

## CAST-IN-PLACE CONCRETE SECTION 03 30 00

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

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

#### 1.02 SUMMARY

- A. This Section specifies cast-in place concrete, including formwork, reinforcement, concrete materials, mix design, placement procedures, and finishes for the following.
  - 1. Pile Caps
  - 2. Grade beams
  - 3. Slabs-on-grade
  - 4. Concrete curbs
  - 5. Concrete toppings
- B. Related Sections of work specified elsewhere include the following:
  - 1. Division 2 Section "Earthwork" for drainage fill under slabs-on-grade.
  - 2. Division 3 Section "Concrete Toppings" for metallic and non-metallic concrete floor toppings.
- C. Coordination: Unless other satisfactory agreements are specifically entered into by contractors concerned, all miscellaneous iron and steel, sleeves, anchors, etc., required by work of other contractors, will be furnished and installed by such other contractors with the cooperation of this contractor.

#### 1.03 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume.

#### 1.04 SUBMITTALS

- A. Product Data: For each type of manufactured material and product indicated.
- B. Design Mixes: For each concrete mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
  - 1. Indicate amounts of mix water to be withheld for later addition at Project site.
- C. Laboratory test reports for concrete mix design with the following data:
  - 1. Method used to determine the proposed mix design (per ACI 301, Article 4.2.3).

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2. Gradation and quantity of fine and coarse aggregates.
  3. Proportions of all ingredients including all admixtures added either at the time of batching or at the job site.
  4. Water/cement ratio and water/cementitious ratio.
  5. Slump - ASTM C143.
  6. Certification and test results of the total water-soluble chloride ion content of the design mix - FHWA RD-77 or AASHTO T 260-84.
  7. Air content of freshly mixed concrete by the pressure method, ASTM C231, or the volumetric method, ASTM C173.
  8. Unit weight of concrete - ASTM C138.
  9. Strength at 7 and 28 days - ASTM C39. Document strength on basis of previous field experience or trial mixtures per ACI 301 Article 4.2.3. Submit strength test records, mix design materials, conditions, and proportions for concrete used for record of tests, standard calculation, and determination of required average compressive strength.
- D. Steel Reinforcement Shop Drawings: Details of fabrication, bending, and placement, prepared according to ACI 315, "Details and Detailing of Concrete Reinforcement." Include material, grade, bar schedules, stirrup spacing, bent bar diagrams, arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports of concrete reinforcement. Include special reinforcement required for openings through concrete structures.
- E. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer detailing fabrication, assembly, and support of formwork. Design and engineering of formwork are Contractor's responsibility.
- F. Welding Certificates: Copies of certificates for welding procedures and personnel.
- G. Material Test Reports or Certificates: Submit material test reports from a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials, or submit material certificates signed by manufacturers certifying that each of the following items complies with requirements:
1. Aggregates Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.
  2. Cementitious materials and aggregates.
  3. Form materials and form-release agents.
  4. Steel reinforcement and reinforcement accessories.
  5. Fiber reinforcement.
  6. Admixtures.
  7. Waterstops.
  8. Curing materials.
  9. Floor and slab treatments.
  10. Bonding agents.
  11. Adhesives.
  12. Vapor retarders.

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13. Epoxy joint filler.
14. Joint-filler strips.
15. Repair materials.

H. Minutes of preinstallation conference.

#### 1.05 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. 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.
- C. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
1. Manufacturer must be certified according to the National Ready Mixed Concrete Association's Certification of Ready Mixed Concrete Production Facilities.
- D. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.
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.
  3. For additional definitions and requirements, refer to Quality Control – “Special Structural Testing and Inspection” section of these Specifications.
- E. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from a single manufacturer.
- F. Welding: Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code-Reinforcing Steel."
- G. ACI Publications: Comply with the following, unless more stringent provisions are indicated:
1. ACI 301, "Specification for Structural Concrete" Sections 1 through 5.
  2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."
- H. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.
- I. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

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1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
  - a. Contractor's superintendent.
  - b. Independent testing agency responsible for concrete design mixtures.
  - c. Ready-mix concrete manufacturer.
  - d. Concrete subcontractor.
  - e. Agency responsible for field quality control.
  - f. Primary admixture manufacturers.
2. Review special structural testing and inspection and inspecting agency procedures for field quality control, concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction contraction and isolation joints, and joint-filler strips, semi-rigid joint fillers, forms and form removal limitations, shoring and reshoring procedures, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, floor and slab flatness and levelness measurement, concrete repair procedures, and concrete protection.

#### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement.
- B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

## **PART 2 - PRODUCTS**

#### 2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  1. Products: Subject to compliance with requirements, provide one of the products specified.
  2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

#### 2.02 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.

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- B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.
- D. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch (19 by 19 mm), minimum.
- E. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.
- F. 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.
- G. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
  - 1. Furnish units that will leave no corrodible metal closer than 1 inch (25 mm) to the plane of exposed concrete surface.
  - 2. Furnish ties that, when removed, will leave holes no larger than 1 inch (25 mm) in diameter in concrete surface.

## 2.03 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
- B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.
- C. Epoxy-Coated Reinforcing Bars: ASTM A 706/A 706M, deformed bars, ASTM A 934/A 934M, epoxy coated, with less than 2 percent damaged coating in each 12-inch (300-mm) bar length.
- D. Plain-Steel Wire: ASTM A 82, galvanized.
- E. Epoxy-Coated Wire: ASTM A 884/A 884M, Class A, Type 1 coated, as-drawn, plain steel wire, with less than 2 percent damaged coating in each 12-inch (300-mm) wire length.
- F. Plain-Steel Welded Wire Reinforcement: ASTM A 185, plain, fabricated from as-drawn steel wire into flat sheets.
- G. Epoxy-Coated Welded Wire Reinforcement: ASTM A 884/A 884M, Class A coated, Type 1, plain steel.

## 2.04 REINFORCEMENT ACCESSORIES

- A. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating; compatible with epoxy coating on reinforcement and complying with ASTM A 775/A 775M.

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- 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 epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
  3. For slabs on grade, use supports with sand plates or horizontal runners where base material will not support chair legs.

## 2.05 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 gray. Supplement with the following:
    - a. Fly Ash: ASTM C 618, Class C or F with no exception to 3% maximum loss on ignition.
    - b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 120.
- B. Normal-Weight Aggregates: ASTM C 33, Class 4S coarse aggregate or better, graded. Provide aggregates from a single 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.
1. Maximum Coarse-Aggregate Size: 1-1/2 inches (38 mm) nominal for foundations.
  2. Maximum Course-Aggregate Size: 3/4" (19mm) for all other concrete.
  3. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- C. Water: ASTM C 94/C 94M and potable.

## 2.06 ADMIXTURES

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

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7. Accelerating Admixture: ASTM C494, Type E.
8. Accelerating Water-Reducing Admixture: ASTM C494, Types C and E.

## 2.07 FIBER REINFORCEMENT

- A. Synthetic (Micro) Fiber (Typical for topping under 2" thick). Monofilament or fibrillated polypropylene fibers engineered and designed for use in concrete pavement, complying with ASTM C 1116, Type III, 1/2 to 1-1/2 inches (13 to 38 mm) long.
  1. Products:
    - a. Monofilament Fibers: Monofilament polypropylene fibers; 1/2" to 3/4" in length, at a dosage of 1.0 lbs./cu.yd.
      - 1) Axim Concrete Technologies; Fibrasol IIP.
      - 2) Euclid Chemical Company (The); Fiberstrand 100.
      - 3) FORTA Corporation; FORTA Econo-Mono.
      - 4) Grace Construction Products, W. R. Grace & Co.; Grace MicroFiber.
      - 5) Metalcrete Industries; Polystrand 1000.
      - 6) SI Concrete Systems; Fibermix Stealth.
    - b. Fibrillated Fibers: Fibrillated polypropylene fibers, 3/4" to 1-1/2" in length, at a dosage of 1.5 lbs./cu.yd.
      - 1) Axim Concrete Technologies; Fibrasol F.
      - 2) Euclid Chemical Company (The); Fiberstrand F.
      - 3) FORTA Corporation; FORTA Econo-Net.
      - 4) Grace Construction Products, W. R. Grace & Co.; Grace Fibers.
      - 5) SI Concrete Systems; Fibermesh.
  2. All toppings under 2" thick shall contain the specified fibers.
- B. Synthetic (Macro) Fiber: (Typical for all slabs on grade). Monofilament or fibrillated polypropylene/polyethylene blend fibers engineered and designed for use in concrete slab on grade, complying with ASTM C1116, Type III.
  1. Products:
    - a. Euclid Chemical Company (The); Tuf-Strand SF.
    - b. Grace Construction Products, W. R. Grace & Co.; Strux 90/40 Fibers, or approved equal.
    - c. FORTA Corporation; FORTA FERRO.
  2. All concrete slabs on grade shall contain the specified fibers with a minimum length of 2".
  3. Manufacturer shall develop minimum dosage requirements based on provision of equivalent bending moments and tensile capacity that would be provided by welded wire mesh reinforcing for the specified thickness of the concrete paving slab. See drawings for welded wire mesh equivalency requirements. Fiber manufacturer shall furnish testing data along with material technical and safety information to Engineer for review. The testing shall comply with the following:
    - a. Flexural strength and toughness testing: ASTM C78 and C1018.
    - b. Average residual strength: ASTM C1550 and ASTM C1399.
    - c. Minimum fiber dosages shall meet the requirements of ASTM C1550, ASTM C1399 and the following minimums:
      - 1) To exceed 125 psi ARS; Minimum 3 lbs./cu.yd. or more.

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- 2) To exceed 150 psi ARS; Minimum 5 lbs./cu.yd. or more.
  - 3) To exceed 175 psi ARS; Minimum 7.5 lbs./cu.yd. or more.
4. See drawings for additional information with regard to direct tensile capacity and average residual strength requirements. Manufacturer must provide demonstration of suitability for use in regard to thorough distribution in mixing, proper placement, and finishing.

## 2.08 WATERSTOPS

- A. Self-Expanding Butyl Strip Waterstops: Manufactured rectangular or trapezoidal strip, butyl rubber with sodium bentonite or other hydrophilic polymers, for adhesive bonding to concrete, 3/4 by 1 inch (19 by 25 mm).
1. Products:
    - a. Colloid Environmental Technologies Company; Volclay Waterstop-RX.
    - b. Concrete Sealants, Inc.; Conseal CS-231.
    - c. Greenstreak; Swellstop.
    - d. Henry Company, Sealants Division; Hydro-Flex.
    - e. JP Specialties, Inc.; Earthshield Type 20.
    - f. Progress Unlimited, Inc.; Superstop.
    - g. TCMiraDRI; Mirastop.

## 2.09 VAPOR BARRIERS AND RETARDERS

- A. Plastic Vapor Retarder: ASTM E 1745, Class A. Include manufacturer's recommended adhesive or pressure-sensitive tape.
1. Products:
    - a. Raven Industries Inc.; VaporBlock 15.
    - b. Stego Industries, LLC; Stego Wrap, 15 mils.
    - c. W. R. Meadows, Inc.; Perminator 15 mil.
    - d. FortiFiber Corporation; Moistop Ultra 15.
    - e. Insulation Solutions, Inc.; Viper II 15 mils.
- B. Fine-Graded Granular Material: Clean mixture of crushed stone, crushed gravel, and manufactured or natural sand; ASTM D 448, Size 10, with 100 percent passing a 3/8-inch (9.5-mm) sieve, 10 to 30 percent passing a No. 100 (0.15-mm) sieve, and at least 5 percent passing No. 200 (0.075-mm) sieve; complying with deleterious substance limits of ASTM C 33 for fine aggregates.

## 2.10 FLOOR AND SLAB TREATMENTS

- A. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; colorless; that penetrates, hardens, and densifies concrete surfaces.
1. VOC Content: Liquid floor treatments shall have a VOC content of 200 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  2. Products:
    - a. Penetrating Liquid Floor Treatment for Mechanical Room Floor Slabs:
      - 1) SLX100 Water and Oil Repellent; ProSoCo, Inc.

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- 2) Eucoguard Vox
- 3) Baracade Silane 40

## 2.11 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
  1. Products:
    - a. Axim Concrete Technologies; Cimfilm.
    - b. ChemMasters; Spray-Film.
    - c. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company; Aquafilm.
    - d. Dayton Superior Corporation; Sure Film.
    - e. Euclid Chemical Company (The); Eucobar.
    - f. MBT Protection and Repair, Div. of ChemRex; Confilm.
    - g. Meadows, W. R., Inc.; Sealtight Evapre.
    - h. Sika Corporation, Inc.; SikaFilm.
  - B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
  - C. Water: Potable.
  - D. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.
    1. Products:
      - a. ChemMasters; Safe-Cure Clear.
      - b. Conspec Marketing & Manufacturing Co., Inc., a Dayton Superior Company; W.B. Resin Cure.
      - c. Dayton Superior Corporation; Day Chem Rez Cure (J-11-W).
      - d. Euclid Chemical Company (The); Kurez DR VOX.
      - e. Meadows, W. R., Inc.; 1100 Clear.
      - f. Symons Corporation, a Dayton Superior Company; Resi-Chem Clear Cure.
    2. VOC Content: Curing and sealing compounds shall have a VOC content of 200 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

## 2.12 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork.
- B. Semi-rigid Joint Filler: Two-component, semi-rigid, 100 percent solids, aromatic polyurea with a Type A shore durometer hardness range of 90 to 95 per ASTM D 2240.
- C. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

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- D. 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 IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
- E. Reglets: Fabricate reglets of not less than 0.0217-inch- (0.55-mm-) thick, galvanized steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.
- F. Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.0336 inch (0.85 mm) thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

## 2.13 REPAIR MATERIALS

- A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3.2 mm) and that can be feathered at edges to match adjacent floor elevations.
  - 1. Cement Binder: ASTM C 150, Portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
  - 2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
  - 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by underlayment manufacturer.
  - 4. Compressive Strength: Not less than 4100 psi (29 MPa) at 28 days when tested according to ASTM C 109/C 109M.
- B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3.2 mm) and that can be feathered at edges to match adjacent floor elevations.
  - 1. Cement Binder: ASTM C 150, Portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
  - 2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
  - 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by topping manufacturer.
  - 4. Compressive Strength: Not less than 5000 psi (34.5 MPa) at 28 days when tested according to ASTM C 109/C 109M.

## 2.14 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.

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1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures. Trial batch and field experience tests shall have been performed within 12 months of submittal date.
  2. Do not use the same testing agency for field quality control testing.
- B. Submit written reports to Architect of each proposed mix for each class of concrete at least 15 days prior to start of work. All mix designs shall be submitted on the Mix Design Submittal Form included at the end of this specification. Do not begin concrete production until proposed mix designs have been reviewed by Architect. The approved mix designs shall be used throughout this project unless changes are approved by Architect/Engineer prior to use.
- C. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
1. Fly Ash: 25 percent.
  2. Combined Fly Ash and Pozzolan: 25 percent.
  3. Ground Granulated Blast-Furnace Slag: 30 percent.
  4. Combined Fly Ash or Pozzolan and Ground Granulated Blast-Furnace Slag: 50 percent portland cement minimum, with fly ash or pozzolan not exceeding 25 percent.
- D. Air Content of Indoor Concrete: Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content of 2 to 4 percent, unless otherwise indicated.
- E. Air Content of Concrete Exposed to Freezing and/or De-icing Chemicals: Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content as follows within a tolerance of plus 1 or minus 1.5 percent, unless otherwise indicated:
1. Air Content: 5.5 percent for 1-1/2" (38 mm) nominal maximum aggregate size.
  2. Air Content: 6 percent for 1" (25 mm) nominal maximum aggregate size.
  3. Air Content: 6 percent for 3/4" (19 mm) nominal maximum aggregate size.
- F. Do not air entrain concrete to trowel-finished interior floors and suspended slabs. Do not allow entrapped air content to exceed 3 percent.
- G. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- H. Admixtures: Use admixtures according to manufacturer's written instructions.
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 required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.
  4. Use accelerating admixture in concrete slabs placed at ambient temperatures below 50 deg. F. (10 deg. C.).

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## 2.15 CONCRETE MIXTURES FOR BUILDING ELEMENTS

- A. Pile Caps and Grade Beams: Proportion normal-weight concrete mixture as follows:
1. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days.
  2. Maximum Water-Cementitious Materials Ratio: 0.50.
  3. Slump Limit: 4 inches (100 mm) and 8 inches (200 mm) for concrete with verified slump of 2 to 4 inches (50 to 100 mm) before adding high-range water-reducing admixture or plasticizing admixture plus or minus 1 inch (25 mm).
- B. Exterior and other concrete exposed to weather: Proportion normal-weight concrete mix as follows:
1. Compressive Strength (28 Days): 5000 psi (34.5 MPa) air-entrained.
  2. Maximum Slump: 4 inches (100 mm).
  3. Maximum Slump for Concrete Containing High-Range Water-Reducing Admixture: 8 inches (200 mm) after admixture is added to concrete with 2- to 4-inch (50- to 100-mm) slump.
  4. Minimum cementitious material content: 610 lb./cu. yd. (362 Kg/cu)
  5. Maximum water-cementitious material ratio: 0.40.
- C. Interior Slabs-on-Grade and Curbs: Proportion normal-weight concrete mixture as follows:
1. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days, non-air-entrained.
  2. Minimum Cementitious Materials Content: 540 lb/cu. yd. (320 kg/cu. m).
  3. Slump Limit: 4 inches (100 mm) plus or minus 1 inch (25 mm).
  4. Maximum Slump for Concrete Containing High-Range Water-Reducing Admixture: 8 inches (200 mm) after admixture is added to concrete with 2- to 4-inch (50- to 100-mm) slump.
  5. Maximum water-cementitious material ratio: 0.50.
- D. Concrete Toppings: Proportion normal-weight concrete mixture as follows:
1. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days, non-air-entrained.
  2. Minimum Cementitious Materials Content: 610 lb/cu. yd. (360 kg/cu. m).
  3. Maximum size coarse aggregate: 1/3 of topping thickness.
  4. Maximum slump:
    - a. Toppings less than 2" – 2" – 3" initial slump (water slump)
    - b. Toppings 2" and thicker – 2-1/2" – 3-1/2" slump (water slump)
    - c. A specified high-range water reducer is required. These slumps may be increased to a maximum water slump of 4" and a maximum superplasticized slump of 8".

## 2.16 FABRICATING REINFORCEMENT

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

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## 2.17 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and ASTM C 1116, and furnish batch ticket information.
  - 1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

## PART 3 - EXECUTION

### 3.01 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. Earth cuts may be used as forms for footing vertical surfaces, if sides are sharp and true, and not exposed in finished structure.
- C. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
- D. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
  - 1. Class A, 1/8 inch (3.2 mm) for smooth-concrete exposed to view.
  - 2. Class C, 1/2 inch (13 mm) for other concrete surfaces.
- E. Construct forms tight enough to prevent loss of concrete mortar.
- F. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
  - 1. Install keyways, reglets, recesses, and the like, for easy removal.
  - 2. Do not use rust-stained steel form-facing material.
- G. 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.
- H. 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.
- I. Chamfer exterior corners and edges of permanently exposed concrete.

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- J. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
- 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. Coat steel forms with a non-staining, rust-preventative material. Rust-stained steel formwork is not acceptable.
- N. 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.

### 3.02 EMBEDDED ITEMS

- A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."
  - 2. Install vertical galvanized filled dovetail anchor slots at 1'-4" o.c. in beams and walls where masonry abuts. Place one slot in each face of each column faced with masonry.
  - 3. No aluminum conduit shall be installed in concrete.
  - 4. No sleeves, holes, or inserts shall be placed within 2'-0" of columns without approval of the structural engineer.

### 3.03 REMOVING AND REUSING FORMS

- A. General: Formwork for sides of beams and pile caps, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
  - 1. 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.

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### 3.04 VAPOR RETARDERS

- A. Granular Course: Place slab on grade on 6"-thick fine-graded granular material, moisten, and compact with mechanical equipment to elevation tolerances of plus 0 inch (0 mm) or minus 3/4 inch (19 mm).
- B. Plastic Vapor Retarders: Cover 6" granular material with plastic vapor retarder, protect, and repair vapor retarders according to ASTM E 1643 and manufacturer's written instructions.
  - 1. Lap joints 6 inches (150 mm) and seal with manufacturer's recommended tape.

### 3.05 STEEL REINFORCEMENT

- A. General: 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. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.
- D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- E. 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.
- F. Where reinforcement is in top (top 3") of all concrete exposed to freeze-thaw conditions, use epoxy-coated bars.
- G. Epoxy-Coated Reinforcement: Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M. Use epoxy-coated steel wire ties to fasten epoxy-coated steel reinforcement.

### 3.06 JOINTS

- A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
- B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
  - 1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.

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2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
  3. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. If joint pattern is not shown, provide joints at a maximum spacing in feet of 3 times the slab thickness in inches in each direction and located to conform to bay spacing wherever possible (at column centerlines, half bays, third bays). 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- (3.2-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.
- D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.
  2. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

### 3.07 WATERSTOPS

- A. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, adhesive bonding, mechanically fastening, and firmly pressing into place. Install in longest lengths practicable.

### 3.08 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.
- B. No concrete shall be placed except when Architect's representative (or independent testing laboratory) is present unless this requirement is specifically waived by the Architect. Give adequate notice to the Architect, the testing laboratory, and all contractors affected before placing concrete.
- C. General: Comply with ACI 304, "Guide for Measuring, Mixing, Transporting, and Placing Concrete," and as specified. Concrete delivery tickets shall show:
1. Batch number
  2. Mix by number with cement content in pounds and maximum size aggregate
  3. Admixtures
  4. Air content
  5. Slump
  6. Time of loading.

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- D. Discharge concrete within 1-1/2 hours after water has been added to the cement, unless a longer time has been authorized by the Architect/Engineer. During hot weather or other conditions contributing to a quick stiffening of the concrete, the Architect/Engineer may require discharge in less than 1-1/2 hours. If loss of slump occurs, HRWR may be redosed at the site as long as a "flash set" has not occurred. Redosage procedures must be discussed and approved by the Engineer and the manufacturer at the Pre-Concrete Conference.
- E. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.
  - 1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.
- F. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
  - 1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
  - 2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
  - 3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.
- G. Place interior slabs on grade that will later receive floor coverings only after floor level or roof above has been placed. Also, protect the slab from any moisture infiltration until building is complete.
- 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. 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. Do not further disturb slab surfaces before starting finishing operations.
- I. Pumping Concrete: Grout used to prime a pump shall not be placed in the forms in any concrete exposed to view in the final structure.
- 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.

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

K. Hot-Weather Placement: Comply with ACI 301 and as follows:

1. Maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

### 3.09 DEFERRED PLACEMENT TOPPING

- A. General: Deferred placement topping not intended for heavy-duty services shall conform to the following paragraphs.
- B. Bonded Toppings: Place bonded toppings over previously placed concrete according to the following requirements:
1. Preparation of base slab: The existing slab shall be thoroughly cleaned of all loose and foreign material by brooming and high pressure air blast. Any contaminated areas shall be cleaned by scrubbing with water. If necessary to clean any areas, a muriatic acid etch may be employed providing the slab is thoroughly rinsed until neutralized, as checked with a pH test.
  2. Bonding: Over a scratched or raked finish base slab (as on precast). The slab shall be thoroughly wet for 2 hours prior to topping placement and a bonding grout shall be scrubbed into the slab. In lieu of wetting and a bonding grout, a non-rewettable bonding compound may be used as specified over a troweled or floated base slab.
  3. Bonding: Over a troweled or floated finish base slab, a bonding compound shall be used. Use in accordance with supplier's directions. Acceptable bonding agents are listed in Part 2.
- C. Unbonded Toppings: Place unbonded toppings over previously placed concrete according to the following requirements:
1. Preparation of base slab: The existing slab shall be thoroughly cleaned of all loose and foreign material by brooming and high pressure air blast.
  2. Bond breaker: 6-mil Visqueen shall be used over the base slab as a bond breaker.
- D. Topping Reinforcement: Provide minimum 6 x 6 – W2.1 x W2.1 mesh in all toppings 2" and thicker. Mesh shall be provided in flat sheets (see drawings for reinforcing requirements). Provide the synthetic fibers in all toppings less than 2" thick.

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### 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. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
  - 1. Apply to concrete surfaces not exposed to public view.
- B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
  - 1. Apply to concrete surfaces exposed to public view, to receive a rubbed finish, to be covered with a coating or covering material applied directly to concrete.

### 3.11 FINISHING FLOORS AND SLABS

- A. General: Comply with ACI 302.1R recommendations for screeding, restraighening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture.
  - 1. Apply float finish to surfaces indicated, to surfaces to receive trowel finish, and to floor and slab surfaces to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo.
- C. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
  - 1. Apply a trowel finish to surfaces indicated and to floor and slab surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic, or quarry tile set over a cleavage membrane, paint, or another thin film-finish coating system.
  - 2. Finish surfaces to the following tolerances, according to ASTM E 1155/E 1155 M for a randomly trafficked floor surface:
    - a. Specified overall values of flatness, F(F) 35; and of levelness, F(L) 25; with minimum local values of flatness, F(F) 24; and of levelness, F(L) 17; for slabs-on-grade.
    - b. Specified overall values of flatness, F(F) 30; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 24; and of levelness, F(L) 15; for suspended slabs.
- D. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, and 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. Coordinate required final finish with Architect before application.
- E. Slip-Resistive Finish: Before final floating, apply slip-resistive aluminum granule finish where indicated and to concrete stair treads, platforms, and ramps. Apply according to manufacturer's written instructions and as follows:
1. Uniformly spread 25 lb/100 sq. ft. (12 kg/10 sq. m) of dampened slip-resistive aluminum granules over surface in 1 or 2 applications. Tamp aggregate flush with surface, but do not force below surface.
  2. After broadcasting and tamping, apply float finish.
  3. After curing, lightly work surface with a steel wire brush or an abrasive stone and water to expose slip-resistive aluminum granules.

### 3.12 MISCELLANEOUS CONCRETE ITEMS

- A. Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, after work of other trades is in place. 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.

### 3.13 CONCRETE PROTECTING AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 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 (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- C. Formed Surfaces: Cure formed concrete 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.

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- D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including slabs, concrete floor toppings, and other surfaces.
- E. Cure concrete according to ACI 308.1, by one or a combination of the following methods and as noted:
  - 1. Moisture Curing: Not permitted for use with slab receiving floor covering with moisture-sensitive adhesives. When permitted, 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 (300-mm) lap over adjacent absorptive covers.
  - 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape. All slabs receiving covering with moisture-sensitive adhesive shall be cured with moisture-retaining cover.
  - 3. Moist cure interior and exterior concrete to be exposed to de-icing salts.
  - 4. Curing Compound: Not permitted for use with slab receiving floor covering with moisture-sensitive adhesives. When permitted, 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. 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.

### 3.14 LIQUID FLOOR TREATMENTS

- A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.
  - 1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
  - 2. Do not apply to concrete that is less than 28 days' old.
  - 3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous.

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### 3.15 CONCRETE SURFACE REPAIRS

- A. Defective Concrete: Repair and patch defective areas when approved by Architect. Remove and replace concrete that cannot be repaired and patched to Architect's approval.
- B. Patching Mortar: Mix dry-pack patching mortar, consisting of one part portland cement to two and one-half parts fine aggregate passing a No. 16 (1.18-mm) 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 (13 mm) in any dimension in solid concrete, but not less than 1 inch (25 mm) in depth. 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 Architect.
- D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
  - 1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.016 inch (0.25 mm) wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
  - 2. After concrete has cured at least 14 days, correct high areas by grinding.
  - 3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
  - 4. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
  - 5. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch (6 mm) 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 (25 mm) or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around. Dampen concrete surfaces in contact with patching concrete and

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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 (25 mm) or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to Architect's approval.

### 3.16 QUALITY CONTROL – SPECIAL STRUCTURAL TESTING AND INSPECTION

A. Testing and Inspecting: The University will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Definitions:

1. Special Inspector – Technical:

- a. Technical I: ACI-Certified Grade I Inspector: Inspector shall be employed by a testing laboratory, under the direct supervision of a Technical III.
- b. Technical II: ACI-Certified Grade II Inspector: Inspector shall be employed by a testing laboratory, under the direct supervision of a Technical III.
- c. Technical III: A civil/structural engineer regularly engaged in this type of work, with a minimum of 4 years experience and licensed in the state in which the project is located and is an employee of a qualified and approved testing laboratory. The licensed engineer shall review and approve all reports.
- d. Testing laboratory shall have C.C.R.L. certification at the National Bureau of Standards.

2. Special Inspector – Structural:

- a. Structural I: Graduate civil/structural engineer, or other personnel acceptable to the SER, with experience in the design of structural systems of this type. Inspections shall be performed under the direct supervision of a Structural II.
- b. Structural II: Civil/structural engineer regularly engaged in the design of structural systems of this type, licensed in the state in which the project is located. The licensed engineer shall review and approve all inspection reports.
- c. Special Inspector: Structural may be an employee of the SER.

C. Structural Testing and Special Inspection Requirements:

#### Item and Frequency

#### Qualifications

1. Verify and inspect reinforcement in all cast-in-place concrete work:
  - a. Verify reinforcing bar grade.
  - b. Verify reinforcing bars are free of dirt, excessive rust, and damage.
  - c. Verify reinforcing bars are adequately tied, chaired, and supported to prevent displacement during concrete placement.
  - d. Verify proper clear distances between bars and to surfaces of concrete.

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- e. Verify reinforcing bar size and placement.
  - f. Verify bar laps for proper length and stagger.
  - g. Verify weldability of reinforcing steel, other than ASTM A706.
    - 1) Verify proper joint preparation is provided and proper electrodes are used and properly stored and dried.
  - h. Verify epoxy coating is present at locations noted on the plans and specifications, including tie wires, chairs, bolsters, etc. Verify coating damage is repaired in accordance with the contract documents.
    - Structural I
2. Perform concrete mix verification:
- a. Verify mixer truck trip ticket conforms to approved mix design.
  - b. Verify that total water added to mix on site does not exceed that allowed by concrete mix design.
  - c. Verify that concrete quality is indicative of adequate mixing time, consistency, and relevant time limits.
    - Technical I
3. Inspect preparation and placement of all concrete:
- a. Verify the following:
    - 1) Verify acceptable general condition of concrete base prior to placement.
    - 2) Verify use of required design mixtures.
    - 3) Verify concrete placement, including conveyance and depositing avoids segregation and contamination.
    - 4) Verify that concrete is properly consolidated.
    - 5) Verify reinforcement remains at proper location.
    - 6) Unless noted, inspections shall be continuous. Inspections shall be performed on a periodic basis for the following types of work: None.
      - Structural I
4. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
- a. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd. (4 cu. m), but less than 25 cu. yd. (19 cu. m), plus one set for each additional 50 cu. yd. (38 cu. m) or fraction thereof.
    - 1) 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.
  - b. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
  - c. Air Content: ASTM C 231, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
  - d. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each composite sample.
  - e. Microwave Test: The water content of freshly mixed concrete will be tested on a random basis during placement using Microwave Drying Oven, in accordance with AASHTO TP23, "Proposed Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying." This test will be performed only on concrete exposed to weather.

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- f. Compression Test Specimens: ASTM C 31/C 31M.
    - 1) Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.
  - g. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.
    - 1) Test one set of two field-cured specimens at 7 days and one set of two specimens at 28 days.
    - 2) 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.
  - h. 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 (3.4 MPa).
  - i. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
  - j. Non-Compliant Test Reports: All test reports indicating non-compliance should be faxed immediately to all parties on the test report distribution list. Copies shall be on different colored paper.
  - k. Non-destructive 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.
  - l. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by Architect.
  - m. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
  - n. Correct deficiencies in the Work that test reports and inspections indicate does not comply with the Contract Documents.
    - Structural I
5. Observe protection and curing methods and maintenance of curing temperature for all concrete:
- a. Verify the following:
    - 1) Verify that specified curing procedures are followed.
    - 2) Verify that specified hot and cold weather procedures are followed.
    - Structural I
6. Inspect all bolts, headed bolts, and headed studs installed in concrete.
- a. Verify specified size, type, spacing, configuration, embedment, and quantity.
  - b. Verify proper concrete placement and means have been taken to achieve consolidation around all bolts.
    - Structural I

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- D. Conventional testing and inspection requirement.
  - 1. Measure floor and slab flatness and levelness according to ASTM E 1155 (ASTM E 1155M) within 24 hours of finishing.

END OF SECTION 033000

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**CONCRETE MIX DESIGN**  
**SUBMITTAL FORM**

Project: \_\_\_\_\_  
 City: \_\_\_\_\_  
 General Contractor: \_\_\_\_\_  
 Concrete Contractor: \_\_\_\_\_  
 Concrete Strength (Class): \_\_\_\_\_  
 Use (describe): \_\_\_\_\_

Design Mix Information (check one of the following):

Based on Standard Deviation Analysis \_\_\_\_\_  
 Trial Mix Test Data \_\_\_\_\_

Design Characteristics

Density - pcf  
 Strength - psi (28 day)  
 Air - % specified

If trial mixes are used, the mix design is proportioned to achieve  $f'_{cr} = f'_c + 1,200$  psi  
 (1,400 psi for strength higher than 5,000 psi at 28 days)

Materials	Type/Source	Specific Gravity	Weight/lb.	Absolute Volume Cu. Ft.
Cement				
Flyash				
Microsilica				
Coarse Aggregate				
Fine Aggregate				
Water				
Air				
Other				
TOTAL				27.0 cu. ft.

Water/Cement Ratio (lbs. water/lbs. cement) = \_\_\_\_\_%

Admixtures	Manufacturer	Dosage oz./cwt.
Water Reducer		
Air-Entraining Agent		
High-Range Water Reducer		
Non-Corrosive Accelerator		
Other		

Slump before HRWR \_\_\_\_\_ inches  
 Slump after HRWR \_\_\_\_\_ inches

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Standard Deviation Analysis (from experience records):

Number of test cylinders evaluated: \_\_\_\_\_

Standard deviation: \_\_\_\_\_

$$f'_{cr} = f'_c + 1.34s \text{ or } f'_{cr} = f'_c + 2.33s - 500$$

(Refer to ACI 301 for increased deviation factor when less than 30 tests are available)

Laboratory Test Data

Compressive Strength:

Age (days)*	Mix #1	Mix #2	Mix #3
7	psi	psi	psi
7	psi	psi	psi
7	psi	psi	psi
28	psi	psi	psi
28	psi	psi	psi
28	psi	psi	psi
28 average	psi	psi	psi

\*Furnish 3 days test results for concrete mixes used for post-tensioned concrete.

Required Attachments:

Coarse Aggregate Gradation Report \_\_\_\_\_

Fine Aggregate Gradation Report \_\_\_\_\_

Concrete Compressive Strength Data or Trial Mixture Test Data \_\_\_\_\_

Admixture Compatibility Certification Letter \_\_\_\_\_

Graph of W/C vs Strength (for Trial Mixes only) \_\_\_\_\_

Submitted by:

Name \_\_\_\_\_

Address \_\_\_\_\_

Phone No. \_\_\_\_\_

Main Plant Location \_\_\_\_\_

Miles from Project \_\_\_\_\_

Secondary Plant Location \_\_\_\_\_

Miles from Project \_\_\_\_\_

Date \_\_\_\_\_

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