

SECTION 03310
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 PROVISIONS INCLUDED

- A. The general provisions of the Contract, including General and Supplementary Conditions and Division 1 - General Requirements, apply to work specified in this Section.

1.02 SUMMARY

- A. This Section specifies cast-in place concrete, including formwork, reinforcing, mix design, placement procedures, and finishes.
- B. Cast-in-place concrete includes the following:
 - 1. Fill for composite steel deck.
 - 2. Fill for steel pan stairs.
 - 3. Housekeeping pads.

1.03 REFERENCED STANDARDS

- A. American Concrete Institute.
 - 1. ACI 117: Standard Tolerances for Concrete Construction and Materials.
 - 2. ACI 301: Specifications for Structural Concrete for Buildings.
 - 3. ACI 302: Guide for Concrete Floor and Slab Construction.
 - 4. ACI 304: Guide for Measuring, Mixing, Transporting and Placing Concrete.
 - 5. ACI 305: Hot Weather Concreting.
 - 6. ACI 306: Cold Weather Concreting.
 - 7. ACI 308: Standard Practice Guide for Curing Concrete.
 - 8. ACI 309: Guide for Consolidation of Concrete .
 - 9. ACI 318: Building Code Requirements for Reinforced Concrete.
 - 10. ACI 347: Guide for Concrete Formwork.
 - 11. ACI SP-15: Field Reference Manual: Specifications for Structural Concrete for Building with Selected ACI and ASTM References.
 - 12. ACI SP-66: Detailing Manual.
- B. American Society for Testing and Materials (ASTM).
 - 1. ASTM A82: Standard Specification for Cold-Drawn Steel Wire for Concrete Reinforcement.
 - 2. ASTM A497: Standard Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement.
 - 3. ASTM A615: Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - 4. ASTM C31: Standard Method of Making and Curing Concrete Test Specimens in the Field.

5. ASTM C33: Standard Specification for Concrete Aggregates.
6. ASTM C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
7. ASTM C42: Standard Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
8. ASTM C94: Standard Specification for Ready-Mixed Concrete.
9. ASTM C143: Standard Test Method for Slump of Portland Cement Concrete.
10. ASTM C150: Standard Specification for Portland Cement.
11. ASTM C171: Standard Specification for Sheet Materials for Curing Concrete.
12. ASTM C260: Standard Specification for Air-Entraining Admixtures for Concrete.
13. ASTM C309: Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
14. ASTM C494: Standard Specification for Chemical Admixtures for Concrete.
15. ASTM D1751: Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
16. ASTM E1155: Standard Test Method for Determining Floor Flatness and Levelness Using the "F-Number" System (Inch-Pound Units).

C. Concrete Reinforcing Steel Institute (CRSI).

1. Reinforced Concrete - A Manual of Standard Practice.
2. Recommended Practice for Placing Bar Supports.
3. Recommended Practice for Placing Reinforcing Bars.

D. National Ready-Mixed Concrete Association (NRMCA): "Certification of Ready-Mixed Concrete Production Facilities."

E. Federal Specifications: Fed. Spec. CCC-C-467: Cloth, Burlap, Jute (or Kenaf).

F. U.S. Department of Commerce, National Bureau of Standards, Product Standards: PS-1, "Construction and Industrial Plywood."

1.04 SUBMITTALS

A. Prior to placing any concrete and within 10 days of award of contract, submit for Architect's review the following:

1. Proposed mix design, accompanied by satisfactory evidence that the proposed mixes will conform with the strength, durability and serviceability requirements of the Specifications. Minimum acceptable evidence shall be laboratory trial mix data or field test data (30 or more tests of mixes, identical to proposed mix, made during the past 12 months) with the appropriate standard deviation analysis, all in accordance with ACI 301.
2. Certification of chloride ion content of proposed admixtures.
3. Test data from an independent laboratory certifying moisture loss characteristics of curing and sealing compound.

- B. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, patching compounds, non-shrink grout, joint systems, curing compounds, finish materials, and others as requested by Architect.
- C. Shop drawings for reinforcement, prepared for fabrication, bending, and placement of concrete reinforcement. Comply with ACI SP-66, "ACI Detailing Manual," showing bar schedules, stirrup spacing, diagrams of bent bars, arrangement of concrete reinforcement, and grade of reinforcing. Include special reinforcement required for openings through concrete structures.
- D. Laboratory test reports for concrete materials and mix design test.
- E. Materials certificates shall be signed by manufacturer and Contractor, certifying that each material item complies with or exceeds specified requirements. Provide certification from admixture manufacturers that chloride content complies with specification requirements.
- F. Minutes of preinstallation conference.

1.05 QUALITY ASSURANCE

- A. It is the intent of the Drawings and Specifications to produce concrete which will have the required strength and appearance. Failure to comply with these requirements will require removal of sufficiently large portions of the work, as determined by the Architect, in order to properly integrate the portions to be replaced with the architectural and structural requirements of the total project. All such removal and replacement shall be made at the expense of the Contractor at no additional cost to the Owner.
- B. Coordinate concrete work with all related work which requires items to be inserted in the forms and cast in the concrete, regardless of whether such inserted items are specifically described in the Contract Documents.
- C. The Owner will employ a testing laboratory to verify design mixes, inspect placement of reinforcing steel, and perform field testing of concrete.
- D. Execute work under specified temperature conditions. Post thermometers at locations of work.
- E. Pre-Construction Conference: Conduct conference at Project site to comply with requirements of Section 01310, "Project Management and Coordination." At least 15 days prior to start of the concrete construction, conduct a meeting to review the proposed mix designs and to discuss the required methods and procedures to achieve the required concrete quality construction. Review requirements for submittals, status of coordinating work, and availability of materials. Establish preliminary work progress schedule and procedures for materials inspection, testing, and certifications.
 - 1. Require representatives of each entity directly concerned with cast-in-place concrete attend the conference, including, but not limited to, the following:
 - a. Contractor's Superintendent.
 - b. Contractor's representative responsible for field quality control.
 - c. Laboratory responsible for Contractor's field quality control.

- d. Laboratory responsible for concrete design mixes.
 - e. Ready-mix concrete producer.
 - f. Concrete subcontractor.
 - g. Primary admixture manufacturers.
 - h. Owner's Testing and Inspection agency.
2. Notify the Architect and the Owner's representative at least 48 hours in advance of the meeting so that they may attend.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Store reinforcing bars and wire mesh raised from the ground and protected from the elements.

PART 2 - PRODUCTS

2.01 FORM MATERIALS

- A. Forms for Exposed Finish Concrete: Plywood, metal, metal-framed-HDO plywood faced, or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on drawings.
- B. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least 2 edges and one side for tight fit.
- C. Plywood shall comply with U.S. Product Standard PS-1, with each piece bearing legible inspection trademark of the American Plywood Association along with the DFPA Quality stamp.
- D. Form Coatings: Provide commercial formulation form-coating compounds with a maximum VOC of 350 mg/l 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, designed to prevent form deflection and to prevent spalling concrete upon removal. Provide units that will leave no metal closer than 1-1/2 inches to exposed surface. Provide ties that, when removed, will leave holes not larger than 1-inch diameter in concrete surface.

2.02 REINFORCING MATERIALS

- A. Reinforcing Bars: ASTM A 615, Grade 60, deformed.
- B. Tie Wire for Reinforcement: ASTM A82, black or galvanized steel wire, 16 gauge or heavier,
- C. Welded Wire Fabric: Deformed-Steel Welded Wire Fabric: ASTM A497. Furnish in flat sheets.

- D. Reinforcing steel shall be bundled and tagged with grades and suitable identification marks for checking, sorting, and placing. Tags and markings shall be waterproof and shall not be removed until steel is placed.
- E. Supports and Accessories for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Use wire-bar-type supports complying with CRSI specifications. Accessories shall be galvanized steel or approved plastic accessories.
 - 1. For elevated slabs, use supports suitable for placement on steel deck.
 - 2. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms, provide supports with legs that are plastic protected (CRSI, Class 1) or stainless steel protected (CRSI, Class 2).

2.03 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, Type I or Type II, except as noted below. For each Type, supply cement from the same manufacturer throughout project, unless otherwise acceptable to Architect.
 - 1. Use Type II cement for slab concrete.
- B. Fly Ash: ASTM C618, Type C or Type F.
- C. Normal Weight Aggregates: ASTM C 33. Provide aggregates from a single source for exposed concrete. For exterior exposed surfaces, do not use fine or coarse aggregates containing spalling-causing deleterious substances.
- D. Lightweight Aggregates: ASTM C 330. Provide aggregates which will result in a concrete unit weight of 115 pounds per cubic foot.
- E. Water: Drinkable.
- F. Admixtures, General: Provide admixtures for concrete that contain not more than 0.1 percent chloride ions.
- G. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with either required admixtures. Subject to compliance with requirements, provide one of the following:
 - 1. "Air-Mix," Euclid Chemical Co.
 - 2. "Darex AEA" or "Daravair," W.R. Grace & Co.
 - 3. "MB-VR" or "Micro-Air," Master Builders, Inc.
 - 4. "Sika AER," Sika Corp.
- H. Water-Reducing Admixture: ASTM C 494, Type A. Subject to compliance with requirements, provide one of the following:
 - 1. "Eucon WR-75 or 89," Euclid Chemical Co.
 - 2. "WRDA w/ Hycol," W.R. Grace & Co.

3. "Pozzolith Normal" or "Polyheed," Master Builders, Inc.
 4. "Plastocrete 161," Sika Corp.
- I. Mid-Range Water-Reducing Admixture: ASTM C 494, Type A. Subject to compliance with requirements, provide one of the following:
 1. "MIRA-70," W.R. Grace & Co.
 2. Mid-Range Water Reducer, Master Builders, Inc.
 - J. Non-Corrosive, Non-Chloride Accelerator: ASTM C494, Type C or E. Admixture shall not contain more chloride ions than are present in municipal drinking water. The admixture manufacturer must have long-term non-corrosive test data from an independent testing laboratory (of at least a year's duration) using an acceptable accelerated corrosion test method such as that using electrical potential measures. Subject to compliance with requirements, provide one of the following:
 1. "Accelguard 80," Euclid Chemical Co.
 2. "Polarset," W.R. Grace & Co.
 - K. Water-Reducing, Retarding Admixture: ASTM C 494, Type D. Subject to compliance with requirements, provide one of the following:
 1. "Eucon Retarder 75," Euclid Chemical Co.
 2. "Daratard-17," W.R. Grace & Co.
 3. "Pozzolith R," Master Builders, Inc.
 4. "Plastiment," Sika Corporation.
 - L. Prohibited Admixtures: Calcium chloride, thiocyanates or admixtures containing more than 0.05% chloride ions are *not* permitted. No admixture shall cause an increase in shrinkage when tested in accordance with ASTM C494 and ASTM C157.
- 2.04 CONCRETE ACCESSORIES
- A. Expansion Joint Filler: Premolded, of sizes and thicknesses shown on Drawings, conforming to ASTM D1751.
 - B. Low-Mod Epoxy Joint Filler: Subject to compliance with requirements, provide one of the following:
 1. "MM-80," Metzger/McGuire.
 2. "Euco 700," Euclid Chemical Company.
 3. "Sikadur 51 SL," Sika Corporation.
 - C. Curing and Sealing Compound for Exposed Concrete Slabs: The compound shall be a clear, low VOC, 30% solids content minimum, and have test data from an independent testing laboratory indicating a maximum moisture loss of 0.030 grams per sq. cm. when applied at a coverage rate of 300 sq. ft. per gallon. Manufacturer's certification required. Subject to compliance with requirements, provide one of the following:
 1. "Super Aqua-Cure VOX" or "Super Diamond Clear VOX," Euclid Chemical Co. or approved equal.

- D. Curing and Sealing Compound: Low VOC dissipating resin compound complying with ASTM C309, compatible with the application of adhered floor finishes. (Concrete floors not indicated to receive finish flooring in this Phase will be receiving finish flooring in the future.)
1. Provide evidence of compatibility with floor finishes in one of the following forms:
 - a. Successful adhesion tests conducted with samples of the flooring system on a test slab cured with the compound and written acceptance of the test results by the flooring contractor.
 - b. Written documentation from the flooring contractor accepting the compound as compatible with the flooring system.
- E. Bonding Compound: Polyvinyl acetate or acrylic base. Subject to compliance with requirements, provide one of the following:
1. Polyvinyl Acetate (Interior Only):
 - a. "Euco Weld," Euclid Chemical Co.
 - b. "Weld-Crete," Larsen Products Corp.
 2. Acrylic or Styrene Butadiene:
 - a. "SBR Latex" or "Flex-Con," Euclid Chemical Co.
 - b. "Daraweld C," W.R. Grace & Co.
 - c. "Sonocrete," Sonneborn-Rexnord.
 3. Epoxy: "Armatec 110," Sika Corporation.
- F. 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. Subject to compliance with requirements, provide one of the following:
1. "Euco Epoxy System #452 MV or #620," Euclid Chemical Co.
 2. "Epoxite Binder 2390," A.C. Horn, Inc.
 3. "Sikadur 32 Hi-Mod," Sika Corp.
- G. Epoxy Anchors:
1. Hilti HVA or HIT System Adhesive.
 2. Simpson SET System Adhesive.
 3. Epcon C-6 System Adhesive or approved equal.

2.05 PROPORTIONING AND DESIGN OF MIXES

- A. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. If trial batch method used, use an independent testing facility acceptable to Architect for preparing and reporting proposed mix designs. The testing facility shall not be the same as used for field quality control testing.
1. Limit use of fly ash to not more than 25% of cement content by weight.
- B. The design of the exact proportions for the mix, including amounts of admixtures and water to meet all specification requirements shall be the responsibility of the concrete supplier.

- C. Submit written reports to Architect of each proposed mix for each class of concrete at least 30 days prior to start of work. Do not begin concrete production until proposed mix designs have been reviewed by Architect.
- D. Design mixes to provide normal weight concrete with the following properties, as indicated on drawings and schedules:
 - 1. 3500-psi, 28-day compressive strength, 3/4" maximum size of aggregate; 540 pounds per cubic yard minimum cement content.
 - 5. Concrete Fill for Steel Pan Stairs: 1 part Portland cement, 1-1/2 parts sand, and 3 part 3/8 inch peastone. Maximum slump 4 inches, unless a mid range water reducing admixture is used, in which case slump may be 6 inches maximum.
- E. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, as accepted by Architect. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Architect before using in work.

2.06 ADMIXTURES

- A. Use mid-range or high-range water-reducing admixture (Superplasticizer) in concrete as required for placement and workability.
 - 1. Use mid-range water-reducing admixture in pumped concrete, concrete for slabs, and concrete with water/cement ratio of 0.50 or less.
- B. Use nonchloride accelerating admixture in concrete slabs placed at ambient temperatures below 50°F (10°C).
- C. Use air-entraining admixture in exterior exposed concrete unless otherwise indicated. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having total air content of 4.5 to 6.5 percent. Interior slabs shall have a maximum air content of 3 percent.
- D. Use admixtures for water reduction and set control in strict compliance with manufacturer's directions.
- E. Water-Cement Ratio: Provide concrete for following conditions with maximum water-cement (W/C) ratios as follows:
 - 1. Subjected to freezing and thawing; W/C 0.45.
 - 2. Interior slabs: W/C 0.50.
 - 3. All other concrete; W/C 0.58.
- F. Slump Limits: Proportion and design mixes to result in concrete slump at point of placement as follows:
 - 1. Concrete containing plant-added mid-range water reducing admixture: 4 inch to 6 inch slump at time of arrival at the site.

2. Other concrete: Not more than 4 inches.

PART 3 - EXECUTION

3.01 GENERAL

- A. Coordinate the installation of joint materials and vapor retarders with placement of forms and reinforcing steel.

3.02 FORMS

- A. General: Design, erect, support, brace, and maintain formwork to support vertical and lateral, static and dynamic loads that might be applied until concrete structure can support such loads. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation, and position. Maintain formwork construction tolerances complying with ACI 347.
- B. Construct forms to sizes, shapes, lines, and dimensions shown and to obtain accurate alignment, location, grades, level, and plumb work in finished structures. Provide for openings, offsets, sinkages, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required in work. Use selected materials to obtain required finishes. Solidly butt joints and provide backup at joints to prevent leakage of cement paste.
- C. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, for easy removal.
- D. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Securely brace temporary openings and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
- E. Chamfer exposed corners and edges as indicated, using wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.
- F. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses, and chases from trades providing such items. Accurately place and securely support items built into forms.
- G. Do not embed electrical and telephone conduit runs larger than 3/4 inch diameter in wall or slab-on-grade concrete. One layer of 3/4 inch diameter or smaller conduit may be run in concrete walls or concrete slabs on-grade provided that parallel runs are spaced a minimum of 12 inches apart. Do not embed conduit runs of any size in elevated concrete slabs. Do not install aluminum conduit in any concrete.

- H. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before concrete is placed. Retighten forms and bracing before concrete placement as required to prevent mortar leaks and maintain proper alignment.

3.03 PLACING REINFORCEMENT

- A. General: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports.
- B. Do not cut or puncture vapor retarder while placing reinforcement and concrete.
- C. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.
- D. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as approved by Architect.
 - 1. Elevated Slabs: Provide support for welded wire fabric with continuous bolsters located along the top of beams and girders and at 4'-0" o.c. maximum between the beams.
- E. Place reinforcement to obtain at least minimum coverages for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.
- F. Install welded wire fabric in as long lengths as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- G. Except where shown otherwise on Drawings, conform to the applicable provisions of ACI 117 and ACI 318 for minimum coverage of steel reinforcement.

3.04 JOINTS

- A. Construction Joints: Locate and install construction joints as indicated or, if not indicated, locate so as not to impair strength and appearance of the structure, as acceptable to Architect.
- B. Provide keyways at least 1-1/2 inches deep in construction joints in walls and slabs and between walls and footings. Accepted bulkheads designed for this purpose may be used for slabs.
- C. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints except as otherwise indicated.
- D. Use bonding agent on cured concrete surfaces that will be joined with fresh concrete.

3.05 INSTALLATION OF EMBEDDED ITEMS

- A. General: Set and build into work anchorage devices and other embedded items required for other 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 thereto.
- B. Forms for Slabs: Set edge forms, bulkheads, and intermediate screed strips for slabs to obtain required elevations and contours in finished surfaces. Provide and secure units to support screed strips using strike-off templates or compacting-type screeds.

3.06 PREPARATION OF FORM SURFACES

- A. General: Coat contact surfaces of forms with an approved, nonresidual, low-VOC, form-coating compound before reinforcement is placed.
- B. Do not allow excess form-coating material to accumulate in forms or to come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions.
- C. Coat steel forms with a nonstaining, rust-preventative material. Rust-stained steel formwork is not acceptable.

3.08 CONCRETE MIXING

- A. Mix and deliver all concrete in accordance with ASTM C94. The batch plant of the concrete producer shall conform to NRMCA Certification of Ready Mixed Concrete Production Facilities.
- B. In the event concrete is mixed at a central batching plant, arrange the delivery so that intervals between batches are kept to a minimum, and in any event not more than 30 minutes. Trucks shall be in first class condition and kept in constant rotation during delivery.
- C. Place concrete within 90 minutes after cement has been mixed with aggregate or 45 minutes after addition of water and admixtures. When the air temperature is within 85 and 90°F, reduce the mixing and delivery time from 90 minutes to 75 minutes; and when the air temperature is above 90°F, reduce the mixing and delivery time to 60 minutes.
- D. Use no admixtures, except those specified, without specific approval of the Architect. Admixtures containing calcium chloride will not be permitted.
- E. Use admixtures in strict accordance with the directions of the manufacturer and in accurate proportions. Dispense the mid-range water-reducing and air entraining admixtures at the ready-mix plant. Dispense the high-range water-reducing admixture (superplasticizer) either from truck mounted tanks at the jobsite or at the ready-mix plant, at Contractor's option. Mix 70 revolutions or 5 minutes to assure a consistent mixture.

- F. At the end of each week, forward to the Architect truck delivery slips of all concrete delivered to the job indicating the quantity and quality of concrete, additives, date and time of delivery, and location of placement.

3.09 CONCRETE PLACEMENT

- A. General: Comply with ACI 304, "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete."
 - 1. Limit size of slab placements to 12,000 square feet (maximum) with an aspect ratio of 1 to 1.5 (maximum).
- B. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other crafts to permit installation of their work; cooperate with other trades in setting such work. Notify the Architect and field inspection/testing agency at least 24 hours in advance of the placing of any concrete.
- C. Remove water from place of deposit before concrete is placed unless otherwise permitted by the Architect. Divert all flow of water into an excavation through proper side drains into a sump, or remove it by other approved methods.
- D. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete that has hardened sufficiently to cause the formation of seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation at its final location.
- E. Do not freely drop concrete where reinforcement will cause segregation, nor more than 6 feet. Place concrete to maintain a plastic surface approximately horizontal, and not more than 3 feet deep. Use tremies for concrete placement over 6 feet high.
- F. Concrete that has partially hardened shall not be placed in the work. The discharge of concrete shall be completed within 90 minutes of the first introduction of water into the mix.
- G. Placing Concrete Slabs: Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints, until the placing of a panel or section is completed.
 - 1. Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.
 - 2. Bring slab surfaces to correct level with 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.
 - 3. Maintain reinforcing in proper position during concrete placement.
- H. Pumping concrete: Concrete may be placed by pumping if first approved in writing by the Architect for the location proposed.

1. Equipment: Use pumping equipment of such size and design that ensures a practically continuous flow of concrete at the delivery end without separation of materials. Do not pump concrete through aluminum pipes.
 2. Concrete Mix: Design concrete mix to the requirements specified, except that mix may be richer in lubricating components in order to allow proper pumping. Include the specified high-range or mid-range water reducing admixture in the mix.
- I. Cold-Weather Placing: Comply with provisions of ACI 306 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
- J. When air temperature has fallen to or is expected to fall below 40°F (4°C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50°F (10°C) and not more than 80°F (27°C) at point of placement.
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, and other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.
- K. Hot-Weather Placing: When hot weather conditions exist that would seriously impair quality and strength of concrete, place concrete in compliance with ACI 305 and as specified below.
1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90°F (32°C). Mixing water may be chilled, or chopped ice may be used to control temperature provided water equivalent of ice is calculated to total amount of mixing water. Use of liquid nitrogen to cool concrete is Contractor's option.
 2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.
 3. Fog spray forms, reinforcing steel, and subgrade just before concrete is placed.
 4. Use water-reducing retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions, when acceptable to Architect.

3.10 FINISH OF FORMED SURFACES

- A. Rough Form Finish: For formed concrete surfaces not exposed to view in the finish work or concealed by other construction. This is the concrete surface having texture imparted by forming material used, with tie holes and defective areas repaired and patched and fins and other projections exceeding 1/4 inch in height rubbed down or chipped off.
- B. Smooth Form Finish: For formed concrete surfaces exposed to view or to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete,

such as waterproofing, dampproofing, veneer plaster, painting, or other similar system. This is an as-cast concrete surface obtained with selected form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch defective areas with fins and other projections completely removed and smoothed.

- C. Smooth Rubbed Finish: Provide smooth rubbed finish to scheduled concrete surfaces, which have received smooth form finish treatment, not later than one day after form removal.
 - 1. Moisten concrete surfaces and rub with Carborundum brick or other abrasive until a uniform color and texture is produced. Do not apply cement grout other than that created by the rubbing process.

3.11 MONOLITHIC SLAB FINISHES

- A. Scratch Finish: Apply scratch finish to monolithic slab surfaces to receive concrete floor topping or mortar setting beds for tile (if any).
 - 1. After placing slabs, plane surface to tolerances for floor flatness (F_f) of 15 and floor levelness (F_l) of 13. Slope surfaces uniformly to drains where required. After leveling, roughen surface before final set with stiff brushes, brooms, or rakes.
- B. Float Finish: Apply float finish to all other monolithic slab surfaces. 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, when concrete has stiffened sufficiently to permit operation of power-driven floats, or both. Consolidate surface with power-driven floats or by hand-floating if area is small or inaccessible to power units. Check and level surface plane to tolerances of F_f - 18, F_l - 15. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.
- C. Trowel Finish: Apply trowel finish to monolithic concrete slab surfaces throughout. After floating, begin first trowel finish operation using a power-driven trowel. Begin final troweling 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, and with surface leveled to specified tolerances. Grind smooth surface defects that would telegraph through applied floor covering system.
 - 1. Trowel Finish Surface Tolerances for Elevated Slabs:
 - a. Specified overall value: F_f - 35.
 - b. Minimum local value: F_f - 25.
 - c. When tested in accordance with the requirements of ASTM E 1155, 80% of elevation samples on deflected elevated floor slab shall fall within a $3/8'' \pm$ envelope centered on the average floor elevation.
- D. Trowel and Fine Broom Finish: In future toilet room areas, where ceramic tile will be installed with thin-set mortar sometime in the future, apply trowel finish as specified, then immediately follow with slightly scarifying surface by fine brooming.

3.12 CONCRETE CURING AND PROTECTION

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. In hot, dry, or windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply in accordance with manufacturer's instructions after screeding and bull floating, but before power floating and troweling.
- B. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.
- C. Curing Methods: Cure concrete by applying specified curing compound, by moist curing, by moisture-retaining cover curing, and by combining these methods, as specified.
- D. Moisture Curing: Keep concrete surface continuously wet by covering with water; use continuous water-fog spray; or cover concrete surface with specified absorptive cover, thoroughly saturate cover with water, and keep continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4-inch lap over adjacent absorptive covers.
- E. Moisture-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width 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.
- F. Curing Compounds: Do not use membrane curing compounds, as almost all surfaces will receive an adhered or painted finish in the future. If curing and sealing compounds are used, apply to concrete slabs as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared). Apply uniformly in continuous operation by power spray or roller in accordance with 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.
- G. Curing Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces, by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.
- H. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, floor topping, and other flat surfaces, by application of appropriate curing method.
- I. Final cure concrete surfaces to receive liquid floor hardener or finish flooring by use of moisture-retaining cover, unless otherwise directed.

3.13 REMOVAL AND REUSE OF FORMS

- A. General: Formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar parts of the work, may be removed after cumulatively curing at not less than 50°F

(10°C) for 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.

- B. Formwork supporting weight of concrete, such as beam soffits, joists, slabs, and other structural elements, may not be removed in less than 7 days, unless concrete has attained at least 75 percent of design minimum compressive strength at 28 days. Determine potential compressive strength of in-place concrete by testing field-cured specimens representative of concrete location or members.
- C. Form-facing material may be removed 4 days after placement only if shores and other vertical supports have been arranged to permit removal of form-facing material without loosening or disturbing shores and supports.
- D. Clean and repair surfaces of forms to be reused in work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-coating compound as specified for new formwork.
- E. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joint to avoid offsets. Do not use "patched" forms for exposed concrete surfaces except as acceptable to Architect.

3.14 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 to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete work.
- B. Curbs: Provide monolithic finish on interior curbs and housekeeping pads by stripping forms while concrete is still green and 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, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.
- D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads and landings and associated items. Cast-in safety inserts and accessories as shown on drawings. Screed, tamp, and finish concrete surfaces as scheduled.
- E. Grouting: Grout all column base plates, equipment bases and other locations noted on the structural drawings with the specified non-shrink, non-metallic grout.

3.15 CONCRETE SURFACE REPAIRS

- A. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removal of forms, when acceptable to Architect.
1. Cut out honeycomb, rock pockets, voids over 1/4 inch in any dimension, and holes left by tie rods and bolts, down to solid concrete but in no case to a depth of less than 1 inch. Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with specified bonding agent. Place patching mortar before bonding compound has dried.
 2. For exposed-to-view surfaces, blend white portland cement and standard portland cement so that, when dry, patching mortar will match color surrounding. Provide test areas at inconspicuous location to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.
- B. Repair of Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of the Architect. Surface defects, as such, include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets, fins and other projections on surface, and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes, fill with dry-pack mortar, or precast cement cone plugs secured in place with bonding agent.
1. Repair concealed formed surfaces, where possible, that contain defects that affect the durability of concrete. If defects cannot be repaired, remove and replace concrete.
- C. Repair of Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface plane to tolerances specified for each surface and finish. Correct low and high areas as specified below. Test unformed surfaces sloped to drain for trueness of slope and smoothness by using a template having required slope.
1. Repair finished unformed surfaces that contain defects that affect durability of concrete. Surface defects, as such, include crazing and cracks in excess of 0.08 inch wide or that penetrate to reinforcement or completely through nonreinforced sections regardless of width, spalling, popouts, honeycomb, rock pockets, and other objectionable conditions.
 2. After concrete has cured at least 14 days, correct high areas in unformed surfaces by grinding.
 3. Correct low areas in unformed surfaces during or immediately after completion of surface finishing operations by cutting out low areas and replacing with patching compound. Finish repaired areas to blend into adjacent concrete. Proprietary underlayment compounds may be used when acceptable to Architect.
 4. Repair defective areas, except random cracks and single holes not exceeding 1 inch in diameter, by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete 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 compound. 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.

- D. Perform structural repairs with prior approval of Architect for method and procedure, using specified epoxy adhesive and mortar.
- E. Repair slab surfaces that are not within specified tolerances when tested in accordance with ASTM E 1155 by grinding.
- F. Repair methods not specified above may be used, subject to acceptance of Architect.
- G. Concrete not in accordance with the intent of the Contract Documents will be considered defective and may be ordered to be removed and replaced at the Contractor's expense if satisfactory repairs cannot or have not been performed by the Contractor.

3.16 QUALITY ASSURANCE TESTING AND INSPECTION

- A. Testing laboratory field personnel will immediately notify both the Contractor and the Architect of any concrete, delivered or discharged, which does not meet the Specifications. Concrete which does not conform to all requirements of the Specifications shall not be incorporated in the structure.
- B. As a minimum, sampling and testing for quality control during placement of concrete shall include the following, as directed by Architect.
 - 1. Checking of truck delivery slips to verify that the mix, as stated on the slip, is correct.
 - 2. Noting duration of mixing.
- C. Sampling Fresh Concrete: ASTM C 172, modified for slump to comply with ASTM C 94.
 - 1. Slump: ASTM C 143; one test at point of discharge for each truck load of concrete.
 - 2. Air Content: ASTM C 173, volumetric method for lightweight or normal weight concrete; ASTM C 231 pressure method for normal weight concrete; one for each set of air-entrained concrete test cylinders molded.
 - 3. Concrete Temperature: Test hourly when air temperature is 40°F (4°C) and below, when 80°F (27°C) and above, and each time a set of compression test specimens is made.
 - 4. Compression Test Specimen: ASTM C 31; one set of 4 standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory-cured test specimens except when field-cure test specimens are required.
 - 5. Compressive Strength Tests: ASTM C 39; one set for each day's pour exceeding 5 cu. yds. plus additional sets for each 50 cu. yds. more than the first 25 cu. yds. of each concrete class placed in any one day; one specimen tested at 7 days, and three specimens tested at 28 days.

6. When frequency of testing will provide fewer than 5 strength tests for a given class of concrete, conduct testing from at least 5 randomly selected batches or from each batch if fewer than 5 are used.
 7. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.
 8. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength, and no individual strength test result falls below specified compressive strength by more than 500 psi.
- E. Inspect reinforcing bars for size, quantity, placement and condition. Notify the Contractor and Architect immediately so that the work can be corrected and reinspected prior to placement of concrete.
 - F. Test surface tolerances for slabs-on-grade in accordance with ASTM E 1155 within 24 hours after each placement. Notify the Architect and Contractor immediately if surface areas are found to be out of specified tolerances. Test additional slab surfaces at the Owner's option.
 - G. In the event the compressive strength of the cylinders, when tested, is below the required level of early test cylinders indicate that the minimum strength may not be reached in 28 days, the Architect may require test cores of the hardened structure to be taken by the testing laboratory in accordance with ASTM C42. If such test indicates that the core specimen is below the required strength, remove and replace the concrete in question without additional cost to the Owner. Replace all other work damaged as a result of this concrete removal with new materials to the satisfaction of the Architect at no additional cost to the Owner. The cost of coring will be deducted from the contract amount. Where core cylinders have been taken by the testing laboratory and the concrete proves to be satisfactory, core holes shall be filled in a manner satisfactory to the Architect at no additional cost to the Owner.
 - H. Test results will be reported in writing to the Architect, Ready-Mix Producer, and Contractor within 24 hours after tests. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day tests and 28-day tests.

END OF SECTION 03310