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Construction Specification Manual

Salt River Project

Technical Specification Index – September 2021

Division 3

Division	Title	Updated
DIVISION 3: CONCRETE		
031000	Concrete Forming & Accessories	Revised 08/21
031526	Under-Slab Sheet Vapor Retarders	Revised 08/21
032000	Concrete Reinforcing	Revised 08/21
033000	Cast-In-Place Concrete	Revised 08/21
033000 X1	Std Concrete Requirements	Revised 08/21
033000 X2	Std Concrete Mixes	Revised 08/21
033053	Misc. Cast-In-Place Concrete	Revised 08/21
033713	Shotcrete	Revised 08/21
035216	Lightweight Insulating Concrete	Revised 08/21
035300	Concrete Topping	Revised 08/21
035416	Hydraulic Cement Underlayment	Revised 08/21

SECTION 03 10 00

CONCRETE FORMING AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Form-facing material for cast-in-place concrete.
 - 2. Form liners.
 - 3. Shoring, bracing, and anchoring.

1.2 DEFINITIONS

- A. Form-Facing Material: Temporary structure or mold for the support of concrete while the concrete is setting and gaining sufficient strength to be self-supporting.
- B. Formwork: The total system of support of freshly placed concrete, including the mold or sheathing that contacts the concrete, as well as supporting members, hardware, and necessary bracing.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review the following:
 - a. Special inspection and testing and inspecting agency procedures for field quality control.
 - b. Construction, movement, contraction, and isolation joints
 - c. Forms and form-removal limitations.
 - d. Shoring and reshoring procedures.
 - e. Anchor rod and anchorage device installation tolerances.

1.4 ACTION SUBMITTALS

- A. Product Data: For each of the following:
 - 1. Exposed surface form-facing material.
 - 2. Concealed surface form-facing material.
 - 3. Forms for cylindrical columns.
 - 4. Pan-type forms.
 - 5. Void forms.
 - 6. Form liners.
 - 7. Form ties.

8. Waterstops.
9. Form-release agent.

B. Shop Drawings: Prepared by, and signed and sealed by, a qualified professional engineer responsible for their preparation, detailing fabrication, assembly, and support of forms.

1. For exposed vertical concrete walls, indicate dimensions and form tie locations.
2. Indicate dimension and locations of construction and movement joints required to construct the structure in accordance with ACI 301 (ACI 301M).
 - a. Location of construction joints is subject to approval of the Architect.
3. Indicate location of waterstops.
4. Indicate form liner layout and form line termination details.
5. Indicate proposed schedule and sequence of stripping of forms, shoring removal, and reshoring installation and removal.

C. Samples:

1. For waterstops.
2. For Form Liners: 12-inch by 12-inch (305-mm by 305-mm) sample, indicating texture.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing and inspection agency.
- B. Field quality-control reports.
- C. Minutes of preinstallation conference.

1.6 QUALITY ASSURANCE

- A. Testing and Inspection Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.
- B. Mockups: Formed surfaces to demonstrate typical joints, surface finish, texture, tolerances, and standard of workmanship.
 1. Build panel approximately 100 sq. ft. (9.3 sq. m) in the location indicated or, if not indicated, as directed by Architect.
 2. Subject to compliance with requirements, approved mockups may become part of the completed Work.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Form Liners: Store form liners under cover to protect from sunlight.

- B. Formwork: Store forms off ground and under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.
- C. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Concrete Formwork: Design, engineer, erect, shore, brace, and maintain formwork, shores, and reshores in accordance with ACI 301 (ACI 301M), to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads, so that resulting concrete conforms to the required shapes, lines, and dimensions.
 - 1. Design wood panel forms in accordance with APA's "Concrete Forming Design/Construction Guide."
 - 2. Design formwork to limit deflection of form-facing material to 1/240 of center-to-center spacing of supports.
 - a. For architectural concrete, limit deflection of form-facing material, studs, and walers to 0.0025 times their respective clear spans (L/400).

2.2 FORM-FACING MATERIALS

- A. As-Cast Surface Form-Facing Material:
 - 1. Provide continuous, true, and smooth concrete surfaces.
 - 2. Furnish in largest practicable sizes to minimize number of joints.
 - 3. Acceptable Materials: As required to comply with Surface Finish designations specified in Section 03 30 00 "Cast-In-Place Concrete, and as follows:
 - a. Plywood, metal, or other approved panel materials.
 - b. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
 - 1) APA HDO (high-density overlay).
 - 2) APA MDO (medium-density overlay); mill-release agent treated and edge sealed.
 - 3) APA Structural 1 Plyform, B-B or better; mill oiled and edge sealed.
 - 4) APA Plyform Class I, B-B or better; mill oiled and edge sealed.
- B. Concealed Surface Form-Facing Material: Lumber, plywood, metal, plastic, or another approved material.
 - 1. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that produce surfaces without spiral or vertical seams not exceeding specified formwork surface class.

1. Provide forms with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.
- D. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation, with straight or tapered end forms.
- E. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.
- F. Form Liners:
 1. Size: As indicated on Drawings .
 2. Face Pattern: Smooth unless otherwise indicated.

2.3 WATERSTOPS

- A. Flexible Rubber Waterstops: U.S. Army Corps of Engineers CRD-C 513, with factory-installed metal eyelets, for embedding in concrete to prevent passage of fluids through joints, with factory fabricated corners, intersections, and directional changes.
 1. Profile: Ribbed with center bulb.
 2. Dimensions: 6 inches by 3/8 inch thick (150 mm by 10 mm thick); nontapered.
- B. Chemically Resistant Flexible Waterstops: Thermoplastic elastomer rubber waterstops with factory-installed metal eyelets, for embedding in concrete to prevent passage of fluids through joints; resistant to oils, solvents, and chemicals, with factory fabricate corners, intersections, and directional changes.
 1. Profile: Ribbed with center bulb.
 2. Dimensions: 6 inches by 3/8 inch thick (150 mm by 10 mm thick); nontapered.
- C. Self-Expanding Rubber Strip Waterstops: Manufactured rectangular or trapezoidal strip, bentonite-free hydrophilic polymer-modified chloroprene rubber, for adhesive bonding to concrete, 3/8 by 3/4 inch (10 by 19 mm).

2.4 RELATED MATERIALS

- A. Reglets: Fabricate reglets of not less than 0.022-inch- (0.55-mm-) thick, galvanized-steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.
- B. Dovetail Anchor Slots: Hot-dip galvanized-steel sheet, not less than 0.034 inch (0.85 mm) thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.
- C. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch (19 by 19 mm), minimum.
- D. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

- E. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.
 - 1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
 - 2. Form release agent for form liners shall be acceptable to form liner manufacturer.
- F. Form Ties: Factory-fabricated, removable or snap-off, glass-fiber-reinforced plastic or metal form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
 - 1. Furnish units that leave no corrodible metal closer than 1 inch (25 mm) to the plane of exposed concrete surface.
 - 2. Furnish ties that, when removed, leave holes no larger than 1 inch (25 mm) in diameter in concrete surface.
 - 3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

PART 3 - EXECUTION

3.1 INSTALLATION OF FORMWORK

- A. Comply with ACI 301 (ACI 301M).
- B. Construct formwork, so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117 (ACI 117M) and to comply with the Surface Finish designations specified in Section 033000 "Cast-In-Place Concrete" for as-cast finishes.
- C. Limit concrete surface irregularities as follows:
 - 1. Surface Finish-1.0: ACI 117 Class D, 1 inch (25 mm).
 - 2. Surface Finish-2.0: ACI 117 Class B, 1/4 inch (6 mm).
 - 3. Surface Finish-3.0: ACI 117 Class A, 1/8 inch (3.0 mm).
- D. Construct forms tight enough to prevent loss of concrete mortar.
 - 1. Minimize joints.
 - 2. Exposed Concrete: Symmetrically align joints in forms.
- E. Construct removable forms for easy removal without hammering or prying against concrete surfaces.
 - 1. Provide crush or wrecking plates where stripping may damage cast-concrete surfaces.
 - 2. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
 - 3. Install keyways, reglets, recesses, and other accessories, for easy removal.
- F. Do not use rust-stained, steel, form-facing material.

- G. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces.
 - 1. Provide and secure units to support screed strips
 - 2. Use strike-off templates or compacting-type screeds.
- H. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible.
 - 1. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar.
 - 2. Locate temporary openings in forms at inconspicuous locations.
- I. Chamfer exterior corners and edges of permanently exposed concrete.
- J. At construction joints, overlap forms onto previously placed concrete not less than 12 inches (305 mm).
- K. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work.
 - 1. Determine sizes and locations from trades providing such items.
 - 2. Obtain written approval of Architect prior to forming openings not indicated on Drawings.
- L. Construction and Movement Joints:
 - 1. Construct joints true to line with faces perpendicular to surface plane of concrete.
 - 2. Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
 - 3. Place joints perpendicular to main reinforcement.
 - 4. Locate joints for beams, slabs, joists, and girders in the middle third of spans.
 - a. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 - 5. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 - 6. Space vertical joints in walls as indicated on Drawings.
 - a. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
- M. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection.
 - 1. Locate ports and openings in bottom of vertical forms, in inconspicuous location, to allow flushing water to drain.
 - 2. Close temporary ports and openings with tight-fitting panels, flush with inside face of form, and neatly fitted, so joints will not be apparent in exposed concrete surfaces.
- N. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

- O. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- P. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 INSTALLATION OF 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.
 - 1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC 303.
 - 3. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.
 - 4. Install dovetail anchor slots in concrete structures, as indicated on Drawings.
 - 5. Clean embedded items immediately prior to concrete placement.

3.3 INSTALLATION OF WATERSTOPS

- A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm.
 - 1. Install in longest lengths practicable.
 - 2. Locate waterstops in center of joint unless otherwise indicated on Drawings.
 - 3. Allow clearance between waterstop and reinforcing steel of not less than 2 times the largest concrete aggregate size specified in Section 03 30 00 "Cast-In-Place Concrete."
 - 4. Secure waterstops in correct position at 12 inches (305 mm) on center.
 - 5. Field fabricate joints in accordance with manufacturer's instructions using heat welding.
 - a. Miter corners, intersections, and directional changes in waterstops.
 - b. Align center bulbs.
 - 6. Clean waterstops immediately prior to placement of concrete.
 - 7. Support and protect exposed waterstops during progress of the Work.
- B. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated on Drawings, according to manufacturer's written instructions, by adhesive bonding, mechanically fastening, and firmly pressing into place.
 - 1. Install in longest lengths practicable.
 - 2. Locate waterstops in center of joint unless otherwise indicated on Drawings.
 - 3. Protect exposed waterstops during progress of the Work.

3.4 REMOVING AND REUSING FORMS

- A. 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 (10 deg C) for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations, and curing and protection operations need to be maintained.
 - 1. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.
 - 2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
- B. Clean and repair surfaces of forms to be reused in the Work.
 - 1. Split, frayed, delaminated, or otherwise damaged form-facing material are unacceptable for exposed surfaces.
 - 2. Apply new form-release agent.
- C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints.
 - 1. Align and secure joints to avoid offsets.
 - 2. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.5 SHORING AND RESHORING INSTALLATION

- A. Comply with ACI 318 (ACI 318M) and ACI 301 (ACI 301M) for design, installation, and removal of shoring and reshoring.
 - 1. Do not remove shoring or reshoring until measurement of slab tolerances is complete.
- B. 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.
- C. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

3.6 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.

Project Name
Project Number

Deliverable
Issue Date

C. Inspections:

1. Inspect formwork for shape, location, and dimensions of the concrete member being formed.

END OF SECTION

Project Name
Project Number

Deliverable
Issue Date

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SECTION 03 15 26

UNDERSLAB SHEET VAPOR RETARDERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Underslab sheet vapor retarders for slab-on-ground applications.
 - 2. Underslab sheet vapor retarders for slab-on-carton form applications.

1.2 DEFINITIONS

- A. Vapor Barrier: Class I vapor retarder.
- B. Vapor Retarder: Material or assembly of materials that resists water vapor diffusion through it when tested in accordance with ASTM E 96, Test Method A.
 - 1. Class I: 0.1 perm or less; vapor impermeable.
 - 2. Class II: 1.0 perms or less and greater than 1.0 perm; vapor semi-impermeable.
 - 3. Class III: 10 perms or less and greater than 1.0 perm; vapor semipermeable.
- C. Vapor Permeable: Greater than 10 perms.

1.3 COORDINATION

- A. Coordinate placement of sheet vapor retarder with applicable Division 03 and 31 Sections.
- B. Job Conditions: Do not install vapor retarder until below-slab fill and utility work has been completed, tested, and backfilled and void forms are in-place.
- C. Coordinate installation with scheduled concrete pours to avoid delays. Make provisions for installation of work by other trades.

1.4 ACTION SUBMITTALS

- A. Product Data: Technical data for each type of product.
- B. Samples for Verification: Of sheet membrane vapor retarder, 8 inches by 10 inches.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is acceptable to manufacturer, who has completed applications similar in material and extent to that required for this Project, and whose work has resulted in construction with a record of successful in-service performance.

1.6 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: Submit reports for each product, for tests performed by a qualified testing agency.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in original packages and containers, with seals unbroken, bearing manufacturer's labels indicating brand name and directions for storage and application.
- B. Store materials in a clean dry location in accordance with manufacturer's written instructions to prevent deterioration from moisture or other detrimental effects.
- C. Stack membrane on elevated wood platform to eliminate warping.
- D. Protect materials during handling and application to prevent damage or contamination.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Comply with manufacturer's written recommendations for substrate temperature and moisture content, ambient temperature and humidity, ventilation, and other conditions affecting materials performance.
- B. Close areas to traffic during installation and for time period after application recommended in writing by manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain vapor retarder and seaming tape from one source from a single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Provide sheet vapor retarders complying with the following:
 - 1. Type: 15 mil polyolefin film meeting requirements of ASTM E 1745, Class A.
 - 2. Water Vapor Transmittance (After mandatory condition per ASTM E154 sections 8,11,12,13): Maximum perm rating of 0.01 as tested in accordance with ASTM E 1745 Section 7.

UNDERSLAB SHEET VAPOR RETARDERS

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3. Strength: ASTM E 1745: Class A.

2.3 UNDERSLAB SHEET VAPOR RETARDERS

- A. Sheet Vapor Retarders for Slab-on-Ground Applications: ASTM D 4397, minimum 15 mil (0.37 mm) thick sheet, monolithic, polyethylene or polyolefin-based resin, nonwoven, unreinforced membrane.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Insulation Solutions Inc.; Viper VaporCheck 15 mil.
 - b. Poly-America, LP; 15 mil Husky Yellow Guard.
 - c. Raven Industries; VaporBlock 15.
 - d. Stego Industries, LLC; Stego Wrap 15 mil Vapor Barrier.
 - e. W.R. Meadows; Perminator 15 Mil.
 2. Physical Properties:
 - a. Permeance Rating: ASTM E 96; maximum permeance rating of 0.1 perm (5.7 ng/Pa x s x sq. m).
 - b. Surface Burning Characteristics: Maximum flame spread and smoke developed indexes of 75 and 200, respectively, per ASTM E 84.
 - c. Tensile Strength: Minimum 60.0 lbf/in. per ASTM E 154.
 - d. Puncture Resistance: Minimum 2250 grams per ASTM D 1709.

2.4 INTEGRALLY BONDED UNDERSLAB VAPOR RETARDERS

- A. Sheet Vapor Retarder for Slab-Over-Form Applications: Adhesive-coated sheet which forms an integral and permanent bond to poured concrete to prevent water and vapor migration at the interface of the membrane and structural concrete.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Florprufe 120 Membrane; GCP Applied Technologies.
 2. Underseal Underslab; Polyguard Products, Inc.
 3. VBC-350 Composite Vapor Retarder; Barrier-Bac Inteplast Group, Ltd.
 4. W.R. Meadows, Inc.; Precon Blindside/Underslab Waterproofing Membrane.
- C. Bonded Vapor Retarder: Monolithic, nonwoven polyolefin film and synthetic adhesive layers that form an integral and permanent bond to poured concrete to prevent vapor migration at the interface of the membrane and structural concrete.
 1. Sheet Membrane Thickness: ASTM E 1745; 0.5 mm (0.021 mm) including 0.4 mm (0.016 inch) of polyolefin film and layers of specially formulated synthetic adhesive layers.
 2. Performance Characteristics:
 - a. Water Vapor Permeance: ASTM E96, Method B (ASTM E1745); 0.03 perms.
 - b. Tensile Strength: ASTM E154; 65 lb/in.
 - c. Puncture Resistance: ASTM D1709; 3300 grams.
 - d. Elongation: ASTM D412; 300%.

UNDERSLAB SHEET VAPOR RETARDERS

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3. Life Expectancy: ASTM E 154; indefinite.
4. Chemical Resistance: ASTM E 154, unaffected.
5. Peel Adhesion to Concrete: ASTM D903; >4 lb/in.

2.5 ACCESSORIES

- A. Vapor Retarder Tape: Pressure sensitive tape of type recommended by vapor retarder manufacturer for sealing joints and penetrations in vapor retarder.
- B. Adhesive for Vapor Retarders: Product recommended by vapor retarder manufacturer and has demonstrated capability to bond vapor retarders securely to substrates indicated.
- C. Mastic Adhesive: Compatible with membrane and recommended by vapor retarder manufacturer.
- D. Vapor Retarder Fasteners: Pancake head, self-tapping steel drill screws; with fender washers.
- E. Pipe Boots: Factory fabricated, recommended by vapor retarder manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas to receive vapor retarder, and conditions for compliance with requirements and conditions affecting installation and performance.
 1. Verify that void carton substrate is flat, smooth, and ready to receive sheet membranes.
- B. Do not proceed until under-slab plumbing and electrical rough-in work is complete, and specified fill or subgrade material has been placed, compacted, and tested; and is smooth, level, and without voids.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean substrates of substances that are harmful to vapor retarders, including removing projections capable of puncturing vapor retarders. Remove loose or foreign matter which might penetrate vapor retarder.
- B. Clean and prime substrate surfaces to receive adhesive in accordance with manufacturer's instructions.
- C. For underslab installation, layout sheet membrane parallel to direction of placement of concrete.

3.3 INSTALLATION

- A. Install vapor retarders in accordance with ASTM E 1643 and manufacturer's written instructions.

- B. Underslab Application: Install vapor retarders continuously at locations under slab as indicated on the drawings. Ensure there are no discontinuities in vapor retarder at seams and penetrations. Install in largest practical widths. Ensure subgrade beneath vapor retarder is smooth, level, and compacted with no sharp projections.
 - 1. Extend vapor retarders to extremities of areas to protect from vapor transmission. Secure vapor retarders in place with adhesives, vapor retarder fasteners, or anchorage system recommended by manufacturer. Extend vapor retarders to cover miscellaneous voids in insulated substrates, including those filled with loose fiber insulation.
 - 2. Install vapor retarder parallel to direction of placement on smooth substrate to form continuous layer over sand base course.
 - 3. Lap sheets not less than 6 inches (150 mm); seal laps tight with mastic tape.
 - 4. Join sections of vapor retarder and seal penetrations with mastic tape. Ensure vapor retarder surfaces receiving mastic tape are clean and dry.
 - a. Ensure no moisture entrapment by vapor retarder due to rainfall or ground water intrusion.
 - 5. Penetrations: Seal around pipes and penetrations in vapor retarder with pipe boots in accordance with manufacturer's instructions.
 - 6. Repair damaged vapor retarder sheet prior to pouring concrete with pressure sensitive tape in accordance with manufacturer's recommendations.
 - a. Immediately repair holes in vapor retarder with self-adhesive repair tape.

- C. Wall Application: Seal vertical joints in vapor retarders over framing by lapping no fewer than two studs and sealing with vapor retarder tape according to vapor retarder manufacturer's written instructions. Locate joints over framing members or other solid substrates.
 - 1. Seal joints caused by pipes, conduits, electrical boxes, and similar items penetrating vapor retarders with vapor retarder tape to create an airtight seal between penetrating objects and vapor retarders.
 - 2. Repair tears or punctures in vapor retarders immediately before concealment by other work. Cover with vapor retarder tape or another layer of vapor retarder recommended by vapor retarder manufacturer.

- D. Crawl Space Application: Install vapor retarders over prepared grade. Lap joints a minimum of 12 inches (305 mm) and seal with manufacturer's recommended tape. Install second layer over pathways to equipment.
 - 1. Extend vapor retarder over footings and seal to foundation wall or grade beam with manufacturer's recommended tape.
 - a. Extend vapor retarder vertically minimum 16 inches (406 mm) above top of footing.
 - 2. Seal around penetrations such as utilities and columns to create a monolithic, airtight membrane at grade surface, perimeter, and all vertical penetrations.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services: Engage manufacturer's technical representative to inspect vapor retarder materials, accessories, and installation for compliance with specified requirements prior to placement of concrete. Inspections include but are not limited to:
1. Continuity of vapor retarder system.
 2. Continuous support of vapor retarder system.
 3. Laps in sheet materials comply with the minimum requirements with no fishmouths.
 4. Compatible materials have been used.
 5. Penetrations have been sealed.
 6. Perimeter of vapor retarder system has been terminated and sealed in accordance with manufacturer recommendations.

3.5 PROTECTION

- A. Do not permit unnecessary foot or vehicular traffic on unprotected horizontal membrane.
- B. Protect vapor retarders from damage until concealed by permanent construction.
- C. Prior to pouring concrete, inspect membrane for punctures or damage and repair as required to maintain vapor retarder integrity.

END OF SECTION

SECTION 03 20 00
CONCRETE REINFORCING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel reinforcement bars.
2. Welded-wire reinforcement.

B. Related Requirements:

1. Section 03 41 00 "Precast Structural Concrete" for reinforcing used in precast structural concrete.
2. Section 03 45 00 "Precast Architectural Concrete" for reinforcing used in precast architectural concrete.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review the following:
 - a. Special inspection and testing and inspecting agency procedures for field quality control.
 - b. Construction contraction and isolation joints.
 - c. Steel-reinforcement installation.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Each type of steel reinforcement.
2. Bar supports.
3. Mechanical splice couplers.

B. Shop Drawings: Comply with ACI SP-066:

1. Include placing drawings that detail fabrication, bending, and placement.
2. Include bar sizes, lengths, materials, grades, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, location of splices, lengths of lap splices, details of mechanical splice couplers, details of welding splices, tie spacing, hoop spacing, and supports for concrete reinforcement.

C. Construction Joint Layout: Indicate proposed construction joints required to build the structure.

1. Location of construction joints is subject to approval of the Architect.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Statements: For testing and inspection agency.
- B. Welding certificates.
 - 1. Reinforcement To Be Welded: Welding procedure specification in accordance with AWS D1.4/D1.4M
- C. Material Test Reports: For the following, from a qualified testing agency:
 - 1. Steel Reinforcement:
 - a. For reinforcement to be welded, mill test analysis for chemical composition and carbon equivalent of the steel in accordance with ASTM A706/A706M.
 - 2. Mechanical splice couplers.
- D. Field quality-control reports.
- E. Minutes of preinstallation conference.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.4/D 1.4M.
- C. Mockups: Reinforcing for cast-concrete formed surfaces, to demonstrate tolerances and standard of workmanship.
 - 1. Build panel approximately 100 sq. ft. (9.3 sq. m) for formed surface in the location indicated on Drawings or, if not indicated, as directed by Architect.
 - 2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. and to avoid damaging coatings on steel reinforcement.
 - 1. Store reinforcement to avoid contact with earth.
 - 2. Do not allow stainless steel reinforcement to come into contact with uncoated reinforcement.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), unless otherwise indicated, deformed.
- B. Low-Alloy Steel Reinforcing Bars: ASTM A706/A706M, deformed.
- C. Headed-Steel Reinforcing Bars: ASTM A970/A970M.
- D. Steel Bar Mats: ASTM A184/A184M, fabricated from ASTM A615/A615M, Grade 60 (Grade 420), deformed bars, assembled with clips.
- E. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, plain, fabricated from as-drawn steel wire into flat sheets.
- F. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet.
- G. Galvanized-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, plain, fabricated from galvanized-steel wire into flat sheets.

2.2 REINFORCEMENT ACCESSORIES

- A. Joint Dowel Bars: ASTM A615/A615M, Grade 60 (Grade 420), plain-steel bars, cut true to length with ends square and free of burrs.
- B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place.
 - 1. Manufacture bar supports from steel wire, plastic, or precast concrete in accordance with CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
 - a. For concrete surfaces exposed to view, where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire, all-plastic bar supports, or CRSI Class 2 stainless steel bar supports.
 - b. For zinc-coated reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.
 - c. For stainless steel reinforcement, use CRSI Class 1 plastic-protected steel wire, all-plastic bar supports, or CRSI Class 2 stainless steel bar supports.
- C. Mechanical Splice Couplers: ACI 318 (ACI 318M) Type as indicated on Drawings, same material of reinforcing bar being spliced; compression-only type, tension-compression type, or mechanical-lap type, as indicated.
- D. Steel Tie Wire: ASTM A1064/A1064M, annealed steel, not less than 0.0508 inch (1.2908 mm) in diameter.
 - 1. Finish: Plain.

2.3 FABRICATING REINFORCEMENT

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

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protection of In-Place Conditions:
 - 1. Do not cut or puncture vapor retarder.
 - 2. Repair damage and reseal vapor retarder before placing concrete.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that reduce bond to concrete.

3.2 INSTALLATION OF STEEL REINFORCEMENT

- A. Comply with CRSI's "Manual of Standard Practice" for placing and supporting reinforcement.
- B. Accurately position, support, and secure reinforcement against displacement.
 - 1. Locate and support reinforcement with bar supports to maintain minimum concrete cover.
 - 2. Do not tack weld crossing reinforcing bars.
- C. Preserve clearance between bars of not less than 1 inch (25 mm), not less than one bar diameter, or not less than 1-1/3 times size of large aggregate, whichever is greater.
- D. Provide concrete coverage in accordance with ACI 318 (ACI 318M).
- E. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- F. Splices: Lap splices as indicated on Drawings.
 - 1. Bars indicated to be continuous, and all vertical bars shall be lapped not less than 36 bar diameters at splices, or 24 inches (610 mm), whichever is greater.
 - 2. Stagger splices in accordance with ACI 318 (ACI 318M).
 - 3. Mechanical Splice Couplers: Install in accordance with manufacturer's instructions.
 - 4. Weld reinforcing bars in accordance with AWS D1.4/D 1.4M, where indicated on Drawings.
- G. Install welded-wire reinforcement in longest practicable lengths.
 - 1. Support welded-wire reinforcement in accordance with CRSI "Manual of Standard Practice."
 - a. For reinforcement less than W4.0 or D4.0, continuous support spacing shall not exceed 12 inches (305 mm).

2. Lap edges and ends of adjoining sheets at least one wire spacing plus 2 inches (50 mm) for plain wire and 8 inches (200 mm) for deformed wire.
 3. Offset laps of adjoining sheet widths to prevent continuous laps in either direction.
 4. Lace overlaps with wire.
- H. Zinc-Coated Reinforcement: Repair cut and damaged zinc coatings with zinc repair material in accordance with ASTM A780/A780M.

3.3 JOINTS

- A. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
1. Place joints perpendicular to main reinforcement.
 2. Continue reinforcement across construction joints unless otherwise indicated.
 3. Do not continue reinforcement through sides of strip placements of floors and slabs.
- B. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length, to prevent concrete bonding to one side of joint.

3.4 INSTALLATION TOLERANCES

- A. Comply with ACI 117 (ACI 117M).

3.5 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
- C. Inspections:
1. Steel-reinforcement placement.
 2. Steel-reinforcement mechanical splice couplers.
 3. Steel-reinforcement welding.

END OF SECTION

Project Name
Project Number

Deliverable
Issue Date

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CONCRETE REINFORCING
03 20 00 - 6

Last Updated:

August 2021

SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cast-in-place concrete, including concrete materials, mixture design, placement procedures, and finishes.

B. Related Requirements:

1. Appendix No. 1 – SRP Standard Specification for Concrete, included at the end of this Section.
2. Appendix No. 2 – SRP Standard Concrete Mixes, included at the end of this Section.
3. Section 03 10 00 "Concrete Forming and Accessories" for form-facing materials, form liners, insulating concrete forms, and waterstops.
4. Section 03 15 26 "Under-Slab Sheet Vapor Retarder."
5. Section 03 20 00 "Concrete Reinforcing" for steel reinforcing bars and welded-wire reinforcement.

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, other pozzolans, subject to compliance with requirements.
- B. Water/Cement Ratio (w/cm): The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Concrete Subcontractor.
 - e. Special concrete finish Subcontractor.
2. Review the following:
 - a. Owner's Standard Specification for Concrete (Appendix No. 1) included at the end of this Section.

- b. Owner's Standard Concrete Mixes (Appendix No. 2) included at the end of this Section.
- c. Construction joints, control joints, isolation joints, and joint-filler strips.
- d. Semirigid joint fillers.
- e. Vapor-retarder installation.
- f. Anchor rod and anchorage device installation tolerances.
- g. Cold and hot weather concreting procedures.
- h. Concrete finishes and finishing.
- i. Curing procedures.
- j. Forms and form-removal limitations.
- k. Shoring and reshoring procedures.
- l. Methods for achieving specified floor and slab flatness and levelness.
- m. Floor and slab flatness and levelness measurements.
- n. Concrete repair procedures.
- o. Concrete protection.
- p. Initial curing and field curing of field test cylinders (ASTM C31/C31M.)
- q. Protection of field cured field test cylinders.

1.4 ACTION SUBMITTALS

A. Product Data: For each of the following.

- 1. Portland cement.
- 2. Fly ash.
- 3. Aggregates.
- 4. Admixtures:
 - a. Include limitations of use, including restrictions on cementitious materials, supplementary cementitious materials, air entrainment, aggregates, temperature at time of concrete placement, relative humidity at time of concrete placement, curing conditions, and use of other admixtures.
- 5. Color pigments.
- 6. Fiber reinforcement.
- 7. Floor and slab treatments.
- 8. Liquid floor treatments.
- 9. Curing materials.
 - a. Include documentation from color pigment manufacturer, indicating that proposed methods of curing are recommended by color pigment manufacturer.
- 10. Joint fillers.
- 11. Repair materials.

B. Design Mixtures: For each concrete mixture, include the following:

- 1. Mixture identification.
- 2. Minimum 28-day compressive strength.
- 3. Durability exposure class.

4. Maximum w/cm.
5. Calculated equilibrium unit weight, for lightweight concrete.
6. Slump limit.
7. Air content.
8. Nominal maximum aggregate size.
9. Steel-fiber reinforcement content.
10. Synthetic micro-fiber content.
11. Additional information required by Owner's Standard Specification for Concrete (Appendix No. 1) included at the end of this Section.
12. Indicate amounts of mixing water to be withheld for later addition at Project site if permitted.
13. Intended placement method.
14. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

C. Shop Drawings:

1. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.
 - a. Location of construction joints is subject to approval of the Architect.

D. Samples: For manufacturer's standard colors for color pigment.

E. Concrete Schedule: For each location of each Class of concrete indicated in "Concrete Mixtures" Article, including the following:

1. Concrete Class designation.
2. Location within Project.
3. Exposure Class designation.
4. Formed Surface Finish designation and final finish.
5. Final finish for floors.
6. Curing process.
7. Floor treatment if any.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For the following:

1. Installer: Include copies of applicable ACI certificates.
2. Ready-mixed concrete manufacturer.
3. Testing Agency: Include copies of applicable ACI certificates.

B. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.
2. Admixtures.
3. Fiber reinforcement.

4. Additional certifications required by Owner's Standard Specification for Concrete (Appendix No. 1) included at the end of this Section.
5. Curing compounds.
6. Floor and slab treatments.
7. Bonding agents.
8. Adhesives.
9. Semirigid joint filler.
10. Joint-filler strips.
11. Repair materials.

C. Material Test Reports: For the following, from a qualified testing agency:

1. Portland cement.
2. Fly ash.
3. Aggregates.
4. Admixtures.

D. Floor surface flatness and levelness measurements report, indicating compliance with specified tolerances.

E. Research Reports:

1. For concrete admixtures in accordance with ICC's Acceptance Criteria AC198.

F. Preconstruction Test Reports: For each mix design.

G. Field quality-control reports.

H. Minutes of preinstallation conference.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs Project personnel qualified as an ACI-certified Flatwork Technician and Finisher and a supervisor who is a certified ACI Flatwork Concrete Finisher/Technician or an ACI Concrete Flatwork Technician.

1. Post-Installed Concrete Anchors Installers: ACI-certified Adhesive Anchor Installer.

B. Ready-Mixed Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

1. Manufacturer certified in accordance with NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

C. Laboratory Testing Agency Qualifications: A testing agency qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated and employing an ACI-certified Concrete Quality Control Technical Manager.

1. Personnel performing laboratory tests shall be an ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician, Grade I. Testing agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician, Grade II.
- D. Field Quality Control Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.
1. Personnel conducting field tests shall be qualified as an ACI Concrete Field Testing Technician, Grade 1, in accordance with ACI CPP 610.1 or an equivalent certification program.
- E. Mockups: Cast concrete slab-on-ground and formed-surface panels to demonstrate typical joints, surface finish, texture, tolerances, floor treatments, and standard of workmanship.
1. Slab-On-Ground: Build panel approximately 15 feet by 15 feet (3.35 meters by 3.35 meters) in the location indicated or, if not indicated, as directed by Architect.
 - a. Divide panel into four equal panels to demonstrate saw joint cutting.
 2. Formed Surfaces: Build panel approximately 100 sq. ft. (9.3 sq. m) in the location indicated or, if not indicated, as directed by Architect.
 3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on each concrete mixture.
1. Include the following information in each test report:
 - a. Admixture dosage rates.
 - b. Slump.
 - c. Air content.
 - d. Seven-day compressive strength.
 - e. 28-day compressive strength.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Comply with ASTM C94/C94M and ACI 301 (ACI 301M).
- B. Comply with additional requirements indicated in Owner's Standard Specification for Concrete (Appendix No. 1) included at the end of this Section.

1.9 FIELD CONDITIONS

- A. Cold-Weather Placement: Comply with ACI 301 (ACI 301M) and ACI 306.1 and as follows:

1. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 2. When average high and low temperature is expected to fall below 40 deg F (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301 (ACI 301M).
 3. Do not use frozen materials or materials containing ice or snow.
 4. Do not place concrete in contact with surfaces less than 35 deg F (1.7 deg C), other than reinforcing steel.
 5. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
- B. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and ACI 305.1 (ACI 305.1M), and as follows:
1. Maintain concrete temperature at time of discharge to not exceed 95 deg F (35 deg C).
 2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. ACI Publications: Comply with ACI 301 (ACI 301M) unless modified by requirements in the Contract Documents.
- B. Comply with additional requirements indicated in Owner's Standard Specification for Concrete (Appendix No. 1) included at the end of this Section.

2.2 CONCRETE MATERIALS

- A. Source Limitations:
1. Obtain all concrete mixtures from a single ready-mixed concrete manufacturer for entire Project.
 2. Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant.
 3. Obtain aggregate from single source.
 4. Obtain each type of admixture from single source from single manufacturer.
- B. Cementitious Materials:
1. Portland Cement: ASTM C150/C150M, Type II, gray.
 2. Fly Ash: ASTM C618, Class F.
- C. Normal-Weight Aggregates: ASTM C33/C33M, Class 3M coarse aggregate or better, graded. Provide aggregates from a single source.

1. Alkali-Silica Reaction: Comply with one of the following:
 - a. Expansion Result of Aggregate: Not more than 0.04 percent at one-year when tested in accordance with ASTM C1293.
 - b. Expansion Results of Aggregate and Cementitious Materials in Combination: Not more than 0.10 percent at an age of 16 days when tested in accordance with ASTM C1567.
 - c. Alkali Content in Concrete: Not more than 4 lb./cu. yd. (2.37 kg/cu. m) for moderately reactive aggregate or 3 lb./cu. yd. (1.78 kg/cu. m) for highly reactive aggregate, when tested in accordance with ASTM C1293 and categorized in accordance with ASTM C1778, based on alkali content being calculated in accordance with ACI 301 (ACI 301M).
 2. Maximum Coarse-Aggregate Size: 1 inch (25 mm) nominal.
 3. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- D. Lightweight Aggregate: ASTM C330/C330M, 3/4-inch (19-mm) nominal maximum aggregate size.
- E. Air-Entraining Admixture: ASTM C260/C260M.
- F. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride in steel-reinforced concrete.
1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 2. Retarding Admixture: ASTM C494/C494M, Type B.
 3. Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type D.
 4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
 5. High-Range, Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type G.
 6. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.
 7. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C494/C494M, Type C.
 8. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.
- G. Color Pigment: ASTM C979/C979M, synthetic mineral-oxide pigments, color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.
1. Color: As selected by Architect from manufacturer's full range.
- H. Water and Water Used to Make Ice: ASTM C94/C94M, potable or complying with ASTM C1602/C1602M, including all limits listed in Table 2 and the requirements of paragraph 5.4

2.3 FIBER REINFORCEMENT

- A. Carbon-Steel-Wire Fiber: ASTM A820/A820M, Type 1, cold-drawn wire, deformed, minimum of 2 inches (50 mm) long, with an aspect ratio of 60 to 65.
- B. Carbon-Steel Cut Sheet Fiber: ASTM A820/A820M, Type 2, cut sheet, deformed, minimum of 2 inches (50 mm) long, and aspect ratio of 60 to 65.
- C. Synthetic Monofilament Micro-Fiber: Monofilament polypropylene micro-fibers engineered and designed for use in concrete, complying with ASTM C1116/C1116M, Type III, 1 to 2-1/4 inches (25 to 57 mm) long.
- D. Synthetic Fibrillated Micro-Fiber: Fibrillated polypropylene micro-fibers engineered and designed for use in concrete, complying with ASTM C1116/C1116M, Type III, 1 to 2-1/4 inches (25 to 57 mm) long.
- E. Synthetic Macro-Fiber: Synthetic macro-fibers engineered and designed for use in concrete, complying with ASTM C1116/C1116M, Type III, 1 to 2-1/4 inches (25 to 57 mm) long.

2.4 FLOOR AND SLAB TREATMENTS

- A. Slip-Resistive Emery Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive, crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials with 100 percent passing No. 4 (4.75-mm) sieve.
- B. Slip-Resistive Aluminum Granule Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of not less than 95 percent fused aluminum-oxide granules.
- C. Emery Dry-Shake Floor Hardener: Pigmented, factory-packaged, dry combination of portland cement, graded emery aggregate, and plasticizing admixture; with emery aggregate consisting of no less than 60 percent of total aggregate content.
 - 1. Color: As selected by Architect from manufacturer's full range.
- D. Metallic Dry-Shake Floor Hardener: Pigmented, factory-packaged, dry combination of portland cement, graded metallic aggregate, rust inhibitors, and plasticizing admixture; with metallic aggregate consisting of no less than 65 percent of total aggregate content.
 - 1. Color: As selected by Architect from manufacturer's full range.
- E. Unpigmented Mineral Dry-Shake Floor Hardener: Factory-packaged dry combination of portland cement, graded quartz aggregate, and plasticizing admixture.
- F. Pigmented Mineral Dry-Shake Floor Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

1. Color: As selected by Architect from manufacturer's full range.

2.5 LIQUID FLOOR TREATMENTS

- A. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.

2.6 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. (305 g/sq. m) when dry.
- C. Moisture-Retaining Cover: ASTM C171, polyethylene film burlap-polyethylene sheet.
 1. Color:
 - a. Ambient Temperature Below 50 deg F (10 deg C): Black.
 - b. Ambient Temperature between 50 deg F (10 deg C) and 85 deg F (29 deg C): Any color.
 - c. Ambient Temperature Above 85 deg F (29 deg C): White.
- D. Water: Potable or complying with ASTM C1602/C1602M.

2.7 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber or ASTM D1752, cork or self-expanding cork.
- B. Bonding Agent: ASTM C1059/C1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.
- C. Epoxy Bonding Adhesive: ASTM C881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade and class to suit requirements, and as follows:
 1. Types I and II, nonload bearing or Types IV and V, load bearing, as applicable to suit conditions, for bonding hardened or freshly mixed concrete to hardened concrete.
- D. Floor Slab Protective Covering: Eight-foot- (2438-mm-) wide cellulose fabric.

2.8 REPAIR MATERIALS

- A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3 mm) and that can be feathered at edges to match adjacent floor elevations.

1. Cement Binder: ASTM C150/C150M portland cement or hydraulic or blended hydraulic cement, as defined in ASTM C219.
2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3 to 6 mm) or coarse sand, as recommended by underlayment manufacturer.
4. Compressive Strength: Not less than 4100 psi (29 MPa) at 28 days when tested in accordance with ASTM C109/C109M.

2.9 CONCRETE MIXTURES, GENERAL

- A. General: Comply with additional Owner requirements as set forth in the following attachments included at the end of this Section:
 1. Appendix No. 1 – SRP Standard Specification for Concrete.
 2. Appendix No. 2 – SRP Standard Concrete Mixes.
- B. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, in accordance with ACI 301 (ACI 301M).
 1. Use a qualified testing agency for preparing and reporting proposed mixture designs, based on laboratory trial mixtures.
- C. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
 1. Fly Ash or Other Pozzolans: 25 percent by mass.
 2. Total of Fly Ash: 35 percent by mass with fly ash or pozzolans not exceeding 25 percent by mass and silica fume not exceeding 10 percent by mass.
- D. Admixtures: Use admixtures in accordance with manufacturer's written instructions.
 1. Use water-reducing or high-range water-reducing admixture in concrete, as required, for placement and workability.
 2. Use water-reducing and -retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs, concrete for parking structure slabs, and concrete with a w/cm below 0.50.
 4. Use corrosion-inhibiting admixture in concrete mixtures where indicated.
- E. Color Pigment: Add color pigment to concrete mixture in accordance with manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.10 CONCRETE MIXTURES

- A. Class A: Normal-weight concrete used for footings, grade beams, and tie beams.
 1. Exposure Class: ACI 318 (ACI 318M), Class as indicated on Drawings.

2. Minimum Compressive Strength: As indicated, at 28 days.
 3. Maximum w/cm: 0.50.
 4. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).
 5. Slump Flow Limit: 22 inches (550 mm), plus or minus 1.5 inches (40 mm).
 6. Air Content:
 - a. Exposure Class F1: As indicated on Drawings.
 - b. Exposure Classes F2 and F3: As indicated on Drawings.
 7. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.
- B. Class B: Normal-weight concrete used for foundation walls.
1. Exposure Class: ACI 318 (ACI 318M), Class as indicated on Drawings.
 2. Minimum Compressive Strength: As indicated, at 28 days.
 3. Maximum w/cm: 0.40.
 4. Slump Limit: 5 inches (125 mm), plus or minus 1 inch (25 mm).
 5. Slump Flow Limit: 22 inches (550 mm), plus or minus 1.5 inches (40 mm).
 6. Air Content:
 - a. Exposure Class F1: As indicated on Drawings.
 - b. Exposure Classes F2 and F3: As indicated on Drawings.
 7. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.
- C. Class C: Normal-weight concrete used for interior slabs-on-ground.
1. Exposure Class: ACI 318 (ACI 318M), Class as indicated on Drawings.
 2. Minimum Compressive Strength: As indicated, at 28 days.
 3. Maximum w/cm: 0.45.
 4. Minimum Cementitious Materials Content: 540 lb/cu. yd. (320 kg/cu. m).
 5. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).
 6. Slump Flow Limit: 22 inches (550 mm), plus or minus 1.5 inches (40 mm).
 7. Air Content:
 - a. Do not use an air-entraining admixture or allow total air content to exceed 3 percent for concrete used in trowel-finished floors.
 8. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.
 9. Steel-Fiber Reinforcement: Add to concrete mixture, in accordance with manufacturer's written instructions, at a rate of 50 lb/cu. yd. (29.7 kg/cu. m).
 10. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of 1.0 lb/cu. yd. (0.60 kg/cu. m).
 11. Synthetic Macro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of 4.0 lb/cu. yd. (2.4 kg/cu. m).

- D. Class D: Normal-weight concrete used for interior suspended slabs.
1. Exposure Class: ACI 318 (ACI 318M), Class as indicated on Drawings.
 2. Minimum Compressive Strength: As indicated, at 28 days.
 3. Maximum w/cm: 0.50.
 4. Minimum Cementitious Materials Content: 540 lb/cu. yd. (320 kg/cu. m).
 5. Slump Limit: 5 inches (125 mm), plus or minus 1 inch (25 mm).
 6. Slump Flow Limit: 22 inches (550 mm), plus or minus 1.5 inches (40 mm).
 7. Air Content:
 - a. Do not use an air-entraining admixture or allow total air content to exceed 3 percent for concrete used in trowel-finished floors.
 8. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.
 9. Steel-Fiber Reinforcement: Add to concrete mixture, in accordance with manufacturer's written instructions, at a rate of 50 lb/cu. yd. (29.7 kg/cu. m).
 10. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of 1.0 lb/cu. yd. (0.60 kg/cu. m).
 11. Synthetic Macro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of 4.0 lb/cu. yd. (2.4 kg/cu. m).
- E. Class E: Structural lightweight concrete used for interior suspended slabs.
1. Exposure Class: ACI 318 (ACI 318M), Class as indicated on Drawings.
 2. Minimum Compressive Strength: As indicated, at 28 days.
 3. Calculated Equilibrium Unit Weight: 110 lb/cu. ft. (1762 kg/cu. m), plus or minus 3 lb/cu. ft. (48.1 kg/cu. m) as determined by ASTM C567/C567M.
 4. Slump Limit: 5 inches (125 mm), plus or minus 1 inch (25 mm).
 5. Slump Flow Limit: 22 inches (550 mm), plus or minus 1.5 inches (40 mm).
 6. Air Content:
 - a. Do not use an air-entraining admixture or allow total air content to exceed 3 percent for concrete used in trowel-finished floors.
 7. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.
 8. Steel-Fiber Reinforcement: Add to concrete mixture, in accordance with manufacturer's written instructions, at a rate of 50 lb/cu. yd. (29.7 kg/cu. m).
 9. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of 1.0 lb/cu. yd. (0.60 kg/cu. m).
 10. Synthetic Macro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of 4.0 lb/cu. yd. (2.4 kg/cu. m).
- F. Class F: Normal-weight concrete used for concrete toppings.
1. Exposure Class: ACI 318 (ACI 318M), Class as indicated on Drawings.
 2. Minimum Compressive Strength: As indicated, at 28 days.
 3. Minimum Cementitious Materials Content: 540 lb/cu. yd. (320 kg/cu. m).

4. Slump Limit: 5 inches (125 mm), plus or minus 1 inch (25 mm).
 5. Air Content:
 - a. Exposure Class F1: As indicated on Drawings.
 - b. Exposure Classes F2 and F3: As indicated on Drawings.
 6. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.
 - a. Do not use an air-entraining admixture or allow total air content to exceed 3 percent for concrete used in trowel-finished toppings.
 7. Steel-Fiber Reinforcement: Add to concrete mixture, in accordance with manufacturer's written instructions, at a rate of 50 lb/cu. yd. (29.7 kg/cu. m).
 8. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of 1.0 lb/cu. yd. (0.60 kg/cu. m).
 9. Synthetic Macro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of 4.0 lb/cu. yd. (2.4 kg/cu. m).
- G. Class G: Normal-weight concrete used for building frame members.
1. Exposure Class: ACI 318 (ACI 318M), Class as indicated on Drawings.
 2. Minimum Compressive Strength: As indicated, at 28 days.
 3. Maximum w/cm: 0.50.
 4. Slump Limit: 5 inches (125 mm), plus or minus 1 inch (25 mm).
 5. Slump Flow Limit: 22 inches (550 mm), plus or minus 1.5 inches (40 mm).
 6. Air Content:
 - a. Exposure Class F1: As indicated on Drawings.
 - b. Exposure Classes F2 and F3: As indicated on Drawings.
 7. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.
- H. Class H: Normal-weight concrete used for building walls.
1. Exposure Class: ACI 318 (ACI 318M), Class as indicated on Drawings.
 2. Minimum Compressive Strength: As indicated, at 28 days.
 3. Maximum w/cm: 0.50.
 4. Slump Limit: 5 inches (125 mm), plus or minus 1 inch (25 mm).
 5. Slump Flow Limit: 22 inches (550 mm), plus or minus 1.5 inches (40 mm).
 6. Air Content:
 - a. Exposure Class F1: As indicated on Drawings.
 - b. Exposure Classes F2 and F3: As indicated on Drawings.
 7. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.
- I. Class J: Normal-weight concrete used for exterior retaining walls.
1. Exposure Class: ACI 318 (ACI 318M), Class as indicated on Drawings.
 2. Minimum Compressive Strength: As indicated, at 28 days.
 3. Maximum w/cm: 0.50.

4. Slump Limit: 5 inches (125 mm), plus or minus 1 inch (25 mm).
5. Slump Flow Limit: 22 inches (550 mm), plus or minus 1.5 inches (40 mm).
6. Air Content:
 - a. Exposure Class F1: As indicated on Drawings.
 - b. Exposure Classes F2 and F3: As indicated on Drawings.
7. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

2.11 CONCRETE MIXING

- A. General: Comply with additional Owner requirements as set forth in the following attachments included at the end of this Section:
 1. Appendix No. 1 – SRP Standard Specification for Concrete.
 2. Appendix No. 2 – SRP Standard Concrete Mixes.
- B. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete in accordance with ASTM C94/C94M and ASTM C1116/C1116M, and furnish batch ticket information.
- C. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete in accordance with ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 1. For mixer capacity of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than five minutes after ingredients are in mixer, before any part of batch is released.
 2. For mixer capacity larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions:
 1. Before placing concrete, verify that installation of concrete forms, accessories, and reinforcement, and embedded items is complete and that required inspections have been performed.
 2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Provide reasonable auxiliary services to accommodate field testing and inspections, acceptable to testing agency, including the following:

1. Daily access to the Work.
2. Incidental labor and facilities necessary to facilitate tests and inspections.
3. Secure space for storage, initial curing, and field curing of test samples, including source of water and continuous electrical power at Project site during site curing period for test samples.
4. Security and protection for test samples and for testing and inspection equipment at Project site.

3.3 INSTALLATION OF 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.
1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 2. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of ANSI/AISC 303.
 3. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.

3.4 JOINTS

- A. Construct joints true to line, with faces perpendicular to surface plane of concrete.
- B. Construction Joints: Coordinate with floor slab pattern and concrete placement sequence.
1. Install so strength and appearance of concrete are not impaired, at locations indicated on Drawings or as approved by Architect.
 2. Place joints perpendicular to main reinforcement.
 - a. Continue reinforcement across construction joints unless otherwise indicated.
 - b. Do not continue reinforcement through sides of strip placements of floors and slabs.
 3. Form keyed joints as indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
 4. Locate joints for beams, slabs, joists, and girders at third points of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 5. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 6. Space vertical joints in walls as indicated on Drawings. Unless otherwise indicated on Drawings, locate vertical joints beside piers integral with walls, near corners, and in concealed locations where possible.
 7. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

8. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- C. Control Joints in Slabs-on-Ground: Form weakened-plane control joints, sectioning concrete into areas as indicated. Construct control joints for a depth equal to at least one-fourth of concrete thickness as follows:
1. Grooved Joints: Form control joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch (3.2 mm). Repeat grooving of control joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
 2. Sawed Joints: Form control joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3.2-mm-) wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random cracks.
- D. Isolation Joints in Slabs-on-Ground: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated on Drawings.
 2. Terminate full-width joint-filler strips not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished concrete surface, where joint sealants, specified in Section 07 92 00 "Joint Sealants," are indicated.
 3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
- E. Doweled Joints:
1. Install dowel bars and support assemblies at joints where indicated on Drawings.
 2. Lubricate or asphalt coat one-half of dowel bar length to prevent concrete bonding to one side of joint.
- F. Dowel Plates: Install dowel plates at joints where indicated on Drawings.

3.5 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, embedded items, and vapor retarder is complete and that required inspections are completed.
1. Immediately prior to concrete placement, inspect vapor retarder for damage and deficient installation, and repair defective areas.
 2. Provide continuous inspection of vapor retarder during concrete placement and make necessary repairs to damaged areas as Work progresses.
- B. Notify Architect and testing and inspection agencies 24 hours prior to commencement of concrete placement.

- C. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect in writing, but not to exceed the amount indicated on the concrete delivery ticket.
 - 1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

- D. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301 (ACI 301M), but not to exceed the amount indicated on the concrete delivery ticket.
 - 1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

- E. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness.
 - 1. If a section cannot be placed continuously, provide construction joints as indicated.
 - 2. Deposit concrete to avoid segregation.
 - 3. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.
 - 4. Consolidate placed concrete with mechanical vibrating equipment in accordance with ACI 301 (ACI 301M).
 - a. Do not use vibrators to transport concrete inside forms.
 - b. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer.
 - c. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity.
 - d. At each insertion, limit duration of vibration to time necessary to consolidate concrete, and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

- F. 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. Do not place concrete floors and slabs in a checkerboard sequence.
 - 2. Consolidate concrete during placement operations, so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
 - 3. Maintain reinforcement in position on chairs during concrete placement.
 - 4. Screed slab surfaces with a straightedge and strike off to correct elevations.
 - 5. Level concrete, cut high areas, and fill low areas.
 - 6. Slope surfaces uniformly to drains where required.
 - 7. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface.
 - 8. Do not further disturb slab surfaces before starting finishing operations.

3.6 FINISHING FORMED SURFACES

A. As-Cast Surface Finishes:

1. ACI 301 (ACI 301M) Surface Finish SF-1.0: As-cast concrete texture imparted by form-facing material.
 - a. Patch voids larger than 1-1/2 inches (38 mm) wide or 1/2 inch (13 mm) deep.
 - b. Remove projections larger than 1 inch (25 mm).
 - c. Tie holes do not require patching.
 - d. Surface Tolerance: ACI 117 (ACI 117M) Class D.
 - e. Apply to concrete surfaces not exposed to public view.
2. ACI 301 (ACI 301M) Surface Finish SF-2.0: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams.
 - a. Patch voids larger than 3/4 inch (19 mm) wide or 1/2 inch (13 mm) deep.
 - b. Remove projections larger than 1/4 inch (6 mm).
 - c. Patch tie holes.
 - d. Surface Tolerance: ACI 117 (ACI 117M) Class B.
 - e. Locations: Apply to concrete surfaces to receive a rubbed finish,.
3. ACI 301 (ACI 301M) Surface Finish SF-3.0:
 - a. Patch voids larger than 3/4 inch (19 mm) wide or 1/2 inch (13 mm) deep.
 - b. Remove projections larger than 1/8 inch (3 mm).
 - c. Patch tie holes.
 - d. Surface Tolerance: ACI 117 (ACI 117M) Class A.
 - e. Locations: Apply to concrete surfaces exposed to public view, or to be covered with a coating or covering material applied directly to concrete.

B. Rubbed Finish: Apply the following to as cast surface finishes where indicated on Drawings:

1. Smooth-Rubbed Finish:
 - a. Perform no later than one day after form removal.
 - b. Moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture.
 - c. If sufficient cement paste cannot be drawn from the concrete by the rubbing process, use a grout made from the same cementitious materials used in the in-place concrete.
 - d. Maintain required patterns or variances as shown on Drawings or to match field sample panels or mockups.
2. Grout-Cleaned Rubbed Finish:
 - a. Clean concrete surfaces after contiguous surfaces are completed and accessible.
 - b. Do not clean concrete surfaces as Work progresses.

- c. Mix 1 part portland cement to 1-1/2 parts fine sand, complying with ASTM C144 or ASTM C404, by volume, with sufficient water to produce a mixture with the consistency of thick paint. Add white portland cement in amounts determined by trial patches, so color of dry grout matches adjacent surfaces.
 - d. Wet concrete surfaces.
 - e. 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.
 - f. Maintain required patterns or variances as shown on Drawings or to match field sample panels or mockups.
 - g. Cork-Floated Finish:
 - h. Mix 1 part portland cement to 1 part fine sand, complying with ASTM C144 or ASTM C404, by volume, with sufficient water to produce a mixture with the consistency of thick paint.
 - i. Mix 1 part portland cement and 1 part fine sand with sufficient water to produce a mixture of stiff grout. Add white portland cement in amounts determined by trial patches, so color of dry grout matches adjacent surfaces.
 - j. Wet concrete surfaces.
 - k. Compress grout into voids by grinding surface.
 - l. In a swirling motion, finish surface with a cork float.
 - m. Maintain required patterns or variances as shown on Drawings or to match mockups.
3. Scrubbed Finish: After concrete has achieved a compressive strength of from 1000 to 1500 psi (6.9 to 10.3 MPa), apply scrubbed finish.
- a. Wet concrete surfaces thoroughly and scrub with stiff fiber or wire brushes, using water freely, until top mortar surface is removed and aggregate is uniformly exposed.
 - b. Rinse scrubbed surfaces with clean water.
 - c. Maintain continuity of finish on each surface or area of Work.
 - d. Remove only enough concrete mortar from surfaces to match field sample panels or mockups.

C. Related Unformed Surfaces:

1. At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a color and texture matching adjacent formed surfaces.
2. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.7 FINISHING FLOORS AND SLABS

- A. Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Scratch Finish:

1. While still plastic, texture concrete surface that has been screeded and bull-floated or darbied.
2. Use stiff brushes, brooms, or rakes to produce a profile depth of 1/4 inch (6 mm) in one direction.
3. Apply scratch finish to surfaces to receive concrete floor toppings and to receive mortar setting beds for bonded cementitious floor finishes.

C. Float Finish:

1. When bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operation of specific float apparatus, consolidate concrete surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats.
2. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture and complies with ACI 117 (ACI A117M) tolerances for conventional concrete.
3. Apply float finish to surfaces to receive trowel finish and to be covered with fluid-applied or sheet waterproofing, or built-up or membrane roofing.

D. Trowel Finish:

1. After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel.
2. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance.
3. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
4. Do not add water to concrete surface.
5. Do not apply hard-troweled finish to concrete, which has a total air content greater than 3 percent.
6. Apply a trowel finish to surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
7. Finish surfaces to the following tolerances, in accordance with ASTM E1155 (ASTM E1155M), for a randomly trafficked floor surface:
 - a. Slabs on Ground Less Than 10,000 sq. ft. (929 sq. m):
 - 1) Finish and measure surface so gap at any point between concrete surface and an unlevelled, freestanding, 10-ft.- (3.05-m-) long straightedge resting on two high spots and placed anywhere on the surface does not exceed 1/8 inch (3 mm).
 - b. Slabs on Ground Greater Than 10,000 sq. ft. (929 sq. m):
 - 1) Slabs Scheduled to Receive Carpeting: Specified overall values of flatness, F_F 25; and of levelness, F_L 20; with minimum local values of flatness, F_F 17; and of levelness, F_L 15.
 - 2) Slabs Scheduled to Receive Resilient, Wood, or Tile Flooring: Specified overall values of flatness, F_F 35; and of levelness, F_L 25; with minimum local values of flatness, F_F 24; and of levelness, F_L 17.

- 3) Slabs Scheduled to Receive Polished Finish or Resinous Flooring: Specified Overall Value (SOV): F_F 50 and F_L 25 with minimum local value (MLV): F_F 40 and F_L 17.
- 4) Slabs Scheduled to Receive Wood Flooring on Sleepers: Specified Overall Value (SOV): F_F 25 and F_L 20 with minimum local value (MLV): F_F 17 and F_L 15.
- c. Suspended Slabs Less Than 10,000 sq. ft. (929 sq. m):
 - 1) Finish and measure surface so gap at any point between concrete surface and an unlevelled, freestanding, 10-ft.- (3.05-m-) long straightedge resting on two high spots and placed anywhere on the surface does not exceed 3/16 inch (4.8 mm).
- d. Suspended Slabs Greater Than 10,000 sq. ft. (929 sq. m):
 - 1) Slabs Scheduled to Receive Carpeting: Specified overall values of flatness, F_F 25; and of levelness, F_L 20; with minimum local values of flatness, F_F 17; and of levelness, F_L 15.
 - 2) Slabs Scheduled to Receive Resilient, Wood, or Tile Flooring: Specified overall values of flatness, F_F 35; and of levelness, F_L 20; with minimum local values of flatness, F_F 24; and of levelness, F_L 15.
- E. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces where ceramic or quarry tile is to be installed by either thickset or thinset method, and elsewhere as indicated on Drawings. While concrete is still plastic, slightly scarify surface with a fine broom perpendicular to main traffic route.
 1. Coordinate required final finish with Architect before application.
 2. Comply with flatness and levelness tolerances for trowel-finished floor surfaces.
- F. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and locations indicated on Drawings.
 1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.
 2. Coordinate required final finish with Architect before application.
- G. Slip-Resistive Finish: Before final floating, apply slip-resistive aggregate finish to concrete stair treads, platforms, ramps as indicated on Drawings
 1. Apply in accordance with manufacturer's written instructions and as follows:
 - a. Uniformly spread 25 lb/100 sq. ft. (12 kg/10 sq. m) of dampened slip-resistive aggregate over surface in one or two applications.
 - b. Tamp aggregate flush with surface, but do not force below surface.
 - c. After broadcasting and tamping, apply float finish.
 - d. After curing, lightly work surface with a steel wire brush or an abrasive stone and water to expose slip-resistive aggregate.
- H. Dry-Shake Floor Hardener Finish: After initial floating, apply dry-shake floor hardener to surfaces in accordance with manufacturer's written instructions and as follows:
 1. Uniformly apply dry-shake floor hardener at a rate of 100 lb/100 sq. ft. (49 kg/10 sq. m) unless greater amount is recommended by manufacturer.

2. Uniformly distribute approximately two-thirds of dry-shake floor hardener over surface by hand or with mechanical spreader, and embed by power floating.
3. Follow power floating with a second dry-shake floor hardener application, uniformly distributing remainder of material, and embed by power floating.
4. After final floating, apply a trowel finish.
5. Cure concrete with curing compound recommended by dry-shake floor hardener manufacturer and apply immediately after final finishing.

3.8 INSTALLATION OF MISCELLANEOUS CONCRETE ITEMS

A. Filling In:

1. Fill in holes and openings left in concrete structures after Work of other trades is in place unless otherwise indicated.
2. Mix, place, and cure concrete, as specified, to blend with in-place construction.
3. Provide other miscellaneous concrete filling indicated or required to complete the Work.

- #### B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

3.9 CONCRETE CURING

A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

1. Comply with ACI 301 (ACI 301M) and ACI 306.1 for cold weather protection during curing.
2. Comply with ACI 301 (ACI 301M) and ACI 305.1 (ACI 305.1M) for hot-weather protection during curing.
3. Maintain moisture loss no more than 0.2 lb/sq. ft. x h (1 kg/sq. m x h), calculated in accordance with ACI 305.1,) before and during finishing operations.

B. Curing Formed Surfaces: Comply with ACI 308.1 (ACI 308.1M) as follows:

1. Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces.
2. Cure concrete containing color pigments in accordance with color pigment manufacturer's instructions.
3. If forms remain during curing period, moist cure after loosening forms.
4. If removing forms before end of curing period, continue curing for remainder of curing period, as follows:
 - a. Continuous Fogging: Maintain standing water on concrete surface until final setting of concrete.
 - b. Continuous Sprinkling: Maintain concrete surface continuously wet.

- c. Absorptive Cover: Pre-dampen absorptive material before application; apply additional water to absorptive material to maintain concrete surface continuously wet.
 - d. Water-Retention Sheeting Materials: Cover exposed concrete surfaces with sheeting material, taping, or lapping seams.
 - e. Membrane-Forming Curing Compound: Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's written instructions.
 - 1) Recoat areas subject to heavy rainfall within three hours after initial application.
 - 2) Maintain continuity of coating and repair damage during curing period.
- C. Curing Unformed Surfaces: Comply with ACI 308.1 (ACI 308.1M) as follows:
- 1. Begin curing immediately after finishing concrete.
 - 2. Interior Concrete Floors:
 - a. Floors to Receive Floor Coverings Specified in Other Sections: Contractor has option of the following:
 - 1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - a) Lap edges and ends of absorptive cover not less than 12-inches (300-mm).
 - b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.
 - 2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive.
 - a) Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - b) Cure for not less than seven days.
 - 3) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:
 - a) Water.
 - b) Continuous water-fog spray.
 - b. Floors to Receive Penetrating Liquid Floor Treatments: Contractor has option of the following:
 - 1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - a) Lap edges and ends of absorptive cover not less than 12 inches (300 mm).
 - b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.

- 2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive.
 - a) Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - b) Cure for not less than seven days.
- 3) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:
 - a) Water.
 - b) Continuous water-fog spray.
- c. Floors to Receive Polished Finish: Contractor has option of the following:
 - 1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - a) Lap edges and ends of absorptive cover not less than 12 inches (300 mm).
 - b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.
 - 2) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:
 - a) Water.
 - b) Continuous water-fog spray.
- d. Floors to Receive Chemical Stain:
 - 1) As soon as concrete has sufficient set to permit application without marring concrete surface, install curing paper over entire area of floor.
 - 2) Install curing paper square to building lines, without wrinkles, and in a single length without end joints.
 - 3) Butt sides of curing paper tight; do not overlap sides of curing paper.
 - 4) Leave curing paper in place for duration of curing period, but not less than 28 days.
- e. Floors to Receive Urethane Flooring:
 - 1) As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - 2) Rewet absorptive cover, and cover immediately with polyethylene moisture-retaining cover with edges lapped 6 inches (150 mm) and sealed in place.
 - 3) Secure polyethylene moisture-retaining cover in place to prohibit air from circulating under polyethylene moisture-retaining cover.
 - 4) Leave absorptive cover and polyethylene moisture-retaining cover in place for duration of curing period, but not less than 28 days.
- f. Floors to Receive Curing and Sealing Compound:
 - 1) Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller in accordance with manufacturer's written instructions.

- 2) Recoat areas subjected to heavy rainfall within three hours after initial application.
- 3) Repeat process 24 hours later, and apply a second coat. Maintain continuity of coating, and repair damage during curing period.

3.10 TOLERANCES

- A. Conform to ACI 117 (ACI 117M).

3.11 APPLICATION OF LIQUID FLOOR TREATMENTS

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

3.12 JOINT FILLING

- A. Prepare, clean, and install joint filler in accordance with manufacturer's written instructions.
 1. Defer joint filling until concrete has aged at least six month(s).
 2. 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 joints clean and dry.
- C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches (50 mm) deep in formed joints.
- D. Overfill joint, and trim joint filler flush with top of joint after hardening.

3.13 CONCRETE SURFACE REPAIRS

- A. Defective Concrete:
 1. Repair and patch defective areas when approved by Architect.
 2. Remove and replace concrete that cannot be repaired and patched to Architect's approval.

- B. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling and placing.
- C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch (13 mm) in any dimension to solid concrete.
 - a. Limit cut depth to 3/4 inch (19 mm).
 - b. Make edges of cuts perpendicular to concrete surface.
 - c. Clean, dampen with water, and brush-coat holes and voids with bonding agent.
 - d. Fill and compact with patching mortar before bonding agent has dried.
 - e. 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 matches surrounding color.
 - a. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching.
 - b. Compact mortar in place and strike off slightly higher than surrounding surface.
 3. Repair defects on concealed formed surfaces that will affect concrete's durability and structural performance as determined by Architect.
- D. Repairing Unformed Surfaces:
1. Test unformed surfaces, such as floors and slabs, for finish, and verify surface tolerances specified for each surface.
 - a. Correct low and high areas.
 - b. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
 2. Repair finished surfaces containing surface defects, including spalls, popouts, honeycombs, rock pockets, crazing, and cracks in excess of 0.01 inch (0.25 mm) wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
 3. After concrete has cured at least 14 days, correct high areas by grinding.
 4. Correct localized low areas during, or immediately after, completing surface-finishing operations by cutting out low areas and replacing with patching mortar.
 - a. Finish repaired areas to blend into adjacent concrete.
 5. Correct other low areas scheduled to receive floor coverings with a repair underlayment.
 - a. Prepare, mix, and apply repair underlayment and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 - b. Feather edges to match adjacent floor elevations.

6. Correct other low areas scheduled to remain exposed with repair topping.
 - a. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch (6 mm) to match adjacent floor elevations.
 - b. Prepare, mix, and apply repair topping and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 7. Repair defective areas, except random cracks and single holes 1 inch (25 mm) or less in diameter, by cutting out and replacing with fresh concrete.
 - a. Remove defective areas with clean, square cuts, and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around.
 - b. Dampen concrete surfaces in contact with patching concrete and apply bonding agent.
 - c. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate.
 - d. Place, compact, and finish to blend with adjacent finished concrete.
 - e. Cure in same manner as adjacent concrete.
 8. Repair random cracks and single holes 1 inch (25 mm) or less in diameter with patching mortar.
 - a. Groove top of cracks and cut out holes to sound concrete, and clean off dust, dirt, and loose particles.
 - b. Dampen cleaned concrete surfaces and apply bonding agent.
 - c. Place patching mortar before bonding agent has dried.
 - d. Compact patching mortar and finish to match adjacent concrete.
 - e. Keep patched area continuously moist for at least 72 hours.
- E. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.
- F. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.14 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector to perform field tests and inspections and prepare testing and inspection reports.
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
 1. Testing agency shall be responsible for providing curing container for composite samples on Site and verifying that field-cured composite samples are cured in accordance with ASTM C31/C31M.
 2. Testing agency shall immediately report to Architect, Contractor, and concrete manufacturer any failure of Work to comply with Contract Documents.
 3. Testing agency shall report results of tests and inspections, in writing, to Owner, Architect, Contractor, and concrete manufacturer within 48 hours of inspections and tests.

- a. Test reports shall include reporting requirements of ASTM C31/C31M, ASTM C39/C39M, and ACI 301, including the following as applicable to each test and inspection:
 - 1) Project name.
 - 2) Name of testing agency.
 - 3) Names and certification numbers of field and laboratory technicians performing inspections and testing.
 - 4) Name of concrete manufacturer.
 - 5) Date and time of inspection, sampling, and field testing.
 - 6) Date and time of concrete placement.
 - 7) Location in Work of concrete represented by samples.
 - 8) Date and time sample was obtained.
 - 9) Truck and batch ticket numbers.
 - 10) Design compressive strength at 28 days.
 - 11) Concrete mixture designation, proportions, and materials.
 - 12) Field test results.
 - 13) Information on storage and curing of samples before testing, including curing method and maximum and minimum temperatures during initial curing period.
 - 14) Type of fracture and compressive break strengths at seven days and 28 days.

- C. Batch Tickets: For each load delivered, submit three copies of batch delivery ticket to testing agency, indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, design slump at time of batching, and amount of water that can be added at Project site.

- D. Inspections:
 1. Headed bolts and studs.
 2. Verification of use of required design mixture.
 3. Concrete placement, including conveying and depositing.
 4. Curing procedures and maintenance of curing temperature.
 5. Verification of concrete strength before removal of shores and forms from beams and slabs.

- E. Concrete Tests: Testing of composite samples of fresh concrete obtained in accordance with ASTM C 172/C 172M shall be performed in accordance with the following requirements:
 1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd. (4 cu. m), but less than 25 cu. yd. (19 cu. m), plus one set for each additional 50 cu. yd. (38 cu. m) or fraction thereof.
 - a. When frequency of testing provides fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C143/C143M:
 - a. One test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture.

- b. Perform additional tests when concrete consistency appears to change.
3. Slump Flow: ASTM C1611/C1611M:
 - a. One test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - b. Perform additional tests when concrete consistency appears to change.
4. Air Content: ASTM C231/C231M pressure method, for normal-weight concrete; ASTM C173/C173M volumetric method, for structural lightweight concrete.
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
5. Concrete Temperature: ASTM C1064/C1064M:
 - a. One test hourly when air temperature is 40 deg F (4.4 deg C) and below or 80 deg F (27 deg C) and above, and one test for each composite sample.
6. Unit Weight: ASTM C567/C567M fresh unit weight of structural lightweight concrete.
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
7. Compression Test Specimens: ASTM C31/C31M:
 - a. Cast and laboratory cure two sets of four 6-inch (150 mm) by 12-inch (300 mm) or 4-inch (100 mm) by 8-inch (200 mm) cylinder specimens for each composite sample.
 - b. Cast, initial cure, and field cure two sets of four standard cylinder specimens for each composite sample.
8. Compressive-Strength Tests: ASTM C39/C39M.
 - a. Test one set of two laboratory-cured specimens at seven days and one set of two specimens at 28 days.
 - b. Test one set of two field-cured specimens at seven days and one set of two specimens at 28 days.
 - c. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
9. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
10. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength, and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa) if specified compressive strength is 5000 psi (34.5 MPa), or no compressive strength test value is less than 10 percent of specified compressive strength if specified compressive strength is greater than 5000 psi (34.5 MPa).
11. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
12. Additional Tests:

- a. Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
 - b. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/C42M or by other methods as directed by Architect.
 - 1) Acceptance criteria for concrete strength shall be in accordance with ACI 301 (ACI 301M), section 1.6.6.3.
13. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 14. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
- F. Measure floor and slab flatness and levelness in accordance with ASTM E1155 (ASTM E1155M) within 48 hours of completion of floor finishing and promptly report test results to Architect.

3.15 PROTECTION

- A. Protect concrete surfaces as follows:
1. Protect from petroleum stains.
 2. Diaper hydraulic equipment used over concrete surfaces.
 3. Prohibit vehicles from interior concrete slabs.
 4. Prohibit use of pipe-cutting machinery over concrete surfaces.
 5. Prohibit placement of steel items on concrete surfaces.
 6. Prohibit use of acids or acidic detergents over concrete surfaces.
 7. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.
 8. Protect concrete surfaces scheduled to receive surface hardener or polished concrete finish using Floor Slab Protective Covering.

3.16 ATTACHMENTS

- A. Appendix No. 1 – SRP Standard Specification for Concrete.
- B. Appendix No. 2 – SRP Standard Concrete Mixes.

END OF SECTION

SECTION 03 30 00 – CAST-IN-PLACE CONCRETE
APPENDIX No. 1

SALT RIVER PROJECT
STANDARD SPECIFICATION
FOR CONCRETE
(SRP 03300)

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REVISED: J. ADAMS

APPROVED: K. L. CHHIBBER

STANDARD SPECIFICATION
FOR CONCRETE
(SRP 03300)

1.0 **GENERAL**

1.1 Work Specified: This specification covers the furnishing of all plant, labor, materials, and equipment necessary for designing, mixing, and delivering normal weight Portland cement concrete ready for placement.

1.2 Work Performed by Concrete Supplier: Concrete Supplier is defined as the concrete supplier responsible for designing, proportioning, mixing, and delivering Portland cement concrete. Concrete may be requested either by the Buyer, or by the Contractor engaged by the Buyer.

1.3 Standard Units: English units are the standard.

1.4 Reference Standards:

1.4.1 Reference to standards or specifications shall be interpreted to mean the latest revision unless noted otherwise.

1.4.2 The following abbreviations appear in this Specification:

ACI	American Concrete Institute
ADEQ	Arizona Department of Environmental Quality
ARPA	Arizona Rock Products Association
ASTM	American Society for Testing and Materials
EPA	U.S. Environmental Protection Agency
ICC	International Code Council
MAG	Maricopa Association of Governments
NRMCA	National Ready-Mixed Concrete Association
SRP	Salt River Project

1.4.3 The following standards shall be made a part of this Specification:

ACI 212.3R	Report on Chemical Admixtures for Concrete
ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305.1	Specification for Hot Weather Concreting
ACI 306.1	Standard Specification for Cold Weather Concreting

ACI 318	Building Code Requirements for Reinforced Concrete
ASTM C31	Standard Practice for Making and Curing Test Specimens in the Field
ASTM C25	Standard Test Method for Chemical Analysis of Limestone, Quicklime and Hydrated Lime
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C40	Standard Test Method for Organic Impurities in Fine Aggregate for Concrete
ASTM C42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C94	Standard Specification for Ready-Mixed Concrete
ASTM C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement
ASTM C117	Standard Test Method for Materials Finer than (75- μ m (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123	Standard Test Method for Lightweight Particles in Aggregate
ASTM C127	Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
ASTM C128	Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C138	Standard Test Method for Unit Weight, Yield, and Air Contents (Gravimetric) of Concrete
ASTM C142	Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143	Standard Test Method for Slump of Hydraulic Cement Concrete
ASTM C150	Standard Specification for Portland Cement
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete

ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C233	Standard Test Method for Air-Entraining Admixtures for Concrete
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C311	Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C403	Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance
ASTM C494	Standard Specification for Chemical Admixtures for Concrete
ASTM C618	Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for use as a Mineral Admixture in Portland Cement Concrete
ASTM C937	Standard Specification for Grout Fluidifer for Preplaced-Aggregate Concrete
ASTM C1064	Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete
ASTM C1097	Standard Specification for Hydrated Lime for Use in Asphalt Cement or Bituminous Paving Mixtures
ASTM C1116	Standard Specification for Fiber Reinforced Concrete
ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM C1603	Standard Test Method for Measurement of Solids in Water
ASTM D512	Standard Test Methods for Chloride Ion in Water
ASTM D516	Standard Test Method for Sulfate Ion in Water
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D5821	Standard Test Method for Determining Percentage of Fractured Particles in Coarse Aggregate
ASTM D7508	Standard Specification for Polyolefin Chopped Strands for Use in Concrete
ICC AC32	Acceptance Criteria for Concrete with Synthetic Fibers
MAG Section 725	Portland Cement Concrete

1.4.4 Exceptions to this specification shall be approved in writing by the Buyer prior to beginning the affected Work.

1.5 Submittals:

1.5.1 Concrete Supplier shall submit the following items for each batch plant (Plant) and mix to be supplied. All submittals must be current and signed by person responsible for testing and/or certification. Expired and unsigned submittals may be rejected. Testing, sampling, and certification must be performed by a qualified, independent laboratory, agency, engineer, and/or oversight group:

- a. Plant Certification: A plant certification is required for each Plant proposed by Concrete Supplier to provide material. Certification to consist of ARPA Certification of Performance for Concrete Production Facilities, or NRMCA Plant Certification.
- b. Portland Cement Certification and Mill Test Report: Manufacturer's certification is required from each source of Portland cement used in proposed mixes. Certification to include Certification of Test for Portland cement Type II/V Low Alkali meeting requirements of ASTM C150. Certification of Test to be dated within 1-year of submittal date and must include source of Portland cement.
- c. Fly Ash Certification: Pozzolan Test Report is required from each source of fly ash used in proposed mixes. Test Report shall meet requirements of ASTM C618. Sampling and testing shall meet requirements of ASTM C311. Test Report to be dated within 1-year of submittal date and must include source of fly ash.
- d. Hydrated Lime Certification: Certificate of Analysis is required from each source of hydrated lime used in proposed mixes. Certification shall meet requirements of ASTM C1097. Certification to be dated within 1-year of submittal date and must include source of hydrated lime.
- e. Source of Water and Water Certification: Water used for the concrete mix and washing aggregate to meet requirements of ASTM C1602. State source of water for each proposed Plant as either City or "Other." City water does not require a submittal. Submit chemical analysis of "Other" water performed by an independent, qualified laboratory certifying suitability in accordance with ASTM C114 and ASTM C1603 for each proposed plant that uses "Other" water. Water analysis methods must meet ADEQ Accepted Laboratory Methods, and, as a minimum, should include the following:

- Alkalies (calculated)
- Chloride Content (EPA SM 4500-Cl C)
- Sulfate Content (EPA SM 4500-SO4 D)
- Total Potassium (EPA 200.7)
- Total Sodium (EPA 200.7)
- Total Solids (EPA SM 2540 B)

Water certification must be dated within 1-year of submittal date. Report to include sample source, sample date, and sample time.

- f. Scale Certification: Documents of Certification are required for all scales used to weigh aggregates, cement, and admixtures. Certifications are required for every scale that may be used at each proposed plant. Date of certification must be within 1-year of submittal date.
- g. Fine Aggregate Certification: Fine aggregates to meet requirements of ASTM C33. Submit testing results of fine aggregates to be used within proposed mixes for each proposed plant. Where a single stockpile provides material for more than one plant, this stockpile requires only one certification with statement of which proposed plants the stockpile provides material. Date of certification must be within 1-year of submittal date. Testing, as a minimum, should include the following:
- Sieve Analysis of Fine and Coarse Aggregates (ASTM C136)
 - Amount of Material Finer Than #200 Sieve (ASTM C117)
 - Fineness Modulus (ASTM C136)
 - Liquid Limit, Plastic Limit and Plasticity Index of Soils (ASTM D4318)
 - Sand Equivalent Value for Soils and Fine Aggregate (ASTM D2419)
 - Specific Gravity and Absorption of Coarse Aggregate (ASTM C128)
 - Soundness of Aggregate by use of Sodium Sulfate (ASTM C88)
 - Lightweight Particles in Aggregate (ASTM C123)
 - Clay Lumps and Friable Particles in Aggregate (ASTM C142)
 - Organic Impurities in Fine Aggregates for Concrete (ASTM C40)
- h. Coarse Aggregate Certification: Coarse aggregates to meet requirements of ASTM C33. Submit testing results of all single size and blended coarse aggregates used within proposed mixes for each proposed plant. Where a single stockpile provides material for more than one proposed plant, this stockpile requires only one certification with statement of which proposed plants the stockpile provides material. Date of certification must be within 1-year of submittal date. Testing, as a minimum, should include the following:
- Sieve Analysis of Fine and Coarse Aggregates (ASTM C136)

- Amount of Material Finer Than #200 Sieve (ASTM C117)
 - Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine (ASTM C131)
 - Clay Lumps and Friable Particles in Aggregate (ASTM C142)
 - Lightweight Pieces in Aggregate (ASTM C123)
 - Specific Gravity and Absorption of Coarse Aggregate (ASTM C127)
 - Soundness of Aggregate by use of Sodium Sulfate (ASTM C88)
 - Percentage of Crushed Particle in Mineral Aggregate (ASTM D5821)
 - Potential Alkali Silica Reaction (ASTM C1260/C1567)
- i. Admixture Certification: Submit manufacturer certifications for proposed admixtures to be used in proposed mixes. Admixtures requiring certification, as a minimum, may include the following:
- Normal Water Reducing Admixture (NWRA)
 - Mid-Range Water Reducing Admixture (MRWRA)
 - High-Range Water Reducing Admixtures (HRWRA)
 - Air Entraining Admixture (AEA)
 - Hydration Stabilizer Admixture “Retarder” (HSA)
 - Accelerator Admixture (Acc)
 - Micro and Macro-Fiber Admixture
 - Permeability Reducing Admixture for Concrete Subject to Hydrostatic Conditions (PRAH)
- j. Mix Designs: Provide sealed mix design for each proposed mix from each proposed plant. Mix designs that are used at more than one proposed plant require only a single submittal with comment on which proposed plants the mix design applies. Mix design to include SRP stock code number, SRP SAP material item number, SRP product name, Concrete Supplier product code number, and Concrete Supplier product name. SRP stock code number is currently used by Concrete Supplier and SRP in ordering material. The new SRP SAP material item number is not presently used by Concrete Supplier and SRP, but will eventually be phased in. Mix design to include the applicable proportions, weights, and quantities of individual materials incorporated into the mix including the size of aggregates, type cement and fly ash, and the brand and designation of admixtures.
- Mix design must be sealed within 1-year of the submittal date by an Arizona-registered professional engineer responsible for the mix.
- Preliminary submittals may use mix designs that are not sealed; however, final submittal of mix design must be sealed.

- k. Mix Design Performance and/or Trial Batch History: Provide performance history (including results of trial batches when available) for each proposed mix. Performance history includes items such as slump, compressive strength, time of set, delayed time of set with hydration stabilizer admixture, flow rate, thermal resistivity (ρ), etc. If performance data is not available so state.
- 1.5.2 Concrete Supplier shall use SRP mix stock code numbers, SRP SAP material item nos., and SRP product names to refer to mixes, but may assign Concrete Supplier product code numbers and Concrete Supplier product names in addition to SRP mix stock code numbers and product names specified in Table 1. SRP SAP material item numbers are currently not used by Concrete Supplier and SRP, but will be eventually phased in.
 - 1.5.3 Mixes and plants that have already been submitted to and approved by Buyer, and are current, do not require re-submittal.
 - 1.5.4 In addition to specified materials and mixes, Concrete Supplier may submit alternative mix designs or deviations to the specifications for review and approval. Buyer may request additional test and/or certification documentation before approving alternatives.
- 1.6 Quality Assurance:
 - 1.6.1 Each batch plant from which Concrete Supplier intends to provide materials governed by this specification must have current NRMCA, ARPA, or equivalent certification.
 - 1.6.2 Concrete Supplier shall provide access to batch plant to Buyer and Buyer's Representative for sampling/inspection of materials and equipment as required by the Buyer.
- 1.7 Storage and Handling:
 - 1.7.1 Materials shall be stored and handled in a manner that prevents deterioration, segregation, or intrusion of foreign matter.
 - 1.7.2 Storage of aggregate on natural ground surface will be permitted if bottom six inches of pile is not used in batching.
- 2.0 PRODUCT
 - 2.1 Cement: Portland Cement, Type II, low alkali, moderate heat of hydration, ASTM C150. Equivalent alkali content shall not exceed 0.60 percent, per Table 2, ASTM C150.
 - 2.2 Coarse and Fine Aggregate: ASTM C33. Fine aggregate shall be sized as noted in Table 1 of ASTM C33. Coarse aggregate shall be sized as presented in Table 3 of ASTM C33.

2.3 Water: Water for washing aggregate and for mixing concrete shall be potable. If potable water is not used, chemical analysis of water shall be performed certifying suitability in accordance with ASTM C94, ASTM C1602, ASTM C1603, ASTM D512, and ASTM D516 by a qualified, independent testing laboratory. Testing will be at Concrete Supplier's expense.

2.4 Admixtures: Admixtures shall be certified by manufacturer and shall be approved by the Buyer prior to use. Admixtures shall be added at the plant at the time of batching, unless otherwise noted. Admixtures shall contain not more than 0.1 percent water-soluble chloride ions by mass and shall be compatible with other admixtures. Do not use admixtures containing calcium chloride. Superplasticizer may be added at batch plant or at Jobsite.

2.4.1 Air-Entraining Admixtures:

- a. Air-entraining admixtures: ASTM C260.
- b. Testing of air-entraining admixtures: ASTM C233.
- c. Air content (unless specified otherwise): ASTM 94, Section 6.1.4, 1, moderate exposure. Tolerance for air content as delivered ± 1.5 percent.

2.4.2 Water-Reducing, Hydration Stabilizing (Retarding), and Accelerating Admixtures:

- a. Water-reducing admixtures: ASTM C494, Type A.
- b. Water-reducing and retarding admixtures: ASTM C494, Type B & D.
- c. Accelerating Admixtures: ASTM C494, Type C.
- d. Water-reducing and accelerating admixture: ASTM C494, Type E.
- e. Water-reducing, high range admixtures (superplasticizers): ASTM C494, Type F.
- f. Water-reducing, high range, and retarding admixtures: ASTM C494, Type G.

2.4.3 Fiber Admixtures:

- a. Macro-fiber, micro-fiber, and macro/micro fiber blend admixtures: ASTM C1116.
- b. Steel Fiber-Reinforced Concrete: ASTM C1116, Type I.
- c. Glass Fiber-Reinforced Concrete: ASTM C1116, Type II.
- d. Synthetic Fiber-Reinforced Concrete: ASTM C1116, Type III, ASTM D7508, and ICC AC32.
- e. Natural Fiber-Reinforced Concrete: ASTM C1116, Type IV.

- f. Fiber may be ordered per ASTM C1116, Section 6, Option A where Buyer assumes responsibility for mixture proportioning and dictates type and dosage of fiber admixtures. Fiber reinforcement ordered by the Buyer will be synthetic macro-fiber, polypropylene copolymer, 2-inches long, unless otherwise requested. Synthetic micro-fiber, or blend of macro/micro fibers may be requested by the Buyer.
- g. Fiber may be ordered per ASTM C1116, Section 6, Option B where Buyer specifies required flexural performance and requires Concrete Supplier to assume full responsibility for fiber type and mixture proportioning. Fiber of Option B may be ASTM Type I, II, III, or IV.
- h. Fiber may be ordered per ASTM C1116, Section 6, Option C where Buyer specifies minimum allowable cement content and required flexural performance, and requires Concrete Supplier to assume responsibility for fiber type and mixture proportioning. Fiber of Option C may be ASTM Type I, II, III, or IV.
- i. Dosage of fiber admixture shall be in pounds per cubic yard of material.

2.4.4 Grout Fluidifiers: ASTM C937.

2.4.5 Permeability Reducing Admixtures: Permeability reducing admixtures must be hydrophilic crystalline product for concrete subject to hydrostatic conditions (PRAH), ACI 212.3R.

2.5 Fly Ash: ASTM C618, Class F.

2.5.1 Fly ash shall be used in all proposed mixes, unless noted otherwise in Table 1.

2.5.2 Fly ash shall be compatible with cement and shall not react deleteriously with alkalis in cement.

2.5.3 Maximum fly ash replacement ratio of cementitious material within mixes shall be as specified within MAG Section 725 "Portland Cement Concrete," unless otherwise specified by the Buyer. Concrete Supplier shall be responsible to determine replacement ratio for each pound of replaced cement to maintain specified compressive strength f'_c and specified performance.

2.6 Proportioning of Mix: ASTM C94.

2.6.1 Option A: Buyer specifies requirement for compressive strength and Concrete Supplier to assume full responsibility for the selection of proportions for the concrete mixture.

2.6.2 Option B: Buyer assumes responsibility for the proportioning of the mixture.

2.6.3 Option C: Buyer specifies minimum allowable cement content and Concrete Supplier to assume responsibility for the selection of the proportions for the mix.

2.6.4 Minimum cementitious material content shall be as recommended in Table 725-1 of MAG Section 725.

Minimum Cementitious Material Content by Concrete Class (Table 725-1, Section 725 of MAG).		
Class of Concrete	Minimum Cementitious Materials Content (lbs./CY)	Minimum Compressive Strength at 28-Days (psi)
AA	600	4000
A	520	3000
B	470	2500
C	420	2000

- 2.6.5 Proportioning of ingredients shall produce a consistent, durable, and workable product that meets specified compressive strength, slump, properties per referenced standards in Section 1.4, requirements of Table 1, and other performance properties as required by the application. Mix shall be homogeneous, readily placeable, and sufficiently and uniformly workable.
- 2.6.6 Source, character or gradation of materials shall not be changed without notification of the Buyer. New mix design and possible performance verification must be submitted to the Buyer for approval when modifications to the mix are categorized in MAG Section 725 as “Modifications that require a new mix design submittal/approval and may require performance verification.”
- 2.7 Measuring Materials: ASTM C94.
- 2.8 Mixing: ASTM C94.
- 2.8.1 Concrete to be central-mixed with all ingredients added to the mix at the batch plant, unless otherwise noted. High range water reducing admixtures (superplasticizers) may be added at batch plant or at Jobsite.
- 2.8.2 Fibers shall be added to the mix per manufacturer’s recommendations and at a rate that insures proper distribution throughout the mix (no clumping). Materials with fiber admixture shall be mixed for a minimum of 5-minutes at high rpm.
- 2.8.3 Fly ash and cement shall be added in a manner and at a rate as to minimize presence of incomplete mixed nodules. Dry nodules over 1-inch diameter are not allowed. Concrete containing non-uniform material exceeding 1% of the total volume may be rejected by the Buyer with full cost the responsibility of the Concrete Supplier.
- 2.8.4 Retarding admixtures may be added to concrete to meet slump requirements and compensate for travel time to specific Jobsites. Volume of retarding agent added is responsibility of Concrete Supplier. Type and volume must be approved by the Buyer prior to batching.
- 2.9 Delivery and Batch Ticket:
- 2.9.1 Delivery: Section 12 of ASTM C94.
- 2.9.2 Batch/Delivery Ticket: Section 14 of ASTM C94.

- 2.9.3 Copy of delivery ticket is to be given to the Buyer at time of delivery. Batch out time of truck shall be machine-stamped on delivery ticket at Concrete Supplier's Plant. Concrete deliveries without machine-stamped batch out time on delivery ticket may be rejected by the Buyer.
- 2.9.4 **Delivery ticket must include SRP Mix Stock Code No., SRP SAP Material Item No., SRP Product Name, Concrete Supplier Product Code No., and Concrete Supplier Product Name.** Material delivered with a delivery ticket that does not include these items may be rejected by the Buyer. SRP SAP material item number is currently not used by Material Supplier and SRP, but will eventually be phased in.
- 2.9.5 Concrete shall be delivered within 30 minutes of requested delivery time. Time lapse between successive deliveries shall not vary by more than 20 minutes from that requested. The Buyer may reject any batch not meeting these requirements.
- 2.10 Hot Weather Concreting: ACI 305.1.
- 2.10.1 Concrete temperature during discharge shall not exceed 90°F.
- 2.10.2 During conditions of high temperature, low relative humidity, or wind which might impair quality of concrete, setting time shall be delayed by using proper admixtures upon approval by the Buyer.
- 2.11 Cold Weather Concreting: ACI 306.1.
- 2.11.1 Required concrete temperatures shall be as recommended in Table 3.2.1 of ACI 306.1. Concrete temperature during discharge shall not be less than 55°F.
- 2.12 Direct and Indirect Costs:
- 2.12.1 Direct and indirect costs incurred by Buyer due to failure to meet requirements of this specification shall be paid by Concrete Supplier and/or Contractor.
- 3.0 **EXECUTION**
- 3.1 Placement:
- 3.1.1 Placement of Concrete and Cementitious Materials: Section 26.5.2 of ACI 318, ACI 304R, and Section 12 of ASTM C94.
- 3.1.2 Unless a different allowable temperature range is pre-approved by the Buyer, temperature of concrete during production, delivery, and discharge shall never be outside the temperature range of 55°F (13°C) to 90°F (32°C). Concrete that is outside the temperature range of 55°F to 90°F, concrete that has become unworkable, or concrete that has attained its initial set, as determined by the Buyer, may be rejected at the Concrete Supplier's and/or Contractor's cost. Buyer may waive these limitations if slump, workability, and temperature is such that concrete can be placed as specified without the addition of water.

- 3.1.3 Unless designed using pre-approved set delay additives, concrete shall be discharged within 1-1/2 hours after initial mixing water has been added to cement and aggregate. This limitation may be waived by the Buyer if the concrete is of such slump, workability, and temperature after 1-1/2 hours that it can be placed, without addition of water to the mix. In hot weather, or under conditions contributing to rapid stiffening of the concrete, a time less than 1-1/2 hours may be specified by the Buyer.
- 3.1.4 Concrete Supplier shall be responsible to make corrections to bring mix to specified slump. Additional water may be added at the Jobsite in accordance with Paragraph 12.7 of ASTM C94 provided the slump after such water addition does not exceed the maximum allowed by the Mix Design, and the water/cementitious material ratio does not exceed that specified by the Mix Design. All water additions are to be completed within 15 minutes from the start of first water addition. Added water must be mixed into the batch for a minimum of 30 additional revolutions at mixing speed. Mix not meeting slump requirements may be rejected by the Buyer at the Concrete Supplier's cost.
- 3.1.5 Material shall be placed at a rate so as to provide adequate supply at the location of placement, at a rate at all times so material retains sufficient workability and can be self-consolidated or consolidated by external method, material remains homogeneous without segregation or loss of material, without interruptions between successive placements that may result in cold joints, and deposited near its final location to avoid segregation due to rehandling or flowing.
- 3.1.6 Cementitious material is prohibited to be in contact with aluminum, copper, or brass. No aluminum, copper, or brass conduits and tremies shall be used to pump or place cementitious material.
- 3.1.7 Masonry filler units that will be in contact with concrete shall be pre-wetted prior to placing concrete.
- 3.1.8 Free-fall height greater than 5 feet is prohibited, unless otherwise approved by the Buyer.
- 3.2 Testing, Strength Compliance, and Acceptance of Concrete:
- 3.2.1 Testing:
- a. Concrete samples will be taken directly from discharge of ready-mix transit truck. Sampling and testing will be in accordance with the following standards:
- | | |
|------------|---------------------|
| ASTM C138 | Unit Weight & Yield |
| ASTM C143 | Slump |
| ASTM C172 | Sampling |
| ASTM C231 | Air |
| ASTM C1064 | Temperature |
- b. Frequency for sampling concrete for strength compliance: Section 17 of ASTM C94 with the exception that Buyer standard requires one test per minimum 50 CY, or as otherwise specified by the Buyer.

- c. Frequency for sampling and testing for slump, air-content, and temperature compliance: Section 17 of ASTM C94, or as otherwise specified by the Buyer. Buyer requires, as a minimum, that this testing be performed when strength specimens are made. Testing of air content only required for batches that include an air-entraining admixture, unless otherwise directed by the Buyer.
- d. Standard set of cylindrical concrete samples for compressive strength testing to consist of 1 at 7-days, 2 at 28-days, and 1-hold cylinder, unless otherwise specified by the Buyer.
- e. Making and curing of concrete strength specimens: ASTM C31. Test specimens 4" diameter by 8" tall cylinders.
- f. Compressive strength testing of cylindrical concrete specimens: ASTM C39.

3.2.2 Testing specified in subsection 3.2.1 will be performed by the Buyer at no cost to Concrete Supplier or Contractor unless otherwise stated in the contract documents.

3.2.3 Compliance With Compressive Strength Provisions:

- a. Compressive strength will be considered satisfactory if test results meet the following requirements and Section 18 of ASTM C94, unless otherwise specified by the Buyer:
- b. 7-day average compressive strength per strength test (average of minimum two cylinder tests) equals or exceeds 70 percent of specified compressive strength f'c.
- c. 28-day average compressive strength of all sets of three consecutive strength tests equals or exceeds specified compressive strength f'c. A set of strength tests consists of minimum two (2) 28-day test cylinders.
- d. For specified compressive strength of 5,000 psi or less, no individual set of strength test (average of minimum two cylinder tests) falls more than 500 psi below specified compressive strength f'c when at least three sets of strength tests are made. When less than three sets of strength tests are made, no individual cylinder strength falls below specified compressive strength f'c.
- e. For specified compressive strength greater than 5,000 psi, no set of strength test (average of minimum two cylinder tests) shall be less than 0.90 f'c. When less than three sets of strength tests are made, no individual cylinder strength falls below specified compressive strength f'c.

3.2.4 Failure to Meet Compliance Requirements:

- a. Failure to meet requirements of subsection 3.2.3a indicates that potentially low-strength concrete has been delivered. Concrete Supplier and Contractor will be notified of potential problem for remedial action.

- b. Failure to meet requirements of subsections 3.2.3b or 3.2.3c or 3.2.3d shall be basis for investigation of low-strength concrete per subsection 3.2.5.

3.2.5 Investigation of Low-Strength Concrete:

- a. A set of three cores representing each strength test shall be taken.
- b. Cores shall be taken within 72 hours of testing for 28-day compressive strength, or as specified by the Buyer, in accordance with ASTM C42 and tested in accordance with ASTM C39.
- c. Concrete Supplier and/or Contractor shall be responsible for costs associated with investigation of low-strength concrete. However, Concrete Material Supplier's and Contractor's cost will be reimbursed if requirements of subsection 3.2.6 have been satisfied.

3.2.6 Acceptance of Low-Strength Concrete:

- a. Concrete in an area represented by core tests will be considered acceptable if the average of three cores is minimum 85 percent of specified compressive strength f'c and no single core is less than 75 percent of specified compressive strength f'c.
- b. When low-strength concrete is accepted by the Buyer on the basis of test results of less than 100% of the required minimum compressive strength, an adjustment in the concrete unit price may be made for the quantity of concrete represented by such strength tests in accordance with Table 725-2 of MAG Section 725.

Table 725-2 of MAG Section 725			
Class AA and Class A		Class B and Class C	
Percent of Specified Minimum 28-day Compressive Strength Attained (Nearest 1%)	Percent of Concrete Unit Price Allowed	Percent of Specified Minimum 28-day Compressive Strength Attained (Nearest 1%)	Percent of Concrete Unit Price Allowed
100% or greater	100	100% or greater	100
98-99	90	95-99	95
96-97	85	90-94	90
95	80	85-89	85

- 3.2.7 Rejection of Low-Strength Concrete: Concrete failing to meet acceptance requirements of subsection 3.2.6 will be rejected. Concrete Supplier and/or Contractor shall be responsible for direct and indirect costs of removal and replacement of rejected concrete.

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**SECTION 03 30 00 – CAST-IN-PLACE CONCRETE
APPENDIX No. 2**

TABLE 1: SRP STANDARD CONCRETE MIXES (11-4-2019)

SRP SAP NUMBER	SRP STOCK CODE NUMBER	Description	Specified Min. Compressive Strength @ 28- Days f'c (psi)	Coarse Aggregate Max. Size, ASTM C33 Table 2 (in)	Slump Range (in)	Air Content (+/- 1.5%) (%)	Min. Cementitious Material (#/CY)	Max. Water/ Cementitious Material Ratio (by Wt.)	Remarks	
5075320	00-00220	MAG C - 1"	2,000	1" (#57)	3 to 5	1.5	420	N/A	Can use as Canal Bottom	
5079391	00-00222	ASTM C-476 Grout for Masonry (Coarse) - 3/8" w/Fly Ash		3/8" (#8)	7 to 11	1.5	PMD	0.55	Mix Per ASTM C476. 1-Part C+P, (0 to 0.10) Part Lime, Fine Agg (2.25 to 3) Times C+P, Coarse Agg (1 to 2) Times C+P (vol.). Use Superplasticizer.	
5075323	00-00230	MAG A - 1" or SRP Normal 3000 Mix	3,000	1" (#57)	3 to 5	1.5	520	0.58	Can Use as Canal Bottom	
5079409	00-00231	MAG A - 1" Flowable			5 to 8				Use Superplasticizer. Can Use as Canal Bottom	
	00-00232	MAG A - 1/2" w/Air or SRP Slipform		1/2" (#7)	2 to 4	5.5				
5075324	00-00233	MAG A - 1/2" or SRP Cable Trench			3 to 5	1.5				
5079319	00-00234	SRP 3000 Shotcrete - 3/8" w/5# Fiber		3/8" (#8)	2 to 4	5.5	PMD	0.50	Use Superplasticizer. Use AEA.	
5079345	00-00235	MAG A - 3/8" w/Air or SRP Ditchmix			3 to 5	6.0	520	0.58	Use AEA.	
	00-00236	SRP 3000 Shotcrete - 3/8" No Fiber		1/2" (#7)	2 to 4	5.5	PMD	0.50	Use AEA.	
	00-00237	MAG A - 1/2" Flowable			5 to 8				Use Superplasticizer	
	00-00238	MAG A - 1/2" Pumpable		3 to 5	1.5	520	0.58	CA Max 40% of Total Agg (vol.)		
	00-00239	MAG A - 1/2" Flowable & Pumpable		5 to 8				CA Max 40% of Total Agg (vol.). Use Superplasticizer.		
5079320	00-00240	MAG AA - 1" or SRP Normal 4000 Mix	4,000	1" (#57)	3 to 5	1.5	600	0.50		
5079326	00-00241	MAG AA - 1" w/Air				5.0			Use AEA.	
5079336	00-00242	MAG AA - 1" Flowable			5 to 8	1.5			Use Superplasticizer	
5079321	00-00243	MAG AA - 1" Flowable w/Air				5.0			Use Superplasticizer. Use AEA.	
5079368	00-00244	SRP 4000 1/2" Precast - No Fly Ash		1/2" (#7)	3 to 5	1.5				
	00-00245	SRP 4000 Pumpable - 1/2"			3 to 6		CA Max 40% of Total Agg (vol.).			
5079341	00-00250	SRP 5000 - 1" Normal	5,000	1" (#57)	3 to 5	1.5	660	0.45		
5079369	00-00251	SRP 5000 - 1" w/Air				5.0			Use AEA.	
5079362	00-00252	SRP 5000 - 1" Flowable			5 to 8	1.5			Use Superplasticizer.	
5079348	00-00253	SRP 5000 - 1" Flowable w/Air				5.0			Use Superplasticizer. Use AEA.	
5079349	00-00254	SRP 5000 - 1" No Fly Ash		1/2" (#7)	3 to 5	1.5				
5079350	00-00255	SRP 5000 - 1/2"								
5079351	00-00256	SRP 5000 - 1/2" No Fly Ash								
	00-00257	SRP 3000@24-Hrs 5000@28-Days - 1"			1" (#57)			PMD	0.40	

Notes:

- 1) Fiber Admixture may be added to any mix. Either Buyer dictates type and amount of fiber per ASTM C1116 Order Information Option A; or Buyer provides minimum flexural strength and Concrete Supplier determines mix proportions including fiber type and dosage. Fiber may consist of Macro, Micro, or Macro/Micro blend meeting requirements of ASTM C1116 "Fiber-Reinforced Concrete."
- 2) Hydration stabilizer admixtures (HSA, retarders) can be added to any mix. Buyer to either dictate dosage rate of HSA, or Buyer to dictate required extension in initial set of product (extending workability of product) and Concrete Supplier to determine admixture type and dosage.
- 3) Permeability reducing admixtures for concrete subject to hydrostatic conditions (PRAH) may be added to any mix. Buyer to either dictate PRAH type and dosage rate, or Buyer to dictate required specification and Concrete Supplier to determine type and dosage.

PMD - Per Mix Design

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SECTION 03 30 53

MISCELLANEOUS CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes for miscellaneous applications, including but not limited to the following items:

1. Exterior: *Edit List to suit project.*
 - a. Thrust blocks for water utility piping.
 - b. Encasement for conduits in underground ductbanks.
 - c. Pads for plumbing cleanouts.
 - d. Transformer pads.
 - e. HVAC equipment pads.
 - f. Foundations for ground-set flagpoles.
 - g. Foundation for site light poles.
 - h. Foundation for site light bollards.
 - i. Foundations for fencing and gate posts.
 - j. Foundations for operable gate operators.
 - k. Foundations for electric vehicle charging stations.
 - l. Foundations for ground-mounted site furnishings.
 - m. Foundations for playing field equipment.
 - n. Foundations for temporary project identification sign.
 - o. Foundations for traffic and parking signage posts.
 - p. Foundations for parking control equipment.
 - q. Foundations for site wayfinding signage.
 - r. Foundations for bollards.
 - s. Concrete fill for pipe bollards.
2. Interior:
 - a. Crawl space mud slabs
 - b. M-E-P Equipment housekeeping pads.
 - c. Locker curbs / bases.
 - d. Fill for treads and platforms of metal pan stairs.
 - e. Topping slabs.
 - f. Floor slab patching where cutting is required to accommodate new work.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
1. Laboratory Test Reports: Submit for sealers and liquid floor treatments, indicating compliance with requirements for low emitting materials.

2. Regional Materials: Submit for materials manufactured within 500 miles (800 km) of Project for each raw material.
 - a. Sourcing Location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
 - b. Manufacturing Location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
 - c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
 - d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate percentage by weight of each component per unit of product.
3. Product Data, Low Emitting Materials: Submit product data for interior coatings, indicating VOC content limits and emissions and description of testing or certification for site installed interior materials and products.
4. Low Emitting Materials: Submit VOC content limits and emissions data, and description of testing or certification for site installed interior materials and products.
5. Construction Waste Management: Submit tabulating and supporting for salvaged, recycled, and reused building waste materials.

1.3 INFORMATIONAL SUBMITTALS

- A. Design Mixtures: For each concrete mixture.

1.4 QUALITY ASSURANCE

- A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. Comply with the following sections of ACI 301 (ACI 301M) unless modified by requirements in the Contract Documents:
 1. "General Requirements."
 2. "Formwork and Formwork Accessories."
 3. "Reinforcement and Reinforcement Supports."
 4. "Concrete Mixtures."
 5. "Handling, Placing, and Constructing."
- B. Comply with ACI 117 (ACI 117M).

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed.
- B. Plain-Steel Wire: ASTM A1064/A1064M, as drawn.
- C. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, plain, fabricated from as-drawn steel wire into flat sheets.
- D. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet.

2.3 CONCRETE MATERIALS

- A. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.
- B. Cementitious Materials:
 - 1. Portland Cement: ASTM C150/C150M, Type I.
- C. Normal-Weight Aggregate: ASTM C33/C33M, 1-inch (25-mm) nominal maximum aggregate size.
- D. Air-Entraining Admixture: ASTM C260/C260M.
- E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
 - 1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 - 2. Retarding Admixture: ASTM C494/C494M, Type B.
 - 3. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
 - 4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
 - 5. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
 - 6. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.
- F. Water: ASTM C94/C94M.

2.4 RELATED MATERIALS

- A. Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber, or ASTM D1752, cork or self-expanding cork.

2.5 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.
- B. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth or cotton mats.
- C. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.
- D. Water: Potable.

2.6 CONCRETE MIXTURES

- A. Comply with ACI 301 (ACI 301M).
- B. Normal-Weight Concrete:
 - 1. Minimum Compressive Strength: 3000 psi (20.7 MPa) at 28 days, unless otherwise indicated.
 - 2. Maximum W/C Ratio: 0.45.
 - 3. Maximum Size Aggregate: 3/4 inch (19 mm).
 - 4. Slump Limit: 5 inches (125 mm), plus or minus 1 inch (25 mm).
 - 5. Air Content: Maintain within range permitted by ACI 301 (ACI 301M). Do not allow air content of trowel-finished floor slabs to exceed 3 percent.
- C. Concrete Fill for Steel Pipe Bollards:
 - 1. Composed of ASTM C150 Type I Portland cement, ASTM C33 sand and coarse aggregates and potable water to produce a low slump mix suitable for placement.
 - 2. Grade coarse aggregate from 1/8 inch (3 mm) with at least 95% passing a 3/8 inch (9 mm) sieve and not more than 10% passing a No. 8 sieve.
 - 3. Proportion fill to provide a minimum 28 day compressive strength of 3000 psi (20 MPa).
- D. Normal-Weight Concrete for Interior Metal Pan Stairs and Landings:
 - 1. Minimum Compressive Strength: 3000 psi (20.7 MPa) at 28 days, unless otherwise indicated.
 - 2. Maximum W/C Ratio: 0.45.
 - 3. Minimum Cementitious Materials Content: 470 lb/cu. yd. (279 kg/cu. m).
 - 4. Maximum Size Aggregate: 1/2 inch (13 mm).
 - 5. Slump Limit: 3 inches (75 mm), plus 1 inch (25 mm) or minus 2 inches (50 mm).
 - 6. Air Content: 0 percent, plus or minus 0.5 percent at point of delivery.
 - 7. Retarding Admixture: Not allowed.
 - 8. Accelerating Admixture: Not allowed.

2.7 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94/C94M, and furnish batch ticket information.
 - 1. When air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 - 1. For mixer capacity of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 - 2. For mixer capacity larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
 - 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mix type, mix time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 FORMWORK INSTALLATION

- A. Design, construct, erect, brace, and maintain formwork according to ACI 301 (ACI 301M).

3.2 EMBEDDED ITEM INSTALLATION

- 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.

3.3 STEEL REINFORCEMENT INSTALLATION

- A. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
 - 1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

3.4 JOINTS

- A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
- B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

MISCELLANEOUS CAST-IN-PLACE CONCRETE

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- C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness, as follows:
 - 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch (3.2 mm). Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.
 - 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3.2-mm-) wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

- D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
 - 1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated.

3.5 CONCRETE PLACEMENT

- A. Comply with ACI 301 (ACI 301M) for placing concrete.
- B. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301 (ACI 301M).
- C. Do not add water to concrete during delivery, at Project site, or during placement.
- D. Consolidate concrete with mechanical vibrating equipment according to ACI 301 (ACI 301M).
- E. Equipment Bases and Foundations:
 - 1. Coordinate sizes and locations of concrete bases with actual equipment provided.
 - 2. Construct concrete bases 4 inches (100 mm) high unless otherwise indicated; and extend base not less than 6 inches (150 mm) in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated or unless required for seismic anchor support.
 - 3. Minimum Compressive Strength: 3500 psi (24.1 MPa) at 28 days.
 - 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor them into structural concrete substrate.
 - 6. Prior to pouring concrete, place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

7. Cast anchor-bolt insert into bases. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.6 FINISHING FORMED SURFACES

- A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections exceeding 1/2 inch (13 mm).
 1. Apply to concrete surfaces not exposed to public view.
- B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defective areas. Remove fins and other projections exceeding 1/8 inch (3 mm).
 1. Apply to concrete surfaces exposed to public view, to receive a rubbed finish, or to be covered with a coating or covering material applied directly to concrete.
- C. Rubbed Finish: Apply the following rubbed finish, defined in ACI 301 (ACI 301M), to smooth-formed-finished as-cast concrete where indicated:
 1. Smooth-rubbed finish.
 2. Grout-cleaned finish.
 3. Cork-floated finish.
- 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.

3.7 FINISHING UNFORMED SURFACES

- A. General: Comply with ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Screed surfaces with a straightedge and strike off. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane before excess moisture or bleedwater appears on surface.
 1. Do not further disturb surfaces before starting finishing operations.
- C. Scratch Finish: Apply scratch finish to surfaces indicated and surfaces to receive concrete floor topping or mortar setting beds for ceramic or quarry tile, portland cement terrazzo, and other bonded cementitious floor finishes unless otherwise indicated.
- D. Float Finish: Apply float finish to surfaces indicated, to surfaces to receive trowel finish, and to floor and slab surfaces to be covered with fluid-applied or sheet waterproofing, fluid-applied or direct-to-deck-applied membrane roofing, or sand-bed terrazzo.

- E. Trowel Finish: Apply a hard trowel finish to surfaces indicated and to floor and slab surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin film-finish coating system.
- F. 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 thinset methods. Immediately after second troweling, and when concrete is still plastic, slightly scarify surface with a fine broom.
- G. Slip-Resistive Broom Finish: Apply a slip-resistive finish to surfaces indicated and to exterior concrete platforms, steps, and ramps. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.

3.8 CONCRETE PROTECTING AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with ACI 305.1 (ACI 305.1M) for hot-weather protection during curing.
- B. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- C. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- D. Curing Methods: Cure formed and unformed concrete for at least seven days by one or a combination of the following methods:
 - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - a. Water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.
 - 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - 3. Housekeeping Pads:
 - a. 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.

- b. 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.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Owner reserves the right to engage a qualified testing agency to perform tests and inspections.
- B. Tests: Perform according to ACI 301 (ACI 301M).
 1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd. (4 cu. m), but less than 25 cu. yd. (19 cu. m), plus one set for each additional 50 cu. yd. (38 cu. m) or fraction thereof.
 2. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. (76 cu. m) or fraction thereof of each concrete mixture placed each day.

END OF SECTION

Project Name
Project Number

Deliverable
Issue Date

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MISCELLANEOUS CAST-IN-PLACE CONCRETE
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Last Updated:

August 2021

SECTION 03 37 13

SHOTCRETE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Wet-mix shotcrete.

1.2 DEFINITIONS

- A. Shotcrete: Mortar or concrete pneumatically projected onto a surface at high velocity.
- B. Dry-Mix Shotcrete: Shotcrete with most of the mixing water added at nozzle.
- C. Wet-Mix Shotcrete: Shotcrete with ingredients, including mixing water, mixed before introduction into delivery hose.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
1. Require representatives of each entity directly concerned with shotcrete to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for shotcrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Shotcrete Installer.
 2. Review methods and procedures related to shotcrete, but not limited to, the following:
 - a. Qualification data, equipment, and facilities needed to make progress and avoid delays.
 - b. Shotcrete finishes and finishing.
 - c. Cold- and hot-weather shotcreting procedures.
 - d. Curing procedures
 - e. Construction joints.
 - f. Forms and form-removal limitations.
 - g. Reinforcement accessory installation.
 - h. Shotcrete repair procedures.
 - i. Protection of shotcrete.
 3. Before submitting design mixtures, review each shotcrete design mixture and examine procedures for ensuring quality of shotcrete materials.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include reinforcement and forming accessories, shotcrete materials, admixtures, and curing compounds.
- B. Design Mixtures: For each shotcrete mixture. Submit alternative design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
- C. Shop Drawings: For shotcrete installation.
 - 1. Include plans, elevations, sections, and support and anchor details.
 - 2. Detail fabrication, bending, and placing of reinforcement; number and location of splices; and special reinforcement required for openings through shotcrete structures.
 - 3. Detail formwork fabrication, assembly, and support.
 - 4. Indicate locations of proposed construction joints.
- D. Samples: For waterstops, approximately 12 inches (300 mm) long.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Material Certificates: For each of the following:
 - 1. Cementitious materials.
 - 2. Admixtures.
 - 3. Form materials.
 - 4. Steel reinforcement and accessories.
 - 5. Fiber reinforcement.
 - 6. Waterstops.
 - 7. Curing compounds.
- C. Preconstruction Test Reports: For shotcrete.
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified installer employing nozzle operators for Project, each of whom attains mean core grades not exceeding 2.5, according to ACI 506.2, on preconstruction tests and is ACI Shotcrete Nozzleman certified in Wet-Mix Process for Vertical and Overhead Positions as appropriate to the required shotcrete work.
- B. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing indicated.

- C. Standard: Comply with ACI 506.2, "Specification for Shotcrete," unless otherwise indicated.
- D. Shotcrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design shotcrete mixtures.
- E. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 - 1. Build mockups for each finish required and for each design mixture, shooting orientation, and nozzle operator.
 - 2. Build mockups in the location and of the size indicated or, if not indicated, as directed by Architect.
 - 3. Demonstrate curing and protecting of shotcrete, finishes, and joints, as applicable.
 - 4. In presence of Architect, damage part of the exposed-face surface for each color and finish, and demonstrate materials and techniques proposed for repair of holes and surface blemishes to match adjacent undamaged surfaces.
 - 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 6. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Owner will engage a qualified testing agency to perform preconstruction testing on shotcrete.
 - 1. Produce and test shotcrete test panels before shotcrete placement according to requirements in ACI 506.2 for each design mixture, shooting orientation, and nozzle operator. Produce test panels with dimensions of 24 by 24 inches (600 by 600 mm) minimum and of average thickness of shotcrete, but not less than 3-1/2 inches (90 mm).
 - 2. From each test panel, testing agency shall obtain six test specimens: one set of three specimens unreinforced, and one set of three specimens reinforced. Agency will perform the following:
 - a. Strength Testing: Test each set of unreinforced specimens for compressive strength according to ASTM C42/C42M.
 - b. Core Grading: Visually inspect each set of reinforced shotcrete cores taken from test panels and determine mean core grades according to ACI 506.2.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.

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

PART 2 - PRODUCTS

2.1 FORM MATERIALS

- A. Forms: Form-facing panels that will provide continuous, straight, smooth, concrete surfaces. Furnish panels in largest practical sizes to minimize number of joints.

2.2 REINFORCING MATERIALS

- A. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed.
- B. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M, deformed.
- C. Galvanized Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed bars, ASTM A767/A767M, Class I zinc coated after fabrication and bending.
- D. Plain-Steel Wire: ASTM A1064/A1064M, as drawn.
- E. Welded Wire Reinforcement: ASTM A1064/A1064M, plain, fabricated from as-drawn steel wire, furnished in flat sheet.
- F. Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place; manufactured according to CRSI's "Manual of Standard Practice" and as follows:
 - 1. For uncoated reinforcement, use all-plastic bar supports.
 - 2. For zinc-coated reinforcement, use galvanized wire or dielectric-polymer-coated wire or all-plastic bar supports.
- G. Reinforcing Anchors: ASTM A36/A36M, unheaded rods or ASTM A307, Grade A, hex-head bolts; carbon steel; and carbon-steel nuts.
 - 1. Finish: Plain, uncoated.
- H. Zinc Repair Material: ASTM A780/A780M, zinc-based solder, paint containing zinc dust, or sprayed zinc.

2.3 SHOTCRETE MATERIALS

- A. Portland Cement: ASTM C150/C150M, Type II/V. Use only one brand and type of cement for Project.
 - 1. Fly Ash: ASTM C618, Class C or Class F.
 - 2. Slag Cement: ASTM C989/C989M, Grade 100 or Grade 120.
 - 3. Silica Fume: ASTM C1240, amorphous silica.

- B. Blended Hydraulic Cement: ASTM C595/C595M, Type IS, portland blast-furnace slag cement.
- C. Normal-Weight Aggregates: ASTM C33/C33M, from a single source, and as follows:
 - 1. Combined Aggregate Size: ACI 506R or ASTM C1436, Grading No. 1 sieve analysis.
 - 2. Deleterious Substances: As specified for coarse-aggregate Class 3S according to ASTM C33/C33M.
- D. Lightweight Aggregates: ASTM C330/C330M.
 - 1. Combined Aggregate Size: ACI 506R, Grading No. 1 sieve analysis.
- E. Water: Potable, complying with ASTM C94/C94M, and free from deleterious materials that may affect color stability, setting, or strength of shotcrete.
- F. Carbon-Steel Fiber: ASTM A820/A820M, Type II, cut sheet, deformed.
 - 1. Nominal Length: 1.5 inches (38 mm).
 - 2. Aspect Ratio: 60 to 65.
- G. Synthetic Fiber: Monofilament polypropylene fibers engineered and designed for use in shotcrete, complying with ASTM C1116/C1116M, Type III, 1.5 to 2 inches (38 to 50 mm) long.
- H. Ground Wire: High-strength steel wire, 0.8 to 1.0 mm in diameter.
- I. Joint Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber or ASTM D1752, cork or self-expanding cork.
- J. Admixtures: ASTM C1141/C1141M, Class A (liquid) or Class B (nonliquid), but limited to the following admixture materials. Provide admixtures for shotcrete that contain no more than 0.1 percent chloride ions. Certify compatibility of admixtures with each other and with other cementitious materials.
 - 1. Accelerating Admixture, Conventional: ASTM C494/C494M, Type C or Type E.
 - 2. Pozzolanic Admixture: Fly ash, slag cement, and silica fume as limited in "Portland Cement" Paragraph in this article.
 - 3. Coloring Admixture: ASTM C979/C979M, synthetic mineral-oxide pigment or colored, water-reducing admixture, free of carbon black; color stable, nonfading, and resistant to lime and other alkalis.
 - 4. Air-Entraining Admixture: As limited in "Shotcrete Mixtures" Article.

2.4 WATERSTOPS

- A. Flexible Rubber Waterstops: CE CRD-C 513, with factory-installed metal eyelets, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
 - 1. Profile: Ribbed without center bulb.

2. Dimensions: 4 inches by 3/16 inch thick (100 mm by 4.75 mm thick); nontapered.

- B. Self-Expanding Butyl Strip Waterstops: Manufactured rectangular or trapezoidal strip, butyl rubber with sodium bentonite or other hydrophilic polymers, for adhesive bonding to concrete, 3/4 by 1 inch (19 by 25 mm).
- C. Self-Expanding Rubber Strip Waterstops: Manufactured rectangular or trapezoidal strip, bentonite-free, hydrophilic polymer-modified chloroprene rubber, for adhesive bonding to concrete; 3/8 by 3/4 inch (10 by 19 mm).

2.5 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry, or cotton mats.
- B. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.
- D. Curing Compound: ASTM C309, Type 1, Class B; clear, **[waterborne] [solvent-borne]**, membrane-forming curing compound.

2.6 SHOTCRETE MIXTURES

- A. Source Limitations for Shotcrete: Obtain each color, size, type, and variety of shotcrete material and shotcrete mixture from single manufacturer with resources to provide shotcrete of consistent quality in appearance and physical properties.
- B. Design Mixtures: Prepare design mixtures for each type and strength of shotcrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 506.2.
 - 1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixture or field test data, or both.
- C. Cementitious Materials Replacing Portland Cement: Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.
- D. Cementitious Materials, Maximum Content: Limit use of fly ash to not exceed, in combination, 25 percent of portland cement by weight.
- E. Limit water-soluble chloride ions to maximum percentage by weight of cement or cementitious materials permitted by ACI 301 (ACI 301M).
- F. Admixtures: Use admixtures according to manufacturer's written instructions.

- G. Coloring Admixture: Add coloring admixture to shotcrete mixture according to manufacturer's written instructions and to result in hardened shotcrete color consistent with approved mockup.
- H. Design-Mixture Adjustments: Subject to compliance with requirements, shotcrete design-mixture adjustments may be proposed when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant.
- I. Shotcrete Mixture: Proportion mixture to provide shotcrete with the following properties:
 - 1. Compressive Strength (28 Days): As indicated on Drawings.
 - 2. Air Content: Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight wet-mix shotcrete having an air content before pumping of 7 percent with a tolerance of plus or minus 1-1/2 percent.
 - 3. Carbon-Steel Fiber: Uniformly disperse in shotcrete mix, according to manufacturer's written instructions, at a rate of 50 lb/cu. yd. (30 kg/cu. m).
 - 4. Synthetic Fiber: Uniformly disperse in shotcrete mix, according to manufacturer's written instructions, at a rate of 1.5 lb/cu. yd. (0.90 kg/cu. m).
 - 5. Color: As selected by Architect from manufacturer's full range of industry colors.
 - 6. Color of Finish Coat: As selected by Architect from manufacturer's full range of industry colors.

2.7 SHOTCRETE EQUIPMENT

- A. Mixing Equipment: Capable of thoroughly mixing shotcrete materials in sufficient quantities to maintain continuous placement.
- B. Wet-Mix Delivery Equipment: Capable of discharging aggregate-cement-water mixture accurately, uniformly, and continuously.

2.8 BATCHING AND MIXING

- A. Wet-Mix Process: Measure, batch, mix, and deliver shotcrete according to ASTM C94/C94M and ASTM C1116/C1116M and furnish batch ticket information.
 - 1. Comply with ASTM C685/C685M when shotcrete ingredients are delivered dry and proportioned and mixed on-site.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Concrete and Masonry Substrates: Before applying shotcrete, remove unsound or loose materials and contaminants that may inhibit shotcrete bonding. Chip or scarify areas to be repaired to extent necessary to provide sound substrate. Cut edges square and 1/2 inch (13 mm) deep at perimeter of work, tapering remaining shoulder at 1:1 slope into cavity to eliminate square shoulders. Dampen surfaces to saturated, surface-dry condition before shotcreting.

1. Abrasive blast or hydroblast existing surfaces that do not require chipping to remove paint, oil, grease, or other contaminants and to provide roughened surface for proper shotcrete bonding.
- B. Earth Substrates: Compact and trim to line and grade before placing shotcrete. Do not place shotcrete on frozen surfaces. Dampen surfaces to saturated, surface-dry condition before shotcreting.
- C. Rock Substrates: Clean rock surfaces of loose materials, mud, and other foreign matter that might weaken shotcrete bonding. Dampen surfaces to saturated, surface-dry condition before shotcreting.
- D. Steel Substrates: Clean steel surfaces by abrasive blasting according to SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

3.2 FORMS

- A. Design, erect, support, brace, and maintain forms, according to ACI 301 (ACI 301M), to support shotcrete and construction loads and to facilitate shotcreting. Construct forms so shotcrete members and structures are secured to prevent excessive vibration or deflection during shotcreting.
 1. Fabricate forms to be readily removable without impact, shock, or damage to shotcrete surfaces and adjacent materials.
 2. Construct forms to required sizes, shapes, lines, and dimensions using ground wires and depth gages to obtain accurate alignment, location, and grades in finished structures. Construct forms to prevent mortar leakage but permit escape of air and rebound during shotcreting. Provide for openings, offsets, blocking, screeds, anchorages, inserts, and other features required in the Work.
- B. Form openings, chases, recesses, bulkheads, keyways, and screeds in formwork. Determine sizes and locations from trades providing such items. Accurately place and securely support items built into forms.

3.3 STEEL REINFORCEMENT

- A. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that weaken shotcrete bonding.
- C. Securely embed reinforcing anchors into existing substrates, located as required.
- D. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports, bolsters, chairs, spacers, and other devices as required to maintain minimum concrete cover.
- E. Set wire ties with ends directed into shotcrete, not toward exposed shotcrete surfaces.

- F. Install welded wire reinforcement in largest practical sheets on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.
- G. Zinc-Coated Reinforcement: Repair cut and damaged zinc coatings with zinc repair material according to ASTM A780/A780M. Use galvanized-steel wire ties to fasten zinc-coated steel reinforcement.

3.4 JOINTS

- A. General: Construct joints at locations indicated or as approved by Architect.
- B. Construction Joints: Locate and install construction joints tapered to a 1:1 slope where joint is not subject to compression loads and square where joint is perpendicular to main reinforcement. Continue reinforcement through construction joints unless otherwise indicated.
- C. Contraction Joints: Construct contraction joints in shotcrete using saw cuts 1/8-inch- (3-mm-) wide by one-third of slab depth or joint-filler strips 1/4-inch- (6-mm-) wide by one-third of shotcrete depth unless otherwise indicated.
 - 1. After shotcrete has cured, remove strip inserts and clean groove of loose debris.
 - 2. Space joints at 15 feet (4.5 m) o.c. horizontally and vertically unless otherwise indicated.
 - 3. Tool edges round on each side of strip inserts if floated or troweled finishes are required.
 - 4. Where shooting over an existing substrate joint, align new shotcrete joint with existing joint.

3.5 INSTALLATION OF WATERSTOPS

- A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.
- B. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, adhesive bonding, mechanically fastening, and firmly pressing into place. Install in longest lengths practicable.
- C. Prevent waterstop displacement during shotcrete application.

3.6 ALIGNMENT CONTROL

- A. Ground Wires: Install ground wires to establish thickness and planes of shotcrete surfaces. Install ground wires at corners and offsets not established by forms. Pull ground wires taut and position adjustment devices to permit additional tightening.

3.7 EMBEDDED ITEMS

- A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by shotcrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

3.8 APPLICATION

- A. Apply shotcrete applied by wet-mix process and according to ACI 506.2.
- B. Apply temporary protective coverings and protect adjacent surfaces against deposit of rebound and overspray or impact from nozzle stream.
- C. Moisten wood forms immediately before placing shotcrete where form coatings are not used.
- D. Apply wet-mix shotcrete materials within 90 minutes after batching.
- E. Deposit shotcrete continuously in multiple passes, to required thickness, without cold joints and laminations developing. Place shotcrete with nozzle held perpendicular to receiving surface. Begin shotcreting in corners and recesses.
 - 1. Remove and dispose of rebound and overspray materials during shotcreting to maintain clean surfaces and to prevent rebound entrapment.
 - 2. Remove and dispose of cuttings during the trimming or rodding process to prevent unconsolidated material from falling onto lower reinforcement.
- F. Maintain reinforcement in position during shotcreting. Place shotcrete to completely encase reinforcement and other embedded items. Maintain steel reinforcement free of overspray, and prevent buildup against front face during shotcreting.
- G. Do not place subsequent lifts until previous lift of shotcrete is capable of supporting new shotcrete.
- H. Do not permit shotcrete to sag, slough, or dislodge.
- I. Remove hardened overspray, rebound, and laitance from shotcrete surfaces to receive additional layers of shotcrete; dampen surfaces before shotcreting.
- J. Do not disturb shotcrete surfaces before beginning finishing operations.
- K. Remove ground wires or other alignment-control devices after shotcrete placement.

- L. Shotcrete Core Grade: Apply shotcrete to achieve mean core grades not exceeding 2.5 according to ACI 506.2, with no single core grade exceeding 3.0.
- M. Installation Tolerances: Place shotcrete without exceeding installation tolerances permitted by ACI 117 (ACI 117M), increased by a factor of two.
- N. Cold-Weather Shotcreting: Mix, place, and protect shotcrete according to ACI 306.1 and as follows. Protect shotcrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - 1. Discontinue shotcreting when ambient temperature is 40 deg F (4.4 deg C) and falling.
 - 2. Uniformly heat water and aggregates before mixing to obtain a shotcrete shooting temperature of not less than 50 deg F (10 deg C) and no more than 90 deg F (32 deg C).
 - 3. Do not use frozen materials or materials containing ice or snow.
 - 4. Do not place shotcrete on frozen surfaces or surfaces containing frozen materials.
 - 5. Do not use calcium chloride, salt, or other materials containing antifreeze agents.
- O. Hot-Weather Shotcreting: Mix, place, and protect shotcrete according to ACI 305.1 when hot-weather conditions and high temperatures would seriously impair quality and strength of shotcrete, and as follows:
 - 1. Cool ingredients before mixing to maintain, at time of placement, shotcrete temperature below 90 deg F (32 deg C) for wet mix.
 - 2. Reduce temperature of reinforcing steel and receiving surfaces below 100 deg F (38 deg C) before shotcreting.

3.9 SURFACE FINISHES

- A. General: Finish shotcrete according to descriptions in ACI 506R.
- B. Natural Finishes:
 - 1. Gun Finish: Natural undisturbed finish as sprayed.
 - 2. Rod Finish: Rough-textured finish obtained by screeding or cutting exposed face of shotcrete to plane with cutting rod, edge of trowel, or straightedge after initial set. Do not push or float with flat part of trowel.
 - 3. Broom Finish: Rough-textured finish obtained by screeding or cutting exposed face of shotcrete to plane with cutting rod, edge of trowel, or straightedge after initial set; followed by uniform brooming.
- C. Flash-Coat Finish: After screeding or cutting exposed face of shotcrete to plane after initial set, apply up to 1/4-inch (6-mm) coat of shotcrete using ACI 506R, Grading No. 1, fine-screened sand modified with maximum aggregate size not exceeding No. 4 (4.75-mm) sieve to provide a finely textured finish.

- D. Flash-Coat with Final Finish: After screeding or cutting exposed face of shotcrete to plane after initial set, apply up to 1/4-inch (6-mm) coat of shotcrete using ACI 506R, Grading No. 1, fine-screened sand modified with maximum aggregate size not exceeding No. 4 (4.75-mm) sieve, and apply wood-float finish.
- E. Finish-Coat Finish: After screeding or cutting exposed face of shotcrete to plane after initial set, apply shotcrete finish coat, 1/4 to 1 inch (6 to 25 mm) thick, using ACI 506R, Grading No. 1, fine-screened sand modified with maximum aggregate size not exceeding No. 4 (4.75-mm) sieve to provide a finish of uniform texture and appearance.
- F. Finish-Coat with Final Finish: After screeding or cutting exposed face of shotcrete to plane after initial set, apply shotcrete finish coat, 1/4 to 1 inch (6 to 25 mm) thick, using ACI 506R, Grading No. 1, fine-screened sand modified with maximum aggregate size not exceeding No. 4 (4.75-mm) sieve, and apply rubber-float finish.

3.10 CURING

- A. Protect freshly placed shotcrete from premature drying and excessive cold or hot temperatures.
- B. Begin curing immediately after placing and finishing but not before free water, if any, has disappeared from shotcrete surface.
- C. Curing Exposed Surfaces: Cure shotcrete by one of the following methods:
 - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - a. Water.
 - b. Continuous water-fog spray.
 - c. Water-saturated absorptive covers or moisture-retaining covers. Lap and seal sides and ends of covers with 12-inch (300-mm) lap over adjacent covers.
 - 2. Curing Compound: Apply uniformly in continuous operation by power spray according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
 - a. Apply curing compound to natural gun and flash-coat finishes at rate of 1 gal./100 sq. ft. (1 L/2.5 sq. m).
- D. Curing Formed Surfaces: Cure formed shotcrete 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.

3.11 FORM REMOVAL

- A. Forms not supporting weight of shotcrete may be removed after curing for 24 consecutive hours at not less than 50 deg F (10 deg C), provided shotcrete is hard

enough not to be damaged by form-removal operations and provided curing and protecting operations are maintained.

1. Leave forms supporting weight of shotcrete in place until shotcrete has attained design compressive strength. Determine compressive strength of in-place shotcrete by testing representative field-cured specimens of shotcrete.
2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

- B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing materials are unacceptable for exposed surfaces. Apply new form-coating compound as specified for new formwork.

3.12 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Air Content: ASTM C173/C173M, volumetric method or ASTM C231/C231M, pressure method; one test for each compressive-strength test for each mixture of air-entrained, wet-mix shotcrete measured before pumping.
- C. Shotcrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each set of compressive-strength specimens.
- D. Test Panels: Make a test panel, reinforced as in structure, for each shotcrete mixture and for each workday or for every 50 cu. yd. (38 cu. m) of shotcrete placed, whichever is less. Produce test panels with dimensions of 24 by 24 inches (600 by 600 mm) minimum and of average thickness of shotcrete, but not less than 4-1/2 inches (115 mm). Testing agency will obtain sets of test specimens from each test panel.
1. Compressive Strength Testing: One set of three unreinforced specimens. Test each set of unreinforced specimens for compressive strength according to construction testing requirements in ACI 506.2.
 2. Visual Core Grading: One set of three reinforced specimens. Visually inspect each set of reinforced shotcrete cores taken from test panels and determine mean core grades according to ACI 506.2.
- E. In-Place Shotcrete Testing: One set of three unreinforced cores for each mixture and for each workday or for every 50 cu. yd. (38 cu. m) of shotcrete placed, whichever is less. Test cores for compressive strength according to ACI 506.2 and ASTM C42/C42M. Do not cut steel reinforcement.
- F. Strength of shotcrete will be considered satisfactory according to the following:
1. Specimen Cores: Mean compressive strength of each set of three unreinforced cores equals or exceeds 85 percent of specified compressive strength, with no individual core less than 75 percent of specified compressive strength.

2. Specimen Cubes: Mean compressive strength of each set of three unreinforced cubes shall equal or exceed design compressive strength with no individual cube less than 88 percent of specified compressive strength.

G. Shotcrete will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

3.13 REPAIRS

A. Remove and replace shotcrete that is delaminated or exhibits laminations, voids, or sand/rock pockets exceeding limits for specified core grade of shotcrete.

1. Remove unsound or loose materials and contaminants that may inhibit bond of shotcrete repairs.
2. Chip or scarify areas to be repaired to extent necessary to provide sound substrate. Cut edges square and 1/2 inch (13 mm) deep at perimeter of work, tapering remaining shoulder at 1:1 slope into cavity to eliminate square shoulders.
3. Dampen surfaces and apply new shotcrete. Match adjacent color and finish.

B. Repair core holes from in-place testing according to repair provisions in ACI 301 (ACI 301M), except do not use shotcrete. Match adjacent color and finish.

3.14 CLEANING

A. Immediately remove and dispose of rebound and overspray materials from final shotcrete surfaces and areas not intended for shotcrete placement.

END OF SECTION

SECTION 03 52 16

LIGHTWEIGHT INSULATING CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cast-in-place cellular foam lightweight insulating concrete.

B. Related Requirements:

1. Section 03 30 00 "Cast-in-Place Concrete" for requirements for normal-weight and structural lightweight concrete, including concrete materials and mixes.
2. Division 05 Section "Metal Roof Deck".

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

B. Shop Drawings: For lightweight insulating concrete.

1. Include plans, sections, and details showing roof slopes, thicknesses, and embedded insulation board.
2. Indicate locations of penetrations, perimeter terminations and curbs, control and expansion joints, and drains.

- C. Design Mixtures: For each lightweight insulating concrete mixture.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.

B. Product Certificates: For the following:

1. Cementitious materials.
2. Foaming agents.
3. Admixtures.
4. Molded-polystyrene insulation board.

- C. Evaluation Reports: For lightweight insulating concrete, from ICC-ES.

- D. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A firm that has been evaluated by UL and found to comply with requirements of NRDCA's Lightweight Insulating Concrete Roof Deck Contractors Accreditation Program.
- B. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing indicated.

1.6 FIELD CONDITIONS

- A. Do not place lightweight insulating concrete unless ambient temperature is at least 40 deg F (4.4 deg C) and rising.
 - 1. When air temperature has fallen or is expected to fall below 40 deg F (4.4 deg C), heat water to a maximum 120 deg F (49 deg C) before mixing so lightweight insulating concrete, at point of placement, reaches a temperature of 50 deg F (10 deg C) minimum and 80 deg F (27 deg C) maximum.
- B. Do not place lightweight insulating concrete during rain or snow or on surfaces covered with standing water, snow, or ice.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cellular Lightweight Insulating Concrete:
 - a. Cellcore Incorporated.
 - b. Elastizell Corporation of America.
 - c. Siplast Inc.

2.2 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance Ratings: Comply with ASTM E119; testing by a qualified testing agency.
 - 1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.
- B. FM Global Listing: Lightweight insulating concrete along with other roofing components shall comply with requirements in FM Global 4454 as part of a roof assembly, and shall be listed in FM Global's "RoofNav" for Class 1 or noncombustible construction, as applicable.

2.3 CELLULAR LIGHTWEIGHT INSULATING CONCRETE

- A. Produce cellular lightweight insulating concrete with the following minimum physical properties using cementitious materials, air-producing liquid-foaming agents complying with ASTM C869/C869M, and the minimum amount of water necessary to produce a workable mix:
1. As-Cast Unit Weight: 34 to 42 lb/cu. ft. (545 to 673 kg/cu. m) at point of placement, when tested according to ASTM C138/C138M.
 2. Oven-Dry Unit Weight: 26 to 32 lb/cu. ft. (416 to 513 kg/cu. m), when tested according to ASTM C495.
 3. Compressive Strength: Minimum 190 psi (1310 kPa), when tested according to ASTM C495.
 4. As-Cast Unit Weight: 40 to 48 lb/cu. ft. (641 to 770 kg/cu. m) at point of placement, when tested according to ASTM C138/C138M.
 5. Oven-Dry Unit Weight: 32 to 40 lb/cu. ft. (513 to 641 kg/cu. m), when tested according to ASTM C495.
 6. Compressive Strength: Minimum 250 psi (1723 kPa), when tested according to ASTM C495.

2.4 MATERIALS

- A. Cementitious Material: Portland cement, ASTM C150/C150M, Type I.
- B. Fly Ash: ASTM C 618, Class C or F.
- C. Water: Clean, potable.
- D. Joint Filler: ASTM C612, Class 2, glass-fiber type; compressing to one-half thickness under a load of 25 psi (172 kPa).
- E. Steel Wire Mesh: Cold-drawn steel wire, galvanized, 0.041-inch (1.04-mm) diameter, woven into 2-inch (50-mm) hexagonal mesh, and reinforced with a longitudinal 0.062-inch- (1.57-mm-) diameter wire spaced 3 inches (75 mm) apart.
- F. Galvanized Plain-Steel Welded Wire Reinforcement: ASTM A185/A185M, 2 by 2 inches (50 by 50 mm), W0.5 by W0.5, fabricated from galvanized-steel wire into flat sheets.
- G. Molded-Polystyrene Insulation Board: ASTM C578, Type I, 0.90-lb/cu. ft. (14.4-kg/cu. m) minimum density.
1. Provide units with manufacturer's standard keying slots or holes of 3 to 4 percent of board's gross surface area.

2.5 DESIGN MIXTURES

- A. Prepare design mixtures for each type and strength of lightweight insulating concrete by laboratory trial batch method or by field-test data method. For trial batch method,

use a qualified independent testing agency for preparing and reporting proposed mixture designs.

1. Limit use of fly ash to not exceed 20 percent of portland cement by weight.
- B. Limit water-soluble chloride ions to the maximum percentage by weight of cement or cementitious material permitted by ACI 301 (ACI 301M).

PART 3 - EXECUTION

3.1 PREPARATION

- A. Control Joints: Install control joints at perimeter of roof deck and at junctures with vertical surfaces, including curbs, walls, and vents, for full depth of lightweight insulating concrete. Fill control joints with joint filler.
1. Provide 1-inch- (25-mm-) wide control joints for roof dimensions up to 100 feet (30 m) in length; 1-1/2-inch- (38-mm-) wide control joints for roof dimensions exceeding 100 feet (30 m).
- B. Wire Mesh: Place steel wire mesh with longest dimension perpendicular to steel deck ribs. Cut mesh to fit around roof openings and projections. Terminate mesh at control joints. Lap sides and ends of mesh at least 6 inches (150 mm).
- C. Welded Wire Reinforcement: Place steel welded wire reinforcement with longest dimension perpendicular to steel deck ribs. Cut reinforcement to fit around roof openings and projections. Terminate reinforcement at control joints. Lap sides and ends of reinforcement at least 6 inches (150 mm).

3.2 MIXING AND PLACING

- A. Mix and place lightweight insulating concrete according to manufacturer's written instructions, using equipment and procedures to avoid segregation of mixture and loss of air content.
- B. Install insulation board according to lightweight insulating concrete manufacturer's written instructions. Place insulation board in wet, lightweight insulating concrete slurry poured a minimum of 1/8 inch (3 mm) over the structural substrate. Ensure full contact of insulation board with slurry. Stagger joints and tightly butt insulation boards. Allow slurry coat to set prior to placing remaining thickness of lightweight insulating concrete.
1. Install insulation board in a stair-step configuration with a maximum step-down of 1 inch (25 mm).
- C. Deposit and screed lightweight insulating concrete in a continuous operation until an entire panel or section of roof area is completed. Do not vibrate or work mix except for screeding or floating. Place to depths and slopes indicated.
- D. Finish top surface smooth, free of ridges and depressions, and maintain surface in condition to receive subsequent roofing system.

- E. Begin curing operations immediately after placement, and air cure for not less than three days, according to manufacturer's written instructions.
- F. If ambient temperature falls below 32 deg F (0 deg C), protect lightweight insulating concrete from freezing and maintain temperature recommended by manufacturer for 72 hours after placement.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to sample materials and perform tests and inspections.
- B. Testing of samples of lightweight insulating concrete obtained according to ASTM C172/C172M, except as modified by ASTM C495, shall be performed according to the following requirements:
 - 1. Determine as-cast unit weight during each hour of placement, according to ASTM C138/C138M.
 - 2. Determine oven-dry unit weight and compressive strength according to ASTM C495. Make a set of at least six molds for each day's placement, but not less than one set of molds for each 4000 sq. ft. (372 sq. m) of roof area.
 - 3. Perform additional tests when test results indicate that as-cast unit weight, oven-dry unit weight, compressive strength, or other requirements have not been met.
 - a. Retest cast-in-place lightweight insulating concrete for oven-dry unit weight and compressive strength.
- C. Prepare test and inspection reports.

END OF SECTION

Project Name
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SECTION 03 53 00
CONCRETE TOPPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Emery-aggregate concrete floor topping.
 - 2. Iron-aggregate concrete floor topping.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For each concrete floor topping, for tests performed by manufacturer and witnessed by a qualified testing agency.
- B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency qualified according to ASTM C1077 and ASTM E329 for testing indicated.
- B. Mockups: Place concrete floor topping mockups to demonstrate typical joints, surface finish, bonding, texture, tolerances, and standard of workmanship.
 - 1. Build mockups approximately 100 sq. ft. (9.3 sq. m) in the location indicated or, if not indicated, as directed by Architect.
 - 2. If Architect determines that mockups do not meet requirements, demolish and remove them from the site and cast others until mockups are approved.
 - 3. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in original packages and containers, with seals unbroken, bearing manufacturer's labels indicating brand name and directions for storage, mixing with other components, and application.
- B. Store materials to comply with manufacturer's written instructions to prevent deterioration from moisture or other detrimental effects.

1.7 FIELD CONDITIONS

- A. Environmental Limitations: Comply with manufacturer's written instructions for substrate temperature and moisture content, ambient temperature and humidity, ventilation, and other conditions affecting concrete floor topping performance.
 - 1. Place concrete floor topping only when ambient temperature and temperature of base slabs are between 50 and 86 deg F (10 and 30 deg C).
- B. Close areas to traffic during topping application and, after application, for time period recommended in writing by manufacturer.

PART 2 - PRODUCTS

2.1 CONCRETE FLOOR TOPPINGS

- A. Emery-Aggregate Concrete Floor Topping: Factory-prepared and dry-packaged mixture of graded, crushed emery aggregate containing not less than 50 percent aluminum oxide, not less than 24 percent ferric oxide, and not more than 8 percent silica; portland cement or blended hydraulic cement; plasticizers; and other admixtures to which only water needs to be added at Project site.
 - 1. Compressive Strength (28 Days): 10,000 psi (69 MPa); ASTM C109/C109M.
- B. Iron-Aggregate Concrete Floor Topping: Factory-prepared and dry-packaged mixture of graded iron aggregate, portland cement, plasticizers, and other admixtures to which only water needs to be added at Project site.
 - 1. Compressive Strength (28 Days): 12,000 psi (83 MPa); ASTM C109/C109M.

2.2 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. (305 g/sq. m) when dry.
- C. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.

- D. Water: Potable.
- E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B, 25 percent solids content, minimum.

2.3 RELATED MATERIALS

- A. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids epoxy resin with a Type A Shore durometer hardness of 80 according to ASTM D2240.
- B. Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber or ASTM D1752, cork or self-expanding cork.
- C. Portland Cement: ASTM C150/C150M, Type I or II.
- D. Sand: ASTM C404, fine aggregate passing No. 16 (1.18-mm) sieve.
- E. Water: Potable.
- F. Acrylic-Bonding Agent: ASTM C1059/C1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- G. Epoxy Adhesive: ASTM C881/C881M, Type V, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class and grade to suit requirements.
- H. Power-Actuated Fasteners: Fastener systems with an evaluation report based on ICC-ES AC70.

2.4 MIXING

- A. Bonding Slurry: Mix portland cement with water to a thick paint consistency.
- B. Floor Topping: Mix concrete floor topping materials and water in appropriate drum-type batch machine mixer or truck mixer according to manufacturer's written instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, with Installer present, for conditions affecting performance of the Work.
- B. Verify that base concrete slabs comply with scratch finish requirements specified in Section 03 30 00 "Cast-in-Place Concrete."

- C. Verify that base slabs are visibly dry and free of moisture. Test for capillary moisture by the plastic sheet method according to ASTM D4263.
- D. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Existing Concrete: Remove existing surface treatments and deteriorated and unsound concrete. Mechanically abrade base slabs to produce a heavily scarified surface profile with an amplitude of 1/4 inch (6 mm).
 - 1. Prepare and clean existing base slabs according to concrete floor topping manufacturer's written instructions. Fill voids, cracks, and cavities in base slabs.
 - 2. Mechanically remove contaminants from existing concrete that might impair bond of floor topping.
 - 3. Saw cut contraction and construction joints in existing concrete to a depth of 1/2 inch (13 mm) and fill with semirigid joint filler.
- B. Install joint-filler strips where topping abuts vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
 - 1. Extend joint-filler strips full width and depth of joint, terminating flush with topping surface unless otherwise indicated.
 - 2. Terminate full-width, joint-filler strips 1/2 inch (13 mm) below topping surface where joint sealants, specified in Section 07 92 00 "Joint Sealants," are indicated.
 - 3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
- C. Install power-actuated fasteners according to written directions of floor topping manufacturer at perimeter of areas that are to receive floor topping, including both edges of locations where joints will be formed in floor topping.

3.3 FLOOR TOPPING APPLICATION

- A. Start floor topping application in presence of manufacturer's technical representative.
- B. Monolithic Floor Topping: After textured-float finish is applied to fresh concrete of base slabs specified in Section 03 30 00 "Cast-in-Place Concrete," place concrete floor topping while concrete is still plastic.
- C. Deferred Floor Topping: Within 72 hours of placing base slabs, mix and scrub bonding slurry into dampened concrete to a thickness of 1/16 to 1/8 inch (1.6 to 3 mm), without puddling. Place floor topping while slurry is still tacky.
- D. Existing Concrete: Apply epoxy-bonding adhesive, mixed according to manufacturer's written instructions, and scrub into dry base slabs to a thickness of 1/16 to 1/8 inch (1.6 to 3 mm), without puddling. Place floor topping while adhesive is still tacky.

- E. Place concrete floor topping continuously in a single layer, tamping and consolidating to achieve tight contact with bonding surface. Do not permit cold joints or seams to develop within pour strip.
 - 1. Screed surface with a straightedge and strike off to correct elevations.
 - 2. Slope surfaces uniformly where indicated.
 - 3. Begin initial floating, using bull floats to form a uniform and open-textured surface plane free of humps or hollows.

- F. Finishing: Consolidate surface with power-driven floats as soon as concrete floor topping can support equipment and operator. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until concrete floor topping surface has a uniform, smooth, granular texture.
 - 1. Hard Trowel Finish: After floating surface, apply first trowel finish and consolidate concrete floor topping by power-driven trowel without allowing blisters to develop. Continue troweling passes and restraighten until surface is smooth and uniform in texture.
 - a. Finish surfaces to specified overall values of flatness, F(F) 25; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 17; and of levelness, F(L) 15, and measure within 24 hours according to ASTM E1155 (ASTM E1155M) for a randomly trafficked floor surface.
 - b. Finish and measure surface, so gap at any point between surface and an unlevelled freestanding 10-foot- (3-m-) long straightedge, resting on two high spots and placed anywhere on the surface, does not exceed 1/4 inch (6 mm).

- G. Construction Joints: Construct joints true to line with faces perpendicular to surface plane of concrete floor topping, at locations indicated or as approved by Architect.
 - 1. Coat face of construction joint with epoxy adhesive at locations where concrete floor topping is placed against hardened or partially hardened concrete floor topping.

- H. Contraction Joints: Form weakened-plane contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3-mm-) wide joints into concrete floor topping when cutting action will not tear, abrade, or otherwise damage surface and before random contraction cracks develop.
 - 1. Form joints in concrete floor topping over contraction joints in base slabs unless otherwise indicated.
 - 2. Construct contraction joints for a combined depth equal to topping thickness and not less than one-fourth of base-slab thickness.
 - 3. Construct contraction joints for a depth equal to one-half of concrete floor topping thickness, but not less than 1/2 inch (13 mm) deep.

3.4 PROTECTING AND CURING

- A. General: Protect freshly placed concrete floor topping from premature drying and excessive cold or hot temperatures.

- B. Evaporation Retarder: Apply evaporation retarder to concrete floor topping surfaces in hot, dry, or windy conditions before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying floor topping, but before float finishing.
- C. Begin curing immediately after finishing concrete floor topping. Cure by one or a combination of the following methods, according to concrete floor topping manufacturer's written instructions:
 - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with continuous water-fog spray or absorptive cover, water saturated and kept continuously wet. Cover topping surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.
 - 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - 3. Curing Compound: Apply uniformly in two coats in continuous operations 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.

3.5 JOINT FILLING

- A. Prepare and clean contraction joints and install semirigid joint filler, according to manufacturer's written instructions, once topping has fully cured.
- B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.
- C. Install semirigid joint filler full depth of contraction joints. Overfill joint and trim semirigid joint filler flush with top of joint after hardening.

3.6 REPAIR

- A. Defective Topping: Repair and patch defective concrete floor topping areas, including areas that have not bonded to concrete substrate.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Testing Services: Testing and inspecting of completed applications of concrete floor toppings shall take place in successive stages, in areas of extent and using methods as follows:

1. Sample Sets: At point of placement, a set of three molded-cube samples shall be taken from the topping mix for the first 1000 sq. ft. (93 sq. m), plus one set of samples for each subsequent 5000 sq. ft. (464 sq. m) of topping, or fraction thereof, but not less than six samples for each day's placement. Samples shall be tested according to ASTM C109/C109M for compliance with compressive-strength requirements.
 2. Concrete floor topping shall be tested for delamination by dragging a steel chain over the surface.
 3. Concrete floor topping shall be tested for compliance with surface flatness and levelness tolerances.
- C. Remove and replace applications of concrete floor topping where test results indicate that it does not comply with specified requirements.
- D. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

END OF SECTION

Project Name
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CONCRETE TOPPING
03 53 00 - 8

Last Updated:

August 2021

SECTION 03 54 16
HYDRAULIC CEMENT UNDERLAYMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Polymer modified self-leveling cementitious underlayment for the following applications:
1. Below non-breathable interior floor coverings.
 2. Below adhered interior floor coverings.
 3. Below adhesively-applied floor coverings.
 4. Repair of cast-in-place concrete floor surfaces and slopes installed out of required tolerances.

1.2 UNIT PRICES

- A. Work of this Section is affected by unit prices for cement underlayment applications, as specified in Section 01 22 00 "Unit Prices."

1.3 COORDINATION

- A. Coordinate application of underlayment with requirements of floor covering products including adhesives ensuring compatibility of products and floor flatness and floor level values of concrete slab.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
1. Review substrate moisture limitations.
 2. Coordinate floor flatness and level requirements and moisture with scheduled finish floor material requirements.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Submit plans indicating substrates, locations, and average depths of underlayment based on survey of substrate conditions.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.

- B. Product Certificates: Signed by manufacturers of underlayment and floor-covering systems certifying that products are compatible.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Installer having minimum 5 years documented experience and approved or certified by underlayment manufacturer for application of underlayment products required.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in unopened packages and protect from moisture. Protect liquids from freezing and from excessive heat. Store on dry pallets.
- B. Protect the materials before, during, and after installation and to protect the installed work.

1.9 FIELD CONDITIONS

- A. Environmental Limitations: Comply with manufacturer's written instructions for substrate temperature, ventilation, ambient temperature and humidity, and conditions affecting underlayment performance.
 - 1. Place cement underlayment when ambient temperature and temperature of substrates are between 50 degrees F and 80 degrees F (10 degrees and 27 degrees C).
- B. Do not permit wheeled or foot traffic once substrate preparation has commenced and until minimum 24 hours after completion, unless otherwise recommended by manufacturer.

PART 2 - PRODUCTS

2.1 CEMENTITIOUS UNDERLAYMENT MATERIALS

- A. Hydraulic Cementitious Underlayment: Polymer modified, self leveling, hydraulic cement product applied in minimum uniform thickness of 1/4 inch (6 mm) that can be feathered at edges to match adjacent floor elevations.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ardex; K-15 Self-Leveling Underlayment Concrete.
 - b. BASF Construction Chemicals, Inc.; Chemrex Self Leveling Underlayment or MBT Mastertop 110 Plus Underlayment.
 - c. Dayton Superior Corporation; LeveLayer.
 - d. Euclid Chemical Company (The); Super Flo-Top, TAMMS SLU.
 - e. MAPEI Corporation; Novoplan Easy, Novoplan 2, Ultraplan 1 Plus.

- f. Specialty Construction Brands, Inc., an H.B. Fuller company; TEC Smooth Start, TEC EZ Level.
 2. Cement Binder: ASTM C 150/C 150M, portland cement, or hydraulic or blended hydraulic cement as defined by ASTM C 219.
 3. Compressive Strength: Not less than 4000 psi (27.6 MPa) at 28 days when tested according to ASTM C 109/C 109M.
- B. Aggregate: Well graded, washed gravel, 1/8 to 1/4 inch (3 to 6 mm); or coarse sand as recommended by underlayment manufacturer.
1. Provide aggregate when recommended in writing by underlayment manufacturer for underlayment thickness required.
- C. Water: Potable and at a temperature of not more than 70 degrees F (21 degrees C).
- D. Primer: Product of underlayment manufacturer recommended in writing for substrate, conditions, and application indicated.
- E. Joint and Crack Filler: Recommended by underlayment manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, with Installer present, for conditions affecting performance of the Work.
- B. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Prepare and clean substrate according to manufacturer's written instructions.
 1. Treat nonmoving substrate cracks according to manufacturer's written instructions to prevent cracks from telegraphing (reflecting) through underlayment.
 2. Fill substrate voids to prevent underlayment from leaking.
- B. Concrete Substrates: Mechanically remove, according to manufacturer's written instructions, laitance, glaze, efflorescence, curing compounds, form release agents, dust, dirt, grease, oil, and contaminants that impair underlayment bond.
 1. Moisture Testing: Perform anhydrous calcium chloride test, ASTM F 1869. Proceed with installation only after substrates do not exceed a maximum moisture vapor emission rate of 3 lb of water/1000 sq. ft. (1.36 kg of water/100 sq. m) in 24 hours.
 - a. Anhydrous Calcium Chloride Test, ASTM F1869: Proceed with installation only after substrates do not exceed a maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. (1.36 kg of water/100 sq. m) in 24 hours.

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- b. Relative Humidity Test: Using in situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 85 percent relative humidity level measurement, or as recommended by hydraulic cement underlayment manufacturer.
- C. Adhesion Tests: After substrate preparation, test substrate for adhesion with underlayment according to manufacturer's written instructions.

3.3 INSTALLATION

- A. Mix and install underlayment components according to manufacturer's written instructions.
 - 1. Close areas to traffic during underlayment application and after application as recommended in writing by manufacturer.
 - 2. Coordinate application of components to provide optimum adhesion to substrate and between coats.
 - 3. At substrate expansion, isolation, and moving joints, allow joint of same width to continue through underlayment.
- B. Apply primer over prepared substrate at manufacturer's recommended spreading rate.
- C. Install underlayment to produce uniform, level surface.
 - 1. Feather edges to match adjacent floor elevations.
- D. Cure underlayment according to manufacturer's written instructions. Prevent contamination during application and curing processes.
- E. Do not install floor coverings over underlayment until after time period recommended in writing by underlayment manufacturer.
- F. Remove and replace underlayment areas that evidence lack of bond with substrate, including areas that emit a "hollow" sound when tapped.

3.4 PROTECTION

- A. Protect underlayment from concentrated and rolling loads for remainder of construction period.

END OF SECTION