

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

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. Section includes furnishing and installing cast-in-place concrete, including:
  1. Formwork, shoring, bracing, anchorage, and removal of concrete formwork.
  2. Permanent extruded plastic foam void form insulation where indicated.
  3. Vapor retarder under building slabs and depressions in slabs on grade.
  4. Pre-formed construction joints, expansion joints, water stops, and other accessories and cast in items required.
  5. Concrete reinforcing, reinforcing supports, spacers, and related accessories.
  6. Cast-in-place concrete, including equipment pads, inertia bases, and corresponding anchorages.
  7. Cast-in-place "exposed concrete" at locations indicated.
  8. Grout in steel base and bearing plates and other locations shown.
  9. Concrete fill, concrete toppings, and non-structural concrete repairs.
  10. Finishing concrete surfaces.
  11. Initial and final curing concrete surfaces.
  12. Concrete sealing, hardening, and dustproofing treatments to concrete surfaces.

#### **1.3 RELATED WORK**

- A. Related Work of Other Sections:
  1. Division 01 Section – Testing Laboratory Services: Quality control inspection and testing performed by the Independent Testing Laboratory.
  2. Division 04 Section – Unit Masonry: Masonry reinforcing and accessories to be cast into concrete.
  3. Division 05 Section – Structural Steel Framing: Anchor bolts, framing and supports cast into concrete.
  4. Division 05 Section – Metal Fabrications: Metal fabrications, anchors, and supports to be cast into concrete and steel pipe bollards to receive concrete fill.
  5. Division 07 Section – Self-Adhering Sheet Air-Water Barriers: Preparing concrete surfaces to receive air-water barriers, flashings, and related work.
  6. Divisions 21 - 26: Sleeves for penetrations, anchors, and supports to be cast into concrete.

#### **1.4 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.

#### **1.5 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 the Project site.
- C. 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, and supports of concrete reinforcement. Include special reinforcement required for openings through concrete structures.
- D. 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 the formwork are the Contractor's responsibility.
- E. Floor Flatness and Levelness: submit floor surface flatness and levelness field measurements.

#### **1.6 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. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
- C. 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.
- D. 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 the same manufacturer.
- E. ACI Publications: Comply with the following, unless more stringent provisions are indicated:
  - 1. ACI 301, "Specification for Structural Concrete."
  - 2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."
- F. Preinstallation Conference: Conduct a conference at the Project site to comply with requirements in Division 1 Section "Project Meetings."
  - 1. Before submitting design mixes, review concrete mix design 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 the concrete design mixes.
  - c. Ready-mix concrete producer.
  - d. Concrete subcontractor.
  - e. Installers of moisture sensitive finish flooring such as tile, stone tile, resinous flooring, resilient flooring and similar materials.
2. Evaluate concrete mix design mixes for slab-on-grade and elevated slab fill for aggregate size, admixtures, water cement ratio, planned placing method, curing materials and methods, slab moisture content and pH at time of floor finish installation, construction schedule and critical path activities. Plan and coordinate installation of moisture sensitive flooring systems to provide flooring installations that do not fail due to alkali attack or excessive moisture vapor transmission rates.
- a. Require installers of moisture sensitive finish flooring such as tile, stone tile, resinous flooring, resilient flooring and similar materials to review the floor slab concrete mix designs for acceptable water cement ratio and approve floor slab curing method, including approval of the proposed concrete curing compound used on interior floor slabs to receive floor coverings.
  - b. Comply with ASTM F 710 - Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring.

## **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver, store, and handle steel reinforcement to prevent bending, corrosion, and damage.

## **PART 2 - PRODUCTS**

### **2.1 FORM-FACING MATERIALS**

- A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.
  - 1. Plywood, metal, or other approved panel materials.
  - 2. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
    - a. High-density overlay, Class 1, or better.
  - 3. Fiberglass and Plastic Forms: Forms of type and design to produce concrete conforming to requirements shown, provide required finishes, and properly engineered and constructed to withstand the applied stresses without appreciable distortion and deflection. Use clean forms free from imperfections.
- 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. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
  - 1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
  - 2. Form release agent: Acceptable products include but are not limited to:

- a. Bio-Form, Leahy-Wolf Company, Franklin, IL
  - b. Enviroform, Conspec Marketing and Manufacturing Co., Inc., Kansas City, KS
  - c. Prägnit 2000, Hermann Ruppert, München, Germany
  - d. Hadagol B 1, Heinrich Hahne GmbH & Co. KG, Datteln, Germany
- D. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
- 1. Furnish units that will leave no corrodible metal closer than 1 inch to the plane of the exposed concrete surface.

## 2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615, Grade 60, deformed.
- B. Steel Bar Mats: ASTM A 184, assembled with clips.
  - 1. Steel Reinforcement: ASTM A 615, Grade 60, deformed bars.
- C. Plain-Steel Wire: ASTM A 82, as drawn.
- D. Deformed Bar Anchors: Deformed Bar Anchors shall conform to ASTM A 496 with a minimum yield strength of 75,000 PSI. Standard ASTM A 615 Grade 60 reinforcing bars may not be substituted for deformed bar anchors.
- E. Plain-Steel Welded Wire Fabric: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
- F. Joint Dowel Bars: Smooth bars used to dowel across slab-on-grade construction joints shall conform to ASTM A615, Grade 40 or A36, plain-steel bars. Cut bars true to length with ends square and free of burrs.
- G. Dowel Bar Sleeves: Plastic or gage metal (26 ga. min.) sleeves with an inside diameter of 1/16 inch greater than the dowel bar that it encases, that have the strength, durability, and design to provide free movement of the dowel relative to the concrete slab and that are specifically manufactured for this purpose.
- H. Tie Wire: Tie wire shall be annealed steel tie wire, minimum 16 gauge. Provide only plastic coated or stainless steel tie wire in exposed concrete structures and all architectural concrete.

## 2.3 REINFORCEMENT ACCESSORIES

- A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete 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 2 stainless-steel bar supports.

- B. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete, and as follows:
  - 1. For slabs on grade, use supports with sand plates or horizontal runners where base material will not support chair legs or precast cement, concrete cubes or steel chairs designed for earth bearing, spaced at a maximum of 3 feet, 0 inches on center in each direction. For slabs on grade, use supports arranged to place reinforcement 1 1/2 inch down from the top of the slab unless indicated otherwise in the Contract Documents.
  - 2. For exposed-to-view concrete surfaces where legs of supports are in contact with forms, use supports with legs that are stainless steel (CRSI, Class 2).
- C. Joint Dowel Bars: Plain-steel bars, ASTM A 615/A 615M, Grade 60. Cut bars true to length with ends square and free of burrs.

## 2.4 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, Type I/II.
  - 1. Fly Ash (Use in Concealed Concrete Only; Not Permitted in Exposed Concrete): ASTM C618, Type C or F, having uniform fineness, color, iron content and carbon content maximum LOI 4%, minimum 80% passing the #325 sieve, and only from sources with a known history of use with the specific admixtures proposed in each concrete mix design.
    - a. Fly ash is not permitted in above grade sight exposed concrete.
    - b. If fly ash is used as a partial replacement for Portland cement in concealed and below grade concrete, the total fly ash content by weight cannot exceed 25% of the weight of the Portland cement.
    - c. In addition to the requirements specified in the Admixtures paragraph of this Section, Contractor must take into consideration the additional curing time that may be required for use of fly ash in the construction schedule.
- B. Normal-Weight Aggregate: ASTM C 33, uniformly graded, and as follows:
  - 1. Class: Negligible weathering region, but not less than 1N.
  - 2. Nominal Maximum Aggregate Size: As indicated in the structural general notes for each class of concrete required.
- C. Water: Potable and complying with ASTM C 94.

## 2.5 ADMIXTURES

- A. General: Admixtures certified by manufacturer to contain not more than 0.05 percent water-soluble chloride ions by mass of cementitious material and to be compatible with other admixtures and cementitious materials. Do not use admixtures containing calcium chloride.
- B. Air-Entraining Admixture: ASTM C 260.
- C. Water-Reducing Admixture: ASTM C 494, Type A.

- D. High-Range, Water-Reducing Admixture: ASTM C 494, Type F.
- E. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.
- F. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

## **2.6 WATERSTOPS**

- A. Self-Expanding Strip Waterstops: Manufactured rectangular or trapezoidal strip, sodium bentonite or other hydrophilic material for adhesive bonding to concrete.
  - 1. Products: Subject to compliance with the specified requirements, provide one of the following:
    - a. Volclay Waterstop-RX; Colloid Environmental Technologies Co.
    - b. Conseal CS-231; Concrete Sealants Inc.
    - c. Swellseal Joint and SwellSeal Gun Grade; De Neef Construction Chemicals (U.S.) Inc.
    - d. Hydrotite; Greenstreak.
    - e. Hydro-Flex; Henry Company, Sealants Div.
    - f. Mirastop; Mirafi Moisture Protection, Div. of Royal Ten Cate (USA), Inc.
    - g. Adeka Ultra Seal; Mitsubishi International Corporation.
    - h. Superstop; Progress Unlimited Inc.

## **2.7 VAPOR RETARDERS**

- A. Underslab Vapor Retarder (Typical): Sheet Vapor Retarder: ASTM E 1745, Class A. Include manufacturer's recommended adhesive or pressure-sensitive tape.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Grace Construction Products, W. R. Grace & Co.; Florprufe 120.
    - b. Meadows, W. R., Inc.; Perminator 15 mil.
    - c. Raven Industries Inc.; Vapor Block 15.
    - d. Stego Industries, LLC; Stego Wrap 15 mil Class A.

## **2.8 CURING MATERIALS**

- A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.
- C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- D. Water: Potable.
- E. Concrete Sealer (Interior Exposed Slabs as Indicated, and Not Scheduled to Receive Other Finishes): Sonneborn "Kure-N-Seal 30," or L & M Construction Chemicals "Dress and Seal 30," or Okon "Seal & Finish" applied in 3 separate coats, with final coat applied just prior to final acceptance of the Work.

- F. Clear, Waterborne, Membrane Curing Compound (Concrete Indicated to Receive Coatings, Adhesives, and Other Direct Applied Finishes): ASTM C309, Type 1, Class B, 18 to 25 percent solids, non-dissipating, and certified by curing compound manufacturer not to interfere with bonding of floor covering; "Spartan Cote WB II 20 Percent" by Burke, "Diamond Clear VOX" by Euclid, "Dress & Seal WB" by L & M Construction Chemicals, Inc., "Vocomp-20" by W.R. Meadows, "Safe Cure and Seal (J-19)" by Dayton Superior, "Kure-N-Seal" by Sonneborn Div. of ChemRex, or "Cure & Seal 200E" by Nox-Crete Products.

## 2.9 RELATED MATERIALS

- A. Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork as compatible with joint filler and sealants.
- B. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- C. Non-Shrink Grout: Non-metallic, pre-mixed, non-shrink; Corps of Engineers CRD-C621; Euclid "NS Grout," Master Builders Company "Masterflow 713," L & M Construction Chemicals "Crystex," Sika "SikaGrout 212," Sonneborn "SonogROUT 10K," Sto "Non-Shrink Grout CR732," or W. R. Meadows "NS Grout." Refer to Structural Drawings for additional requirements.
  - 1. Provide fluid grout mix complying with manufacturer's recommendations and capable of developing a minimum compressive strength of 2400 psi in 2 days and a minimum compressive strength of 8000 psi in 28 days.
  - 2. Where high fluidity and/or increased placing time is required use Hi-Flow Grout by the Euclid Chemical Co. or Masterflow 928 by Master Builders. In addition, the grout manufacturer shall furnish test data from an Independent Testing Laboratory indicating that the grout when placed at a fluid consistency shall achieve 95% bearing under a 18" x 36" base plate.
  - 3. Submit test data from an Independent Testing Laboratory indicating that the grout when placed at a fluid consistency shall achieve 95% bearing under a 4' x 4' base plate.
- D. Form Coating: For all exposed concrete, use non-staining form coating.
- E. Form Sealer: For wood forms, use Nox-crete pre-form sealer before applying form coating by the Kinsman Corp., Nox Crete Products Group, Omaha, NE.
- F. Curing Compound Residue Cleaner: Orange Pine Sol cleaner or similar citrus-based degreaser-cleaner.

## 2.10 REPAIR MATERIALS

- A. Polymer Modified Concrete Patching Mortar: "Thin Top Supreme/Concrete Top Supreme (horizontal repairs), "Verticoat or Verticoat Supreme" (vertical and overhead repairs) by The Euclid Chemical Co. or "SikaTop 121 or 122" (horizontal repairs), "SikaTop 123" (vertical and overhead repairs) by Sika Chemical Corp., L & M Construction Chemicals "Fastrak 15," Sto "Overhead Mortar CR702," Sonneborn "Gel Patch," Shepler's "Shep-Patch Plus," or deneef "Denopox Gel LPL with sand." These patching mortars may be used when color match of the adjacent concrete is not required. Prior approval by the Architect/Engineer is required.

- B. Self-Leveling Underlayment: Self-leveling, polymer modified high strength topping with a Chaplin Abrasion Test of not more than 0.02 mm maximum at 28 days (British Standard 8204). Subject to compliance with requirements, provide "Thin-Top Supreme" by The Euclid Chemical Co., Shepler's "Super Flowcrete," Ardex "K-15," Ardex SD-T or Sonneborn "Sonoflow" including bonding agent (if any) recommended by underlayment manufacturer.

## 2.11 CONCRETE MIXES

- A. Proportioning and Design of Mixes, General: Provide concrete of each compressive strength classification indicated on the Structural Drawings, designed by either laboratory trial batch (Method 1) or field experience method (Method 2) as follows.
1. Proportion normal-weight concrete according to ACI 211.1 and ACI 301.
  2. Each concrete mix design class shall be proportioned to achieve an average strength in excess of the specified strength in accordance with the standard deviation developed from previous tests or by 1200 psi if the mix is prepared by the trial mixture method.
  3. All concrete must contain the specified water-reducing admixture or water-reducing-retarding admixture and/or the specified high-range water-reducing admixture (superplasticizer).
  4. All concrete slabs placed at air temperatures below 50 degrees F shall contain the specified non-corrosive, non-chloride accelerator.
  5. All concrete required to be air entrained shall contain an approved air-entraining admixture.
  6. All pumped concrete, concrete for slabs, concrete containing synthetic fibers, architectural concrete, concrete required to be watertight and concrete with a water/cement ratio below 0.45 shall contain the specified high-range water-reducing admixture (superplasticizer). Concrete for interior slabs-on-grade and interior elevated slabs shall use the largest aggregate size permissible for pumping.
  7. Select the proportions of the ingredients to produce the proper placeability, durability, strength, and water-cement ratio to produce a mixture which will work readily into the corners and angles of forms and around the reinforcement by methods of placement and consolidation employed on the work, but without permitting materials to segregate or permitting excessive free water to collect on the surface.
  8. In no case will adjustments be allowed which increase the maximum water-cement ratio for concrete slabs on grade, interior elevated slab floor slabs, and concrete to be exposed to the weather or salts.
- B. Use a qualified independent testing agency for preparing and reporting proposed mix designs for the laboratory trial mix basis. Do not use the same testing agency for field quality control testing.
- C. Footings, Grade Beams, Foundation Walls, and Slabs Located Below Grade: Proportion normal-weight concrete mix with a 28-day compressive strength as shown on the Drawings and a water cement ratio of 0.55 maximum (non-air-entrained).
- D. Interior Slabs on Grade and Interior Elevated Slabs: Proportion normal-weight concrete mix with a 28-day compressive strength as shown on the Drawings and a water cement ratio of 0.45 maximum (non-air-entrained).

- E. Exterior Paving, Drives, Ramps, Walks, Slabs, Housekeeping Pads, Curbs and Gutters Subject to Freeze/Thaw: Proportion normal-weight concrete mix with a 28-day compressive strength as shown on the Drawings and a water cement ratio of 0.45 maximum (air-entrained).
- F. Slump Limits:
  - 1. Reinforced Foundation Systems: Not less than 4-inches and not more than 5-inches.
  - 2. Ramps, Slabs and Sloping Surfaces: Not less than 3-inches.
  - 3. Other Concrete: Not less than 1-inch and not more than 5-inches.
  - 4. Concrete Containing High-Range Water Reducing Admixture (Superplasticizer): Maximum 9-inches slump after adding admixture to site-verified 2- to-3-inch slump concrete.
- G. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement in specified concealed concrete as follows:
  - 1. Fly Ash: 25 percent.
- H. Air Content: 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: 6 percent for 1-inch- nominal maximum aggregate size.
  - 2. Air Content: 6 percent for 3/4-inch- nominal maximum aggregate size.
- I. Do not air entrain concrete to trowel-finished interior floors and suspended slabs. Do not allow entrained air content to exceed 3 percent.
- J. Limit water-soluble, chloride-ion content in non-prestressed hardened reinforced concrete to 0.05 percent by weight of cement.

## **2.12 FABRICATING REINFORCEMENT**

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

## **2.13 CONCRETE MIXING**

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

## **PART 3 - EXECUTION**

### **3.1 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 concrete structure can support such loads.

- B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
- C. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
  - 1. Class A, 1/8 inch for all permanently exposed concrete.
  - 2. Class B, 1/4 inch for all permanently concealed concrete.
- D. Construct forms tight enough to prevent loss of concrete mortar.
- E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood inserts for forming keyways, reglets, recesses, and the like, for easy removal.
  - 1. Do not use rust-stained steel form-facing material.
- F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.
- G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
- H. Chamfer exterior corners and edges of permanently exposed concrete.
- I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
- J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

### **3.2 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 bolts, accurately located, to elevations required.

### 3.3 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 provided concrete is hard enough to not be damaged by form-removal operations and provided curing and protection operations are maintained.
- B. Leave formwork, for structural elements, that supports weight of concrete in place until concrete has achieved the following:
  - 1. At least 75 percent of the 28-day design compressive strength.
  - 2. Determine compressive strength of in-place concrete by testing representative field- or laboratory-cured test specimens according to ACI 301.
  - 3. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
  - 4. Contractor may submit an alternative scheme for form removal that will protect the work from excessive stress or deflection, justified by a structural engineer registered in the State of Texas.
- C. 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.
- D. 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 the Architect/Engineer.

### 3.4 VAPOR RETARDERS

- A. Vapor Retarder: Place, lap joints, seal, protect, and repair vapor-retarder sheets according to ASTM E 1643 and manufacturer's written instructions.

### 3.5 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.
- C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.
  - 1. Shop- or field-weld reinforcement where shown according to AWS D1.4, where shown.
- D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

### 3.6 JOINTS

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

- B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by the Architect/Engineer.
1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated.
  2. Form from preformed galvanized steel, plastic keyway-section forms, or bulkhead forms with keys, unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
  3. Locate joints for beams in the middle third of spans. 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 the locations shown.
  5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
  6. Waterstops: Provide waterstops in all horizontal and vertical construction joints as indicated on the Architectural and Structural Drawings. Install waterstops to form continuous diaphragm in each joint. Make provisions to support and protect exposed waterstops during progress of work. Fabricate field joints in waterstops in accordance with manufacturer's printed instructions.
  7. Isolation Joints in Slabs-on-Ground: Construct isolation joints (without dowels) in slabs-on-ground at points of contact between slabs on ground and vertical surfaces only where specifically detailed on the drawings. Provide construction joints with dowels at all locations unless isolation joints are detailed.
    - a. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.
    - b. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface where joint sealants, specified in Division 7 Section "Joint Sealants," are indicated.
    - c. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
  8. Contraction (Control) Joints in Slabs-on-Ground: Maximum joint spacing shall be as noted on the Structural Drawings. Use one of the two following methods (sawed or formed) to create the joints.
    - a. Sawed Joints
      - (1). Primary Method: Early-Entry, dry-cut method, by Soff-Cut International, Corona, CA (800) 776-3328. Finisher must have documented successful experience in the use of this method prior to this project. Install cuts within 1 to 4 hours after final finish as soon as the concrete surface is firm enough to not be torn or damaged by the blade at each saw cut location. Use 1/8 inch thick blade, cutting 1 1/4" inch into the slab.
      - (2). Optional Method (where Soff-Cut System method equipment is not available): Use a conventional saw to cut joints within 4 to 12 hours after finishing as soon as the concrete has hardened sufficiently to prevent aggregates from being dislodged by the saw. Complete cutting before shrinkage stresses become sufficient to produce cracking. Use 1/8 inch thick blade, cutting to a depth of 1/4 of the slab thickness but not less than 1 inch.

- b. Formed Joints: Form contraction joints by inserting premolded plastic hard-board or fiberboard strip into fresh concrete until top surface of strip is flush with slab surface. The depth is to be 1/4 the slab thickness, but not less than 1 inch. Tool slab edges round on each side of insert. After concrete has cured, remove inserts and clean groove of loose debris.
  - c. Joint Filler
    - (1). Remove dirt and debris from the joint by vacuuming immediately prior to filling joint. Clean the joint of curing compounds and sealers.
    - (2). Filler material shall be applied to the joints when the building is under permanent temperature control, but no less than 90 days after slab construction.
    - (3). Strictly following the manufacturer's recommended procedure for installing filler material.
  - d. The Contractor shall protect the joints from damage caused by wheeled traffic or other sources during construction until a joint-filler material (if specified) has been installed.
- C. Dowel Joints: Install dowel sleeves and dowels or dowel bar and support assemblies at joints where indicated.
- 1. Use dowel sleeves or lubricate or asphalt-coat one-half of dowel length to prevent concrete bonding to one side of joint.

### **3.7 WATERSTOPS**

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

### **3.8 CONCRETE PLACEMENT**

- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.
- B. Before placing concrete, water may be added at Project site, up to the amount allowed in the design mix and approved by Architect/Engineer for each class of concrete required.
  - 1. Do not add water to concrete after adding high-range water-reducing admixtures to the mix.
- C. Deposit concrete continuously or in 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 specified. Deposit concrete to avoid segregation.
- D. Deposit concrete in forms in horizontal layers no deeper than 24 inches and in a manner to avoid inclined construction joints. Place each layer while preceding layer is still plastic, to avoid cold joints.
  - 1. Consolidate placed concrete with mechanical vibrating equipment. Use equipment and procedures for consolidating concrete recommended by ACI 309R.

2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the vibrator. Place vibrators 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 mix constituents to segregate.
- E. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
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, free of humps or hollows, before excess moisture or bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.
- F. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
  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 the mix designs.
- G. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows, when hot-weather conditions exist:
1. Cool ingredients before mixing to maintain concrete temperature below 95 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.
  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 moisture uniform without standing water, soft spots, or dry areas.

### **3.9 FINISHING FORMED SURFACES**

- A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defective areas repaired and patched. Remove fins and other projections exceeding ACI 347R limits for class of surface specified.
1. Apply to concrete surfaces concealed from 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 defective areas. Remove fins and other projections exceeding 1/8 inch in height.
  - 1. Apply to concrete surfaces exposed to public view or to be covered with a coating or covering material applied directly to concrete, such as waterproofing, damp-proofing, veneer plaster, or painting.
  - 2. Do not apply rubbed finish to smooth-formed finish.
- C. Rubbed Finish: Apply the following to smooth-formed finished concrete:
  - 1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
  - 2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part Portland cement to one and one-half 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. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
- D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

### **3.10 FINISHING FLOORS AND SLABS**

- A. General: Comply with recommendations in ACI 302.1R for screeding, restraighening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. Use stiff brushes, brooms, or rakes.
  - 1. Apply scratch finish to surfaces indicated and to surfaces to receive concrete floor topping or mortar setting beds for ceramic or quarry tile, and other bonded cementitious floor finishes.
- C. 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 sheet waterproofing, built-up or membrane roofing.

- D. Trowel Finish: After applying float finish, apply first trowel finish 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. Do not over trowel surfaces or apply trowel finish before bleed water has evaporated. 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, ceramic or quarry tile set over a cleavage membrane, paint, or another thin film-finish coating system.
  2. Finish surfaces to the following tolerances, measured within 24 hours according to ASTM E 1155 for a randomly trafficked floor surface:
    - a. Specified overall values of flatness, F(F) 25; and levelness, F(L) 20; with minimum local values of flatness, F(F) 17; and levelness, F(L) 15 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. Levelness numbers F(L) for suspended slabs only apply to slabs shored at the time of testing.
- E. Trowel and Fine-Broom Finish: Apply a partial trowel finish, stopping after second troweling, to surfaces indicated and to surfaces where ceramic or quarry tile is to be installed by either thickset or thin-set method. Immediately after second troweling, and when concrete is still plastic, slightly scarify surface with a fine broom.
- F. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated.
1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate the required final finish with the Architect before application.
- G. Mineral Dry-Shake Floor Hardener Finish (Handicapped Ramps): After initial floating, apply mineral dry-shake materials to surfaces according to manufacturer's written instructions and as follows:
1. Uniformly apply mineral dry-shake materials at a rate of 100 lb/100 sq. ft. unless greater amount is recommended by the manufacturer.
  2. Uniformly distribute approximately two-thirds of mineral dry-shake materials over surface by hand or with mechanical spreader, and embed by power floating. Follow power floating with a second mineral dry-shake application, uniformly distributing remainder of material, and embed by power floating.
  3. After final floating, apply a trowel finish. Cure concrete with curing compound recommended by dry-shake material manufacturer and apply immediately after final finishing.

### **3.11 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 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 Pads, Bases, and Foundations: Provide machine and equipment pads, bases, and foundations as required. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates of manufacturer furnishing machines and equipment.

### 3.12 CONCRETE PROTECTION 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 with recommendations in ACI 305R for hot-weather protection during curing.
- B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to the manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing by one or a combination of the methods indicated for Unformed Surfaces below.
- D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces, by one or a combination of the following methods:
  - 1. Moisture Curing (Exterior Exposed Concrete): Keep surfaces continuously moist for not less than seven days with the following materials:
    - a. Water.
    - b. Continuous water-fog spray.
    - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
  - 2. Moisture-Retaining-Cover Curing (Interior Exposed Concrete): Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
    - a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
  - 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.

4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

### **3.13 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 seven 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.
- B. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller according to manufacturer's written instructions.

### **3.14 JOINT FILLING**

- A. Prepare, clean, and install joint filler according to manufacturer's written instructions.
  1. Defer joint filling until concrete has aged at least six months. Do not fill joints until construction traffic has permanently ceased.
- B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.
- C. Install semi-rigid epoxy 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.

### **3.15 CONCRETE SURFACE REPAIRS**

- A. Defective Concrete: Repair and patch defective areas when approved by the Architect/Engineer. Remove and replace concrete that cannot be repaired and patched to the Architect/engineer'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 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 the Architect/Engineer.
- 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 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
  2. After concrete has cured at least 14 days, correct high areas by grinding.
  3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
  4. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
  5. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
  6. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least 3/4 inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mix as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
  7. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.
- E. Perform structural repairs of concrete, subject to the Architect/engineer's approval, using epoxy adhesive and patching mortar.

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

### 3.16 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to sample materials, perform tests, and submit test reports during concrete placement. Sampling and testing for quality control may include those specified in this Article. See Section 01 45 29 – Testing Laboratory Services for additional requirements.
- B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 at point of concrete placement shall be performed according to the following requirements:
  - 1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mix exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. or fraction thereof.
    - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mix, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
  - 2. Slump: ASTM C 143; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
  - 3. Air Content: ASTM C 231, pressure method, for normal-weight concrete; ASTM C 173, volumetric method.
  - 4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
  - 5. Compression Test Specimens: ASTM C 31; cast and laboratory cure one set of five standard cylinder specimens for conventional concrete construction.
  - 6. Compressive-Strength Tests: ASTM C 39; test one laboratory-cured specimen at 3 days for all formed elevated concrete slabs and beams, one at 7 days and two at 28 days; hold one in reserve for future testing.
    - a. Test two field-cured specimens at 7 days and two at 28 days.
    - b. Hold one cylinder in reserve for future testing in the event of controversy with previous tests.
- C. Strength of each concrete mix 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.
- D. Test results shall be reported in writing to the 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 the in Work, the specified design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 3-, 7-and 28-day tests.

- E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by the Architect/Engineer but will not be used as sole basis for approval or rejection of concrete.
- F. 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 the Architect/Engineer. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42 or by other methods as directed by the Architect/Engineer.

**END OF SECTION 03 30 00**