

SECTION 03300 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes.
- B. Cast-in-place concrete includes the following:
 - 1. Equipment pads and bases.

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one of blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, or silica fume; subject to compliance with requirements.

1.3 SUBMITTALS

- A. General: Submit the following according to Conditions of the Contract and Division 1 Specification Sections. Shop drawing review is only for conformance with the design concept of the project and compliance with the information given in the contract documents.
- B. Product Data: For each type of manufactured material and product indicated.
- C. Design Mixtures: For each concrete mixture. Include alternate mixtures designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
 - 1. Mix design shall indicate the weight of each ingredient of the mixture, aggregate graduation, slump, air content, water/ cement ratio, admixtures, and 7 and 28 day compressive strength test results of trial mixes or acceptable record of field results.
 - 2. Indicate amounts of mix water to be withheld for later addition at Project site.
 - 3. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and installing and removing reshoring.
 - 4. Review is for general applications and features only. Designing formwork and shoring sequence for structural stability and efficiency is Contractor's responsibility.
- D. Welding Certificates: Copies of certificates for welding procedures and personnel.

- E. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
 - 1. Aggregates Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.
- F. Steel Reinforcement: From a qualified testing agency, indicating compliance with requirements.
- G. Material Certificates: Signed by manufacturers certifying that each of the following items complies with requirements, including where applicable, compatibility with other subsequent materials and finishes:
 - 1. Cementitious materials.
 - 2. Admixtures.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed concrete Work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
- C. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.
- D. Welding: Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code--Reinforcing Steel."
- E. Codes and Standards: Comply with provisions of the latest editions of the following codes, specifications, and standards, except where more stringent requirements are shown or specified.
 - 1. American Concrete Institute (ACI) 301-99, "Specifications for Structural Concrete for Buildings."
 - 2. ACI 117-90, "Specification for Tolerances for Concrete Construction and Materials".
 - 3. ACI 211.1-91, "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete."
- F. Place concrete after the placement of all forms, reinforcement, inserts, sleeves, and other embedments have been inspected and approved by the Contractor's superintendent and the Quality Control Manager and reviewed by the COR.
- G. Place concrete only under the supervision of the Contractor's superintendent and the Quality Control Manager.

- H. The Contractor is responsible for the establishment of a quality control program to manage forming, reinforcement, production, delivery, placement, compaction, finishing, curing, protection and patching of all concrete. Comply with the requirements specified in Section 01401.
- I. Provide the Quality Control Manager and the COR with access to the site or to the plant to facilitate inspection of the reinforcement. Submit a schedule, showing the beginning and the duration of the shop fabrication, in sufficient time to allow for the proper inspection.
- J. Provide the Quality Control Manager and the COR, with access to the concrete plant to facilitate inspection of concrete. Notify the Quality Control Manager when production of concrete is to commence and the plant location in sufficient time to allow for the proper inspection.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store cement, aggregate, admixture, water, embedded items and reinforcing in a manner to prevent deterioration or intrusion of any foreign matter. Do not use damaged or deteriorated materials.
- B. Deliver, store, and handle steel reinforcement to prevent bending and damage.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

- A. Forms for Exposed Finish Concrete: Plywood, metal-framed plywood faced, or other acceptable panel-type materials to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints or as shown on drawings.
- B. Chamfer Strips: Wood, metal, PVC or rubber strips, 20 mm by 20 mm.
- C. Form Release Agent: Provide commercially formulated form release agent with a maximum of 350 mg/l volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 420 (Grade 60), deformed. Reinforcing as indicated on the structural drawings to comply with the special ductility requirements of ACI-318M, paragraph 21.2.5, parts (a) and (b).
- B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.

2.3 REINFORCEMENT ACCESSORIES

- A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete, and as follows:
 - 1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected or CRSI Class 2 stainless-steel bar supports.
 - 2. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.
- B. Joint Dowel Bars: Plain-Steel bars, ASTM A615M, Grade 420, cut bars true to length with ends square and free of burs.
- C. Mechanical Splices and Connections: As indicated on Drawings.

2.4 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150; Type V (High Sulfate Resistance) shall be used for all foundations and below grade concrete. Type II concrete shall be used for all other work.
 - 1. Use one brand of cement throughout Project unless otherwise acceptable to Project Director.
- B. Fly Ash: ASTM C 618, Class F.
- C. Normal-Weight Aggregate: ASTM C 33, uniformly graded, and as follows:
 - 1. Coarse aggregate size for concrete in walls, columns, beams, and structural slabs shall not exceed 20 mm.
 - 2. Coarse Aggregates: (a) General Use: 25 mm to 4.75 mm; (b) Walls, Columns, Beams, and Structural Slabs: 20 mm to 4.75 mm; (c) Tight Placement: 12.5 mm to 4.75 mm.
 - 3. Fine Aggregates: Fineness modulus shall not be less than 2.3 nor more than 3.1.
 - 4. Combined Aggregate Gradation: Well graded from coarsest to finest with not more than 18 percent and not less than 8 percent retained on an individual sieve, except that less than 8 percent may be retained on coarsest sieve, on the No. 50 (0.300 mm) sieve, and the No. 100 (0.150 mm) sieve.
 - 5. Materials that contain particles that will discolor the surface shall not be used for any exposed concrete.
 - 6. Provide aggregates from a single source for exposed concrete.
 - 7. Do not use aggregates containing chloride ions in excess to the requirements of ACI for concrete construction in corrosive environments.

2.5 ADMIXTURES

- A. General: Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material and to be compatible with other admixtures and cementitious materials. Do not use admixtures containing calcium chloride. Accelerating admixtures shall not be used unless approved by the Quality Control Manager.
- B. Air-Entraining Admixture: ASTM C 260, Type C.
- C. Retarding Admixture: ASTM C 494, Type B.

2.6 RELATED MATERIALS

- A. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- B. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of type, class, and grade to suit requirements.
- C. Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.85 mm (22 gage) thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

2.7 CONCRETE MIXES

- A. Prepare design mixes for each type and strength of concrete determined by laboratory trial batch method as specified ACI 211.1, ACI 301 and ACI 318M. Use an independent testing agency acceptable to the Project Director for preparing and reporting proposed mix designs. Do not use the same testing agency for field quality control testing.
- B. Submit written reports to the Project Director of each proposed mix prepared and sealed by a professional engineer for each class of concrete at least 15 days prior to start of Work. Do not begin concrete production until the Project Director has approved proposed mix designs.
- C. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
 - 1. Limit use of fly ash and ground granulated blast furnace (GGBF) slag to not exceed 20 percent of cementitious content by weight.
- D. Design mixes to provide normal weight concrete with properties as indicated herein unless indicated otherwise on the Structural Drawings.
 - 1. Proportion normal-weight concrete mix as follows:
 - a. Compressive Strength (28 Days): 25 MPa minimum.
 - b. Maximum Slump: 125 mm.

- E. Water-Cementitious Materials Ratio: Provide concrete for following conditions with maximum water-cementitious materials (W/C) ratios as follows:
 - 1. Unless noted otherwise: Maximum W/C = 0.50.
- F. Limit water-soluble, chloride ion content in hardened concrete to 0.15 percent by weight of cement.
- G. Air Content: Use air-entraining admixtures in exterior exposed concrete unless otherwise indicated. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having total air content of 6 percent with a tolerance of plus or minus 1½ percent.
 - 1. Do not air entrain concrete for trowel finished interior floors and suspended slabs.
 - 2. Do not allow entrapped air content to exceed 3 percent.
 - 3. Concrete exposed to sulfates shall be air-entrained.
- H. Admixtures: Use admixtures according to manufacturers written instructions.

2.8 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94, and furnish batch ticket information.
 - 1. When air temperature is between 30 deg C and 32 deg C, reduce mixing and delivery time from 90 minutes to 75 minutes, and when air temperature is above 32 deg C, reduce mixing and delivery time to 60 minutes.
 - 2. Hand-Mixed Concrete: Hand mixed concrete is not allowed.

PART 3 - EXECUTION

3.1 FORMWORK

- A. Design, erect, shore, brace, and maintain formwork, according to ACI 301 and as shown on formwork shop drawings which have been reviewed by the Project Director, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until concrete structure can support such loads.
- B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
- C. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
 - 1. Class B, 6 mm.

- D. Construct forms tight enough to prevent loss of concrete mortar.
- E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood inserts for forming keyways, reglets, recesses, and the like, for easy removal.
 - 1. Do not use rust-stained steel form-facing material.
- F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.
- G. 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.
- H. Chamfer exterior corners and edges of permanently exposed concrete.
- I. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- J. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- K. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 EMBEDDED ITEMS

- A. Place and secure anchorage devices and other embedded items required for adjoining work that are attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 1. Install anchor bolts, accurately located, to elevations required.

3.3 REMOVING AND REUSING FORMS

- A. General: Formwork, for sides of beams, walls, columns, and similar parts of the Work, that does not support weight of concrete may be removed after cumulatively curing at not less than 10 deg C for 24 hours after placing concrete provided concrete is hard enough to not be damaged by form-removal operations and provided curing and protection operations are maintained.

- B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.
- C. When forms are reused, clean surfaces, remove fins and laticence, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by COR.

3.4 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
 - 1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.
- B. Install in accordance with steel reinforcement placement shop drawings that have been reviewed by the Project Director.
- C. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials.
- D. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover as approved by the Project Director. Do not tack weld crossing reinforcing bars.
 - 1. Shop- or field-weld reinforcement according to AWS D1.4, where indicated.
 - 2. Welding of reinforcing bars is not permitted unless indicated on the structural drawings.
- E. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- F. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Secure overlaps with wire.

3.5 CONCRETE PLACEMENT

- A. General: Comply with ACI 304, "Guide for Measuring, Mixing, Transporting, and Placing Concrete," and as specified.
- B. Before placing concrete, verify that installation of formwork, 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 Project Director.
- D. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot

be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation and at such a rate of placement not to exceed the maximum shown on the formwork shop drawings.

- E. Deposit concrete in forms in horizontal layers no deeper than 600 mm and in a manner to avoid inclined construction joints. Place each layer while preceding layer is still plastic, to avoid cold joints.
1. Consolidate placed concrete with mechanical vibrating equipment supplemented by hand spading, rodding, or tamping. Use equipment and procedures for consolidating concrete recommended by ACI 309R.
 2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the vibrator. Place vibrators to rapidly penetrate placed layer and at least 150 mm into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mix constituents to segregate.
- F. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows, when hot-weather conditions exist:
1. Cool ingredients before mixing to maintain concrete temperature below 32 deg C at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.
 4. Concrete placement shall not be started if the temperature is 40 deg. C and rising or until it is 43 deg. C and falling. All concrete placement shall be completed at ambient air temperature of less than 45 deg. C.

3.6 FINISHING FORMED SURFACES

- A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defective areas repaired and patched. Remove fins and other projections exceeding ACI 347R limits for class of surface specified.
- B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defective areas. Remove fins and other projections exceeding 3 mm in height.
1. Apply to concrete surfaces exposed to public view or to be covered with a coating or covering material applied directly to concrete, such as waterproofing, dampproofing, veneer plaster, or painting.

- C. Rubbed Finish: Apply the following to smooth-formed finished concrete:
1. Smooth-Rubbed Finish: No later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
 2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white Portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
- D. 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. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

3.7 MISCELLANEOUS CONCRETE ITEMS

- A. Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, after work of other trades is in place. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete Work.
- B. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates of manufacturer furnishing machines and equipment.

3.8 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with recommendations in ACI 305R for hot-weather protection during curing.
- B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching $1 \text{ kg/m}^2 \times \text{hour}$ ($0.20 \text{ lbs./ft.}^2 \times \text{hour}$) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing by one or a combination of the following methods:
1. Moisture Curing: Keep surfaces 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 300-mm 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 300 mm, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
- a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
 - b. Cure concrete surfaces to receive floor coverings by moisture cure or with either a moisture-retaining cover or a curing compound that the manufacturer recommends for use with floor coverings.

3.9 QUALITY CONTROL TESTING DURING CONSTRUCTION

- A. General: The Contractor shall employ a qualified independent testing and inspecting agency, approved by the COR, to sample materials, perform tests, and submit test reports according to the requirements specified in this Article.
- B. When strength of field-cured cylinders 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 as approved by the Project Director.
- C. Test results shall be reported in writing to COR, ready-mix producer, and the Contractor within 24 hours after testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspection agency, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day, 28-day, and 56 day (reserve) tests.
- D. Additional Tests: The testing and inspecting agency shall make additional test of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by the COR. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed by the COR. Any concrete that does not comply with this specification will not be accepted. Concrete found to be deficient shall be corrected in a manner satisfactory to the COR. All investigations, testing, load tests, and correction of deficiencies shall be performed at the expense of the Contractor and approved by the COR.

END OF SECTION 03300