

SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, finishes, and the following related materials:
 - 1. Vapor retarders.
 - 2. Finishes (CON-1, CON-2).
- B. Finish Matching: All project sand finishes shall match, CON-1 and exterior concrete finishes in Section 32 32 13.
- C. Requirements in this Section applicable to Section 32 32 13 "Cast-in-Place Concrete Walls":
 - 1. Finish tolerance for exterior concrete elements.
- D. Related Requirements:
 - 1. Section 03 35 43 "Polished Concrete Finishes" for mix requirements and concrete finish PC-1.
 - 2. Section 07 21 00 "Thermal Insulation" for below-slab insulation.
 - 3. Division 5 for cast-in anchors, including rods and embed plates.
 - 4. Division 31 for subbase, drainage fill under slabs-on-grade.
 - 5. Division 32 for exterior site concrete.
 - a. Exterior joint filler with sealant at all paving and concrete assemblies abutting building construction.

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.
- B. Form-Facing Material: Temporary structure or mold for the support of concrete while the concrete is setting and gaining sufficient strength to be self-supporting.
- C. Formwork: The total system of support of freshly placed concrete, including the mold or sheathing that contacts the concrete, as well as supporting members, hardware, and necessary bracing.
- D. W/C Ratio: The ratio by weight of water to cementitious materials.

1.3 COORDINATION

- A. Coordinate finishing and matching, including mix designs, materials and installation for successful results for matching concrete finishes.
- B. Coordinate items to be embedded in concrete.

- C. Coordinate penetrations, openings, sleeves and other interfacing work.
- D. Coordinate perimeter interfaces with air barriers and vapor retarders.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
 - a. Contractor's superintendent.
 - b. Ready-mix concrete manufacturer.
 - c. Concrete Subcontractor.
 - d. Architect.
 - e. Structural Engineer.
 - f. Required installers of items embedded in or interfacing with concrete.
 - g. Concrete finishers.
 - 2. Review the following items:
 - a. Mockups.
 - b. Special inspection and testing and inspecting agency procedures for field quality control.
 - c. Vapor retarders and their terminations, and preparation for surface coatings and membranes.
 - d. Insulation, below slab, edge of slab, back of walls, and interface with reinforcement.
 - e. Forms and form removal limitations.
 - f. Shoring and reshoring procedures
 - g. Steel reinforcement installation.
 - h. Anchor placement and installation tolerances.
 - i. Cold- and hot-weather concreting procedures, and placement methods.
 - j. Curing procedures and materials.
 - k. Concrete finishes and finishing, including finishes required for Work specified elsewhere.
 - 1) Concrete polishing operations, materials and tolerances, including surface requirements for work of this Section.
 - 2) See Section 03 35 43 if concurrent meetings where concurrent with this Section.
 - l. Construction joints, control joints, isolation joints and joint fillers.
 - m. Penetrations and perimeter conditions, including expansion joint filler requirements.
 - n. Methods for achieving specified floor and slab flatness and levelness; floor and slab flatness and levelness measurement
 - o. Concrete repair procedures.
 - p. Concrete protection.

1.5 SUBMITTALS

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

- 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.
 - 1. Reference General Structural Notes for mixing water to be withheld for later addition at Project site.
- C. Steel Reinforcement Shop Drawings: For fabrication and installation.
 - 1. Requirements:
 - a. Provide details of fabrication, bending, and placement, prepared according to ACI SP-66 "ACI Detailing Manual." Include special reinforcement required for openings through concrete structures.
 - b. Shop Drawings shall contain sufficient detail and information to allow complete fabrication, bending, and placement of steel reinforcement without reference to the contract drawings either on the fabrication shop floor or at the project site.
 - c. The detailer shall generate all shop drawings including fabrication and installation details from the structural and architectural drawings and specifications. The use of reproductions or photocopies of the contract drawings are not permitted. When CAD or REVIT files are provided, it is the responsibility of the detailers to remove all information not directly relevant to the creation of the placing drawings as well as all references to the outside sources of the files.
 - d. Re-submittals shall clearly identify all revisions to previous submittals.
 - 1) Heavy ink clouded outlines (revision clouds) shall be drawn around revised areas of individual sheets.
 - 2) Architect/Engineer will not review information outside of revision clouds on resubmitted drawings.
 - 2. Include plans for all slabs and walls columns to show bar arrangement. Plans and elevations to include special reinforcement required for openings through concrete structures.
 - 3. Show bar arrangement identifying size, shape, grade, and location of steel reinforcement. Include bar material, grade, sizes, lengths, bar schedules, bent bar diagrams, bar arrangement, splices and laps, tie spacing, hoop spacing, and supports for concrete reinforcement.
- D. Vapor Retarder Shop Drawings: Show termination details, penetration details and transition details coordinated with other work.
 - 1. Drawing Format, Plans: Use of Drawings is acceptable where PDF-writer is used. Hand drawing is prohibited.
 - 2. Provide manufacturer's standard details or other CAD-generated drawings.
 - 3. Coordinate requirements of Section 31 21 13 "Radon Mitigation" for sealing penetrations.
- E. Finish Schedule Shop Drawings: For each exposed concrete finish specified.
 - 1. Include information on other shop drawings required as applicable, or separately, with plans and elevations as required to verify scope of finishes.
 - 2. Show the following:
 - a. Formed Surface Finish designation and final finish.
 - b. Show joints and corner treatments.
 - c. Show interface of reinforcement with insulation.
 - d. Show insulation installed under this Section or between concrete.

- e. Final finish for floors, including surface finish and tolerances.
 - f. Curing process.
 - g. Floor treatment.
- 3. Include list of materials for joints, for isolation joints and for slab penetrations of each type required.
- 4. Drawing Format: Use of Drawings is acceptable where PDF-writer is used. Hand drawing is prohibited.
- F. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.
 - 1. Location of construction joints is subject to approval of the Architect.
- G. Qualification Data: For the following:
 - 1. Ready-mixed concrete manufacturer.
 - 2. Testing agency: Include copies of applicable ACI certificates.
- H. Welding certificates.
- I. Material Certificates: For each of the following, signed by manufacturers:
 - 1. Cementitious materials.
 - 2. Admixtures.
 - 3. Form materials and form-release agents.
 - 4. Steel reinforcement and accessories.
 - 5. Vapor retarders.
 - 6. Floor and slab treatments.
 - 7. Bonding agents.
 - 8. Adhesives.
 - 9. Semirigid joint filler.
 - 10. Joint-filler strips.
 - 11. Repair materials.
- J. Floor surface flatness and levelness measurements report, indicating compliance with specified tolerances.
- K. Research Reports:
 - 1. For concrete admixtures in accordance with ICC's Acceptance Criteria AC198.
 - 2. For sheet vapor retarder/termite barrier, showing compliance with ICC AC380.
- L. Field quality-control reports.
- M. Minutes of preinstallation conference.

1.6 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. Installer is responsible for mix design proportions, admixtures, curing and finishing techniques required for the Work to achieve specified finishes and aesthetic effects indicated.
- B. Ready-Mix Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94 requirements for production facilities and equipment.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4.
- D. Field Quality-Control Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.

1.7 MOCKUPS

- A. Mockups: Cast concrete slab-on-grade and formed-surface panels to demonstrate typical joints, surface finish, texture, tolerances, floor treatments, and standard of workmanship.
 - 1. Build panel approximately 200 sq. ft. for slab-on-grade and 100 sq. ft. for formed surface in the location indicated, or, if not indicated, as directed by Architect.
 - a. Use stem walls to be concealed with subsequent work or concealed from view.
 - b. Use floor slabs in storage rooms or to be covered with other finishes.
 - 2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Owner's qualified testing agency to perform preconstruction testing on each concrete mixture.
 - 1. Include the following information in each test report:
 - a. Admixture dosage rates.
 - b. Slump.
 - c. Air content.
 - d. Seven-day compressive strength.
 - e. 28-day compressive strength.
 - f. Evaluation of permeability-reducing admixtures.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.
 - 1. Store reinforcement to avoid contact with earth.

- B. Foam Insulation: Store foam under cover to protect from sunlight according to manufacturer's recommendations.

1.10 FIELD CONDITIONS

- A. Cold-Weather Placement: Comply with ACI 301 and ACI 306.1 and as follows.
 - 1. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - 2. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
 - 3. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 - 4. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
- B. Hot-Weather Placement: Comply with ACI 301 and ACI 305.1, and as follows:
 - 1. Maintain concrete temperature below 90 deg F 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.
- C. Protect joints in slabs on grade during curing to prevent water from entering below-grade and vapor retarder assemblies.

1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to furnish replacement sheet vapor retarder barrier material and accessories for sheet vapor retarder/ termite barrier and accessories that do not comply with requirements or that fail to resist penetration by termites within specified warranty period.
 - 1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Concrete Formwork: Design, engineer, erect, shore, brace, and maintain formwork, shores, and reshores in accordance with ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads, so that resulting concrete conforms to the required shapes, lines, and dimensions.
 - 1. Design wood panel forms in accordance with APA's "Concrete Forming Design/Construction Guide."
 - 2. Design formwork to limit deflection of form-facing material to 1/240 of center-to-center spacing of supports.

- a. CON-1, Sand-Finished: For exposed concrete limit deflection of form-facing material, studs, and walers to 0.0025 times their respective clear spans (L/400).
3. Use tieless formwork on exposed faces.

2.2 CONCRETE, GENERAL

- A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
1. ACI 301.
 2. ACI 117.
 3. ACI 310-20, for PC-1 finishes in Section 03 35 43 for slabs installed in this Section.

2.3 FORM-FACING MATERIALS

- A. Exposed, Smooth-Formed Finished Concrete: Including CON-1. Form-facing panels that 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 as follows:
 - a. Stem Walls, Exposed Surfaces, CON-1:
 - 1) APA HDO (high-density overlay), Class I or better.
 - 2) APA MDO (medium-density overlay) Class I or better.; mill-release agent treated and edge sealed.
 - b. Edge of Slab, Thickened:
 - 1) APA Structural 1 Plyform, B-B or better; mill oiled and edge sealed.
 - 2) APA Plyform Class I, B-B or better; mill oiled and edge sealed.
- 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. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.
- D. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.
- E. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.
1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
- F. Form Ties: Factory-fabricated, removable or snap-off glass-fiber-reinforced plastic or metal form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
1. Not permitted on exposed surfaces scheduled for sand finish, CON-1 finishes.
 2. Furnish units that leave no corrodible metal closer than 1 inch to the plane of exposed concrete surface.

3. Furnish ties that, when removed, leave holes no larger than 1 inch in diameter in concrete surface.
4. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

G. In-Form Retarder: See Section 32 32 13, Part 3, "Finishing Vertical Concrete" for product.

2.4 STEEL REINFORCEMENT AND ACCESSORIES

- A. Reinforcing Bars: Types indicated on Drawings.
- B. Joint Dowel Bars: ASTM A615, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.
- C. Steel Tie Wire: Plain finished, ASTM A1064, annealed steel, not less than 0.0508 inch in diameter.
- D. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place. Manufacture bar supports from steel wire, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete.
 1. Use CRSI Class 1 plastic-protected steel wire, CRSI Class 2 stainless-steel bar supports or precast dobies.

2.5 CONCRETE MATERIALS

- A. Source Limitations:
 1. Obtain all concrete mixtures from a single ready-mixed concrete manufacturer for entire Project.
 2. Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant.
 3. Obtain aggregate from single source.
 4. Obtain each type of admixture from single source from single manufacturer.
- B. Cementitious Materials:
 1. Portland Cement: ASTM C150, Type I/II gray.
 - a. Type I for polished concrete floor slabs.
 2. Fly Ash: ASTM C618, Class F or C.
 3. Slag Cement: ASTM C989, Grade 100 or 120.
 4. Blended Hydraulic Cement: ASTM C595, Type IS (<70) (Portland blast-furnace slag), Type IP (Portland-pozzolan), Type IL (Portland-limestone), Type IT (S<70) (ternary blended) cement.
- C. Normal-Weight Aggregates: ASTM C33.
 1. Maximum Coarse-Aggregate Size: As indicated.
 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- D. Air-Entraining Admixture: ASTM C260.

- E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
1. Water-Reducing Admixture: ASTM C494, Type A.
 2. Retarding Admixture: ASTM C494, Type B.
 3. Water-Reducing and Retarding Admixture: ASTM C494, Type D.
 4. High-Range, Water-Reducing Admixture: ASTM C494, Type F.
 5. High-Range, Water-Reducing and Retarding Admixture: ASTM C494, Type G.
 6. Plasticizing and Retarding Admixture: ASTM C1017, Type II.
 7. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C494, Type C.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) BASF Corp. - Construction Chemicals.
 - 2) Euclid Chemical Company (The); an RPM company.
 - 3) GCP Applied Technologies Inc. (formerly Grace Construction Products).
 - 4) Sika Corporation.
 8. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) BASF Corp. - Construction Chemicals.
 - 2) Euclid Chemical Company (The); an RPM company.
 - 3) GCP Applied Technologies Inc. (formerly Grace Construction Products).
 - 4) Sika Corporation.
- F. Water: ASTM C94 and potable and ASTM C1602.

2.6 VAPOR RETARDERS

- A. Sheet Vapor Retarder, Soil and Gas: ASTM E1745, Class A 15 mil. Include manufacturer's mechanical bonding termination tape, recommended mastics and adhesive or pressure-sensitive tape for seams and penetrations.
1. Basis-of-Design Products: Stego Industries, LLC., Stego Wrap;
 - a. Termination Tape: Stego Crete Claw Tape 3.

2.7 LIQUID FLOOR TREATMENTS

- A. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.
1. For CON-2 surfaces, apply prior to scheduled TR-2 coating in Section 07 19 00.

2. Product: Use same densifier in Section 03 35 43.

2.8 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 C171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.

2.9 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber or ASTM D1752, cork or self-expanding cork. With removable top strip for post sealant placement. Compatible with sealants placed over expansion filler.
 1. For Curved and Irregular Shapes: Closed cell neoprene.
- B. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, aromatic polyurea with a Type A shore durometer hardness of 90 to 95 according to ASTM D2240.
- C. Bonding Agent: ASTM C1059, Type II, nonredispersible, acrylic emulsion or styrene butadiene.
- D. Epoxy Bonding Adhesive: ASTM C881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:
 1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
- E. Reglets: Fabricate reglets of not less than 0.022-inch-thick, galvanized-steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.
- F. Floor Slab Protective Covering: Eight-foot-wide cellulose fabric or construction product made for protecting slab surfaces.

2.10 REPAIR MATERIALS

- A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.
 1. Cement Binder: ASTM C150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C219.
 2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by underlayment manufacturer.
 4. Compressive Strength: Not less than 4100 psi at 28 days when tested according to ASTM C109.

- B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch and that can be filled in over a scarified surface to match adjacent floor elevations.
 - 1. Cement Binder: ASTM C150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C219.
 - 2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
 - 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by topping manufacturer.
 - 4. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C109.
- C. Vertical and Overhead Surface Repairs: Cement-based, polymer modified product, identified by the manufacturer for use in vertical or overhead applications, that can be applied in thicknesses from 1/8 inch to match adjacent surfaces. For permanently exposed conditions, provide color sample to architect for review prior to application.
 - 1. Cement Binder: ASTM C150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C219.
 - 2. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand.
 - 3. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C109.

2.11 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. Reference the General Structural Notes for compressive strength, maximum W/C ratio, and air content.
- B. Cementitious Materials: Refer to General Structural Notes.
- 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 admixtures indicated on Drawings, and as required for placement and workability
 - a. Use water-reducing admixture in concrete, for placement and workability.
 - 2. Use high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.
 - 3. Use-retarding admixture and water-reducing admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 - 4. Use corrosion-inhibiting admixture in concrete mixtures where indicated.
 - 5. Use permeability-reducing admixture in concrete mixtures where indicated.

2.12 FABRICATING REINFORCEMENT

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

2.13 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94 and ASTM C1116, and furnish batch ticket information.
 - 1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions:
 - 1. Before placing concrete, verify that installation of concrete forms, accessories, and reinforcement, and embedded items is complete and that required inspections have been performed.
 - a. Remove standing water from vapor retarders.
 - 2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 FORMWORK INSTALLATION

- A. Design, erect, shore, brace, and maintain formwork, according to ACI 301 and approved formwork drawings, 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:
 - 1. Datums in Alignment: Class A for elevation and plan location.
 - 2. Stairs, Interior and Exterior:
 - 3. Stadium Seating, Exterior: Match exposed stairs.
 - 4. Curbs, Building: Class A, for elevation and plan location for exposed faces.
 - a. Class B for concealed faces.
 - 5. Exposed Edges of Building Concrete: Class A, for elevation and plan location.
- C. Limit concrete surface irregularities, designated by ACI 347 and ACI 117 as abrupt or gradual, as follows:
 - 1. Class A, Surface Finish-3.0: 1/8 inch
 - 2. Class B, Surface Finish-2.0: 1/4 inch.
 - 3. Class C: 1/2 inch.
 - 4. Class D, Surface Finish-1.0: 1 inch.
- D. Construct forms tight enough to prevent loss of concrete mortar.
 - 1. Construct faces to be exposed watertight and to provide gap- and void-free installation of in-form coatings.

- E. Construct 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, dovetail slots, 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. Do not chamfer exterior corners and edges of permanently exposed concrete. Chamfer corners of stem walls under flashings except where glazing system is bearing on entire surface. Coordinate interfacing requirements and chamfer corners where approved by Architect in Shop Drawing Submittals.
- 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. Coat contact surface of forms to be exposed with in-form retarders, according to manufacturer's written instructions, before placing reinforcement.

3.3 EMBEDDED ITEM INSTALLATION

- 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.
 - 1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC 303.
 - 3. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.
 - 4. Install dovetail anchor slots in concrete structures, as indicated on Drawings.
 - 5. Clean embedded items immediately prior to concrete placement.
- B. Penetrating Items: Expansion joint material at penetrations.
 - 1. Place expansion joint material where indicated. Refer to "Isolation Joints" in "Joints" Article below.

2. All plumbing piping, HVAC and sewerage piping penetrating concrete slabs and shall have expansion joint material at interface with concrete. No piping shall be embedded in concrete without expansion joint material.

3.4 REMOVING AND REUSING FORMS

- A. Refer to General Structural Notes for removal time.
- B. Clean and repair surfaces of forms to be reused in the Work.
 1. Split, frayed, delaminated, or otherwise damaged form-facing material are not acceptable for exposed surfaces.
 2. Apply new form-release agent.
- C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints.
 1. Align and secure joints to avoid offsets.
 2. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.5 VAPOR-RETARDER INSTALLATION

- A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E1643 and manufacturer's written instructions.
 1. Install vapor retarder with longest dimension parallel with direction of concrete pour.
 2. Face laps away from exposed direction of concrete pour.
 3. Lap vapor retarder over footings and grade beams not less than 6 inches, sealing vapor retarder to concrete.
 4. Lap joints 6 inches and seal with manufacturer's recommended tape.
 5. Terminate vapor retarder at the top of floor slabs, grade beams, and pile caps, sealing entire perimeter to floor slabs, grade beams, foundation walls, or pile caps.
 6. Seal penetrations in accordance with vapor retarder manufacturer's instructions.
 7. Protect vapor retarder during placement of reinforcement and concrete.
 - a. Repair damaged areas by patching with vapor retarder material, overlapping damages area by 6 inches on all sides, and sealing to vapor retarder.

3.6 STEEL REINFORCEMENT INSTALLATION

- A. General: 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.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that 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.
 1. Weld reinforcing bars according to AWS D1.4, where indicated.

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

3.7 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 Architect.
 - 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 into concrete and complying with cover requirements indicated.
 - 3. Locate joints for beams, slabs, joists, and girders in the middle third of spans and at approved locations where exposed. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 - 4. Space vertical joints in walls as indicated on Drawings. Unless otherwise indicated on Drawings, locate vertical joints beside piers integral with walls, near corners, and in concealed locations where possible.
 - 5. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 - 6. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth as indicated.
 - 1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.
 - 2. Grooved Joints: Form control joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of control joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
- D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
 - 1. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
 - 2. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated on Drawings.
 - 3. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface, where joint sealants, specified in Section 07 92 00 "Joint Sealants," are indicated.
- E. 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.
- F. Insulation Joints: Install insulation according to Section 07 21 00 "Thermal Insulation."
 - 1. Insulation in vertical plane of edges of slab to be XPS type.

3.8 CONCRETE PLACEMENT

- A. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.
 - 1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.
- B. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness.
 - 1. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
 - 2. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.
 - a. Place grout mix slurry in formwork corners during placement to ensure consolidation at formwork corners and to minimize deformation and damage during form removal.
 - 3. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
 - a. Do not use vibrators to transport concrete inside forms.
 - b. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer.
 - c. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity.
 - d. 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.
- C. Deposit and consolidate concrete for floors and 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. Scream slab surfaces with a straightedge and strike off to correct elevations.
 - 4. Slope surfaces uniformly to drains 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.
 - 6. Do not further disturb slab surfaces before starting finishing operations.

3.9 FINISHING FORMED SURFACES

- A. As-Cast Concrete Finishes: As-cast concrete texture imparted by form-facing material, as follows:
 - 1. Rough-Formed Finish: ACI 301 Surface Finish SF-1.0.
 - a. Finish: As-cast. Tie holes patched.
 - b. Remove fins and other projections larger than 1-inch that exceed specified limits on formed-surface irregularities.
 - c. Surface Tolerance: ACI 117, Class C or D.
 - d. Application: Apply to concrete surfaces not exposed to public view.
 - 2. Smooth-Formed Finish: ACI 301 Surface Finish SF-2.0 and SF-3.0.

- a. Finish: Panel joints and tie-hole arranged in an orderly and symmetrical manner with a minimum seams. Minimize surface imperfections.
 - b. Repair and patch tie holes and defects with materials and methods approved by Architect.
 - c. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
 - d. Surface Tolerance by Application:
 - 1) ACI 117 Class A: Where exposed to public view.
 - 2) ACI 117 Class B:
 - a) Where exposed but back-of-house spaces
 - b) At other finishes are scheduled or covering directly placed on concrete.
- B. Sand Finishes (CON-1): At sanded, smooth-formed-finished as-cast concrete where indicated:
- 1. Follow in-form retarder manufacturer's written instruction.
 - 2. Sand Finish: After concrete has achieved a compressive strength of from 1000 to 1500 psi, apply finish by removing in-form retarder.
 - a. Wet concrete surfaces thoroughly scrub with stiff fiber or wire brushes, using water freely, until top mortar surface is removed and aggregate is uniformly exposed.
 - b. Rinse scrubbed surfaces with clean water.
 - c. Maintain continuity of finish on each surface or area of Work.
 - d. Remove only enough concrete mortar from surfaces to match mockups.
- 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.

3.10 FINISHING FLOORS AND SLABS

- A. General: Comply with ACI 302.1R recommendations for screeding, restraighening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Scratch Finish:
- 1. While still plastic, texture concrete surface that has been screeded and bull-floated or darbied.
 - 2. Use stiff brushes, brooms, or rakes to produce a profile amplitude of 1/4 inch in one direction.
- C. Float Finish:
- 1. Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats.
 - 2. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture complying with ACI 117 for conventional concrete.
 - 3. Apply float finish to surfaces to receive trowel finish and to be covered with fluid-applied or sheet waterproofing or air barrier materials.
- D. Trowel Finish:

1. After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel.
2. Continue troweling passes and restraighthen until surface is free of trowel marks and uniform in texture and appearance.
3. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings. Revise locations of trowel finish in first subparagraph below to suit Project.
4. Apply a trowel finish to 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.
5. Finish surfaces to the following tolerances, according to ASTM E1155, for a randomly trafficked floor surface:

a. Slabs on Ground Finish:

- 1) Polished Concrete (PC-1) and Exposed Same Elevation and Carpet Areas Bordered by PC-1: Finish uniformly with minimum surface variation in surface so to provide consistent and without density variations in size and distribution of exposed aggregate.
 - a) Specified Overall Value (SOV): F_F 50 and F_L 35 with minimum local value (MLV): F_F 40 and F_L 17.
 - b) Increase FF and FL values as required to reduce exposure of uneven aggregate due to finishing operations in Section 03 35 43 "Polished Concrete Finishing".
- 2) Prior to ASTM E1155 testing-validating, and measure surface so gap at any point between concrete surface and an unlevelled, freestanding, 10-ft.-long straightedge resting on two high spots and placed anywhere on the surface does not exceed 1/16 inch.

b. Offices with Carpet and Exposed, Storage Areas (CON-2): Minimum of specified overall values of flatness, FF 45; and of levelness, FL 35; with minimum local values of flatness, FF 30; and of levelness, FL 24.

- 1) Measure surface so gap at any point between concrete surface and an unlevelled, freestanding, 10-ft.-long straightedge resting on two high spots and placed anywhere on the surface does not exceed 1/8 inch.

E. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces indicated. While concrete is still plastic, slightly scarify surface with a fine broom.

1. Comply with flatness and levelness tolerances for trowel-finished floor surfaces.

F. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and elsewhere as indicated.

1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.

3.11 MISCELLANEOUS CONCRETE ITEM INSTALLATION

- 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.
- C. Equipment Bases and Foundations:
 - 1. Coordinate sizes and locations of concrete bases with actual equipment provided.
 - 2. Construct concrete bases 4 inches high unless otherwise indicated, and extend base not less than 6 inches in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated or unless required for seismic anchor support. Reinforce with #4 bars at 12 inches on center each way unless otherwise noted.
 - 3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 4. Prior to pouring concrete, place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Cast anchor-bolt insert into bases. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.12 CONCRETE PROTECTING AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
 - 1. Comply with ACI 301 and ACI 306.1 for cold-weather protection and ACI 305.1 for hot-weather protection during curing.
 - 2. Maintain moisture loss no more than 0.2 lb/sq. ft. x h before and during finishing operations.
- B. 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 remainder of curing period.
- C. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.
- D. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
 - 1. Protect joints and edges that have other treatments or coatings from saturation. Areas include those with insulation or applied coatings including but not limited to dampproofing, membrane flashings or other moisture-mitigating products.
 - a. Protect edges and materials by damming or other temporary and watertight separation from scheduled areas of refined finishes.
 - 2. 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 12-inch lap over adjacent absorptive covers.

3. 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.
 - a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
 - b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
 - c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies does not interfere with bonding of floor covering used on Project.
4. Floors to Receive Penetrating Liquid Floor Treatments: Contractor has option of the following:
 - a. Absorptive cover.
 - b. Moisture-retaining-cover
 - c. Ponding or continuous sprinkling of water:
 - 1) Only acceptable where perimeter and other conditions are fitted with water diversion so no water penetrates the insulation or edges of slab.
5. Floors to Receive Polished Finish: Contractor has option of the following:
 - a. Absorptive Cover:
 - b. Ponding or continuous sprinkling of water:
 - 1) Only acceptable where perimeter and other conditions are fitted with water diversion so no water penetrates the insulation or edges of slab.

3.13 TOLERANCES

- A. Conform to ACI 117.

3.14 APPLICATION OF LIQUID FLOOR TREATMENTS

- A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment in accordance with 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 three days' old.
 3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing.
 4. Rinse with water; remove excess material until surface is dry.
 5. Apply a second coat in a similar manner if surface is rough or porous.

3.15 JOINT FILLING

- A. Prepare, clean, and install joint filler according to manufacturer's written instructions.

1. Defer joint filling until concrete has aged at least one month. Do not fill joints until construction traffic has permanently ceased.
- B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.
- C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.16 CONCRETE SURFACE REPAIRS

- A. Defective Concrete:
 1. Correct areas that deviate beyond specified tolerance until they are brought into compliance.
 2. Repair and patch defective areas when approved by Architect.
 3. Remove and replace concrete that cannot be repaired and patched to Architect's approval.
 4. Prior to repairing defective areas, Contractor shall provide mockup for Architect's review of materials and methods for matching.
- B. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.
- C. 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 in any dimension to solid concrete. Limit cut depth to 3/4 inch. 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 patching mortar before bonding agent has dried. Fill form-tie voids with patching 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, patching mortar matches 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 Architect.
- D. Repairing Unformed Surfaces: Test unformed surfaces, such as 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 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 patching mortar. Finish repaired areas to blend into adjacent concrete.

4. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
 5. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 6. Repair defective areas, except random cracks and single holes 1 inch 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 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.
 7. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.
- E. Perform structural repairs of concrete, subject to Architect's approval and Structural Engineer of Record's review, using epoxy adhesive and patching mortar.
- F. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.17 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
1. Steel reinforcement placement.
 2. Steel reinforcement welding.
 3. Headed bolts and studs.
 4. Verification of use of required design mixture.
 5. Concrete placement, including conveying and depositing.
 6. Curing procedures and maintenance of curing temperature.
 7. Verification of concrete strength before removal of shores and forms from beams and slabs.
- B. Testing Agency: Owner will engage a qualified testing agency to perform tests and to submit reports.
- C. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C172/C172M shall be performed according to the following requirements:
1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 150 cu. yd. or fraction thereof.
 - a. When frequency of testing provides 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. Slump: ASTM C143/C143M; 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.
3. Slump Flow: ASTM C1611; 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.
4. Air Content: ASTM C231, 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.
5. Concrete Temperature: ASTM C1064; one test hourly when air temperature is 40 deg F and below or 80 deg F and above, and one test for each composite sample.
6. Unit Weight: ASTM C567 fresh unit weight of structural lightweight concrete.
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
7. Compression Test Specimens: ASTM C31.
 - a. Cast and laboratory cure four standard cylinder specimens for each composite sample.
 - b. Cast and field cure additional cylinder specimens for each composite sample as required by Contractor's sequence, including but not limited to early backfill placement, cold or hot weather concreting. Contractor is responsible for determining number of additional specimens required.
8. Compressive-Strength Tests: ASTM C39; test one laboratory-cured specimen at 7 days and three specimens at 28 days.
 - a. Test one field-cured specimens at 7 days and three specimens at 28 days.
 - b. A compressive-strength test shall be the average compressive strength from a set of three specimens obtained from same composite sample and tested at age indicated.
9. 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.
10. 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.
11. Test results shall be reported in writing to Architect, 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.
12. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
13. 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 Architect. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42 or by other methods as directed by Architect.
14. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
15. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

- D. Measure floor and slab flatness and levelness according to ASTM E1155 within 48 hours of finishing.

END OF SECTION