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SECTION 03301 - CAST-IN-PLACE CONCRETE (LIMITED APPLICATIONS)

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section specifies cast-in-place concrete, including reinforcement, concrete materials, mixture design, placement procedures, and finishes, for noncritical applications of concrete and for projects using small quantities of concrete.
- B. Related Sections include the following:

List below only products and construction that the reader might expect to find in this Section but are specified elsewhere.

1. Division 2 Section "Earthwork" for drainage fill under slabs-on-grade.
2. Division 2 Section "Cement Concrete Pavement" for concrete pavement and walks.
3. Division 2 Section "Decorative Cement Concrete Pavement" for decorative concrete pavement and walks.
4. Division 3 Section "Cast-in-Place Architectural Concrete" for general building applications of specially finished formed concrete.

1.3 SUBMITTALS

Submittal checklist in ACI 301, Sections 1 through 5, includes 68 items. Many deal with Contractor-requested options; others would not apply to less-complex projects.

- A. General: In addition to the following, comply with submittal requirements in ACI 301.
- B. Product Data: For each type of product indicated.

C. LEED Submittal:

Retain subparagraph below if recycled content is required for LEED-NC or LEED-CI Credits MR 4.1 and MR 4.2. An alternative method of complying with Credit MR 4.1 and MR 4.2 requirements is to retain requirement in Division 1 Section "LEED Requirements" that gives Contractor the option and responsibility for determining how Credit MR 4.1 and MR 4.2 requirements will be met.

1. Product Data for Credit MR 4.1[**and Credit MR 4.2**]: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
 - a. Include statement indicating costs for each product having recycled content.

D. Design Mixtures: For each concrete mixture.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
- B. Source Limitations: Obtain each type of cement of the same brand from the same manufacturer's plant, obtain aggregate from one source, and obtain admixtures through one source from a single manufacturer.

Always retain paragraph below because this Section is based on ACI 301.

- C. Comply with ACI 301, "Specification for Structural Concrete," including the following sections, unless modified by requirements in the Contract Documents:

Usually retain five subparagraphs below. See Evaluations for ACI 301 organization. Four other Sections of ACI 301, "Architectural Concrete," "Mass Concrete," "Prestressed Concrete," and "Shrinkage-Compensating Concrete," could be added but usually fall outside the scope of this Section.

1. "General Requirements."
2. "Formwork and Formwork Accessories."
3. "Reinforcement and Reinforcement Supports."
4. "Concrete Mixtures."
5. "Handling, Placing, and Constructing."

Delete subparagraph below if no structural lightweight concrete is required.

6. "Lightweight Concrete."
- D. Comply with ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

PART 2 - PRODUCTS

2.1 FORMWORK

- A. Furnish formwork and formwork accessories according to ACI 301.

2.2 STEEL REINFORCEMENT

Select requirements from this Article or revise to suit Project.

Retain first paragraph below if recycled content is required for LEED-NC or LEED-CI Credits MR 4.1 and MR 4.2. USGBC allows a default value of 25 percent to be used for steel, without documentation; higher percentages can be claimed if they are supported by appropriate documentation. The Steel Recycling Institute indicates that reinforcing bars are made by the electric arc furnace method, which typically has 57.5 percent postconsumer recycled content and 6.5 percent preconsumer recycled content.

- A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than [25] [60] <Insert number> percent.
- B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
- C. Plain-Steel Wire: ASTM A 82, as drawn.
- D. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
- E. Deformed-Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.

2.3 CONCRETE MATERIALS

- A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source throughout Project:

Select portland cement type from options in subparagraph below.

1. Portland Cement: ASTM C 150, Type [I] [II] [I/II] [III] [V]. [**Supplement with the following:**]

Select supplementary cementing materials from two subparagraphs below if permitted. Ready-mix manufacturer blends these materials with portland cement. Fly ash, slag, or pozzolanic materials may slow rate of concrete strengthening and affect color uniformity. Availability of Class F fly ash predominates over Class C fly ash.

- a. Fly Ash: ASTM C 618, Class [C] [F].
- b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

Retain subparagraph below if factory-blended hydraulic cement is permitted; verify availability of options before specifying. Fly ash, slag, or pozzolanic materials in the nonportland cement part of blended hydraulic cement may slow rate of concrete strengthening and affect color uniformity.

2. Blended Hydraulic Cement: ASTM C 595, Type [**IS, portland blast-furnace slag**] [**IP, portland-pozzolan**] [**I (PM), pozzolan-modified portland**] [**I (SM), slag-modified portland**] cement.

Nominal maximum size of coarse aggregate in first paragraph below is common. Revise to smaller size if required. ACI 301 sets maximum sizes based on spacing of reinforcement, dimensions between sides of forms, and thicknesses of slabs.

- B. Normal-Weight Aggregate: ASTM C 33, graded, [**1-1/2-inch (38-mm)**] <Insert dimension> nominal maximum aggregate size.
- C. Lightweight Aggregate: ASTM C 330, [**1-inch (25-mm)**] <Insert dimension> nominal maximum aggregate size.
- D. Water: ASTM C 94/C 94M[; **potable**].

Retain paragraph below if using synthetic-fiber reinforcement. Revise fiber type if adding polyester or nylon fibers. Monofilament fibers help reduce plastic shrinkage cracking. Manufacturers claim fibrillated fibers also improve hardened concrete properties.

- E. Synthetic Fiber: [**Monofilament**] [**or**] [**fibrillated**] polypropylene fibers engineered and designed for use in concrete pavement, complying with ASTM C 1116, Type III, [**1/2 to 1-1/2 inches (13 to 38 mm)**] <Insert dimensions> long.

2.4 ADMIXTURES

- A. Air-Entraining Admixture: ASTM C 260.
- B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

Select one or more chemical admixtures from six subparagraphs below.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.5 RELATED MATERIALS

Retain first paragraph below for under-slab moisture protection.

- A. Vapor Retarder: Multi-ply reinforced polyethylene sheet, ASTM E 1745, Class C, or polyethylene sheet, ASTM D 4397, not less than 10 mils (0.25 mm) thick.
- B. Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork.

2.6 CURING MATERIALS

Select curing aids from this Article, retaining optional materials if applicable.

Evaporation retarder in paragraph below temporarily reduces moisture loss from concrete surfaces awaiting finishing in hot, dry, and windy conditions.

- A. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.
- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry.
- C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- D. Water: Potable.

Select first paragraph below if a curing compound is required. Delete if a combination curing and sealing compound is required.

- E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
- F. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

Select paragraph above or below if nonyellowing curing and sealing compound is required. Above is solvent borne; below is waterborne. Delete both paragraphs if curing compound alone is required.

- G. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

2.7 CONCRETE MIXTURES

- A. Comply with ACI 301 requirements for concrete mixtures.
- B. Normal-Weight Concrete: Prepare design mixes, proportioned according to ACI 301, as follows:

Select strength from options in subparagraph below or revise to suit Project.

1. Minimum Compressive Strength: **[4500 psi (31 MPa)] [4000 psi (27.6 MPa)] [3500 psi (24.1 MPa)] [3000 psi (20.7 MPa)] <Insert strength>** at 28 days.

Select water-cementitious materials ratio from options in subparagraph below, revise to suit Project, or delete if in-service durability conditions are benign and limits on water-cementitious materials ratio are not required.

2. Maximum Water-Cementitious Materials Ratio: **[0.50] [0.45] <Insert ratio>**.

Select slump limit from options in subparagraph below or revise to suit Project.

3. Slump Limit: **[4 inches (100 mm)] [5 inches (125 mm)] [8 inches (200 mm) for concrete with verified slump of 2 to 4 inches (50 to 100 mm) before adding high-range water-reducing admixture or plasticizing admixture] <Insert dimension>**, plus or minus 1 inch (25 mm).

ACI 301 sets air content depending on severity of exposure conditions of concrete. Air content in second sentence in subparagraph below is maximum recommended by ACI 302.1R for trowel-finished slabs

4. Air Content: Maintain within range permitted by ACI 301. Do not allow air content of floor slabs to receive troweled finishes to exceed 3 percent.

Delete paragraph and subparagraph below if no structural lightweight concrete. If retaining, revise to suit Project. Coordinate with lightweight aggregate supplier and structural engineer. Weights range from 95 to 115 lb/cu. ft. (1520 to 1840 kg/cu. m). Strengths range from 2500 to 6000 psi (17.2 to 41.4 MPa).

- C. Structural Lightweight Concrete Mix: ASTM C 330, proportioned to produce concrete with a minimum compressive strength of **[3000 psi (20.7 MPa)] <Insert strength>** at 28 days and a calculated equilibrium unit weight of **[110 lb/cu. ft. (1762 kg/cu. m)] <Insert weight>** plus or minus 3 lb/cu. ft. (48.1 kg/cu. m), as determined by ASTM C 567. Concrete slump at point of placement shall be the minimum necessary for efficient mixing, placing, and finishing.
 1. Limit slump to 5 inches (125 mm) for troweled slabs and 4 inches (100 mm) for other slabs.

Synthetic-fiber dosage rates in paragraph below reflect typical recommendations of manufacturers. Retain first option for synthetic fiber used for reducing plastic shrinkage cracking. Retain second option for synthetic fiber used for improving hardened concrete properties. Revise dosage if required.

- D. Synthetic Fiber: Uniformly disperse in concrete mix at manufacturer's recommended rate but not less than a rate of **[1.0 lb/cu. yd. (0.60 kg/cu. m)] [1.5 lb/cu. yd. (0.90 kg/cu. m)] <Insert rate>**.

2.8 CONCRETE MIXING

Retain option in paragraph below if synthetic fibers are required.

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M [**and ASTM C 1116**], and furnish batch ticket information.

1. When air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

Delete Project-site mixing in paragraph below if not permitted. ACI 301 applies measuring, batching, and mixing requirements from ASTM C 94/C 94M to Project-site mixing.

- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 1. For mixer capacity of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 2. For mixer capacity larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mix type, mix time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 FORMWORK

- A. Design, construct, erect, brace, and maintain formwork according to ACI 301.

3.2 VAPOR RETARDERS

Delete this Article if no vapor retarder under slabs-on-grade.

- A. Install, protect, and repair vapor retarders according to ASTM E 1643; place sheets in position with longest dimension parallel with direction of pour.
 1. Lap joints 6 inches (150 mm) and seal with manufacturer's recommended adhesive or joint tape.

3.3 STEEL REINFORCEMENT

- A. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
 1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

3.4 JOINTS

Coordinate joint types, description, and locations with Drawings.

- A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
- B. Construction Joints: Locate and install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

Insert spacing of contraction (control) joints here or on Drawings if required. Contraction-joint spacings vary with slab thickness, aggregate size, and slump based on PCA's recommendations. Depth of joint may be varied to suit cutting method; early-entry saws may cut less than one-fourth of concrete thickness.

- C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least [**one-fourth**] <Insert depth> of concrete thickness, as follows:

Select type of joint-forming method from two subparagraphs below or retain both subparagraphs as Contractor's option. Add spacing of joints if not indicated on Drawings.

- 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with groover tool to a radius of 1/8 inch (3.2 mm). Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.

Delete subparagraph below if saw cutting is not permitted. Description does not distinguish conventional wet- and dry-cut saws from early-entry dry-cut saws. Timing is critical to sawed joints. Early-entry dry-cut saws have been used within one to two hours of finishing concrete. Conventional saw cutting must be delayed, usually 4 to 12 hours, to leave concrete undamaged, but not so long that uncontrolled cracking of concrete could occur.

- 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3.2-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

- D. Isolation Joints: Install joint-filler strips at junctions with slabs-on-grade and vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

- 1. Extend joint fillers full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.

3.5 CONCRETE PLACEMENT

- A. Comply with ACI 301 for measuring, batching, mixing, transporting, and placing concrete.
- B. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.

Retain paragraph above or first paragraph below. Delete below if adding water after batch mixing is permitted. ACI 301 permits water to be added to concrete mix on-site to adjust slump, up to amount allowed in design mixture.

- C. Do not add water to concrete during delivery, at Project site, or during placement.

- D. Consolidate concrete with mechanical vibrating equipment.

3.6 FINISHING FORMED SURFACES

Coordinate finishes selected from this Article with a finish schedule or indicate location of each on Drawings.

- 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 1/2 inch (13 mm).
1. Apply to concrete surfaces [**not exposed to public view**] <Insert locations>.
- 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 1/8 inch (3 mm).

Revise locations in subparagraph below to suit Project. Retain second option if further finishing is required.

1. Apply to concrete surfaces [**exposed to public view,**] [**to receive a rubbed finish,**] [**or to be covered with a coating or covering material applied directly to concrete**] <Insert locations>.

Retain rubbed finish in first paragraph below with smooth-formed finish above.

- C. Rubbed Finish: Apply the following rubbed finish, defined in ACI 301, to smooth-formed finished as-cast concrete where indicated:

Select one or more rubbed finishes from three subparagraphs below.

1. Smooth-rubbed finish.
 2. Grout-cleaned finish.
 3. Cork-floated finish.
- 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 FINISHING UNFORMED SURFACES

Retain paragraph below. Some floating and troweling machines have watering attachments. Adding water weakens concrete surface and can cause dusting, blistering, and scaling.

- A. General: Comply with ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

Retain paragraph and subparagraph below before applying scratch finish, float finish, or trowel or broom finish.

- B. Screed surfaces with a straightedge and strike off. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane before excess moisture or bleedwater appears on surface.
 - 1. Do not further disturb surfaces before starting finishing operations.

In remaining paragraphs, select types of slab finishes required. Coordinate slab finishes selected with a finish schedule or indicate location of each on Drawings.

- C. Scratch Finish: Apply scratch finish to surfaces indicated and surfaces to receive concrete floor topping or mortar setting beds for ceramic or quarry tile, portland cement terrazzo, and other bonded cementitious floor finishes, unless otherwise indicated.
- D. Float Finish: Apply float finish to surfaces indicated, to surfaces to receive trowel finish, and to floor and slab surfaces to be covered with fluid-applied or sheet waterproofing, fluid-applied or direct-to-deck-applied membrane roofing, or sand-bed terrazzo.
- E. Trowel Finish: Apply a hard trowel finish to surfaces indicated and to floor and slab surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin film-finish coating system.
- F. Trowel and Fine-Broom Finish: Apply a partial trowel finish, stopping after second troweling, to surfaces indicated and to surfaces where ceramic or quarry tile is to be installed by either thickset or thin-set methods. Immediately after second troweling, and when concrete is still plastic, slightly scarify surface with a fine broom.
- G. Nonslip Broom Finish: Apply a nonslip broom finish to surfaces indicated and to exterior concrete platforms, steps, and ramps. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.

3.8 CONCRETE PROTECTING 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 ACI 301 for hot-weather protection during curing.

If evaporation rate in first paragraph below is exceeded, ACI 305R states that plastic shrinkage cracking is probable. See manufacturers' literature or ACI 305R for estimated moisture-loss chart relating relative humidity, air and concrete temperature, and wind velocity to rate of evaporation.

- B. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) 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. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

- D. Curing Methods: Cure formed and unformed concrete for at least seven days by one or a combination of the following methods:

Select one or more curing methods from four subparagraphs and associated subparagraphs below. Delete methods or restrict use of curing methods to specific locations or types of surfaces if required.

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

Retain first three subparagraphs below as Contractor's options unless not suited for Project.

- a. Water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch (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 12 inches (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.
 3. Curing Compound: Apply 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.

Curing and sealing compound below is usually for floors and slabs and may act as a permanent surface finish.

4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a 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. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.9 FIELD QUALITY CONTROL

Revise field quality-control testing in this Article to suit Project or delete if not required for small projects.

- A. Testing Agency: **[Owner will engage]** **[Engage]** a qualified independent testing and inspecting agency to sample materials, perform tests, and submit test reports during concrete placement according to requirements specified in this Article.
- B. Tests: Perform according to ACI 301.
 1. Testing Frequency: One composite sample shall be obtained for each day's pour of each concrete mix exceeding 5 cu. yd. (4 cu. m) but less than 25 cu. yd. (19 cu. m), plus one set for each additional 50 cu. yd. (38 cu. m) or fraction thereof.

Retain subparagraph above or below. Above is an example that produces more frequent testing than below, which is the testing frequency required to comply with ACI 301.

2. Testing Frequency: One composite sample shall be obtained for each 100 cu. yd. (76 cu. m) or fraction thereof of each concrete mix placed each day.

3.10 REPAIRS

- A. Remove and replace concrete that does not comply with requirements in this Section.

END OF SECTION 03301END OF SECTION 03301