SECTION 033000 - CAST-IN-PLACE CONCRETE

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

"Elemix" is a registered trademark of NOVA Chemicals, Inc. for its lightweight synthetic particle concrete additive.

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes.

B. Related Sections:

Retain Section in subparagraph below that contains requirements Contractor might expect to find in this Section but are specified in other Sections.

1. Division 31 Section "Earth Moving" for drainage fill under slabs-on-grade.

1.2 SUBMITTALS

First five paragraphs below are defined in Division 01 Section "Submittal Procedures" as "action submittals."

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

B. LEED Submittals:

Retain first subparagraph below if recycled content is required for LEED-NC or LEED-CI Credits MR 4.1 and MR 4.2.

1. Product Data for Credit MR 4.1[**and Credit MR 4.2**]: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.

a. Include statement indicating costs for each product having recycled content.

Retain subparagraph below if fly ash, ground granulated blast-furnace slag, silica fume, or other materials are used as portland cement replacements for LEED-NC Credit ID 1.1.

2. Design Mixtures for Credit ID 1.1: For each concrete mixture containing fly ash as a replacement for portland cement or other portland cement replacements, and for equivalent concrete mixtures that do not contain portland cement replacements.

C. Design Mixtures: For each concrete mixture.

D. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement.

Retain first paragraph below if required.

E. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer detailing fabrication, assembly, and support of formwork.

Remaining paragraphs are defined in Division 01 Section "Submittal Procedures" as "informational submittals."

F. Welding certificates.

G. Material certificates.

H. Material test reports.

I. Floor surface flatness and levelness measurements.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

Retain subparagraph below if required.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

Retain first paragraph below if Contractor or manufacturer retains testing agency for concrete mixture design, material test reports, or field quality control.

B. Testing Agency Qualifications: An independent agency,[**acceptable to authorities having jurisdiction,**] qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

Retain "Welding Qualifications" Paragraph below if shop or field welding is required. If retaining, also retain "Welding certificates" Paragraph in "Submittals" Article.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M, "Structural Welding Code - Reinforcing Steel."

D. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

Retain second option in first subparagraph below if ACI 301, Section 7, for structural lightweight concrete is applicable.

1. ACI 301, "Specifications for Structural Concrete," [**Sections 1 through 5.**] [**Sections 1 through 5 and Section 7, "Lightweight Concrete."**]
2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

E. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

F. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

PART 2 - PRODUCTS

2.1 FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

2.2 STEEL REINFORCEMENT

Revise this article to suit steel reinforcement requirements; delete if not required.

Retain first paragraph below if recycled content is required for LEED-NC or LEED-CI Credits MR 4.1 and MR 4.2. The Steel Recycling Institute indicates that reinforcing bars are made by the electric arc

furnace method, which typically has 57.5 percent postconsumer recycled content and 6.5 percent preconsumer recycled content.

A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than [**25**] [**60**] <**Insert number**> percent.

B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

Retain first subparagraph below for galvanized-steel reinforcement. Class I has at least 50 percent more zinc weight than Class II.

1. Galvanized Reinforcing Bars: ASTM A 767/A 767M, [**Class I**] [**Class II**] zinc coated after fabrication and bending.
2. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M, epoxy coated, with less than 2 percent damaged coating in each 12-inch (300-mm) bar length.

C. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, plain, fabricated from as-drawn steel wire into flat sheets.

D. Deformed-Steel Welded Wire Reinforcement: ASTM A 497/A 497M, flat sheet.

E. Galvanized-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, plain, fabricated from galvanized-steel wire into flat sheets.

F. Epoxy-Coated Welded Wire Reinforcement: ASTM A 884/A 884M, Class A coated, Type 1, [**plain**] [**deformed**] steel.

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

2.3 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:

Retain type and color of portland cement from options in first subparagraph below.

1. Portland Cement: ASTM C 150, [**Type I**] [**Type II**] [**Type I/II**] [**Type III**] [**Type V**], [**gray**] [**white**].[**Supplement with the following:**]

Retain supplementary cementing materials from first two subparagraphs below if permitted. Ready-mix concrete manufacturer blends these materials with portland cement. Fly ash, slag, or pozzolanic materials may slow rate of concrete strengthening and affect color uniformity. Availability of Class F fly ash predominates over Class C fly ash.

a. Fly Ash: ASTM C 618, [**Class F**] [**Class F or C**].
b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

Retain subparagraph below if factory-blended hydraulic cement is permitted; verify availability of options before specifying. Fly ash, slag, or pozzolanic materials in the nonportland cement part of blended hydraulic cement may slow rate of concrete strengthening and affect color uniformity.

2. Blended Hydraulic Cement: ASTM C 595, [**Type IS, portland blast-furnace slag**] [**Type IP, portland-pozzolan**] [**Type I (PM), pozzolan-modified portland**] [**Type I (SM), slag-modified portland**] cement.

B. Normal-Weight Aggregates: ASTM C 33, graded.

1. Maximum Coarse-Aggregate Size: [**1-1/2 inches (38 mm)**] [**1 inch (25 mm)**] [**3/4 inch (19 mm)**] nominal.

Retain subparagraph below if optional restriction for fine aggregate in ASTM C 33 is required.

2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

Retain first paragraph below if using lightweight aggregate for structural lightweight concrete. Retain size limit from four options below.

C. Lightweight Aggregate: ASTM C 330, [**1-inch (25-mm)**] [**3/4-inch (19-mm)**] [**1/2-inch (13-mm)**] [**3/8-inch (10-mm)**] nominal maximum aggregate size.

D. Water: ASTM C 94/C 94M[**and potable**].

2.4 ADMIXTURES

A. Air-Entraining Admixture: ASTM C 260.

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

Retain one or more chemical admixtures from six subparagraphs below.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.5 SPECIAL CONCRETE MIXTURE ADDITIVES

NOVA Chemicals, Inc. Elemix additive is an innovative concrete additive designed to distribute uniformly in the mix and provide lightweight, durable concrete for structural and non-structural applications. It has a honeycomb-like closed cell interior structure, and is non-absorptive. The physical characteristics of Elemix additive improve concrete performance in relation to cracking and thermal

conductivity through reduced unit weight and a reduction in cracking. Concrete formulated with Elemix additive allows the producer to customize lower unit weights using conventional fine and coarse aggregates, while improving the physical characteristics of concrete.

A. Lightweight Synthetic Particle Additive: Commercially manufactured additive comprised of specially formulated polymeric spheres, complying with International Code Council ICC-ES Acceptance Criteria AC 408 (Acceptance Criteria For Structural Concrete With Lightweight Synthetic Particles).

1. Basis-of-Design Product: Subject to compliance with requirements, provide NOVA Chemicals, Inc.; Elemix additive, or a comparable product by one of the following:

a. <**Insert manufacturer's name**>.

Retain subparagraph below when required to suit project requirements.

2. Additive shall comply with ICC-ES ESR-2574.

Retain subparagraph below when required to suit project requirements.

3. Where fire-resistance rated floor-ceiling or roof-ceiling construction is indicated, comply with requirements of Underwriters Laboratories Design D 974.

2.6 FIBER REINFORCEMENT

A. Synthetic Micro-Fiber: [**Monofilament**] [**or**] [**fibrillated**] polypropylene micro-fibers engineered and designed for use in concrete, complying with ASTM C 1116/C 1116M, Type III, [**1/2 to 1-1/2 inches (13 to 38 mm)**] [**1 to 2-1/4 inches (25 to 57 mm)**] <**Insert dimensions**> long.

2.7 WATERSTOPS

Retain one of first three paragraphs below if flexible waterstops produced from rubber, thermoplastic elastomer rubber, or PVC are required.

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.

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. Factory fabricate corners, intersections, and directional changes.

C. Flexible PVC Waterstops: CE CRD-C 572,[**with factory-installed metal eyelets,**] for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.

Retain one of two paragraphs below if self-expanding waterstops are required.

D. 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).

E. 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).

2.8 VAPOR RETARDERS

Retain first paragraph below if a non-bituminous water vapor retarder is required.

A. Sheet Vapor Retarder: ASTM E 1745, Class [**A**] [**B**] [**C**]. Include manufacturer's recommended adhesive or pressure-sensitive tape.

Retain paragraph below if generic polyethylene, not complying with ASTM E 1745, is permitted.

B. Sheet Vapor Retarder: Polyethylene sheet, ASTM D 4397, not less than 10 mils (0.25 mm) thick.

2.9 CURING MATERIALS

Evaporation retarder in first paragraph below temporarily reduces moisture loss from concrete surfaces awaiting finishing in hot, dry, and windy conditions. Evaporation retarders are not curing compounds.

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

Retain curing aids and materials from remaining paragraphs.

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 C 171, polyethylene film or white burlap-polyethylene sheet.

D. Water: Potable.

Retain first paragraph below if a dissipating-type, waterborne, membrane-forming curing compound is required.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

Retain first paragraph below if a nondissipating-type, waterborne, membrane-forming curing compound with minimal solids content is required. Retain option if applicable.

F. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, nondissipating[**, certified by curing compound manufacturer to not interfere with bonding of floor covering**].

Retain first paragraph below if a clear, nonyellowing, solvent-borne, membrane-forming curing and sealing compound is required.

G. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

Retain paragraph below if a clear, nonyellowing, waterborne, membrane-forming curing and sealing compound is required.

H. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

2.10 RELATED MATERIALS

Retain one or all options in paragraph below. Joint-filler strips are used in floor isolation joints.

A. Expansion- and Isolation-Joint-Filler Strips: [**ASTM D 1751, asphalt-saturated cellulosic fiber**] [**or**] [**ASTM D 1752, cork or self-expanding cork**].

2.11 CONCRETE MIXTURES

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

B. Cementitious Materials: Use fly ash, pozzolan, ground granulated blast-furnace slag, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.

C. Admixtures: Use admixtures according to manufacturer's written instructions.

Revise three subparagraphs below to suit Project; delete if not required.

1. Use [**water-reducing**] [**high-range water-reducing**] [**or**] [**plasticizing**] 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 and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.

If different normal-weight concrete mixtures are required for various building elements, copy and paste first paragraph and applicable characteristics below as required for each normal-weight concrete mixture.

Consider inserting minimum cementitious material content for mix designs.

D. Proportion normal-weight concrete mixture as follows:

Retain strength from five options in first subparagraph below or revise to suit Project. Coordinate compressive strength with water-cementitious materials ratio if concrete will be subject to special exposure conditions or sulfate exposure as identified in ACI 318 (ACI 318M).

1. Minimum Compressive Strength: [**5000 psi (34.5 MPa)**] [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] <**Insert strength**> at 28 days.

Retain water-cementitious materials ratio from three options in first subparagraph below, revise to suit Project, or delete if in-service durability conditions are benign and limits on water-cementitious materials ratio are not required. Coordinate water-cementitious materials ratio with compressive strength. See Evaluations for discussion.

2. Maximum Water-Cementitious Materials Ratio: [**0.50**] [**0.45**] [**0.40**] <**Insert ratio**>.

Retain slump limit from three options in first subparagraph below or revise to suit Project.

3. Slump Limit: [**4 inches (100 mm)**] [**5 inches (125 mm)**] [**8 inches (200 mm) for concrete with verified slump of 2 to 4 inches (50 to 100 mm) before adding high-range water-reducing admixture or plasticizing admixture**] <**Insert dimension**>, plus or minus 1 inch (25 mm).

Retain one or more of first three subparagraphs below. Percentages in options in first two subparagraphs are default air contents required by ACI 301 for severe exposure.

4. Air Content: [**5.5**] <**Insert number**> percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch (38-mm) nominal maximum aggregate size.
5. Air Content: [**6**] <**Insert number**> percent, plus or minus 1.5 percent at point of delivery for [**1-inch (25-mm)**] [**3/4-inch (19-mm)**] nominal maximum aggregate size.

Air content in first subparagraph below is maximum recommended by ACI 302.1R for trowel-finished floors.

6. Air Content: Do not allow air content of trowel-finished floors to exceed 3 percent.

Synthetic-micro-fiber dosage rates in subparagraph below reflect typical recommendations of manufacturers. Retain first option for minimum dosage of synthetic micro-fiber used for reducing plastic shrinkage cracking. Retain second option or increase dosage for synthetic micro-fiber used for improving hardened concrete properties.

7. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than [**1.0 lb/cu. yd. (0.60 kg/cu. m)**] [**1.5 lb/cu. yd. (0.90 kg/cu. m)**] <**Insert dosage**>.

If different structural lightweight concrete mixtures are required for various building elements, copy and paste paragraph and applicable characteristics below as required for each structural lightweight concrete mixture.

E. Proportion structural lightweight concrete mixture as follows:

Retain strength from five options in first subparagraph below or revise to suit Project.

1. Minimum Compressive Strength: [**5000 psi (34.5 MPa)**] [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] <**Insert strength**> at 28 days.

Retain one of three options in first subparagraph below or revise values or unit weight terminology. "Calculated equilibrium unit weight" is the basis preferred by the Expanded Shale Clay and Slate Institute rather than "maximum air dry unit weight" included in ACI 301 for measuring unit weight.

2. Calculated Equilibrium Unit Weight: [**115 lb/cu. ft. (1842 kg/cu. m)**] [**110 lb/cu. ft. (1762 kg/cu. m)**] [**105 lb/cu. ft. (1682 kg/cu. m)**], plus or minus 3 lb/cu. ft. (48.1 kg/cu. m) as determined by ASTM C 567.

Retain slump limit from two options in first subparagraph below or revise to suit Project.

3. Slump Limit: [**4 inches (100 mm)**] [**5 inches (125 mm)**], plus or minus 1 inch (25 mm).

Retain one or more of first three subparagraphs below. Percentages in first two subparagraphs are default air contents required by ACI 301 for lightweight concrete subject to freezing and thawing, severe weather, or deicer chemicals.

4. Air Content: 6 percent, plus or minus 2 percent at point of delivery for nominal maximum aggregate size greater than 3/8 inch (10 mm).
5. Air Content: 7 percent, plus or minus 2 percent at point of delivery for nominal maximum aggregate size 3/8 inch (10 mm) or less.

Air content in first subparagraph below is maximum recommended by ACI 302.1R for trowel-finished floors.

6. Air Content: Do not allow air content of trowel-finished floors to exceed 3 percent.

Synthetic-micro-fiber dosage rates in subparagraph below reflect typical recommendations of manufacturers. Retain first option for minimum dosage of synthetic micro-fiber used for reducing plastic shrinkage cracking. Retain second option or increase dosage for synthetic micro-fiber used for improving hardened concrete properties.

7. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than [**1.0 lb/cu. yd. (0.60 kg/cu. m)**] [**1.5 lb/cu. yd. (0.90 kg/cu. m)**] <**Insert dosage**>

2.12 FABRICATING REINFORCEMENT

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

2.13 CONCRETE MIXING

Retain option in paragraph below if synthetic fibers are required.

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M[**and ASTM C 1116/C 1116M**], and furnish batch ticket information.

1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 FORMWORK

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

Retain one of two options in paragraph below. ACI 301 requires chamfers unless otherwise specified.

C. [**Chamfer**] [**Do not chamfer**] exterior corners and edges of permanently exposed concrete.

3.2 EMBEDDED ITEMS

Specify embedded items and anchorage devices for other work attached to or supported by cast-in-place concrete. Insert specific requirements for installing embedded items, if any, that are part of the Work.

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 VAPOR RETARDERS

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.

1. Lap joints 6 inches (150 mm) and seal with manufacturer's recommended tape.

3.4 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.

1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

3.5 JOINTS

Coordinate joint types, description, and location with Drawings. Joint types have been consolidated in this article for consistency rather than for strict sequence of installation.

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

Revise criteria for locating construction joints in first paragraph below to suit Project.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

Insert spacing of contraction joints here or on Drawings if required. Contraction-joint spacings vary with slab thickness, aggregate size, and slump based on PCA's recommendations. Depth of joint may be varied to suit cutting method or if steel-fiber reinforcement is used. Early-entry saws may cut less than one-fourth of concrete thickness; steel-fiber-reinforced slabs, one-third of concrete thickness.

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**] <**Insert depth**> of concrete thickness as follows:

Retain type of joint-forming method from two subparagraphs below or retain both subparagraphs as Contractor's option. Insert joint spacing if not indicated on Drawings.

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 tool marks on concrete surfaces.

Retain subparagraph below if saw cutting is permitted. Description does not distinguish conventional wet- and dry-cut saws from early-entry dry-cut saws. Timing is critical to sawed joints. Early-entry dry-cut saws have been used within one to two hours of finishing concrete. To leave concrete undamaged from sawing, conventional saw cutting must be delayed, usually 4 to 12 hours, but not so long that uncontrolled cracking of concrete could occur.

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 will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

E. Waterstops: Install in construction joints and at other joints indicated according to manufacturer's written instructions.

3.6 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.

1. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.

C. Cold-Weather Placement: Comply with ACI 306.1.

D. Hot-Weather Placement: Comply with ACI 301.

3.7 FINISHING FORMED SURFACES

Retain types of formed finishes required in this article. Coordinate finishes retained with finish schedule or indicate location of each finish on Drawings.

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces [**not exposed to public view**] <**Insert locations**>.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

Revise locations in subparagraph below to suit Project. Retain rubbed finish option if additional finishing is required.

1. Apply to concrete surfaces [**exposed to public view,**] [**to receive a rubbed finish,**] [**to be covered with a coating or covering material applied directly to concrete**] <**Insert locations**>.

Retain rubbed finish in first paragraph below with smooth-formed finish in paragraph above.

C. Rubbed Finish: Apply the following to smooth-formed finished as-cast concrete where indicated:

Retain one or more rubbed finishes from three subparagraphs below.

1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
3. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one part portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

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.

3.8 FINISHING FLOORS AND SLABS

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

Retain types of slab finishes required from remaining paragraphs. Coordinate finishes retained with finish schedule or indicate location of each finish on Drawings.

B. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. Use stiff brushes, brooms, or rakes to produce a profile amplitude of 1/4 inch (6 mm) in one direction.

Revise locations of scratch finish in subparagraph below to suit Project.

1. Apply scratch finish to surfaces [**indicated**] [**and**] [**to receive concrete floor toppings**] [**to receive mortar setting beds for bonded cementitious floor finishes**] <**Insert locations**>.

C. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture.

Revise locations of float finish in subparagraph below to suit Project.

1. Apply float finish to surfaces [**indicated**] [**to receive trowel finish**] [**and**] [**to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo**] <**Insert locations**>.

D. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.

Revise locations of trowel finish in first subparagraph below to suit Project.

1. Apply a trowel finish to surfaces [**indicated**] [**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**] <**Insert locations**>.
2. Finish and measure surface so gap at any point between concrete surface and an unleveled, freestanding, 10-ft.- (3.05-m-) long straightedge resting on two high spots and placed anywhere on the surface does not exceed [**1/4 inch (6 mm)**] [**3/16 inch (4.8 mm)**] [**1/8 inch (3.2 mm)**].

E. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces [**indicated**] [**where ceramic or quarry tile is to be installed by either thickset or thin-set method**]. While concrete is still plastic, slightly scarify surface with a fine broom.

1. Comply with flatness and levelness tolerances for trowel-finished floor surfaces.

Retain paragraph below if applicable. Broom finish is generally used on exterior concrete steps and platforms, ramps, and other surfaces subject to light foot traffic.

F. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and elsewhere as indicated.

3.9 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.

If evaporation rate in first paragraph below is exceeded, ACI 305R states that plastic shrinkage cracking is probable. See manufacturers' literature or ACI 305R for estimated moisture-loss chart relating relative humidity, air and concrete temperature, and wind velocity to rate of evaporation.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Cure concrete according to ACI 308.1, by one or a combination of the following methods:

Retain one or more curing methods from four subparagraphs below. Delete methods or restrict use of curing methods to specific locations or types of surfaces if required.

1. Moisture Curing: Keep surfaces continuously moist for 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. 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 continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

Retain first subparagraph below if requiring removal of curing compounds that may interfere with adhesion of floor coverings.

a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer[**unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project**].

Curing and sealing compound in subparagraph below is usually for floors and slabs and may act as a permanent surface finish.

4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written

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

3.10 CONCRETE SURFACE REPAIRS

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

3.11 FIELD QUALITY CONTROL

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

B. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

ACI stipulates the ASTM C 231/C 231M test procedure be used to determine air content in normal weight concrete. When traditional lightweight aggregates are used, ASTM C 173/C 173M is the recommended test method. The Elemix additive is considered a synthetic lightweight particle. When used to determine air content in structural concrete, NOVA Chemicals, Inc. recommends modifications to the ASTM C 231/C 231M pressure method and ASTM C 173/C 173M volumetric method.

1. Air Content: ASTM C 231, pressure method, for [**normal-weight concrete**] [**and**] [**concrete made with lightweight synthetic particle additive**]; [**ASTM C 173/C 173M, volumetric method, for structural lightweight concrete;**] [**and**] [**concrete made with lightweight synthetic particles additive,**] one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.

END OF SECTION 033000