained according to ASTM C172 shall be performed according to the following requirements:
1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mix.
 2. Slump: ASTM C143; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.

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3. Air Content: ASTM C231, pressure method, for normal-weight concrete; ASTM C173, volumetric method, for structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
 4. Concrete Temperature: ASTM C1064; one test hourly when air temperature is 40° F and below and when 80° F and above, and one test for each composite sample. Not less than one test for each day's pour of each concrete mix.
 5. Unit Weight: ASTM C567, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
 6. Compression Test Specimens: ASTM C31/C31M;
 - a. Cast and laboratory cure one set of six (6) standard cylinder specimens for each composite sample.
 7. Compressive-Strength Tests: ASTM C39;
 - a. Test two laboratory-cured specimens at 7 days and two at 28 days.
 - b. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at age indicated. One average for lab cured specimens and a separate average for field cured specimens.
 - c. Two remaining cylinders shall be retained until notified by the Owner of approval for disposal.
- C. When strength of field-cured cylinders (if required) is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
- D. Strength of each concrete mix will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi, for normal-weight concrete.
- E. Test results shall be reported in writing to the Owner, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-and 28-day tests.

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F. Additional Tests:

Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Engineering Consultant. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42 or by other methods as directed by Owner.

G. Load Testing.

Should the compression test of the cores taken from the structure fail to be in compliance with these Specifications, the CONTRACTOR will be directed by the Owner to conduct a load test of the structure in conformance with ACI 318 under the direction of the Contractor's laboratory testing firm. Should the load test fail, the structure shall be removed from the site and replaced. All tests associated with the load testing and removal and replacement of the structure will be by the Contractor, at no cost to the Owner.

The Contractor must allow the Engineering Consultant to inspect concrete surfaces immediately upon removal of forms. Excessive honeycomb or embedded debris in concrete is not acceptable. Notify the Engineering Consultant immediately upon discovery. Patch imperfections as directed by The Engineering Consultant in accordance with ACI 301. Core holes shall be roughened, cleaned and dampened. Fill core holes with 4000 psi (minimum) concrete and wet cure for 7 days after placement.

H. Acceptance of Concrete at Site:

Reject concrete delivered without a complete concrete delivery batch ticket as specified. Copies of the signed batch ticket will be furnished by the concrete supplier to the Contractor and the Engineering Consultant. Inspect the concrete transit truck's barrel revolution counter and gauge for measuring water added to the concrete. Reject concrete which exceeds the maximum barrel revolution of 300 or which has had water added during transit. Reject concrete exceeding specified time limitations. Concrete not conforming to these Specifications shall be rejected by the Contractor or the Engineering Consultant before discharging into the forms.

3.05 WATERSTOPS

Approved waterstops shall be provided at all vertical and horizontal joints.

Install dumbbell or centerbulb waterstops as specified herein and as depicted on the Drawings at locations where new concrete expansion or construction joints are to meet new expansion or construction joints. Waterstops shall be cut and spliced in accordance with manufacturer's recommendations using tools specifically designed for that purpose.

Apply bentonite-free pre-formed swellable water stop at all locations where new concrete is placed against existing (i.e. recently poured) concrete, masonry, or other structures. Additionally, Contractor shall be prepared to place bentonite-free pre-formed swellable water stop at locations deemed necessary by the Engineering Consultant based on conditions observed in the field during actual construction at no additional cost.

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PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT FOR PAYMENT

No measurement shall be made of this item. The bid item under this section is a lump sum quantity.

4.02 PAYMENT

Payment for the scope of the work specified herein, including all labor, materials, equipment and incidentals to provide cast-in-place concrete structures shall be paid for at the applicable Lump Sum price stated on the Form for Bid.

<u>Item No.</u>	<u>Payment Item</u>	<u>Unit</u>
03300.01	Normal-Weight Concrete	Lump Sum
03300.02	Lightweight Foamed Concrete	Lump Sum

***** END OF SECTION *****

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