SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, accessories, placement procedures, and finishes, for the following:

1. Footings
2. Foundation Walls
3. Slab-on-grade
4. Concrete Repair

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1. Form-facing materials, smooth-formed finish
2. Form-facing materials, rough-formed finish
3. Chamfer strips
4. Rustification strips
5. Form-release agent
6. Form ties
7. Bar supports
8. Admixtures
9. Fibrous reinforcement
10. Concrete sealer
11. Moisture-retaining cover
12. Curing compound
13. Evaporation retarder
14. Expansion- and isolation-joint filler strips
15. Slab control joint sealer
16. Penetrating silane sealer
17. Bond breakers
18. Bonding agent
19. Grout
20. Chemical anchor adhesives
21. Repair mortar
22. Thin coat patching mortar
23. Repair overlayment

B. Design Mixtures: For each concrete mixture: Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments. Pumping of concrete requires a mix design specifically prepared and previously used for pumping.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.
2. Include compressive strength test reports.
3. Include all ingredient certifications and product data concurrently.

C. Steel Reinforcement Shop Drawings: Place drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement. Show all concrete wall and footing reinforcement on elevation drawings at a scale not less than 1/4-inch = 1 ft. Do not submit placement plans showing only piece marks referencing a cut list.

D. Construction Joint Layout: Shop Drawings indicate proposed construction joint locations and details in concrete slabs and concrete beams. Contractor to wait a minimum of 48 hours between casting slabs to mitigate plastic shrinkage.

E. Slab-on-Grade Control Joint Layout Drawings: Indicate joints as shown on Drawings and proposed locations following required spacing requirements.

F. Refer to Section 01 33 00 for submittal requirements.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturer.

B. Material Certificates: For each type of the following, signed by manufacturers or suppliers:

1. Reinforcing bars
2. Joint dowel bars
3. Cementitious materials
4. Water

C. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:

1. Aggregates

D. Proposed curing method for all concrete elements.

E. Proposed cold and/or hot weather concrete protection procedures.

F. Refer to Section 01 33 00 for submittal requirements.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

B. 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.

C. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

D. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

E. ACI 301, "Specifications for Structural Concrete," Sections 1 through 5.

F. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

1. Structural Preconstruction Conference: Attend conference at Project site.
2. Slab Pre-Pour Conference: Attend conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement.

PART 2 - PRODUCTS

2.1 FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

1. Plywood, metal, or other approved panel materials
2. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and is high-density overlay, Class 1 or better.

B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

C. Chamfer Strips: Wood, metal, PVC, or rubber strips 3/4 by 3/4 inch (19 by 19 mm), minimum.

D. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

E. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces. VOC compliant.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

F. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

1. Furnish units that will leave no corrodible metal closer than 1 inch (25 mm) to the plane of exposed concrete surface.
2. Furnish ties that, when removed, will leave holes no larger than 1 inch (25 mm) in diameter in concrete surface.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

2.3 REINFORCEMENT ACCESSORIES

A. Joint Dowel Bars: ASTM F1554, Grade 60 (Grade 420), plain-steel bars, cut true to length with ends square and free of burrs.

B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

1. For exterior concrete, use galvanized wire or dielectric-polymer-coated wire bar supports.
2. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.

2.4 CONCRETE MATERIALS

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

1. Portland Cement: ASTM C 150, Type I or Type II. Supplement with the following (optional):

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

2. Blended Hydraulic Cement: ASTM C 595 - Type IS, Portland blast-furnace slag; Type IP, Portland-pozzolan; Type I (PM), pozzolan-modified Portland; or Type I (SM), slag-modified Portland cement.

B. Normal-Weight Aggregates:

1. Provide aggregates from a single source.
2. ASTM C 33, Class 4S coarse aggregate or better, graded.
3. Maximum Coarse-Aggregate Size:

   a. Slabs on Grade: 1-1/2 inches (38 mm) nominal.
   b. All Other Concrete: 1 inch (25 mm) nominal.

4. Fine Aggregate: ASTM C 33. Free of materials with deleterious reactivity to alkali in cement.

C. Water: ASTM C 1602/C 1602M and potable

2.5 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 chlorides.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A
2. Retarding Admixture: ASTM C 494/C 494M, Type B
3. Accelerating Admixture: ASTM C 494/C 494M, Type C
4. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D
5. Water-Reducing and Accelerating Admixture: ASTM C 494/C 494M, Type E
6. Mid-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type A or Type F. Water content reduction to be greater than 7%
7. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F
8. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G
9. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II

2.6 FIBER REINFORCEMENT

A. Synthetic Micro-Fiber: Monofilament polypropylene micro-fibers engineered and designed for use in concrete, complying with ASTM C1116, Type III, 1/2 to 1-1/2 inches long.

2.7 SEALED CONCRETE

A. Sealer: Clear, chemically reactive, waterborne solution of inorganic silicate or siliconate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. ChemMasters; Chemisil Plus
b. ChemTec Int'l; ChemTec One
c. Conspec by Dayton Superior; Intraseal
d. Curecrete Distribution Inc.; Ashford Formula
e. Dayton Superior Corporation; Day-Chem Sure Hard (J-17)
f. Edoco by Dayton Superior; Titan Hard
g. Euclid Chemical Company (The), an RPM company; Euco Diamond Hard
h. Kaufman Products, Inc.; SureHard
i. L&M Construction Chemicals, Inc.; Seal Hard
j. Meadows, W. R., Inc.; LIQUI-HARD
k. Metalcrete Industries; Floorsaver
l. Nox-Crete Products Group; Duro-Nox
m. Symons by Dayton Superior; Buff Hard
n. US SPEC, Division of US Mix Products Company; US SPEC Industraseal
o. Vexcon Chemicals, Inc.; Vexcon StarSeal PS Clear

2.8 LIQUID FLOOR TREATMENTS

A. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or siliconate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.

2.9 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz/sq. yd. when dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap–polyethylene sheet

C. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1-D, Class B, dissipating, with fugitive dye

D. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete

2.10 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ½-inch rigid, extruded polystyrene insulation (at exterior walls,) ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork.

B. Slab Control Joint Sealer: Two-component, self-leveling, flexible, 100 percent solids, epoxy resin and adhesive with a Type A shore durometer hardness of 80 per ASTM D 2240 and conforming to ACI 302.1R (5.12-Joint Materials).

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Chem Masters; PolyTops 480
b. Euclid Chemical Company (The); Euco 800
c. Sika Corporation; Sikadur 51 SL

C. Penetrating, Silane Sealer: Single component, minimum 40% silane, waterbased slab sealer that forms chemical bond to the concrete. VOC compliant.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. BASF Construction Chemicals; Enviroseal 40
b. Chem Masters; Aquanil Plus 40
c. Dayton Superior Corporation; Weather Worker 40% J29WB

D. Bond breakers: Waterborne, VOC compliant form release agent.

E. Grout: ASTM C 1107, factory-packaged, shrinkage-resistant, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

F. Chemical Anchor Adhesives: Heavy duty, two component injectable adhesive designed to be dispensed using double chamber gun with mixing nozzle. Adhesives in capsule form will not be accepted.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Hilti, Inc.; Hit-HY 200
b. ITW Redhead; Epcon C6.
c. Powers Fasteners, Inc.; AC100+ Gold.

G. Self-Expanding Rubber Strip Waterstops: Manufactured rectangular or trapezoidal strip, bentonite-free hydrophilic polymer-modified chloroprene rubber, for adhesive bonding to concrete, 3/8 by 3/4 inch (10 by 19 mm). Installed per manufacturer's written instructions.

2.11 REPAIR MATERIALS

A. Repair Mortar: Site-mixed Portland-cement mix for vertical surfaces. Mix dry-pack repair mortar, consisting of one part shrinkage-compensating, Portland cement to two and one-half parts fine aggregate passing a No. 16 (1.18-mm) sieve by damp, loose volume, using only enough water for handling and placing.

B. Thin Coat Patching Mortar: Polymer modified, Portland cement, suitable for exterior applications. Featheredge up to 3/16 inch. For thicker applications manufacturer's recommendations to extend mix with an aggregate may apply.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. BASF Construction Chemicals; Chemrex Levelprep

b. ChemMasters, Inc.; ChemFlow HS
c. Euclid Chemical Company (The); Duraltop Flowable Mortar

C. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch (6.4 mm) and that can be filled in over a scarified surface to match adjacent floor elevations. For thicker applications manufacturer's recommendations to extend mix with an aggregate may apply.
1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219
2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by topping manufacturer
4. Compressive Strength: Not less than 5000 psi (34.5 MPa) at 28 days when tested according to ASTM C 109/C 109M

2.12 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement in concrete as follows:

1. Fly Ash: 25 percent, but if used, a minimum of 15 percent.
2. Combined Fly Ash and Pozzolan: 25 percent.
3. Ground Granulated Blast-Furnace Slag: 50 percent.
4. Combined Fly Ash or Pozzolan and Ground Granulated Blast-Furnace Slag: 50 percent Portland cement minimum, with fly ash or pozzolan not exceeding 25 percent.

C. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

D. Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing, high-range water-reducing or plasticizing admixture in all concrete. Design mix for optimum placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
3. Use a mid-range, water-reducing admixture in pumped concrete, all concrete slabs (including concrete walks), concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.

2.13 CONCRETE MIXTURES FOR BUILDING ELEMENTS

A. Footings, Piers and Foundation Walls: Proportion normal-weight concrete mixture as follows:

1. ACI 318 Exposure Category and Classes: F3, S1, W0, C2
2. Minimum Compressive Strength: 5,000 psi (27.6 MPa) at 28 days
3. Maximum Water-Cementitious Materials Ratio: 0.40
4. Slump Limit: 4 inches, (100 mm) plus or minus 1 inch (25 mm); or 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, plus or minus 1 inch (25 mm)
5. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch (25-mm) nominal maximum aggregate size

B. Slabs on Grade: Proportion normal-weight concrete mixture as follows:

1. ACI 318 Exposure Category and Classes: F1, S1, W0, C2
2. Minimum Compressive Strength: 5,000 psi at 28 days
3. Maximum Water-Cementitious Materials Ratio: 0.40
4. Minimum Cementitious Materials Content: 470 lb/cu. yd. (279 kg/cu. m)
5. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm)
6. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch (25-mm) nominal maximum aggregate size.
7. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture, at concrete batch facility, at manufacturer's recommended rate, but not less than 3.0 lb/cu. yd. (2.4 kg/cu. m)

2.14 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.15 CONCRETE MIXING

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

1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade conditions are satisfactory prior to forming or pouring concrete. Owner’s Testing Agency shall inspect slab and footing subgrade prior to placing concrete.

B. Verify that reinforcing, is properly in place prior to pouring concrete.

C. Verify that formwork is complete and properly secured prior to placing concrete.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

E. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

3.2 FORMWORK

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until 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 347 as abrupt or gradual, as follows:

1. Class C, 1/2 inch (3.2 mm) for smooth-formed finished surfaces.
2. Class D, 1 inch (25 mm) for concealed, rough-formed finished surfaces.

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.

1. Install keyways, reglets, recesses, and the like, for easy removal.
2. 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. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

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

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

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

M. For smooth-rubbed finish, provide uniform spacing and size of cone ties which break off at least 1-1/2 inches from face of concrete and leave holes not more than 1-inch diameter in face of concrete.

3.3 EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining work that is 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 rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."
2. Install leveling plates, bearing plates, railing sleeves, brackets, and all other embedded steel items shown on Drawings.
3. Install sleeves for pipe, conduit and other items passing through cast-in-place structural concrete. Coordinate with other trades for sleeve details, invert elevations, locations, and sizes.

3.4 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 50 deg F (10 deg C) for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations, and curing and protection operations need to be maintained.

1. Leave formwork for beam soffits, joists, slabs, and other structural elements that supports weight of concrete in place until concrete has achieved at least 75 percent of its 28-day design compressive strength.
2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

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 laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Owner’s Representative.

3.5 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

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

E. Field bending or straightening of bars partially embedded in concrete is permitted only where shown on the Drawings.

1. All openings in concrete walls with a dimension of one foot or greater are to have two #5 bars on all sides of opening

3.6 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Owner's Representative.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
3. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders, and at the top of footings or floor slabs.
4. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
5. Roughen surface of hardened concrete, wet surface, and immediately pour fresh concrete against wet surface.

C. Control joints in Slabs-on-Grade: Form weakened-plane control joints, sectioning concrete into areas as indicated. Construct control joints for a depth equal to at least one-fourth of concrete thickness as follows:

1. Sawed Joints: Form control 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. Space joints as shown on Drawings or, if not indicated, at average spacing of 12 feet, not to exceed 15 feet. Locate joints at column centerlines where possible.
2. Isolation Joints in Slabs-on-Grade: Install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

a. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated.

b. Terminate full-width joint-filler strips not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished concrete surface where joint sealants, specified in Division 07 Section "Joint Sealants," are indicated.
c. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

D. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.

3.7 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301, (4.3.2.1 Slump Adjustment.)

1. With each concrete mixture submittal, indicate amounts of mixing water to be withheld for later addition at Project site.
2. Water added must not increase the water-cement ratio past the approved mix design ratio.
3. Add additional water reducer or plasticizer to mix instead of adding water to achieve flowable, workable concrete. Do not add water to concrete after adding these admixtures to mixture.
4. Do not add water after truck is more than half empty.

C. Deposit concrete continuously in one layer or in horizontal 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 indicated. Deposit concrete to avoid segregation.

1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (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 mixture constituents to segregate.

D. Deposit and consolidate concrete for slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
2. Maintain reinforcement in position on chairs during concrete placement.

3. Screed slab surfaces with a straightedge and strike off to correct elevations.
4. Slope surfaces uniformly where required.
5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

E. Cold-Weather Placement: Comply with ACI 306.1 and protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures, as follows:

1. When average high and low temperature is expected to fall below 40 deg F (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

F. Hot-Weather Placement: Comply with ACI 301 and ACI 305R and as follows:

1. Maintain concrete temperature below 90 deg F (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. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

3.8 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities. Apply to concrete surfaces not exposed to public view.

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 defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities. Apply to concrete surfaces exposed to public view, or to receive a rubbed finish, or to be covered with a coating or covering material applied directly to concrete.

C. 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.

3.9 FINISHING FLOORS AND SLABS

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

B. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and re-straighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.

1. Apply a trowel finish to surfaces exposed to view.

a. For fiber reinforced concrete, to provide consolidation and bury surface fibers, open slab surfaces to be struck off with a vibrating screed or laser screed. Where a laser screed is used, adjust the magnitude of vibration and control the speed of the refracting leveling head to ensure adequate consolidation of the concrete and embedment of the fibers. Magnesium floats in the form of a bullfloat, channel radius float, or highway straightedge to be used to establish a surface and close tears or open areas. Do not use wood floats.

2. Flatness and Levelness: Finish surfaces to the following tolerances, according to ASTM E 1155, for a randomly trafficked floor surface:

a. Specified overall values of flatness, F(F) 35; and of levelness, F(L) 25; with minimum local values of flatness, F(F) 24; and of levelness, F(L) 17; for slabs.

C. Exterior Concrete Walks and Slabs: Apply penetrating, silane sealer per manufacturer's instructions.

3.10 MISCELLANEOUS CONCRETE ITEMS

A. Filling In: Fill in holes and openings left in concrete structures after work of other trades is in place unless otherwise indicated. Mix, place, and cure concrete as specified to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

3.11 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 ACI 301 and 305R for hot-weather protection during curing.

B. Slabs: Protect slabs within building from precipitation accumulation. Immediately remove water, snow or ice from surface of slabs within building regardless of source (e.g., from precipitation, construction activities, etc.).

C. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. 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.

D. 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 for the remainder of the curing period.

E. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

F. Cure concrete according to ACI 308.1, by one of the following methods:

1. 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, 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.
2. 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.

3.12 LIQUID FLOOR TREATMENT APPLICATION

A. Penetrating liquid floor treatment: Prepare, apply, and finish penetrating floor treatment according to manufacturer's written instructions.

1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
2. Do not apply to concrete that is less than 28 days old.
3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous.

3.13 JOINT SEALING

A. Prepare, clean, and install slab control joint sealer according to manufacturer's written instructions. Defer joint sealing until concrete has aged at least one month(s). Do not seal joints until construction traffic has permanently ceased.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.

C. Install semi-rigid joint sealer full depth in saw-cut joints and at least 2 inches (50 mm) deep in formed joints. Overfill joint and trim joint sealer flush with top of joint after hardening.

3.14 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas when approved by Owner's Representative. Remove and replace concrete that cannot be repaired and patched to Owner's Representative approval.

B. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch (13 mm) in any dimension to solid concrete. Limit cut depth to 3/4 inch (19 mm). Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with repair mortar before bonding agent has dried. Fill form-tie voids with repair mortar or cone plugs secured in place with bonding agent.
2. Repair defects on surfaces exposed to view by blending white Portland cement and standard Portland cement so that, when dry, repair mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance, as determined by Owner's Representative.

C. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch (0.25 mm) wide or that penetrate to reinforcement or completely through unreinforced sections, regardless of width, and other objectionable conditions.
2. After concrete has cured at least 14 days, correct high areas by grinding.
3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with thin coat patching mortar. Finish repaired areas to blend into adjacent concrete.
4. Correct other low areas scheduled to remain exposed with a repair overlayment. Cut out low areas to ensure a minimum repair overlayment depth of 1/4 inch (6 mm) to match adjacent floor elevations. Prepare, mix, and apply repair overlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
5. Repair defective areas, except random cracks and single holes 1 inch (25 mm) or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original

concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.

6. Repair random cracks and single holes 1 inch (25 mm) or less in diameter with repair overlayment. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete. Place repair overlayment before surface has dried. Finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

3.15 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports, except where noted.

B. Contractor to supply all batch tickets to Owner's testing agency. Batch tickets to note w/c ratio and amount of water allowed to be added at Project site.

C. Inspections:

1. Steel reinforcement placement.
2. Chemical Anchors: Test 5% of all chemical anchors in tension, randomly selected but in varied locations. Testing to be in accordance with ASTM E 488 to the approved manufacturer's allowable loads. Concrete must cure a minimum of 3 days prior to testing. Do not test anchors until after the anchor manufacturer's recommended curing time. If an anchor fails during this test additional anchors may be requested to be tested as directed by the Owner's Representative.

    a. Headed bolts and studs.
    b. Verification of use of required design mixture.
    c. Concrete placement, including conveying and depositing.
    d. Curing procedures and maintenance of curing temperature.
    e. Verification of concrete strength before removal of shores and forms from beams and slabs.

D. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day, nor less than once per each 5000 square foot of surface area of walls or slabs.

    a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Include corresponding concrete mix batch tickets with each test report.
3. Indicate amount of water added to batch at Project site.

4. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change. Measure after slump adjustment. Pumped concrete is to be tested at point of placement, with an additional slump test taken at point of delivery.
5. Air Content: ASTM C 231, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
6. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
7. Density (Unit Weight): ASTM C 138/C 138M, fresh unit weight of concrete. Two tests per truck load; one at beginning of pour and near end of pour.
8. Compression Test Specimens: ASTM C 31/C 31M.

    a. Cast and standard cure six (6) cylinder specimens for each composite sample.
    b. Cast and field cure two (2) standard cylinder specimens for each composite sample.
    c. Autoclave curing and oven-drying of test specimens containing synthetic fiber is not permitted.

9. Compressive-Strength Tests: ASTM C 39/C 39M;

    a. Test two standard cured specimens at 7 days, three specimens at 28 days, and retain one specimen for testing at 56 days as deemed necessary by Owner's Representative.
    b. Test two field-cured specimens at 28 days.
    c. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
    d. If one specimen in the test shows evidence of improper sampling, molding or testing, discard the specimen and consider the strength of the remaining cylinders to be the test result. If more than one specimen in a test shows any defects, discard the entire test.

10. Test for workability and air content of each synthetic fiber reinforced concrete mixture composite sample taken according to ASTM C172 (except that wet-sieving is not permitted) and whenever consistency of concrete appears to vary, according to ASTM C 1116.
11. 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.
12. Strength of each concrete mixture 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.
13. Test results shall be reported in writing to Owner's Representative, 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 mixture proportions and

materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

14. Nondestructive Testing: Impact-echo, ultrasonic methods, or other nondestructive methods may be permitted by Owner's Representative but will not be used as sole basis for approval or rejection of concrete.
15. 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 Owner's Representative. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods, as directed by Owner's Representative.
16. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
17. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

E. Measure floor and slab flatness and levelness according to ASTM E 1155 within 48 hours of finishing.

3.16 PROTECTION OF LIQUID FLOOR TREATMENTS

A. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.

END OF SECTION