

## SECTION 03300 - CAST-IN-PLACE CONCRETE

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes: Cast-in place concrete, including formwork, reinforcing, mix design, placement procedures, and finishes, for the following:
  - 1. Pile caps.
  - 2. Foundations and footings.
  - 3. Floor slabs.
  - 4. Equipment pads and bases
  
- B. Related Sections:
  - 1. Section 01450 - Testing Laboratory Services.
  - 2. Section 01300 - Shop Drawings and Submittals.
  - 3. Section 07920 - Joint Sealants.
  - 4. Division 15: Equipment bases.

#### 1.2 SUBMITTALS

- A. Product Data: Submit manufacturer's descriptive literature and application recommendations for reinforcement and forming accessories, admixtures, patching compounds, water stops, joint systems, curing compounds, and other proprietary materials and items if requested by Architect.
  
- B. Shop Drawings: Submit details for fabricating, bending, and placing concrete reinforcement. Comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures". Show bar schedules, spacing, bent bar diagrams, and arrangement of concrete reinforcement, ties, and stirrups. Include special reinforcing for openings through concrete.
  
- C. Mix Design Data: Submit laboratory test reports or evaluation reports for concrete materials and each proposed concrete mix.
  - 1. The Contractor shall engage a testing agency acceptable to Architect to perform material evaluation tests and to design concrete mixes.
  - 2. Submit written mix design data at least 15 days prior to scheduled start of concrete placement.
  - 3. Do not begin concrete production until mix designs have been reviewed by the Architect.

#### 1.3 QUALITY ASSURANCE

- A. Codes and Standards: Comply with provisions of the following, except where more stringent requirements are shown or specified:

1. ACI 301, "Specifications for Structural Concrete for Buildings."
2. ACI 318, "Building Code Requirements for Reinforced Concrete."
3. Concrete Reinforcing Steel Institute (CRSI) "Manual of Standard Practice."

B. Concrete Testing Service: As specified in PART 3 of this Section.

## PART 2 - PRODUCTS

### 2.1 FORM MATERIALS

- A. General: Furnish form materials capable of supporting construction loads in addition to weight of fresh concrete, without displacement or excessive deflection.
- B. Forms for Exposed Concrete: Plywood, metal, or other acceptable panel-type materials to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints.
- C. Forms for Unexposed Concrete: Plywood, lumber, metal, or another acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.
- D. Form Release Agent: Commercial formulations that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
- E. Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal form ties that will leave no metal closer than 1-1/2 inches to the exposed concrete surface.

### 2.2 REINFORCING MATERIALS

- A. Reinforcing Bars: ASTM A 615, Grade 60, deformed.
- B. Welded Wire Fabric: ASTM A 185, welded steel wire fabric.
- C. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting, and positioning reinforcing bars and welded wire fabric in place. Use wire bar-type supports complying with CRSI specifications.
  1. For slabs-on-grade, use supports with sand plates or horizontal runners.
  2. For exposed-to-view concrete surfaces where legs of supports are in contact with forms, provide supports with legs that are protected by plastic (CRSI, Class 1) or stainless steel (CRSI, Class 2).
- D. Fiber Reinforcement:
  1. Synthetic Fiber: Fibrillated polypropylene fibers engineered and designed for use in concrete, complying with ASTM C 1116, Type III, ½ to 1 inch (13 to 25mm) long.
  2. Products: Subject to compliance with requirements, provide one of the following:

- a. Fribillated Fibers:
  - (1). Fibrasol F; Axim Concrete Technologies
  - (2). Fibermesh; Fibermesh, Div. of Synthetic Industries
  - (3). Forta CR; Forta Corporation
  - (4). Grace Fibers; W.R. Grace & Co., Construction Products Division

## 2.3 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, Type I.
- B. Fly Ash: ASTM C 618, Type C.
- C. Normal-Weight Aggregates: Normal-Weight, ASTM C 33, except local aggregates proven by special tests or actual service to produce concrete of adequate strength and durability may be used, subject to acceptance by Architect.
- D. Lightweight Aggregates: ASTM C 330.
- E. Water: Potable.

## 2.4 ADMIXTURES

- A. General: Provide concrete admixtures that are compatible with other concrete ingredients and that contain not more than 0.1 percent chloride ions.
- B. Air-Entraining Admixture: ASTM C 260.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Air-Mix or Perma-Air, Euclid Chemical Co.
    - b. Darex AEA or Daravair, W.R. Grace & Co.
    - c. MB-VR or Micro-Air, Master Builders, Inc.
    - d. Sika AER, Sika Corp.
- C. Water-Reducing Admixture: ASTM C 494, Type A.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Eucon WR-75, Euclid Chemical Co.
    - b. WRDA, W.R. Grace & Co.
    - c. Pozzolith Normal or Polyheed, Master Builders, Inc.
    - d. Plastocrete 161, Sika Corp.
- D. High-Range Water-Reducing Admixture: ASTM C 494, Type F or Type G.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Eucon 37, Euclid Chemical Co.
    - b. WRDA 19 or Daracem, W.R. Grace & Co.

- c. Rheobuild or Polyheed, Master Builders, Inc.
  - d. Sikament 300, Sika Corp.
- E. Water-Reducing, Accelerating Admixture: ASTM C 494, Type E.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Accelguard 80, Euclid Chemical Co.
    - b. Daraset, W.R. Grace & Co.
    - c. Pozzutec 20, Master Builders, Inc.
- F. Water-Reducing, Retarding Admixture: ASTM C 494, Type D.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Eucon Retarder 75, Euclid Chemical Co.
    - b. Daratard-17, W.R. Grace & Co.
    - c. Pozzolith R, Master Builders, Inc.
    - d. Plastiment, Sika Corporation.
- G. Shrinkage Inhibiting Admixture: Shrinkage reducing admixture shall be Tetraguard manufactured by Master Builders Technologies or equal. Dosage rate shall be in accordance with the manufacturer's recommendations for the designated usage, but not less than 1.5 gal./yd.<sup>3</sup>

## 2.5 RELATED MATERIALS

- A. Expansion Joint Filler: Non-bituminous, non-extruding cork or rubber joint filler, ASTM D 1752. Joint sealants are specified in Section 07920.
- B. Vapor Retarder: 10-mil polyethylene sheet vapor retarder that is resistant to deterioration when tested according to ASTM E 154. Two (2) layers of 10-mil polyethylene sheet vapor retarder in areas having a seamless flooring.
- C. Water stops:
  - 1. Volclay water stop RX 101 or approved equal.
  - 2. Volclay WB-Adhesive or approved equal.

## 2.6 CURING MATERIALS

- A. Absorptive Cover: Burlap cloth weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.
- B. Moisture-Retaining Cover: Waterproof paper, polyethylene film or polyethylene-coated burlap, complying with ASTM C 171.
- C. Liquid Membrane-Forming Curing Compound: ASTM C 309, Type I, Class A. Moisture loss not more than 0.55 kg/sq. meter when applied at 200 sq. ft./gal.

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. A-H 3 Way Sealer, Anti-Hydro Co., Inc.
  - b. Eucocure, Euclid Chemical Co.
  - c. L&M Cure R, L&M Construction Chemicals, Inc.
  - d. Masterkure, Master Builders, Inc.
  - e. Kure-N-Seal, Sonneborn-Chemrex.

D. Water-Based Membrane Curing Compound: Acrylic formulation, ASTM C 309, Type I, Class

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Aqua-Cure, Euclid Chemical Co.
  - b. Dress & Seal WB, L&M Construction Chemicals, Inc.
  - c. Masterkure 100W, Master Builders, Inc.

E. Evaporation Control: Monomolecular film-forming compound intended for application to fresh concrete for temporary protection against rapid moisture loss.

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Eucobar, Euclid Chemical Co.
  - b. E-Con, L&M Construction Chemicals, Inc.
  - c. Confilm, Master Builders, Inc.

## 2.7 ADHESIVE

A. Epoxy Adhesive: ASTM C 881, two-component material suitable for use on dry or damp surfaces. Provide material type, grade, and class to suit Project requirements.

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Euco Epoxy System #452 or #620, Euclid Chemical Co.
  - b. Epabond, L&M Construction Chemicals, Inc.
  - c. Concsive Standard Liquid, Master Builders, Inc.
  - d. Sikadur 32 Hi-Mod, Sika Corp.

## 2.8 PROPORTIONING AND DESIGNING MIXES

A. General: Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. Comply with "SUBMITTALS" provisions in PART 1 of this Section.

1. Limit use of fly ash to not exceed 15 percent of cement content by weight.
2. Limit water/cement ratio of concrete exposed to freezing to 0.45.

B. Slump Limits: Design mixes for concrete slump at point of placement as follows:

1. Ramps, slabs, and sloping surfaces: Not more than 3 inches.
  2. Reinforced foundation systems: Not less than 1 inch and not more than 3 inches.
  3. Concrete containing high-range water-reducing admixture (superplasticizer): Not more than 8 inches after adding admixture to site-verified 2-to-3-inch slump concrete.
  4. Other concrete: Not more than 4 inches.
- C. **Lightweight Structural Concrete:** Lightweight aggregate and concrete shall conform to ASTM C 330. Proportion mix to produce concrete with a minimum compressive strength of 3000 psi at 28 days and a calculated equilibrium unit weight of 115 pcf plus or minus 3 pcf as determined by ASTM C 567. Concrete slump at the point of placement shall be the minimum necessary for efficient mixing, placing, and finishing. Maximum slump shall be 6 inches for pumped concrete and 5 inches elsewhere. Air entrain concrete exposed to weather according to ACI 301 requirements.
- D. **Adjustment to Concrete Mixes:** Adjust mix design when characteristics of materials, job conditions, weather, test results, or other circumstances warrant. Do not use revised mix designs until test data and strength results have been submitted to and accepted by the Architect.

## 2.9 ADMIXTURES

- A. **General:** Use only admixtures that have been accepted in mix designs. Use admixtures in accordance with manufacturer's directions and recommendations.
- B. **Use of Admixtures:** Use water-reducing admixture in concrete, as necessary for placement and workability.
1. Use accelerating admixture in concrete placed at ambient temperatures below 50 deg F (10 deg C).
  2. Use high-range water-reducing admixture in pumped concrete, concrete with water-cement ratios below 0.50, and elsewhere only as instructed.
  3. Use air-entraining admixture in exterior exposed concrete unless otherwise indicated, to result in concrete at point of placement having total air content from 2 to 4 percent.

## 2.10 CONCRETE MIXING

- A. **Ready-Mixed Concrete:** Use ready-mixed concrete throughout, unless otherwise approved by the Architect. Comply with requirements of ASTM C 94, and as specified.
- B. **Hot Weather Mixing:** When air temperature is between 85 deg F (30 deg C) and 90 deg F (32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes, and when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Coordination: Coordinate the installation of joint materials, vapor retarder/barrier, and other related materials with placement of forms and reinforcing steel.
- B. Tolerances: Control form construction, reinforcement placement, and placing and finishing concrete to meet the following requirements in the completed construction.
  - 1. Slab Surfaces on Grade - Maximum variation from true plane and levelness will be as follows: F25, FL 20.
  - 2. Other Exposed Surfaces and Edges –
    - a. Cross section dimension: Minus  $\frac{1}{4}$ ", plus  $\frac{1}{2}$ ".
    - b. Variation from indicated level:  $\pm\frac{1}{4}$ " in 10 feet;  $\pm\frac{1}{2}$ " max.
    - c. Variation from plumb:  $\pm\frac{1}{4}$ " in 10 feet;  $\pm\frac{1}{2}$ " max.
    - d. Variation from true line:  $\pm\frac{1}{4}$ " in 10 feet;  $\pm\frac{3}{8}$ " in 20 feet;  $\pm\frac{1}{2}$ " max.
    - e. Alignment of columns and walls (bottom versus top):  $\pm\frac{1}{2}$ ".
    - f. Location in plan:  $\pm\frac{1}{2}$ " in 20 feet;  $\pm\frac{3}{4}$ " max.
  - 3. Reinforcement Placement –
    - a. Concrete cover: Plus  $\frac{1}{4}$ ", minus 0.
    - b. Spacing of parallel bars:  $\pm\frac{1}{4}$ ".
    - c. Length of bars:  $\pm 1$ ".
    - d. Vertical or horizontal displacement: One bar diameter.

### 3.2 FORMS

- A. General: Design, erect, support, brace, and maintain formwork to resist wind loads and to support vertical, lateral, static, and dynamic loads of concrete and subsequent operations until concrete structure can support such loads. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation, and position.
- B. Formwork Tolerances: Maintain formwork construction tolerances and surface irregularities within ACI 347 limits:
  - 1. Provide Class A tolerances for concrete surfaces exposed to view.
  - 2. Provide Class C tolerances for other concrete surfaces.
- C. Embedded Items: Set and build into formwork reglets, dovetail slots, anchorage devices, sleeves, and other embedded items for work that is attached to or supported by cast-in-place concrete. Use setting drawings, diagrams, instructions, and directions provided by suppliers of items to be attached.

- D. Formwork Construction: Fabricate forms for easy removal without hammering or prying against concrete surfaces. Kerf wood inserts for keyways, reglets, recesses, and similar features for easy removal.
  - 1. Provide necessary temporary openings for clean-outs and inspections before and during concrete placement. Locate temporary openings at inconspicuous locations.
  - 2. Chamfer exposed corners and edges as indicated.
  - 3. Apply form release agent or wet forms as necessary.
- E. Provisions for Other Trades: Provide openings in formwork to accommodate work of other trades. Accurately place and securely support sleeves and other items built into forms.
- F. Forms for Slabs: Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and contours in finished surfaces. Provide and securely support screed strips for use with strike-off templates or compacting-type screeds.
- G. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces prior to concrete placement. Retighten forms and bracing during placement if necessary to prevent mortar leaks and maintain proper alignment.
- H. Vapor Retarder: Provide vapor retarder sheeting for all slabs on grade. Place sheeting with longest dimension parallel with direction of pour.
  - 1. Lap joints and seal with mastic or pressure-sensitive tape.
  - 2. Avoid cutting or puncturing vapor retarder/barrier during reinforcement placement and concreting operations. Repair damages before placing concrete.
- I. Earth Cuts as Forms: All building pile caps must be wood formed. Earth cuts will be acceptable in lieu of forms at, grade beams, foundations of independent structures, and similar in-ground concrete work unless otherwise prohibited on the drawings. Exterior exposed to view grade beam sides must be wood formed. Dimensions of earth cuts shall be controlled so that indicated member sizes will be achieved without decrease or 3" increase. The Contractor shall provide necessary dewatering or dry bottoms in accordance with Section 02201, without additional cost to the Owner.

### 3.3 REINFORCEMENT

- A. General: Comply with Concrete Reinforcing Steel Institute's recommended practice for details and methods of reinforcement placement and supports.
  - 1. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.
  - 2. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, and wire ties. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.
  - 3. Maintain minimum coverage's as indicated.
- B. Welded Wire Fabric: Install welded wire fabric in lengths as long as practicable. Lap at least one full mesh and tie splices with wire. Offset laps of adjoining widths to prevent continuous laps in both directions.

- C. Fiber Reinforcement: Add to mix at a rate of 1.5 lb. per cubic yard unless otherwise recommended by the manufacturer.

### 3.4 JOINTS

- A. Construction Joints: Locate and install construction joints so they do not impair strength or appearance of the structure.
  - 1. Provide keyways at least 1-1/2 inches deep in construction joints.
  - 2. Place construction joints perpendicular to main reinforcement and continue reinforcement across construction joints unless indicated otherwise.
  - 3. Use bonding agent on concrete surfaces that will be joined with fresh concrete.
  - 4. Submit construction joint layout to Architect for review as indicated on the drawings.
- B. Waterstops:
  - 1. Installation shall be as stated in the manufacturers written instructions.
- C. Shores and Reshores:
  - 1. Comply with ACI 318 (ACI 318M), ACI 301, and recommendations in ACI 347R for design, installation, and removal of shoring and reshoring.
  - 2. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.
  - 3. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide reshoring to support construction without excessive stress or deflection.

### 3.5 CONCRETE PLACEMENT

- A. General: Comply with ACI 304, "Guide for Measuring, Mixing, Transporting, and Placing Concrete". Deposit concrete continuously so that no new concrete will be placed on concrete that has hardened sufficiently to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified.
  - 1. Deposit concrete to avoid segregation at its final location.
  - 2. Maintain reinforcing in proper position during concrete placement.
- B. Consolidation: Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping in compliance with ACI 309. Do not use vibrators to transport concrete inside forms. Limit vibration to time necessary to consolidate concrete and embed reinforcement and other items without causing mix to segregate.
- C. Placing Concrete Slabs: Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints. Bring slab surfaces to correct level with a straightedge and strike off. Use bull floats or darbies to smooth surface free of humps or hollows. Do not disturb slab surfaces prior to beginning finishing operations.

- D. Cold-Weather Placement: Comply with ACI 306 and the following. Protect concrete work from physical damage or reduced strength from frost, freezing actions, or low temperatures.
  - 1. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
  - 2. Do not use calcium chloride, salt, or other antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.
  
- E. Hot-Weather Placement: Comply with ACI 305 and the following. Protect concrete work from reduced strength and impaired quality from too-rapid drying and elevated temperature.
  - 1. Water-fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without puddles or dry areas.
  - 2. Use water-reducing retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions, if acceptable to Architect.

### 3.6 FORMED SURFACES FINISHES

- A. Rough-Formed Finish: Provide concrete surfaces not exposed to view in the finished construction with texture imparted by form material used, with tie holes and defective areas repaired and patched, and fins and other projections exceeding ¼ inch in height rubbed down or chipped off.
  
- B. Smooth-Formed Finish: Provide concrete surfaces exposed to view or to be covered with a coating or covering material applied directly to concrete (such as waterproofing, damp proofing, veneer plaster, or similar system). with an as-cast surface obtained with selected form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch defective concrete areas. Fins and other projections shall be completely removed and smoothed.
  
- C. Smooth-Rubbed Finish: Provide smooth-rubbed finish within 24 hours after form removal on concrete surfaces to be painted or left exposed at occupied rooms and spaces in the completed construction. In addition to smooth-formed finish as specified, moisten concrete surfaces and rub with carborundum brick or another abrasive to produce a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
  
- 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.

### 3.7 MONOLITHIC SLAB FINISHES

- A. General: Verify required slab finishes with Architect before concrete is placed. Slope surfaces uniformly to drains where required.
  
- B. Scratch Finish: Apply scratch finish to monolithic slab surfaces to receive concrete floor topping or mortar setting beds for tile, portland cement terrazzo, and other bonded applied cementitious

finish flooring material, and where indicated. After leveling, roughen surface before final set with stiff brushes, brooms, or rakes.

- C. Float Finish: Apply float finish to monolithic slab surfaces to receive trowel finish and other finishes as specified; slab surfaces to be covered with membrane or elastic waterproofing, membrane or elastic roofing and roof insulation, or sand-bed terrazzo; and where indicated.
  - 1. After screeding, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating, using float blades or float shoes only, when surface water has disappeared and concrete has stiffened sufficiently to permit operation of power-driven floats. Consolidate surface with power-driven floats or by hand-floating if area is small or inaccessible to power units. Produce a uniform, smooth, granular texture.
  - 2. Finish surfaces to tolerances specified. Cut down high spots and fill low spots; refloat such corrections.
- D. Trowel Finish: Apply a trowel finish to monolithic slab surfaces exposed to view and slab surfaces to be covered with resilient flooring, carpet, adhesive-set ceramic or quarry tile, paint, or other thin-film coating system or adhesive-set finish.
  - 1. After floating, begin first trowel-finish operation using a power-driven trowel when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance.
  - 2. Finish surfaces to tolerances specified. After concrete has hardened, grind smooth surface defects that would telegraph through applied floor covering system.
- E. Trowel and Fine Broom Finish: Where ceramic or quarry tile is to be installed with thin-set mortar, apply a trowel finish as specified, then immediately follow by slightly scarifying the surface with a fine broom.
- F. Nonslip Broom Finish: Apply a nonslip broom finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated. Uniformly slope exterior surfaces to eliminate "bird baths". Immediately after float finishing, slightly roughen concrete surface by brooming with fiber-bristle broom perpendicular to main traffic route.

### 3.8 MISCELLANEOUS CONCRETE ITEMS

- A. Filling In: Fill in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, 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 shown 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 Bases and Foundations: Provide machine and equipment bases and foundations as shown on drawings. Set anchor bolts for machines and equipment to template at correct elevations. Comply with diagrams or templates of manufacturer furnishing machines and equipment.

### 3.9 CONCRETE CURING AND PROTECTION

- A. General: Protect freshly placed concrete from physical damage, premature drying and excessive cold or hot temperatures. In hot, dry, and windy weather apply an evaporation-control material to slab surfaces according to manufacturer's instructions after screeding and bull floating, but before power floating and troweling.
- B. Initial Curing: Begin curing as soon as free water has disappeared from concrete surface after placing and finishing. Continue curing for not less than 7 days.
- C. Curing Methods: Cure concrete by one or a combination of the following methods.
  - 1. Continuous water-fog spray, or completely cover with specified absorptive cover, thoroughly saturated with water and kept continuously wet, with sides and ends lapped 4 inches.
  - 2. Cover with moisture-retaining cover with sides and ends lapped at least 3 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
  - 3. Use membrane curing compounds that will not affect bond or adhesion of finish materials applied directly to concrete. Apply curing compound as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared). Apply uniformly according to manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.
- D. Curing Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and similar surfaces, by moist curing with forms in place for the full curing period or until forms are removed. After forms are removed, continue curing by methods specified above, as applicable.

### 3.10 REMOVING FORMS

- A. General: Formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar elements, may be removed 24 hours after placing concrete, provided concrete is sufficiently hard to not be damaged by form-removal operations, and provided curing and protection operations are maintained. Formwork supporting weight of concrete, such as beam soffits, joists, slabs, and other structural elements, may be removed in 14 days or when concrete has attained at least 75 percent of specified 28-day compressive strength.
- B. Form Re-Use: Clean and repair surfaces of forms to be reused. Split, frayed, delaminated, or otherwise damaged form material will not be acceptable. Apply new form-coating compound.
- C. Extending Formed Surfaces: When forms are extended for successive concrete placement, thoroughly clean forms and in-place concrete surfaces, remove fins and latence, and tighten forms to close joints. Align and secure forms to avoid offsets.

### 3.11 CONCRETE REPAIRS

- A. Patching Defective Areas: Immediately after removing forms, repair and patch defective areas with cement mortar consisting of one part portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only the amount of water necessary for handling and placing.
1. Patch voids over ¼ inch in any dimension and holes left by tie rods and bolts. Cut down to solid concrete, but in no case to a depth less than 1 inch. Make edges of cuts perpendicular to the concrete surface.
  2. Thoroughly clean, dampen with water, and brush-coat the area to be patched with bonding agent. Place patching mortar before bonding agent has dried.
  3. Correct high areas in formed and unformed surfaces by grinding after concrete has cured at least 14 days.
  4. Correct low areas in unformed surfaces during or immediately after completing surface finishing operations by cutting out low areas and replacing with fresh concrete. Finish repaired areas to blend into adjacent concrete. Proprietary underlayment compounds may be used when acceptable to Architect.
- B. Replacing Defective Areas: Remove and replace defective concrete if defects cannot be satisfactorily patched. Defects include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
1. Remove defective areas with clean, square cuts and expose reinforcing steel 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 to provide concrete of same type or class as original concrete. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
  2. Perform structural repairs with prior approval of Architect for method and procedure, using specified epoxy adhesive and mortar.

### 3.12 FIELD QUALITY CONTROL TESTING

- A. General: The testing agency specified in Section 01450 will perform tests and submit test reports. Minimum testing will be as specified below. Additional testing may be ordered by the Owner or Architect.
- B. Minimum Testing: Sampling and testing for quality control during concrete placement will include the following.
1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
  2. Slump: ASTM C 143; one test at point of discharge for each day's pour of each type of concrete; additional tests when concrete consistency seems to have changed.
  3. Compression Test Specimen: ASTM C 31; one set of four standard cylinders for each compressive-strength test, unless otherwise directed.

4. Compressive-Strength Tests: ASTM C 39; one set for each day's pour exceeding 5 cu. yd. plus additional sets for each 50 cu. yd. more than the first 100 cu. yd. of each concrete class placed in any one day; one specimen tested at 7 days, two specimens tested at 28 days, and one specimen retained in reserve for later testing if required.
- C. Random Sampling: When specified frequency of testing will provide fewer than five sets of cylinders for a given class of concrete, obtain samples and conduct testing from at least five randomly selected batches or from each batch if fewer than five is used.
- D. Reporting: Test results will be reported in writing to Architect, Structural Engineer, ready-mix producer, and Contractor within 24 hours after tests.
- E. Additional Tests: The testing agency may make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by Architect, by cored cylinders complying with ASTM C 42, or by other methods as directed.

END OF SECTION 03300