

SECTION 03 3000 - CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Concrete formwork.
- B. Concrete building frame members
- C. Floors and slabs on grade.
 - 1. Vapor barrier and granular fill below concrete slab-on-grade
- D. Concrete foundation walls.
- E. Concrete foundations
- F. Joint devices associated with concrete work.
- G. Miscellaneous concrete elements, including curbs, equipment pads, and concrete fill for stair tread pans.
- H. Concrete curing.
- I. Waterstops
- J. Concrete finishes
- K. Non-Shrink Cementitious Grout

1.02 RELATED REQUIREMENTS

- A. Section 03 2000 - Concrete Reinforcing.
- B. Section 05 2100 – Structural Steel Framing: anchor bolts.
- C. Section 07 9005 - Joint Sealers: Sealants for saw cut joints and isolation joints in slabs.

1.03 REFERENCE STANDARDS (LATEST EDITION)

- A. ACI 117 - Standard Specifications for Tolerances for Concrete Construction and Materials; American Concrete Institute International.
- B. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete; American Concrete Institute International.
- C. ACI 211.2 - Standard Practice for Selecting Proportions for Structural Lightweight Concrete; American Concrete Institute International.
- D. ACI 301 - Specifications for Structural Concrete for Buildings; American Concrete Institute International.
- E. ACI 302.1R - Guide for Concrete Floor and Slab Construction; American Concrete Institute International.

- F. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete; American Concrete Institute International.
- G. ACI 305R - Hot Weather Concreting; American Concrete Institute International.
- H. ACI 306R - Cold Weather Concreting; American Concrete Institute International.
- I. ACI 308R - Guide to Curing Concrete; American Concrete Institute International.
- J. ACI 318 - Building Code Requirements for Structural Concrete and Commentary; American Concrete Institute International.
- K. ACI 347 - Guide to Formwork for Concrete; American Concrete Institute International.
- L. ASTM C33/C33M - Standard Specification for Concrete Aggregates.
- M. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- N. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
- O. ASTM C109/C109M - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm) Cube Specimens).
- P. ASTM C150/C150M - Standard Specification for Portland Cement.
- Q. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete.
- R. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
- S. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
- T. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
- U. ASTM C330 - Standard Specification for Lightweight Aggregates for Structural Concrete.
- V. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete.
- W. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
- X. ASTM C685/C685M - Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing.
- Y. ASTM C881/C881M - Standard Specification for Epoxy-Resin-Base Bonding System for Concrete.
- Z. ASTM C979/C979M - Standard Specification for Pigments for Integrally Colored Concrete.
- AA. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
- AB. ASTM C1240 - Standard Specification for Silica Fume Used in Cementitious Mixtures.
- AC. ASTM C1315 - Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.

- AD. ASTM D994/D994M - Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
- AE. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types).
- AF. ASTM D2103 – Standard Specification for Polyethylene Film and Sheeting.
- AG. ASTM E154 - Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover.
- AH. ASTM E1155 - Standard Test Method for Determining F(F) Floor Flatness and F(L) Floor Levelness Numbers.
- AI. ASTM E1643 - Standard Practice for Selection, Design, Installation and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs.
- AJ. ASTM E1745 - Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.
- AK. COE CRD-C 48 – Method of Test for Water Permeability of Concrete; Corps of Engineers
- AL. COE CRD-C 513 - Corps of Engineers Specifications for Rubber Waterstops; Corps of Engineers
- AM. COE CRD-C 572 - Corps of Engineers Specifications for Polyvinylchloride Waterstop; Corps of Engineers.
- AN. NSF 61 - Drinking Water System Components - Health Effects.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Submit manufacturers' data on manufactured products showing compliance with specified requirements and installation instructions.
 - 1. For curing compounds, provide data on method of removal in the event of incompatibility with floor covering adhesives.
- C. Samples for Pigment Color Selection: Submit manufacturer's complete sample chip set, including pigment number and required dosage rate for each color.
- D. Verification Samples: Submit sample chips of specified colors indicating pigment numbers and required dosage rates, for subsequent comparison to installed concrete.
- E. Samples: Submit samples of under-slab vapor retarder to be used.
- F. Manufacturer's Installation Instructions: For concrete accessories, indicate installation procedures and interface required with adjacent construction.
- G. Concrete Mix Design:
 - 1. Employ an independent testing laboratory to test proposed aggregate and design concrete mixes for each type of concrete required. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
 - 2. Submit aggregate test reports and mix designs for approval 14 days prior to placing concrete.

3. Test each type of fine and coarse aggregate for conformance to ASTM C33-78. Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.
 4. Design mixes in accordance with ACI 301, Section 3.8.2, Method 1 or Method 2.
- H. Slab-on-grade Construction/Control Joint Layout: Indicate proposed construction/contraction joints. Space joints to comply with requirements in structural general notes. Location of contraction joints is subject to approval of Architect.
- I. Material Certificates: For each of the following, signed by manufacturers:
1. Cementitious materials
 2. Admixtures
 3. Form materials and form-release agents
 4. Fiber reinforcement
 5. Curing compounds
 6. Bonding agents
 7. Adhesives
 8. Vapor retarders
 9. Semi-rigid joint fillers
 10. Joint filler strips
 11. Repair materials
- J. Project Record Documents: Accurately record actual locations of embedded utilities and components that will be concealed from view upon completion of concrete work.
- K. Floor surface flatness and levelness measurements indicating compliance with specified tolerances.
- L. Qualification Data: Upon Architect's request, provide qualification data for installer and manufacturers.

1.05 QUALITY ASSURANCE

- A. Perform work of this section in accordance with ACI 301, ACI 318, and ACI 317, unless modified by requirements in the Contract Documents.
- B. Follow recommendations of ACI 305R when concreting during hot weather.
- C. Follow recommendations of ACI 306R when concreting during cold weather.
- D. 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.
- E. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94 requirements for production facilities and equipment.
- F. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 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.
 2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician – Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician – Grade II.

- G. 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.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

PART 2 PRODUCTS

2.01 FORMWORK

- A. Formwork Design and Construction: Comply with guidelines of ACI 347 to provide formwork that will produce concrete complying with tolerances of ACI 117.
- B. Form Materials: Contractor's choice of standard products with sufficient strength to withstand hydrostatic head without distortion in excess of permitted tolerances.
 - 1. Smooth Form Facing for Exposed Finish Concrete: Contractor's choice of materials (plywood, metal, or other approved panel materials) that will provide continuous, true, smooth, stain-free final appearance. Furnish in largest practicable sizes to minimize number of joints.
 - 2. Rough Form Facing for Non-Exposed Finish Concrete: Contractor's choice of materials; plywood, lumber, metal, or other approved panel materials. Provide lumber dressed on at least two edges and one side for tight fit.
 - 3. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that will produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.
 - 4. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.
 - 5. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.
 - 6. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 x 3/4 inch, minimum.
 - 7. Earth Cuts: Do not use earth cuts as forms for vertical surfaces. Natural rock formations that maintain a stable vertical edge may be used as side forms.
 - 8. Form Coating: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete or interfere with application of coatings.
 - 9. 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.
 - a. Furnish units that will leave no corrodible metal closer than 1-1/2 inches to the plane of exposed concrete surface.
 - b. Furnish ties that, when removed, will leave holes no larger than 1 inch in diameter in concrete surface.

2.03 CONCRETE MATERIALS

- A. Cement: ASTM C150, Type I/II - Normal Portland type, unless noted otherwise in Structural Drawings. Use same cementitious materials, of the same type, brand, and source throughout Project.
 - B. Normal-Weight Aggregates: ASTM C33, Class 3S coarse aggregate or better, graded.
- 1. Acquire all aggregates for entire project from same source with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.

2. Maximum Coarse-Aggregate Size: 1 inch nominal.
 3. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
 4. For exposed exterior surfaces, do not use fine or coarse aggregates that contain substances that cause spalling. In no case shall the use of pit-run or naturally mixed aggregates be permitted. Shale and iron based aggregate shall not be used.
- B. Fly Ash: ASTM C618, Class C or F.
- C. Water: ASTM C94, clean, potable and not detrimental to concrete.
- D. For concrete exposed to de-icers, limit percentage, by weight, of Cementitious materials other than Portland cement according to ACI 301 requirements.

2.04 CHEMICAL ADMIXTURES

- A. Do not use chemicals that will result in soluble chloride ions in excess of 0.1 percent by weight of cement.
- B. Air-Entraining Admixture: ASTM C260.
- 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.
- D. High-Range, Water-Reducing and Retarding Admixture: ASTM C494, Type G.
- E. High-Range, Water-Reducing Admixture: ASTM C494, Type F.
- F. Water-Reducing Admixture: ASTM C494, Type A.

2.05 ACCESSORY MATERIALS

- A. Under-slab Vapor Retarder (Material ID: VPR RET-4): Multi-layer, fabric-, cord-, grid-, or aluminum-reinforced polyethylene or equivalent, complying with ASTM E1745, Class A; stated by manufacturer as suitable for installation in contact with soil or granular fill under concrete slabs. Single ply polyethylene is prohibited.
1. Accessory Products: Vapor retarder manufacturer's recommended tape, adhesive, mastic, prefabricated boots, etc., for sealing seams and penetrations in vapor retarder.
 2. Acceptable Products:
 - a. Intertape Polymer Group, Inc; VaporMaster 15: www.intertapepolymer.com.
 - b. W.R. Meadows, Inc.; PERMINATOR 15 mils (0.38 mm): www.wrmeadows.com.
 - c. Raven Industries; VaporBlock VB 15: www.ravenefd.com.
 - d. Stego Industries, LLC; Stego Wrap Vapor Barrier 15 mil: www.stegoindustries.com.
 - e. Substitutions: See Section 01 6000 - Product Requirements.
 3. Fine-Graded Granular Fill: Unless noted otherwise, clean mixture of crushed stone, crushed gravel, and manufactured; ASTM D448, Size 10, with 100 percent passing a 3/8-inch sieve, 10 to 30 percent passing a No. 100 sieve, and at least 5 percent passing No. 200 sieve; complying with deleterious substances limits of ASTM C33 for fine aggregates.
- B. Non-Shrink Cementitious Grout: Premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; non-corrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.
1. ASTM C1107/C1107M; Grade A, B, or C.

2.06 BONDING AND JOINTING PRODUCTS

- A. Bonding Agent: Non-redispersible, acrylic emulsion or styrene butadiene complying with ASTM C1059, Type II.
- B. Epoxy Bonding System: Complying with ASTM C881/C881M; 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.
- C. Waterstops: Flexible PVC waterstop, complying with COE CRD-C 572, with factory-installed metal eyelets, for embedding in concrete to prevent passage of fluids through joints. Factory-fabricate corners, intersections, and directional changes. Waterstop material fabricated from virgin materials.
 - 1. Profile: Flat, Ribbed with center bulb; Greenstreak 705, 643 or approved equal.
 - 2. Profile: Flat, Ribbed; Greenstreak 781, 783 or approved equal.
- D. Waterstops: Cold Joint Waterstop Hydrotite, item CJ-0725-3D (nominal size – 1 inch x ¼-inch), as manufactured by Greenstreak or approved equal.
- E. Waterstops: Bentonite and butyl rubber, complying with NSF 61.
 - 1. Configuration: As indicated on drawings.
 - 2. Size: As indicated on drawings.
- F. Reglets: Formed steel sheet, galvanized, with temporary filler to prevent concrete intrusion during placement.
- G. Slab Expansion/Isolation Joint Filler: 1/2 inch (13 mm) thick, height equal to slab thickness, with removable top section that will form 1/2 inch (13 mm) deep sealant pocket after removal.
 - 1. Material: ASTM D1751, asphalt-saturated cellulose fiber.
- H. Slab Construction Joint Devices: Combination keyed joint form and screed, galvanized steel, with minimum 1 inch (25 mm) diameter holes for conduit or rebars to pass through at 6 inches (150 mm) on center; ribbed steel stakes for setting.
- I. Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.0336 inch thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

2.07 CURING MATERIALS

- A. Curing and Sealing Compound, Low Gloss: Liquid, membrane-forming, clear, non-yellowing acrylic; complying with ASTM C1315 Type 1 Class A.
 - 1. Vehicle: Water-based.
 - 2. Solids by Mass: 20 percent, minimum.
 - 3. Products:
 - a. W.R. Meadows, Inc.; VOCOMP-20: www.wrmeadows.com.
 - b. BASF; Kure 1315: www.buildingsystems.basf.com.
 - c. Scofield; Cureseal-W: www.scofield.com.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
- B. Curing and Sealing Compound, High Gloss: Liquid, membrane-forming, clear, non-yellowing acrylic; complying with ASTM C1315 Type 1 Class A.
 - 1. Vehicle: Water-based.
 - 2. Solids by Mass: 30 percent, minimum.
 - 3. Products:

- a. W.R. Meadows, Inc.; VOCOMP-30: www.wrmeadows.com.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- C. Moisture Retaining Sheet: ASTM C171
- 1. Polyethylene film, clear, minimum nominal thickness of 0.0040 inches.
 - 2. White burlap-polyethylene sheet, weighing not less than 10 oz/per linear yd, 40 inches wide.
- D. Polyethylene Film: ASTM D2103, 4 mil thick, clear.
- E. Water: Potable, not detrimental to concrete.
- F. Absorptive Cover: AASHTO M182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz. / square yard when dry.

2.08 CONCRETE MIX DESIGN

- A. Proportioning Normal Weight Concrete: Comply with ACI 211.1 recommendations.
- B. 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. For trial mixtures method, employ a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.
 - 2. Adjustments to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, as accepted by Engineer. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Engineer before using in Work.
- C. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- D. Admixtures: Add acceptable admixtures as recommended in ACI 211.1 and at rates recommended by manufacturer.
- 1. Use water-reducing, high-range water-reducing or plasticizing 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.
- E. Normal Weight Concrete:
- 1. Compressive Strength, when tested in accordance with ASTM C39/C39M at 28 days: as indicated on Structural Drawings.
 - 2. Fly Ash Content: Maximum 15 percent of cementitious materials by weight.

2.09 CONCRETE MIXTURES FOR BUILDING ELEMENTS

- A. Footings: Proportion normal-weight concrete mixture as follows:
- 1. Minimum Compressive Strength: 4000 psi at 28 days.
 - 2. Maximum Water-Cementitious Materials Ratio: 0.45.
 - 3. Slump Limit: 4 inches, plus or minus 1 inch.
 - 4. Air Content: 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch nominal maximum aggregate size.

5. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch and 3/4-inch nominal maximum aggregate size.
- B. Foundation Walls: Proportion normal-weight concrete mixture as follows:
1. Minimum Compressive Strength: 4000 psi at 28 days.
 2. Maximum Water-Cementitious Materials Ratio: 0.45.
 3. Slump Limit: 2 to 4 inches, plus or minus 1 inch. If admixture is utilized, not more than 8 inches for concrete with verified slump of 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture, plus or minus 1 inch.
 4. Air Content: 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch nominal maximum aggregate size.
 5. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch and 3/4-inch nominal maximum aggregate size.
- C. Slabs-on-Grade: Proportion normal-weight concrete mixture as follows:
1. Minimum Compressive Strength: 4000 psi at 28 days.
 2. Maximum Water-Cementitious Materials Ratio: 0.45.
 3. Slump Limit: 4 inches, plus or minus 1 inch.
 4. Air Content: 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch nominal maximum aggregate size.
 5. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch and 3/4-inch nominal maximum aggregate size.
 6. Air Content: Do not allow air content of trowel-finished floors exceed 3 percent.

2.10 MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94/C94M and ASTM C1116, furnish batch ticket information.
1. When air temperature is between 85 and 90 degree F, reduce mixing and delivery time from 90 minutes to 75 minutes; when air temperature is above 90 degree F, reduce mixing and delivery time to 60 minutes.

2.11 REPAIR MATERIALS

- A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thickness 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 thickness 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.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify lines, levels, and dimensions before proceeding with work of this section.

3.02 PREPARATION

- A. Formwork: Design, erect, shore, brace, and maintain 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, and for easy removal without damage to concrete.
 1. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
 2. Limit concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:
 - a. Class A, 1/8 inch for smooth-formed finished surfaces.
 - b. Class C, 1/2 inch for rough-formed finished surfaces.
 3. Construct forms tight enough to prevent loss of concrete mortar.
 4. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1.0 vertical.
 - a. Install keyways, reglets, recesses, and the like, for easy removal.
 - b. Do not use rust-stained steel form-facing material.
 5. 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.
 6. 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.
 7. Chamfer exterior corners and edges of permanently exposed concrete.
 8. Forming openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
 9. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
 10. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
 11. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.
 12. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses, and chases from trades providing such items. Accurately place and securely support items built into forms.
 13. Do not allow excess form-coating material to accumulate in forms or come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply according to manufacturer's instructions.
- B. Verify that forms are clean and free of rust before applying release agent.
- C. Coordinate placement of embedded items with erection of concrete formwork and placement of form accessories.

1. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - a. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings, and Bridges".
 - b. 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.
 - c. Install dovetail anchor slots in concrete structures as indicated.

- D. Where new concrete is to be bonded to previously placed concrete, prepare existing surface by cleaning with steel brush and applying bonding agent in accordance with manufacturer's instructions.

- E. In locations where new concrete is doweled to existing work, drill holes in existing concrete, and epoxy adhere steel dowels.

- F. Interior Slabs on Grade: Install vapor retarder under interior slabs on grade. Lap joints minimum 6 inches. Seal joints, seams and penetrations watertight with manufacturer's recommended products and follow manufacturer's written instructions. Repair damaged vapor retarder before covering.
 1. Granular Fill Over Vapor Retarder: Cover vapor retarder with compactible granular fill as shown on the drawings. Do not use sand.
 2. Vapor Retarder Over Granular Fill: Install compactible granular fill before placing vapor retarder as shown on the drawings. Do not use sand.
 3. Place granular fill and compact with mechanical equipment to elevation tolerances of plus 0 inch or minus 3/4-inch.

3.03 WATERSTOPS

- A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.

3.04 PLACING CONCRETE

- A. Place concrete in accordance with ACI 304R.
 1. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items are complete and that required inspections have been performed.

- B. Place concrete for floor slabs in accordance with ACI 302.1R.

- C. Notify Architect not less than 24 hours prior to commencement of placement operations.

- D. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.

- E. Ensure reinforcement, inserts, waterstops, embedded parts, and formed construction joint devices will not be disturbed during concrete placement. Maintain reinforcement in position on chairs during concrete placement.

- F. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Engineer.

- G. Place concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
 - 1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
 - 2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
 - 3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

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

- I. Finish floors level and flat, unless otherwise indicated, within the tolerances specified below.

- J. 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 anti-freeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

- K. 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.

3.05 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 had 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.

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 Engineer.

3.06 SHORES AND RE-SHORES

- A. Comply with ACI 318 and ACI 301 for design, installation, and removal of shoring and re-shoring.
 1. Do not remove shoring or re-shoring until measurement of slab tolerances is complete.
- B. In multistory construction, extend shoring or re-shoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.
- C. Plan sequence of removal of shores and re-shore to avoid damage to concrete. Locate and provide adequate re-shoring to support construction without excessive stress or deflection.

3.07 SLAB JOINTING

- A. Locate joints as indicated on the drawings. Construct joints true to line with faces perpendicular to surface plane of concrete.
- B. Anchor joint fillers and devices to prevent movement during concrete placement.
- C. Isolation Joints: Use preformed joint filler with removable top section for joint sealant, total height equal to thickness of slab, set flush with top of slab.
 1. Install wherever necessary to separate slab from other building members, including columns, walls, equipment foundations, footings, stairs, manholes, sumps, and drains.
 2. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
- D. Load Transfer Construction and Contraction Joint: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding one side of joint. Saw cut joint at surface as indicated for contraction joints.
- E. Saw Cut Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Saw cut joints before concrete begins to cool and develops random contraction cracks; use 3/16 inch thick blade and cut at least 1 inch deep but not less than one quarter (1/4) the depth of the slab.
- F. Construction Joints: Install so strength and appearance of concrete are not impaired, at location indicated or as approved by Structural Engineer.
 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.

3. Locate joints for beams, structural slabs, joists, and girders in the middle third of spans (unless noted otherwise). Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 5. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 6. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- G. Joint Filling
1. Prepare, clean, and install joint filler according to manufacturer's written instructions. Defer joint filling until concrete has aged at least six months. Do not fill joints until construction traffic has permanently ceased.
 2. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.
 3. Install semi-rigid 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.

3.08 FLOOR FLATNESS AND LEVELNESS TOLERANCES

- A. Upon Architect's request, an independent testing agency, as specified in Section 01 4000, will inspect finished slabs for conformance to specified tolerances.
- B. Minimum F(F) Floor Flatness and F(L) Floor Levelness Values:
 1. F(F) of 20 and F(L) of 15
 - a. Non-critical mechanical rooms, non-public areas, surfaces to have raised access flooring, surfaces to have thick-set tile, and parking structure slabs.
 2. F(F) of 25 and F(L) of 20.
 - a. Carpeted areas of commercial office buildings or lightly-trafficked office/industrial buildings.
 3. F(F) of 35 and F(L) of 25.
 - a. Thin-set flooring or warehouse floor with moderate or heavy traffic.
 4. F(F) of 45 and F(L) of 35.
 - a. Warehouse with air-pallet use, ice, or roller rinks.
 5. F(F) of 50 and F(L) of 50.
 - a. Movie or television studio.
- C. Measure F(F) and F(L) in accordance with ASTM E1155, within 48 hours after slab installation; report both composite overall values and local values for each measured section.
- D. Correct the slab surface if composite overall value is less than specified and if local value is less than two-thirds of specified value or less than F(F) 13/F(L) 10.
- E. Correct defects by grinding or by removal and replacement of the defective work. Areas requiring corrective work will be identified. Re-measure corrected areas by the same process.

3.09 CONCRETE FINISHING

- A. Repair surface defects, including tie holes, immediately after removing formwork.
- B. Unexposed Form Finish: Rub down or chip off fins or other raised areas 1/4 inch or more in height.

- C. Exposed Form Finish: Rub down or chip off and smooth fins or other raised areas 1/4 inch or more in height. Provide finish as follows:
1. Smooth Rubbed Finish: Wet concrete and rub with carborundum brick or other abrasive, not more than 24 hours after form removal.
 2. Grout Cleaned Finish: Wet areas to be cleaned and apply grout mixture, of a consistency of thick paint to coat surfaces and fill small holes, by brush or spray; scrub immediately to remove excess grout. Mix 1.0 part Portland cement to 1.5 parts fine sand with a 1:1 mixture of bonding admixture and water. Add white Portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. After drying, rub vigorously with clean burlap, and keep surface damp by fog spray for at least 36 hours.
 3. Cork Floated Finish: Immediately after form removal, apply grout with trowel or firm rubber float; compress grout with low-speed grinder, and apply final texture with cork float.
 4. 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.
- D. Concrete Slabs: Finish to requirements of ACI 302.1R, and as follows:
1. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. Use stiff brushes, brooms, or rakes to produce a profile amplitude of 1/4 inch in 1 direction. Apply scratch finish to surfaces indicated and to receive concrete floor topping or to receive mortar setting beds for bonded Cementitious floor finishes.
 2. Surfaces to Receive Thick Floor Coverings: "Wood float" as described in ACI 302.1R; thick floor coverings include quarry tile, ceramic tile, and terrazzo with full bed setting system. Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Re-straighten, cut down high spots, and fill low spots. Repeat float passes and re-straightening until surface is left with a uniform, smooth, granular texture. Apply float finish to surfaces to receive trowel finish and to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing.
 3. Surfaces to Receive Thin Floor Coverings: "Steel trowel" as described in ACI 302.1R; thin floor coverings include carpeting, resilient flooring, seamless flooring, thin set quarry tile, and thin set ceramic tile. After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and re-straighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
 4. Decorative Exposed Surfaces: "Steel trowel" as described in ACI 302.1R; use steel-reinforced plastic trowel blades instead of steel blades to avoid black-burnish marks; decorative exposed surfaces include surfaces to be stained or dyed, pigmented concrete, surfaces to be polished, and all other slab surfaces. After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and re-straighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
 5. Trowel and Fine-Broom Finish: Apply a first trowel finish to surface 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.
 6. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and elsewhere as indicated. 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.
 7. Architectural Concrete Finish: Match Architect's approved sample, identified and described as indicated, to satisfaction of Architect.

3.10 MISCELLANEOUS CONCRETE ITEMS

- A. Filling In: Fill in holes and openings left in concrete structures after work of other trades is in place unless otherwise indicated. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.
- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.
- D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Screed, tamp, and trowel-finish concrete surfaces.

3.11 CURING AND PROTECTION

- A. Comply with requirements of ACI 308R. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.
- B. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.
- C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported structural 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. Surfaces Not in Contact with Forms: Cure unformed surfaces, including floors and slabs, concrete floor toppings and other surfaces.
 - 1. Slabs and Floors To Receive Adhesive-Applied Flooring: Curing compounds and other surface coatings are usually considered unacceptable by flooring and adhesive manufacturers. If such materials must be used, either obtain the approval of the flooring and adhesive manufacturers prior to use or remove the surface coating after curing to flooring manufacturer's satisfaction.
 - 2. Initial Curing: Start as soon as free water has disappeared and before surface is dry.
- 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; spray water over floor slab areas and maintain wet.
 - 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 covers.
 - 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.

3.12 FIELD QUALITY CONTROL

- A. An independent testing agency will perform field quality control tests, as specified in Section 01 4000.
- B. Provide free access to concrete operations at project site and cooperate with appointed firm.
- C. Submit proposed mix design of each class of concrete to inspection and testing firm for review prior to commencement of concrete operations.
- D. Test of concrete and concrete materials may be performed at any time to ensure conformance with specified requirements.
- E. Inspections:
 - 1. Steel reinforcement placement.
 - 2. Headed bolts and studs.
 - 3. Verification of use of required design mixture.
 - 4. Concrete placement, including conveying and depositing.
 - 5. Curing procedures and maintenance of curing temperature.
 - 6. Verification of concrete strength before removal of shores and forms from beams and structural slabs.
- F. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C172 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 1 cubic yard, but less than 25 cubic yards, plus one set for each additional 50 cubic yards 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 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. 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.
 - 4. Concrete Temperature: ASTM C1064/C1064M; 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. Unit Weight: ASTM C567, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - 6. Compression Test Specimens: ASTM C31/C31M.
 - a. Cast and laboratory cure standard cylinder specimens for each composite sample.

- b. For 4x8 cylinders; cast 5 cylinder specimens for each composite sample. For 6x12 cylinders, cast 4 cylinder specimens for each composite sample.
 - c. Additional cylinders requested by the Contractor are the responsibility of the Contractor.
 - 7. Compressive-Strength Tests: ASTM C39/C39M.
 - a. For 4x8 cylinders; test one cylinder specimen at 7 days, test three cylinder specimens at 28 days, and hold the remaining cylinder specimen. For 6x12 cylinders; test one cylinder specimen at 7 days, test two cylinder specimens at 28 days, and hold the remaining cylinder specimen.
 - b. A compressive-strength test shall be the average compressive strength from specimens obtained from same composite sample and tested at age indicated.
 - 8. 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.
 - 9. 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.
 - 10. Test results shall be reported in writing to Architect/Engineer, 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.
 - 11. Non-destructive Testing: Impact hammer, sonoscope, or other non-destructive device may be permitted by Engineer but will not be used as sole basis for approval or rejection of concrete.
 - 12. 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 Engineer. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/C42M or by other methods as directed by Engineer.
 - 13. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 - 14. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
- G. Take one additional test cylinder during cold weather concreting, cured on job site under same conditions as concrete it represents.
 - H. Measure floor and slab flatness and levelness according to ASTM E1155 within 48 hours of finishing.

3.13 DEFECTIVE CONCRETE

- A. Test Results: The testing agency shall report test results in writing to Architect and Contractor within 24 hours of test.
- B. Defective Concrete: Concrete not conforming to required lines, details, dimensions, tolerances or specified requirements.
- C. Repair or replacement of defective concrete will be determined by the Architect. The cost of additional testing shall be borne by Contractor when defective concrete is identified.
- D. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of Architect for each individual area.

- E. Patching Mortar: Mix dry-pack patching mortar, consisting of 1.0 part Portland cement to 2.5 parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.
1. Cut out honeycombs, rock pockets, voids over 1/4-inch in any direction, and holes left by tie rods and bolts down to solid concrete but in no case to a depth less than 1 inch. Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with bonding agent. Place patching mortar before bonding agent has dried.
 2. For surfaces exposed to view, blend white Portland cement and standard Portland cement so that, when dry, patching mortar will match surrounding color. Provide test areas 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.
- F. 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 will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
 3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Engineer.
- G. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pocket, 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 schedule 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 3/4-inch clearance all around. Dampen concrete surface 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.
- H. Perform structural repairs of concrete, subject to Engineer's approval, using epoxy adhesive and patching mortar.
- I. Repair materials and installation not specified above may be used, subject to Engineer's approval.

3.14 PROTECTION

- A. Do not permit traffic over unprotected concrete floor surface until fully cured.
- B. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.

END OF SECTION