

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, placement procedures, and finishes, for the following:
 - 1. Footings.
 - 2. Foundation walls.
 - 3. Slabs-on-grade.
 - 4. Suspended slabs.
 - 5. Ramps, sidewalks, stairs, and curbs.
 - 6. Footings and fill for steel pipe bollards.
 - 7. Equipment pads and bases.
 - 8. Other cast-in-place concrete as indicated on the Drawings.
- B. Related Sections:
 - 1. Division 03 Section "Hydraulic Cement Underlayment" for self leveling underlayment below floor coverings.
 - 2. Division 05 Section "Structural Steel Framing" for steel and anchor bolts.
 - 3. Division 07 Section "Bituminous Dampproofing" for dampproofing installed on below-grade concrete.
 - 4. Division 07 Section "Water Repellents" for water repellents installed on exterior concrete.
 - 5. Division 07 Section "Joint Sealants" for sealants used in conjunction with interior and exterior concrete work, and water repellent applications to exterior concrete.
 - 6. Division 09 Sections for application of finish materials/systems to concrete surfaces.
 - 7. Division 31 Section "Earth Moving" for drainage fill under slabs-on-grade.

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement; subject to compliance with requirements.
- B. Water/Cement Ratio (W/CM): The ratio by weight of water to cementitious material.

1.4 UNIT PRICES

- A. Specific work of this section is itemized as Unit Prices on the Bid Form to add or deduct specific units of work to the project. Unit Price descriptions, requirements and units of work are enumerated in Division 01 Section "Unit Prices". Unit Prices are inclusive of all labor, materials, overhead and profit per unit of work indicated.

1.5 ALLOWANCES

- A. Work included in Base Bid: The Contractor shall include in the space provided on the Bid Form, the allowances for work of this section itemized on the Bid Form. The cost of these quantities shall be computed using the Unit Prices stated on the Bid Form. The work listed is in addition to that required to complete the work of the Contract and, consequently, the sum therefore may be deducted from the Contract amount if the corresponding work is not required by actual conditions encountered.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- 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. Indicate amounts of mixing water to be withheld for later addition at Project site.
- C. Admixtures:
 - 1. Include limitations of use, including restrictions on cementitious materials, supplementary cementitious materials, air entrainment, aggregates, temperature at time of concrete placement, relative humidity at time of concrete placement, curing conditions, and use of other admixtures.
- D. Steel Reinforcement Shop Drawings: Comply with ACI SP-066. Include placing 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.
- E. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer detailing fabrication, assembly, and support of formwork.
 - 1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and reshoring installation and removal.
 - 2. For exposed vertical concrete walls, indicate dimensions and form tie locations.
 - 3. Indicate dimension and locations of construction and movement joints required to construct the structure in accordance with ACI 301.
 - a. Location of construction joints is subject to approval of the Architect.
 - 4. Indicate location of waterstops.
 - 5. Indicate proposed schedule and sequence of stripping of forms, shoring removal, and reshoring installation and removal.
- F. Joint Layout Drawing: Indicate proposed construction joints, contraction joints, isolation joints, and saw-cut joints, required to construct the structure.
 - 1. Location of construction joints is subject to approval of the Architect.
- G. Samples: For vapor retarder.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Professional Engineer, Installer, ready-mixed manufacturer, and testing agency.

- B. Welding certificates.
- C. Material Certificates: For each of the following, signed by manufacturers:
 - 1. Cementitious materials and aggregates.
 - 2. Admixtures.
 - 3. Form materials and form-release agents.
 - 4. Steel reinforcement and accessories.
 - 5. Curing compounds.
 - 6. Bonding agents.
 - 7. Adhesives.
 - 8. Vapor retarders.
 - 9. Semirigid joint filler.
 - 10. Joint-filler strips.
 - 11. Repair materials.
 - 12. Fiber reinforcement.
- D. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
 - 1. Portland cement.
 - 2. Aggregates.
 - 3. Admixtures.
- E. Field quality-control reports from testing agency.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed concrete Work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. Ready-Mixed Concrete 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.
 - 1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
- C. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for formwork and shoring and reshoring installations that are similar to those indicated for this Project in material, design, and extent.
- D. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified in accordance with ASTM C 1077 and ASTM E 329 for testing indicated.
 - 1. Personnel conducting field tests shall be qualified as ACI Concrete Field-Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program. Laboratory testing agency supervisor shall be ACI-certified concrete laboratory testing technician, Grade II.
- E. 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.

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- F. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M, "Structural Welding Code - Reinforcing Steel."
- G. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
 - 1. ACI 301, "Specifications for Structural Concrete,"
 - 2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."
 - 3. ACI 318 "Building Code Requirements for Reinforced Concrete."

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Comply with ASTM C94/C94M and ACI 301
- B. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.

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 as follows:
 - a. APA HDO (high-density overlay).
 - b. APA Structural 1 Plyform, B-B or better; mill oiled and edge sealed.
 - c. APA Plyform Class 1, B-B or better; mill oiled and edge sealed.
- B. Concealed Surface Form-Facing Material: Plywood, lumber, metal, plastic, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.
 - 1. The use of trimmed excavating for concrete forming is permitted for footings only.
- C. 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.
 - 1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
 - 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Laticrete International, Inc., "L&M™ DEBOND."
 - b. Euclid Chemical Company, an RPM company, "Formshield Pure."
 - c. W.R. Meadows, Inc.; "Duogard N.E."
- D. 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 to the plane of exposed concrete surface.
 - 2. Furnish ties that, when removed, will leave holes no larger than 1 inch in diameter in concrete surface.

3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
- B. Steel Bar Mats: ASTM A 184/A 184M, fabricated from deformed bars, assembled with clips.
- C. Deformed-Steel Wire: ASTM A 496/A 496M.
- D. Deformed-Steel Welded Wire Reinforcement: ASTM A 497/A 497M, flat sheet.

2.3 REINFORCEMENT ACCESSORIES

- A. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burns.
- B. 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, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
 1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.
 2. For slabs-on-grade, use supports with sand plates or horizontal runners where wetted base material will not support chair legs.
 3. For epoxy-coated reinforcement, use CRSI Class 1A epoxy-coated or other dielectric-polymer-coated wire 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 III.
 2. Flyash, pozzolan, slag or silica fume are not permitted in any design mix.
- B. Normal-Weight Aggregates: ASTM C 33, Class 3S coarse aggregate or better, graded. Provide aggregates from a single source.
 1. Coarse Aggregate: Clean, uncoated, processed aggregate containing no clay, mud, loam, or foreign matter; crushed stone, processed from natural rock or stone, with maximum size between $\frac{3}{4}$ " and 1-1/2", and with a minimum size Number 4.
 2. Fine Aggregate: Clean, sharp, natural sand free from loam, clay, lumps, or other deleterious substances. Hard and durable particles varying from fine to particles passing a 3/8" screen, of which at least 12% shall pass a 50-mesh screen. Dune sand, bank-run sand and manufactured sand shall not be used.
 3. Local aggregates not complying with ASTM C 33, but which have shown by special test or actual service to produce concrete of adequate strength and durability, may be used when acceptable to the Architect.

4. For exposed interior surfaces, do not use fine or coarse aggregates that contain substrates that cause spalling.
- C. Water: ASTM C 94/C 94M and potable.
- D. Volatile Organic Compounds (VOC's): No product used shall contain a level of VOC's exceeding the limits established by the EPA in 40 CFR Part 59.

2.5 ADMIXTURES

- A. General: Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material and to be compatible with other admixtures and cementitious materials. Use of calcium chloride is not permitted.
- B. Air-Entraining Admixture: ASTM C 260.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Euclid Chemical Company; "Air-Mix."
 - b. GCP Applied Technologies Inc.; "Darex AEA" or "Daravair."
 - c. Master Builders Solutions; "MasterAir-AE90."
 - d. Sika Corporation; "Sika AER."
- C. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
 1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 2. Retarding Admixture: ASTM C 494/C 494M, Type B.
 3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
 5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
 6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
- D. 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 C 494/C 494M, Type C.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Euclid Chemical Company; "EUCON BCN".
 - b. GCP Applied Technologies Inc.; W. R. Grace & Co.; "DCI."
 - c. Master Builders Solutions; "MasterLife CI 30."
 - d. Sika Corporation; "Sika CNI."

2.6 VAPOR RETARDERS

- A. Sheet Vapor Retarder, Class A: ASTM E 1745, Class A, except with maximum water-vapor permeance of .006 per ASTM E154. Include manufacturer's recommended adhesive or pressure-sensitive tape.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. W.R. Meadows, Inc.; "Perminator 15 mil."

- b. Raven Industries, Inc.; "Vapor Block VB15."
- c. Reef Industries, Inc.; "Griffolyn® 15 mil."
- d. Stego Industries, LLC; "Stego® Wrap 15-mil Vapor Barrier."

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 for use on interior floor surfaces indicated as exposed concrete.

1. Products: Subject to compliance with requirements, provide one of the following:

- a. Curecrete Distribution Inc.; "Ashford Formula."
- b. Laticrete International, Inc.; "L&M™ Seal Hard."
- c. W. R. Meadows, Inc.; "LIQUI-HARD."

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 C 171, white, polyethylene film burlap-polyethylene sheet.

- C. Water: Potable, complying with ASTM C 1602/C 1602M

- D. Clear, Waterborne, Membrane-Forming, Dissipating Curing Compound: ASTM C 309, Type 1, Class B, certified by manufacturer to be compatible with clear penetrating water repellent for use at exterior concrete and all areas receiving a clear penetrating water repellent.

1. Products: Subject to compliance with requirements, provide one of the following:

- a. Laticrete International, Inc.; "L&M Cure R™."
- b. W. R. Meadows, Inc.; "1100-CLEAR."

- E. Clear, Waterborne, Membrane-Forming, Non-Dissipating Curing Compound: ASTM C 309, Type 1, Class B, minimum 30% solids nondissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering for use on concrete to receive tile, carpet and other specified flooring. Do not use on concrete receiving a specialty coating, cementitious topping or clear penetrating water repellent.

1. Products: Subject to compliance with requirements, provide one of the following:

- a. Laticrete International, Inc.; "Dress & Seal WB 30™."
- b. W. R. Meadows, Inc.; "Vocomp-30."

2.9 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

1. Products: Subject to compliance with requirements, provide the following product or an equal product of another manufacturer that meets or exceeds the properties of the following product:

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- a. W.R. Meadows, Inc.; "Fibre Expansion Joint."
- B. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- C. Epoxy Bonding Adhesive: ASTM C 881, 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 I and II, non-load bearing and Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
- D. Chamfer Strips: Wood, metal, PVC, or rubber strips, $\frac{3}{4}$ " x $\frac{3}{4}$ " minimum.
- E. Grout: Pre-mixed, non-shrink grout complying with ASTM C 1107, Grade C:
 - 1. Products subject to compliance with requirements, provide one of the following:
 - a. Euclid Chemical Company (The), an RPM company; "NS Grout."
 - b. Laticrete International, Inc.; "L&M™ Duragrout™."
 - c. W.R. Meadows, Inc; "588-10K."
- F. Keyed Construction Joint: Preformed tongue and groove, 24 gauge, hot dipped galvanized steel construction joint with removable plastic cap to allow for floor sealant application as specified in Division 07 Section "Joint Sealants."
 - 1. Products subject to compliance with requirements, provide the following:
 - a. Joint: BoMetals, Inc.; "Pro-Key™."
 - b. Cap: Sika Corporation; "G-Seal® Paving Cap Seal."

2.10 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.
 - 2. Proportion normal-weight concrete according to ACI 211.1 and ACI 301.
 - 3. Adjustment to Concrete Mixtures: Mixture design adjustments may be requested by the Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to the Owner and as accepted by the Architect. Laboratory test data for revised mix design and strength results shall be submitted to and accepted by the Architect before using in the work.
- B. Materials Not Permitted: The following materials, or any combination of materials are not permitted to be incorporated in concrete mixtures:
 - 1. Fly Ash.
 - 2. Pozzolan.
 - 3. Ground Granulated Blast Furnace Slag.
 - 4. Silica Fume.
- 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 for prevailing climatic conditions at the time of placement. Adjust quantities and type of admixtures as required to maintain quality control. Reduction in cement content is not permitted. Do not use admixtures not specified or approved.
1. Use water-reducing or high-range water-reducing admixture in concrete, as required, for placement and workability.
 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.
 4. Use corrosion-inhibiting admixture in concrete mixtures where indicated.
 5. Use air-entraining admixture in exterior exposed concrete. Add air-entraining admixture at manufacturer's prescribed rate and in accordance with ACI 318.

2.11 CONCRETE MIXTURES FOR BUILDING ELEMENTS

- A. Footings: Proportion normal-weight concrete mixture as follows:
1. Minimum Compressive Strength: 3500 psi at 28 days.
 2. Minimum Cement Content 500 lb./cu.yd.
 3. Slump Limit: 3 inches or 8 inches for concrete with verified slump of 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture.
 4. Air Content: 5.5 percent, plus or minus 1 percent at point of delivery.
- B. Foundation Walls: Proportion normal-weight concrete mixture as follows:
1. Minimum Compressive Strength: 4000 psi at 28 days.
 2. Minimum Cement Content 500 lb./cu.yd.
 3. Slump Limit: 3 inches or 8 inches for concrete with verified slump of 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture.
 4. Air Content: 5.5 percent, plus or minus 1 percent at point of delivery for 1-1/2-inch nominal maximum aggregate size.
- C. Slabs-on-Grade, Curbs, Sidewalks, Stairs, Site Concrete, Concrete Paving etc.: Proportion normal-weight concrete mixture as follows:
1. Minimum Compressive Strength: 3500 psi at 28 days.
 2. Minimum Cementitious Materials Content: 520 lb/cu. yd.
 - a. For concrete exposed to deicers, limit percentage, by weight, of cementitious materials other than Portland cement according to ACI 301 requirements.
 3. Slump Limit: 3 inches.
 4. Air Content: 5.5 percent, plus or minus 1 percent at point of delivery for 1-1/2-inch nominal maximum aggregate size.
- D. Suspended Slabs: Proportion normal-weight concrete mixture as follows:
1. Minimum Compressive Strength: 3500 psi at 28 days.
 2. Minimum Cementitious Materials Content: 520 lb/cu. yd.
 3. Slump Limit: 3 inches.
 4. Air Content: 3 percent maximum.

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 C 94/C 94M, 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.
- B. Joint Sealing Materials
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Silicone Joint Sealing Material: Low modulus, nonsag-silicone, sealing material in a nonacid-curing, one part formulation.
 - b. Rubberized Joint Sealing Material: ASTM D 6690, Type I or II.
 - c. Preformed Neoprene Compression Seals and Strip Seals and Lubricant Adhesive: AASHTO M 220, ASTM D 3542.

PART 3 - EXECUTION

3.1 GENERAL

- A. Provide all labor, materials, and equipment to construct and complete all cast-in-place concrete work, according to all drawings and details, together with any other work specified herein.
 - 1. Contractor shall verify all measurements, lines, connections, methods and materials, and clarify with the Architect all discrepancies before proceeding with the work.
 - 2. Include all appliances, scaffoldings, runways, shorings, forms, reinforcing steel, welded wire fabric, all reinforcing accessories, vapor retarder under slabs on ground, expansion joints, control joints, water stops, and other specialties.
 - 3. All concrete shall be reinforced. Where reinforcement is not called for on the plans or schedules, minimum reinforcement shall be provided in accordance with ACI 318. Minimum temperatures for reinforcement shall be provided in all slabs in accordance with ACI 318.
 - 4. Verification of Conditions:
 - a. Before placing concrete, verify that installation of concrete forms, accessories, and reinforcement, and embedded items is complete and that required inspections have been performed.
 - b. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Provide reasonable auxiliary services to accommodate field testing and inspections, acceptable to testing agency, including the following:
 - 1. Daily access to the Work.

2. Incidental labor and facilities necessary to facilitate tests and inspections.
3. Secure space for storage, initial curing, and field curing of test samples, including source of water and continuous electrical power at Project site during site curing period for test samples.
4. Security and protection for test samples and for testing and inspection equipment at Project site.

3.3 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, and to comply with the Surface Finish designations specified herein.
- C. Limit concrete surface irregularities, designated by ACI 117 as follows:
 1. Surface Finish – 1.0: ACI 117 Class D, 1-inch for rough-formed finished surfaces.
 2. Surface Finish – 2.0: ACI 117, Class B, 1/4 inch for coarse-textured surfaces to receive plaster or stucco.
 3. Surface Finish – 3.0: ACI 117, Class A, 1/8 inch for exposed smooth-formed finished surfaces exposed to view.
- D. Construct forms tight enough to prevent loss of concrete mortar, to sizes, shapes, lines and dimensions shown, and to obtain accurate alignment, location, grades, level, and plumb work in finished structures. Minimize joints and symmetrically align all joints in forms.
- 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, 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 unless indicated otherwise.
- 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. Construction and Movement Joints:
 1. Construct joints true to line with faces perpendicular to surface plane of concrete.
 2. Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

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- K. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- L. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- M. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.
 - 1. Do not allow excess form-coating materials to accumulate in forms or to come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply according to manufacturer's instructions.
 - 2. Coat steel forms with a non-staining, manufactured form-release agent to protect against rusting. Rust-stained steel formwork is not acceptable.

3.4 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.
 - 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 ANSI/AISC 303
 - 3. Clean embedded items immediately prior to concrete placement.

3.5 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 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 70 percent of its 28-day design compressive strength as confirmed by laboratory testing.
 - 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 Architect.

3.6 VAPOR RETARDERS

- A. Sheet Vapor Retarder: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.

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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, sealing entire perimeter to floor slabs, or foundation walls.
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.

3.7 INSTALLATION OF STEEL REINFORCEMENT

- A. Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
 1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.
- C. Do not use reinforcement having any of the following defects:
 1. Bar lengths, depth, or bends exceeding the specified fabricating tolerances.
 2. Bends or kinks not indicated on the drawings or required for the work.
 3. Bars with cross-section reduced due to excessive rust or other causes.
- D. 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. Minimum concrete coverage for reinforcement:
 - a. Footings, 3".
 - b. Columns and pedestals, 2".
 - c. Walls, 2".
 - d. Interior slabs, 2".
 - e. Exterior slabs 2".
- E. Reinforce all concrete in accordance with indicated schedules, notes and details indicated on the Drawings.
 1. Where reinforcement is not on the Drawings, walls shall be reinforced as follows:
 - a. Up to 8" walls: #4 at 10" E.W. in center.
 - b. 8" up to 12" walls: #4 at 8" E.W. in center.
 - c. 12" walls and over: #4 at 12" E.W., E.F.
 - d. Provide #4 at 8" spacing dowels from main walls to secondary walls. Provide #4 at 12" spacing corner bars – all outside corners of walls. Provide two #4 at 5'-0" each corner of openings in concrete floors and walls.
 - e. Replace area of steel interrupted by openings in concrete walls with $\frac{1}{2}$ of the area on each side of the opening. Reinforcing to extend full length of span or height in the short

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directions and clear span plus 6' in the long direction of the walls. Provide a minimum of two #6 bars bottom, two #5 bars top, #4 ties at 12" and #4 bars at 12" H.E.F. over openings in concrete walls.

- F. Lap all horizontal reinforcing steel 48 bar diameters.
- G. Perform all cutting of reinforcing steel where the reinforcing steel interferes with Plumbing, Electrical, and other trades, and where reinforcing steel cannot be moved. Reinforcing steel that is cut shall be replaced as directed by the Architect at the Contractor's expense.
- H. Weld reinforcing bars according to AWS D1.4/D 1.4M, where indicated
- I. Conduits or pipes shall be spaced not closer than three (3) diameters on center, and shall be so placed as to avoid changing the locations of the reinforcement from that shown on the Drawings.
- J. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- K. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

3.8 JOINTS

- A. Construct joints true to line with faces perpendicular to surface plane of concrete.
- B. Construction Joints: Coordinate with floor slab pattern or lay out and concrete placement sequence.
 - 1. Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
 - 2. 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.
 - 3. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete.
 - 4. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 - 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. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
 - 7. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - 8. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- C. Control Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness as follows:
 - 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 will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.
- 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.

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1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated.
 2. 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 Division 07 Section "Joint Sealants," are indicated.
 3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
 4. Remove plastic caps for application of sealants as required.
- 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.

3.9 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, embedded items and vapor retarder is complete and that required inspections have been performed.
1. Immediately prior to concrete placement, inspect vapor retarder for damage and deficient installation, and repair defective areas.
 2. Provide continuous inspection of vapor retarder during concrete placement and make necessary repairs to damaged areas as Work progresses.
 3. Coordinate the installation of joint materials and vapor retarders with placement of forms and reinforcing steel.
- B. Notify Architect and schedule testing and inspection agencies a minimum of 24 hours prior to commencement of concrete placement.
- C. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect.
1. Do not add water to concrete after adding high-range water-reducing admixtures.
- D. 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.
1. If a section cannot be placed continuously, provide construction joints as indicated.
 2. Deposit concrete to avoid segregation.
 3. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
 4. 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.
 5. Pour foundation walls in lengths not exceeding 75'. Provide a gap of at least 2'-0" between succeeding pours. Gaps shall not be filled less than 72 hours after the adjacent sections are poured.
- E. 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.

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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 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.

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

1. 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.
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.

G. Hot-Weather Placement: Comply with ACI 301 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.
3. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
4. Do not use retarding admixtures unless otherwise accepted in mix designs submitted to the Architect for acceptability.

3.10 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Patch voids larger than 1 inch wide and ½-inch deep. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces not exposed to 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. Patch voids larger than ½-inch wide by ½-inch deep. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces exposed to view, to be covered with a coating or covering material applied directly to concrete.

C. Rubbed Finish: Apply the following to smooth-formed finished as-cast concrete where indicated:

1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.

D. Related Unformed Surfaces:

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

3.11 FINISHING FLOORS AND SLABS

A. General: Comply with ACI 302.1R recommendations for screeding, re-straightening, 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.
3. Apply scratch finish to surfaces indicated to receive concrete floor toppings and to receive mortar setting beds for bonded cementitious floor finishes.

C. Float Finish:

1. When bleed water sheen has disappeared and concrete has stiffened sufficiently to permit operation of specific float apparatus, consolidate concrete surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats.
2. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture and complies with ACI 117 tolerances for conventional concrete.
3. Apply float finish to surfaces indicated to receive trowel finish and to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo.

D. Trowel Finish:

1. After applying float finish, apply first troweling and consolidate concrete by power-driven trowel.
2. Continue troweling passes and restraighen 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.
4. Do not add water to concrete surface.
5. Do not apply hard-troweled finish to concrete, which has a total air content greater than 3%.
6. 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.
7. Finish surfaces to the following tolerances, according to ASTM E 1155, for a randomly trafficked floor surface:

E. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces indicated and where ceramic or quarry tile is to be installed by either thickset or thin-set method. While concrete is still plastic, slightly scarify surface with a fine broom perpendicular to main traffic route.

1. Coordinate required final finish with Architect before application.
2. 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.

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

3.12 INSTALLATION OF MISCELLANEOUS CONCRETE ITEMS

A. Filling In:

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

B. Curbs: Provide monolithic finish to 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.

1. Cut joints in curbs at ten feet (10') on center with alternate joints provided with 1/2-inch thick expansion (isolation) strips, except where the curbs adjoin concrete walks in which case they shall have cut and expansion (isolation) joints to coincide with the adjacent walks.

C. Exterior Walks and Slabs: Exterior walks and slabs shall have scored joints, tooled to a depth of one-fifth (1/5) of the slab thickness. Where joints are not indicated on the Drawings, provide scored joints of approximately 25 square foot blocks but not larger than 30 square feet.

1. Isolation and Expansion Joints: Provide 1/2-inch thick premolded expansion (isolation) joint filler in walks and slabs. Consult with Architect prior to pouring. Expansion joints shall be a maximum of twenty-five feet (25') apart and continuous against all building walls, concrete curbs and similar vertical surfaces. Recess top edge of filler 1/2-inch to allow for sealing of joints.

D. Equipment Bases and Foundations:

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct concrete bases to height 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.
3. Minimum Compressive Strength: 3500 psi at 28 days.
4. Install dowel rods to connect concrete base to concrete floor.
5. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
6. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete substrate.
7. Prior to pouring concrete, place and secure anchorage devices.
 - a. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - b. Cast anchor-bolt insert into bases.
 - c. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Reinforced Masonry: Provide concrete grout for reinforced masonry where indicated on Drawings and as scheduled.

F. Isolation Slabs: Provide isolated slabs as indicated on the Drawings to prevent vibration transmission.

3.13 CONCRETE CURING

- A. 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 during curing.
 - 2. Comply with ACI 301 and ACI 305.1 for hot-weather protection during curing.
- B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 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.
- C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.
- D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.
- E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
 - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - a. Water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
 - 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, 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 will not interfere with bonding of floor covering used on Project.
 - 3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
 - a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.
 - 4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours

later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.14 APPLICATION OF LIQUID FLOOR TREATMENTS

- A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatments on interior floor surfaces indicated as finished exposed concrete 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 three days' old but no earlier than recommended by the manufacturer.
 - 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.
- B. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller according to manufacturer's written instructions.

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 two month(s).
 - 2. 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 joint clean and dry.
- C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints.
- D. Overfill joint and trim joint filler flush with top of joint after hardening.

3.16 CONCRETE SURFACE REPAIRS

- A. Defective Concrete:
 - 1. Repair and patch defective areas when approved or directed by Architect.
 - 2. Remove and replace concrete that cannot be repaired and patched to Architect's approval.
- 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.

- a. Limit cut depth to 3/4 inch.
 - b. Make edges of cuts perpendicular to concrete surface.
 - c. Clean, dampen with water, and brush-coat holes and voids with bonding agent.
 - d. Fill and compact with patching mortar before bonding agent has dried.
 - e. 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 will match surrounding color.
 - a. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching.
 - b. 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:
1. Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface.
 - a. Correct low and high areas.
 - b. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
 2. Repair finished surfaces containing defects including 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.
 3. After concrete has cured at least 14 days, correct high areas by grinding.
 4. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar.
 - a. Finish repaired areas to blend into adjacent concrete.
 5. Correct other low areas scheduled to receive floor coverings with a repair underlayment.
 - a. Prepare, mix, and apply repair underlayment and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 - b. Feather edges to match adjacent floor elevations.
 6. Correct other low areas scheduled to remain exposed with a repair topping.
 - a. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations.
 - b. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 7. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete.
 - a. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch clearance all around.
 - b. Dampen concrete surfaces in contact with patching concrete and apply bonding agent.
 - c. Mix patching concrete of same materials and mixture as original concrete except without coarse aggregate.
 - d. Place, compact, and finish to blend with adjacent finished concrete.

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- e. Cure in same manner as adjacent concrete.
- 8. Repair random cracks and single holes 1 inch or less in diameter with patching mortar.
 - a. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles.
 - b. Dampen cleaned concrete surfaces and apply bonding agent.
 - c. Place patching mortar before bonding agent has dried.
 - d. Compact patching mortar and finish to match adjacent concrete.
 - e. Keep patched area continuously moist for at least 72 hours.
- E. Perform structural repairs of concrete, subject to Architect's approval, 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. Testing and Inspecting: Contractor shall engage a qualified testing and inspecting agency to witness concrete placement and to perform tests and inspections and to submit reports.
 - 1. Testing agency shall be responsible for providing curing container for composite samples on Site and verifying that field-cured composite samples are cured in accordance with ASTM C31/C31M.
 - 2. Testing agency shall immediately report to Architect, Contractor, and concrete manufacturer any failure of Work to comply with Contract Documents.
 - 3. Testing agency shall report results of tests and inspections, in writing, to Owner, Architect, Contractor, and concrete manufacturer within 48 hours of inspections and tests.
 - a. Test reports shall include reporting requirements of ASTM C31/C31M, ASTM C39/C39M, and ACI 301, including the following as applicable to each test and inspection:
 - 1) Project name.
 - 2) Name of testing agency.
 - 3) Names and certification numbers of field and laboratory technicians performing inspections and testing.
 - 4) Name of concrete manufacturer.
 - 5) Date and time of inspection, sampling, and field testing.
 - 6) Date and time of concrete placement.
 - 7) Location in Work of concrete represented by samples.
 - 8) Date and time sample was obtained.
 - 9) Truck and batch ticket numbers.
 - 10) Design compressive strength at 28 days.
 - 11) Concrete mixture designation, proportions, and materials.
 - 12) Field test results.
 - 13) Information on storage and curing of samples before testing, including curing method and maximum and minimum temperatures during initial curing period.
 - 14) Type of fracture and compressive break strengths at seven days and 28 days.
- B. Batch Tickets: For each load delivered, submit three copies of batch delivery ticket to testing agency, indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, design slump at time of batching, and amount of water that can be added at Project site.
- C. Inspections:

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1. Observe concrete placement and confirm no water is added on-site.
 2. Inspect formwork for shape, location, and dimensions of the concrete member(s) being formed.
 3. Steel reinforcement placement.
 4. Steel reinforcement welding.
 5. Headed bolts and studs.
 6. Verification of use of required design mixture.
 7. Concrete placement, including conveying and depositing.
 8. Curing procedures and maintenance of curing temperature.
 9. 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 in accordance with ASTM C 172/C 172M 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 50 cu. yd. or fraction thereof.
 - 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. Slump: ASTM C 143/C 143M;
 - a. 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.
 - b. Perform additional tests when concrete consistency appears to change.
 3. Air Content: ASTM C 231/C 231M, pressure method, for normal-weight concrete;
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 4. Concrete Temperature: ASTM C 1064/C 1064M:
 - a. 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.
 5. Compression Test Specimens: ASTM C 31/C 31M:
 - a. Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.
 - b. Cast, initial cure, and field cure three standard cylinder specimens for each composite sample.
 6. Compressive-Strength Tests: ASTM C 39/C 39M:
 - a. Test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.
 - b. Test one set of two field-cured specimens at 7 days and one set of two 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.
 7. 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.

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8. 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, if specified compressive strength is 5000 psi or no compressive strength test value is less than 10 percent of specified compressive strength if greater than 5000 psi.
 9. 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.
 10. Additional Tests:
 - a. 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.
 - b. 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 Architect.
 - 1) Acceptance criteria for concrete strength shall be in accordance with ACI 301 Section 1.6.6.3.
 11. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 12. 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 and promptly report test results to Architect.

3.18 PROTECTION

- A. Protect concrete surfaces as follows:
1. Protect from petroleum stains.
 2. Diaper hydraulic equipment used over concrete surfaces.
 3. Prohibit vehicles from interior concrete slabs.
 4. Prohibit use of pipe-cutting machinery over concrete surfaces.
 5. Prohibit placement of steel items on concrete surfaces.
 6. Prohibit use of acids or acidic detergents over concrete surfaces.
 7. 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.
 8. Protect concrete surfaces scheduled to receive surface hardener or polished concrete finish using Floor Slab Protective Covering.

END OF SECTION 03 30 00