SECTION 03 3300

ARCHITECTURAL CONCRETE

PART 1 GENERAL

1.1 SUMMARY

A. This Section specifies cast-in-place board-formed architectural concrete including form facings, reinforcement accessories, concrete materials, concrete mixture design, placement procedures, and finishes.

B. Related Documents and Sections: Examine Contract Documents for requirements that directly affect or are affected by Work of this Section. A list of those Documents and Sections include, but is not limited to the following:

1. General provisions of the Contract, including General and Supplementary Conditions, and Division 01 General Requirements Specification Sections.
2. Section 03 3000 - CAST-IN-PLACE CONCRETE.
3. Section 03 4500 - PRECAST ARCHITECTURAL CONCRETE.
4. Section 06 1000 - ROUGH CARPENTRY.
5. Section 07 9200 - JOINT SEALANTS.

1.2 SYSTEM DESCRIPTION

A. Definitions

1. Cast-in-Place Architectural Concrete: Formed concrete that is exposed to view on surfaces of completed structure or building and that requires special concrete materials, formwork, placement, or finishes to obtain specified architectural appearance.
2. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.
3. Design Reference Sample: Sample designated by Architect in the Contract Documents that reflects acceptable surface quality and appearance of cast-in-place architectural concrete.
4. Reveal: Projection of coarse aggregate from matrix or mortar after completion of exposure operations.

B. Referenced Documents:

1. American Concrete Institute:
   a. ACI 117 - Specifications for Tolerances for Concrete Construction and Materials
   b. ACI 301 - Specifications for Structural Concrete
   c. ACI 303.1 - Standard Specification for Cast-In-Place Architectural Concrete
   d. ACI 308.1 - Specification for Curing Concrete:
   e. ACI 347 - Guide to Formwork for Concrete
2. ASTM International:
   a. ASTM C 94 - Standard Specification for Ready-Mixed Concrete
   b. ASTM C 979 - Standard Specification for Pigments for Integrally Colored Concrete

C. Performance Criteria: Concrete work shall be performed so that no evidence of the following will be evident when the concrete is subject to imposed loads, temperature and weather conditions, in accordance with ACI 303 and ACI 347:

1. Damage of any kind.

2. Formwork fastening penetrations or formwork anchoring devices or projections other than approved form ties and specified embedded items.
3. Cracking, other than at control/construction joints, due to improper forming, placing, or curing.
4. Out of alignment or incorrect profiles.
5. Voids, sand pockets or discoloration due to fluid loss through the formwork or improper concrete placement.
6. Surface voids caused by entrapped air.
7. Rock pockets and honeycombs.
8. Discoloration caused from staining and from improper placing of the concrete.
9. Discoloration and/or color tonal variations caused by form release agents, admixtures, or densities of materials used for forms.
10. Color difference due to different placement batches or patches.
11. If any of the above-mentioned deficiencies occur, the Architect may order the affected concrete replaced with acceptable concrete. Repair only when directed by the Architect. Corrected deficiencies must meet with the Architect's approval.
12. There shall be no visible effect (variation from that cast using phenolic-faced wood, for instance) from fiberglass forms on the surface of the as-cast concrete.

1.3 SUBMITTALS

A. General: Do not proceed with the Work of this section, including fabrication of formwork, until Submittals have been accepted by the Architect.

B. Formwork Shop Drawings: Show formwork construction including layout and details of formwork, form-facing joints, rustications, construction and contraction joints, crack control joints, expansion joints, form joint-sealant details, form tie locations and patterns, inserts and embedments, cutouts, cleanout panels, and other items that visually affect cast-in-place architectural concrete.

C. Placement Schedule: Submit concrete placement schedule before start of placement operations. Include locations of all joints including construction joints.

D. Samples: For each of the following materials:

1. Form-facing panel.
2. Form ties.
3. Form liners.
4. Coarse- and fine-aggregate gradations.
5. Chamfers and rustications.

E. Samples for Verification: Architectural concrete Samples, cast vertically, approximately 18 in. by 18 in. x 2 in., of finishes, colors, and textures to match design reference sample. Include Sample sets showing the full range of variations expected in these characteristics.

1.4 QUALITY ASSURANCE

A. Source Limitations for Cast-in-Place Architectural Concrete: Obtain each color, size, type, and variety of concrete material and concrete mixture from one manufacturer with resources to provide cast-in-place architectural concrete of consistent quality in appearance and physical properties.

B. Field Sample Panels: After approval of verification sample and before casting architectural concrete, produce field sample panels to demonstrate the approved range of selections made under sample submittals. Produce a minimum of 3 sets of full-scale panels, cast vertically, approximately 48 in. by 48 in. by 6 in. minimum, to demonstrate the expected range of finish, color, and texture variations.

1. Locate panels as indicated or, if not indicated, as directed by Architect.
2. In presence of Architect, damage part of an exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
3. Maintain field sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
4. Demolish and remove field sample panels when directed.

C. Mockups: Before casting architectural concrete, build mockups to verify selections made under sample submittals and to demonstrate typical joints, surface finish, texture, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed Work:

1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Architect.
2. Build mockups of typical exterior wall of cast-in-place architectural concrete as shown on Drawings.
3. Demonstrate curing, cleaning, and protecting of cast-in-place architectural concrete, finishes, and contraction joints, as applicable.
4. Obtain Architect's approval of mockups before casting architectural concrete.
5. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 PRODUCTS

2.1 MATERIALS

A. General: Comply with Section 03 3000 - CAST-IN-PLACE CONCRETE for the following:

1. Steel reinforcement and other requirements for reinforcement accessories.
2. Cement and admixtures.
3. Concrete material requirements.

2.2 ADMIXTURES

A. Admixtures: Admixtures must be certified to be compatible with the cement, aggregates, and other constituent materials in the mix and shall contain less than 0.05% of Calcium Chloride.

B. Water Reducing Admixture: ASTM C 494, Type F or G.

C. Viscosity Enhancing Admixtures: Admixture shall be manufactured by a company certified to conform to the requirements of the quality, environmental and occupational health & safety standards ISO 9002, ISO 14001 and OSHA S18001.

D. Cement Replacement Admixture: Use one of the following (as determined by samples):

1. For light color replacement admix: White granulated blast furnace slag.
2. For dark color replacement admix: Fly ash.
3. Silica Fume is not permitted in architectural concrete.

E. Air Entraining Admixture: ASTM C 260.

F. Admixtures for retardation and acceleration may be used if shown there is no adverse effect on architectural requirements and are approved for use.

G. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing

admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.

1. Color: Match Architect's sample.

2.3 CONCRETE MIXTURES

A. General: Comply with Section 03 3000 - CAST-IN-PLACE CONCRETE for concrete mix requirements. Architectural Concrete shall be proportioned to yield 4000 psi compressive strength at 28 days.

B. Limit water-soluble, chloride-ion content in hardened concrete to 0.06 percent by weight of cement.

C. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.4 FORMWORK MATERIALS

A. Joint Sealing Material:

1. Foam gaskets for sealing field erected corner form joints shall be highly compressible foam rubber or neoprene, filly skinned tape, paper backed, with pressure sensitive adhesive on one side, and shall be of sufficient width and thickness for specific use.
2. Sealant for sealing permanent shop or bench fabricated unrevealed joints shall be non-staining, silicone caulking. Clean all sealant from surfaces of formwork so it does not cause discoloration to cast concrete.

B. Form Reveal Strips:

1. Reveal Strips shall be Rigid Polyethylene, (white slick plastic) milled smooth on all contact drafted surfaces. Contact surfaces shall not have projections or saw marks.
2. Contact surfaces shall be milled smooth on all contact drafted surfaces and shall not have projections, saw marks or deformities that will cause edge chipping on removal from newly hardened concrete.

C. Form Release Coating for all formwork surfaces: Colorless, non-staining and having no deleterious effects on the concrete, manufactured specifically for non-absorbent surfaces and for reducing surface voids. Do not use form release agents on water holding vessels unless specifically approved in writing by waterproofing manufacturers.

D. Crack Control Joints: Internal (installed within the concrete) crack control devices shall be units as follows:

1. Device for crack control joints at all surfaces shall be a steel unit fabricated with attachments for securing to the reinforcing bars and manufactured for installation inside the form cavity. Devices at exterior surfaces shall be stainless steel bent to a waterstop configuration. For exterior surfaces device system shall be continuous units from building envelope seal at grade to seal at roof. If top of wall is exposed install continuous inverted "U" shape device.

E. Construction Joints: Provide control joints/cold joints as indicated on the Drawings. Where not shown, they shall be installed 12 ft. apart or less.

F. Fiber-Polymer Composite Wythe Connectors: Manufactured composite glass-fiber and vinyl-ester polymer connector rods, notched, with polymer collars injection molded around shaft of connector rod; alkaline resistant; for noncomposite structural action.

1. Provide the following at locations indicated, where cast-in-place concrete shall be formed

with insulation suspended in the cavity:
a. Composite Technologies Corporation; THERMOMASS Building Insulation Systems.
2. Material and Physical Properties:
a. Tensile Strength: 120 ksi
b. Elongation at Fracture: 2.1% F
c. Flexural Strength (Strong Axis): 120 ksi
d. Compressive Strength (½") Specimen: 67.4 ksi
e. Flexural Elasticity Modulus: 4,764 ksi
f. Tensile Elasticity Modulus: 5,800 ksi
g. Rockwell Hardness E, minimum: 70

2.5 CONCRETE MIXING

A. Ready-Mixed Architectural Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94 and furnish batch ticket information.

1. Clean equipment used to mix and deliver cast-in-place architectural concrete to prevent contamination from other concrete.
2. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 EXECUTION

3.1 FORMWORK

A. General: Comply with Section 03 3000 - CAST-IN-PLACE CONCRETE for formwork, embedded items, and shoring and reshoring.

B. Limit deflection of form-facing panels to not exceed ACI 303.1 requirements.

1. In addition to ACI 303.1 limits on form-facing panel deflection, limit cast-in-place architectural concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
a. Class A, 1/16 in.

C. Fabricate forms to result in cast-in-place architectural concrete that complies with ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

D. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-in-place surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood rustications, keyways, reglets, recesses, and the like, for easy removal.

1. Seal form joints and penetrations at form ties with form joint tape or form joint sealant to prevent cement paste leakage.
2. Do not use rust-stained steel form-facing material.

E. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

F. Coat contact surfaces of wood rustications with sealer before placing reinforcement, anchoring devices, and embedded items.

G. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

H. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

I. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

J. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

K. Coat contact surfaces of forms with surface retarder, according to manufacturer's written instructions, before placing reinforcement.

L. Board-Formed Finish:

1. New boards shall be sealed with several applications of a form oil and then ‘pickled’ by the application of a cement grout or slurry to the surface, which is then allowed to dry before being brushed off.
2. Special attention to the care of boards is required to ensure a good quality off-form finish. Keep boards at a constant moisture content to control gaps between boards to yield textures required.
3. Reduce deflections by back screwing to plywood.

3.2 REINFORCEMENT AND INSERTS

A. General: Comply with Section 03 3000 - CAST-IN-PLACE CONCRETE for fabricating and installing steel reinforcement. Securely fasten steel reinforcement and wire ties against shifting during concrete placement.

B. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

3.3 REMOVING FORMS

A. Formwork for walls may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.

1. Schedule form removal to maintain surface appearance that matches approved mockups.

3.4 JOINTS

A. Construction Joints: Install construction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated.
2. Form joints as indicated. Align construction joint within rustications attached to form-facing material.
3. Locate horizontal joints in walls at the top of footings.
4. Space vertical joints in walls as indicated.

3.5 MIXING AND TRANSPORTING CONCRETE

A. Clean equipment used to mix and deliver architectural concrete to prevent contamination from other concrete.

B. All concrete for each placement, or a minimum of two truck loads shall be on the site prior to starting the placement. The concrete shall be completely discharged into the forms within the time determined by the design mixes to be the optimum duration of fluid stability provided by the mix design. In no case will the concrete be placed after excessive stiffening of the concrete has occurred. Discharge two trucks into the pump at one time in a manner that will enable one truck to be half full and discharging while the other is finished and being replaced with another truck.

3.6 CONCRETE PLACEMENT

A. Refer to Section 03 3000 - CAST-IN-PLACE CONCRETE.

B. Before placing concrete, verify that installation of formwork, form-release agent, reinforcement, and embedded items is complete and that required inspections have been performed.

C. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect.

D. Deposit concrete continuously between construction joints. Deposit concrete to avoid segregation.

E. Depositing Concrete:

1. Concrete for walls, columns and spandrels shall be placed with pump hoses inserted onto the form cavity.
2. Deposit concrete as nearly as practical at its final position, but not farther than 5 ft. horizontally from the final position.
3. Do not drop concrete from a height greater than 5 ft.
4. Place concrete by inserting pump hose into form and into face of fresh concrete. Place an adequate number of trunks in wall and deep spandrel forms to enable a continuous placement without causing delays in moving hoses.
5. Deposit layers in walls or deep spandrels shall not exceed 24 in. in height. Top deposit lift of placement shall not exceed 18 in. in height.
6. Deposits of concrete in walls, beams or slab placements shall have a subsequent deposit placed on top and/or adjacent to the fresh face and consolidated within 30 minutes. Plan construction joints and placements so that the placing sequence will follow this requirement.
7. Deposit concrete as one lift between construction/control joints.

F. Consolidating Concrete:

1. All concrete shall be consolidated by internal vibration using sufficient vibrators for the schedule pour; a minimum of two vibrators is required at each placement. Use as many vibrators as necessary to achieve quality matching approved mockup. Vibrators used to consolidate shall follow deposit location and consolidate concrete after deposit is leveled. Vibrators shall be placed into the concrete vertically at a consistent spacing that will thoroughly blend the deposits, remove entrapped air, and consolidate the concrete. Vibrator head shall be inserted rapidly and withdrawn slowly and evenly to remove maximum amount of entrapped air (optimum withdrawal speed approx. 2 to 4 inches per second). Do not jiggle vibrator up and down during consolidation, use continuous and even insertion and withdrawal of vibrator.
2. After top out leveling in walls and spandrels, the concrete shall be allowed to set 10 to 15 minutes and then shall be given a final vibration of the top 24 inches. Immediately thereafter the top surface shall be finished as required.
3. Caution must be exercised in using vibrators to prevent injury to the form surface material or displacement of embedded items.
4. Keep spare working vibrators on site at all times.
5. Vigorously tap form facing panels just below deposit area during consolidation with rubber

mallets. Strike in an even and consistent pattern to break up large entrapped air bubbles at the contact form face.

3.7 FINISHES, GENERAL

A. Architectural Concrete Finish: Match Architect's design reference sample, identified and described as indicated, to satisfaction of Architect.

B. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces.

1. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

C. Maintain uniformity of special finishes over construction joints, unless otherwise indicated.

3.8 AS-CAST FORMED FINISHES

A. As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Remove fins and other projections exceeding specified limits on formed-surface irregularities. Repair and patch tie holes and defects.

3.9 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 301 for hot-weather protection during curing.

B. Begin curing cast-in-place architectural concrete immediately after removing forms from concrete. Cure according to ACI 308.1, by one or a combination of the following methods that will not mottle, discolor, or stain concrete:

1. Moisture Curing: Keep exposed surfaces of cast-in-place architectural concrete continuously moist for not less than seven days with the following materials:
   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12 in. lap over adjacent absorptive covers.
2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 in., and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period; use cover material and waterproof tape.
3. Curing Compound: Mist concrete surfaces with water. Apply curing compound uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.10 FIELD QUALITY CONTROL

A. General: Comply with Section 03 3000 - CAST-IN-PLACE CONCRETE for field quality-control requirements.

B. Surface Texture:

1. Surface finish is to be a smooth, as formed finish, with no rubbing or patching.

2. Offsets between form panels will be limited to 1/16 in. for architectural and Class A surfaces.
3. Forms will be constructed of phenolic resin faced plywood with at least one ply of birch wood on each face.
4. Form joints and form tie penetrations will be sealed with either caulking or foam tape to minimize water and grout leakage.

C. Surface Porosity: Care will be taken to minimize surface voids or “bug holes”.

D. Color Uniformity:

1. The color of the concrete should be generally uniform. Any variations shall be gradual, with no particularly light or dark areas.
2. Procedures used to achieve color uniformity shall include single source of cement and aggregates and similar applications of admixtures.

E. Surface Irregularities:

1. For Class A surfaces:
   a. Abrupt deviation or gradual deviation over 60 inches is no more than 1/16 in.
   b. Formwork face deflection is limited to L/400.

F. Patching And Repair Of Surfaces: An acceptable patch and repair procedure shall be established in the mockup process for those occasions where it is desired to minimize an irregularity. Do not proceed with patching or repair of finished work unless directed by the Architect.

3.11 REPAIRS, PROTECTION, AND CLEANING

A. Repair and cure damaged finished surfaces of cast-in-place architectural concrete when approved by Architect. Match repairs to color, texture, and uniformity of surrounding surfaces and to repairs on approved mockups.

1. Remove and replace cast-in-place architectural concrete that cannot be repaired and cured to Architect's approval.

B. Protect corners, edges, and surfaces of cast-in-place architectural concrete from damage; use guards and barricades.

C. Protect cast-in-place architectural concrete from staining, laitance, and contamination during remainder of construction period.

D. Clean cast-in-place architectural concrete surfaces after finish treatment to remove stains, markings, dust, and debris.

E. Wash and rinse surfaces according to concrete finish applicator's written recommendations. Protect other Work from staining or damage due to cleaning operations.

1. Do not use cleaning materials or processes that could change the appearance of cast-in-place architectural concrete finishes.

END OF SECTION

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