**SECTION 033000 - CAST-IN-PLACE CONCRETE**

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Note: this document contains specific guidance (in green) that enables the user to select the appropriate solution for the required application. This three-part guide specification is representative of a specification meeting the CSI section code and containing multiple product options. For an individual product specifi­cation visit : http s ://www.master-builders -solutions com/en-us/architects -and-designers .

PART 1 - GENERAL

1.1 RELATED DOCUMENTSA. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

1. Section Includes:

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

1. Related Requirements:

Retain subparagraphs below to cross-reference requirements Contractor might expect to find in this Section but are specified in other Sections.

1. Section 031000 "Concrete Forming and Accessories" for form-facing materials, form liners, insulating concrete forms, and waterstops.
2. Section 032000 "Concrete Reinforcing" for steel reinforcing bars and welded-wire reinforcement.
3. Section 033300 "Architectural Concrete" for general building applications of specially finished formed concrete.
4. Section 033543 "Polished Concrete Finishing" for concrete floors scheduled to receive a polished concrete finish.
5. Section 035300 "Concrete Topping" for emery- and iron-aggregate concrete floor toppings.
6. Section 312000 "Earth Moving" for drainage fill under slabs-on-ground.
7. Section 321313 "Concrete Paving" for concrete pavement and walks.
8. Section 321316 "Decorative Concrete Paving" for decorative concrete pavement and walks.

1.3 DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

Definition in "Cementitious Materials" Paragraph below refers to those materials that make up the cementitious component of the w/cm.

1. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.
2. w/cm: The ratio by mass of water to cementitious materials.

1.4 PREINSTALLATION MEETINGS

Retain "Preinstallation Conference" Paragraph below if Work of this Section is extensive or complex enough to justify a conference.

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

Retain first subparagraph below if warranted by complexity of design mixtures and quality control of concrete materials.

1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:

1. Contractor's superintendent.
2. Independent testing agency responsible for concrete design mixtures.
3. Ready-mixed concrete manufacturer.
4. Concrete Subcontractor.

Retain first subparagraph below if special concrete finishes are included in Project.

1. Special concrete finish Subcontractor.

2. Review the following:

1. Special inspection and testing and inspecting agency procedures for field quality control.
2. Construction joints, control joints, isolation joints, and joint-filler strips.
3. Semirigid joint fillers.
4. Vapor-retarder installation.
5. Anchor rod and anchorage device installation tolerances.
6. Cold and hot weather concreting procedures.
7. Concrete finishes and finishing.
8. Curing procedures.
9. Forms and form-removal limitations.
10. Shoring and reshoring procedures.
11. Methods for achieving specified floor and slab flatness and levelness.

1. Floor and slab flatness and levelness measurements.

1. Concrete repair procedures.
2. Concrete protection.
3. Initial curing and field curing of field test cylinders (ASTM C31/C31M.)
4. Protection of field cured field test cylinders.

1.5 ACTION SUBMITTALS

A. Product Data: For each of the following.

1. Portland cement. x
2. Fly ash.
3. Slag cement.
4. Blended hydraulic cement.
5. Silica fume.
6. Performance-based hydraulic cement
7. Aggregates.
8. 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.

1. Color pigments.
2. Fiber reinforcement.
3. Vapor retarders.
4. Floor and slab treatments.
5. Liquid floor treatments.
6. Curing materials.

Retain first subparagraph below if color pigments are applicable to Project.

a. Include documentation from color pigment manufacturer, indicating that proposed

methods of curing are recommended by color pigment manufacturer.

1. Joint fillers.
2. Repair materials.

B. Sustainable Design Submittals:

Retain "Product Data" Subparagraph below to require minimum recycled content for LEED 2009, MRc 2, "Recycled Content."

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.

"Product Certificates" Subparagraph below applies to LEED 2009, MRc 5, "Regional Materials."

1. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.Retain first three subparagraphs below to be eligible for LEED v4 credit. See the Evaluations.

"Environmental Product Declaration" Subparagraph below applies to LEED v4 (all), MRc "Building Product Disclosure and Optimization - Environmental Product Declarations." Confirm with manufacturer that EPDs are available for each product.

1. Environmental Product Declaration: For each product.

"Health Product Declaration" Subparagraph below applies to LEED v4 (all), MRc "Building Product Disclosure and Optimization - Material Ingredients, Option 1 - Material Ingredient Reporting." Confirm with manufacturer that HPDs are available and meet requirements of the HPD Open Standard or approved USGBC program.

1. Health Product Declaration: For each product.

"Sourcing of Raw Materials" Subparagraph below applies to LEED v4 (all), MRc "Building Project Disclosure and Optimization - Sourcing of Raw Materials, Option 1 - Raw Material Source and Extraction Reporting." Confirm with manufacturer that corporate sustainability reports are available, have been prepared within the last year or are applicable to the year of production, and are by an organization approved by the USGBC.

1. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.

"Product Certificates" Subparagraph below applies to IgCC, which requires that a minimum of 55 percent of building materials or products be extracted, harvested, manufactured, or recovered within 500 miles (800 km) of Project. See IgCC-2012, 505.2.5.

1. Product Certificates: For indigenous materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.

Retain "Environmental Product Declaration" Subparagraph below if products specified in the Section are required to have an EPD to meet the IgCC's requirement of 55 percent recycled materials.

1. Environmental Product Declaration: For each product.

"Product Certificates" Subparagraph below applies to ASHRAE 189.1, which requires that a minimum of 15 percent of building materials or products be extracted, harvested, manufactured, or recovered within 500 miles (800 km) of Project. See ASHRAE 189.1-2014, 9.4.1.2.

1. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.

"Environmental Product Declaration" Subparagraph below applies to ASHRAE 189.1 if products specified in the Section are used to meet the requirements of paragraph 9.4.1.4, "Multiple -Attribute Product Declaration or Certification," which requires EPDs for a minimum of **10** products.

1. Environmental Product Declaration: For each product.

Subparagraphs below apply to Green Globes v1.4 if products specified in the Section are used to meet the requirements of paragraph 3.5.1.2 "Path B: Prescriptive Path for Building Core and Shell," which requires that a certain percentage of the materials used in the core and shell have EPDs, third-party certifications, and/or third-party life cycle assessments.

1. Environmental Product Declaration: For each product.
2. Third-Party Certifications: For each product.
3. Third-Party Certified Life Cycle Assessment: For each product.

"Laboratory Test Reports" Subparagraph below applies to LEED 2009 for Schools, LEED v4, IgCC, ASHRAE 189.1, and Green Globes. Coordinate with requirements for liquid floor treatments and curing and sealing compounds.

1. Laboratory Test Reports: For **[liquid floor treatments] [and] [curing and sealing compounds],** indicating compliance with requirements for low-emitting materials.

14. Environmental Assessment Report: Submit for the concrete mixture. Compare submitted concrete mixture with conventional/typical reference concrete mixture that would otherwise be used to achieve the specified performance. At minimum, include information in the following environmental impact areas: air emissions (climate change, acidification, photochemical ozone formation, ozone depletion), water emissions (aquatic eutrophication), consumption of raw materials (resource depletion - mineral, fossil), and human toxicity potential. Methodology used to conduct analysis and assessment in accordance with ISO 14040 and ISO 14044 (ecological part) and be third-party-verified by NSF International, or another accredited third-party agency.

Design mixtures in "Design Mixtures" Paragraph below are usually considered to be an action submittal.

C. 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.

Use of workability-retaining admixtures, such as Master Builders Solutions' "MasterSure Z 60 (Pre-2014: RheoTEC Z-60)," reduces or eliminates the need for adding water in the field.

1. Indicate amounts of mixing water to be withheld for later addition at Project site if permitted.

Retain first two subparagraphs below if permeability-reducing admixture is applicable to any concrete mix design.

1. Include manufacturer's certification that permeability-reducing admixture is compatible with mix design.
2. Include certification that dosage rate for permeability-reducing admixture matches dosage rate used in performance compliance test.
3. Intended placement method.
4. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

D. 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.

E. Samples: For **[manufacturer's standard colors for color pigment] [vapor retarder] <Insert products>.**

F. 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.

1.6 INFORMATIONAL SUBMITTALS

Coordinate "Qualification Data" Paragraph below with qualification requirements in Section 014000 "Quality Requirements" and as supplemented in "Quality Assurance" Article.

A. Qualification Data: For the following:

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

Retain subparagraph below if Contractor retains testing agency for field quality control.

1. Testing agency: Include copies of applicable ACI certificates.

Retain "Material Certificates" Paragraph below to require submittal of material certificates from manufacturers.

B. Material Certificates: For each of the following:   
Revise 11 subparagraphs below to suit Project.

1. Cementitious materials.
2. Admixtures.
3. Fiber reinforcement.
4. Curing compounds.
5. Floor and slab treatments.
6. Bonding agents.
7. Adhesives.
8. Vapor retarders.
9. Semirigid joint filler.
10. Joint-filler strips.
11. Repair materials.

Retain "Material Test Reports" Paragraph below for material test reports that are Contractor's responsibility.

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

1. Portland cement.
2. Fly ash.
3. Slag cement.
4. Blended hydraulic cement.
5. Silica fume.
6. Performance-based hydraulic cement.
7. Aggregates.
8. Admixtures:

a. Permeability-Reducing Admixture: Include independent test reports, indicating

compliance with specified requirements, including dosage rate used in test.

Retain first paragraph below if Contractor engages testing agency for measuring floor surface flatness and levelness.

1. Floor surface flatness and levelness measurements report, indicating compliance with specified tolerances.
2. Research Reports:

1. For sheet vapor retarder/termite barrier, showing compliance with ICC AC380.

1. Preconstruction Test Reports: For each mix design.

Retain "Field quality-control reports" Paragraph below if Contractor is responsible for field quality-control testing and inspecting.

1. Field quality-control reports.

Retain paragraph below if preinstallation conference is held.

1. Minutes of preinstallation conference.

1.7 QUALITY ASSURANCE

Retain "Installer Qualifications" Paragraph below if required. See Section 014000 "Quality Requirements" for general installer qualifications. Verify availability of qualified personnel with a local ACI chapter or concrete contractors. These desirable programs may have limited grass-mots penetration.

1. 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 **[with experience installing and finishing concrete, incorporating permeability -reducing admixtures].**

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

1. 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.

Retain subparagraph below if required.

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

Concrete Production Facilities."

Retain "Laboratory Testing Agency Qualifications" Paragraph below if Contractor retains testing agency for concrete mixture design or material test reports.

1. 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.

Retain subparagraph below if requiring minimum qualifications for laboratory personnel performing testing and for laboratory supervisor.

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.

Retain "Field Quality Testing Agency Qualifications" Paragraph below if Contractor retains testing agency field quality control. Retain option if field quality-control testing agency employed by Contractor must be approved by authorities having jurisdiction.

1. 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.

Retain subparagraph below, required by ACI 301 (ACI 301M) and ASTM C31/C31M if emphasis is needed. ASTM C1077 notes relevant field certification by ACI, NRMCA, and Portland Cement Association; or the National Institute for Certification in Engineering Technologies may demonstrate evidence of competence.

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.

Retain "Mockups" Paragraph below if required. If retaining, indicate location, concrete type, and other details of mockups on Drawings or by inserts. Revise wording if only one mockup is required or if mockup of concrete in another location in a building is required.

1. Mockups: Cast concrete **[slab-on-ground] [and] [formed-surface]** panels to demonstrate typical joints, surface finish, texture, tolerances, floor treatments, and standard of workmanship.

Panel for slab-on-ground may need to be enlarged if powered riding trowels are used and if it is a portion of the floor slab. Dividing panel into four equal sections permits observation of saw joints and may be used for demonstrating different classes of polished concrete specified under Section 033543 "Polished Concrete Finishing" or other special finishes.

1. Slab-On-Ground: Build panel approximately 15 by 15 ft. (3.35 by 3.35 m) **<Insert area>**

in the location indicated or, if not indicated, as directed by Architect.

a. Divide panel into four equal panels to demonstrate saw joint cutting.

1. Formed Surfaces: Build panel approximately 100 sq. ft. (9.3 sq. m) **<Insert area>** in the location indicated or, if not indicated, as directed by Architect.

Retain subparagraph below if the intention is to make an exception to the default requirement in Section 014000 "Quality Requirements" for demolishing and removing mockups.

1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 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:

1. Admixture dosage rates.
2. Slump.
3. Air content.
4. Seven-day compressive strength.
5. 28-day compressive strength.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Comply with ASTM C94/C94M and ACI-SPEC-301 (ACI-SPEC-301M).

1.10 FIELD CONDITIONS

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

1. Protect concrete walk 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-SPEC-301 (ACI-SPEC-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.

B. Hot-Weather Placement: Comply with ACI-SPEC-305.1 (ACI-SPEC-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

Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI-SPEC-301 (ACI-SPEC-301M) unless modified by requirements in the Contract Documents.

2.2 CONCRETE MATERIALS

"Regional Materials" Paragraph below applies to LEED 2009 NC, CS, and LEED 2009 for Schools, MRc 5 and to LEED 2009 CI, MRc 5, Option 2; before retaining, verify availability of materials that comply.

1. Regional Materials: Concrete shall be manufactured within 500 miles (800 km) of Project site from aggregates [ **and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site.

"Regional Materials" Paragraph below applies to LEED 2009 CI, MRc 5, Option 1.

1. Regional Materials: Concrete shall be manufactured within 500 miles (800 km) of Project site. "Regional Materials" Paragraph below applies to LEED v4.
2. Regional Materials: Concrete shall be manufactured within 100 miles (160 km) of Project site from aggregates [ **and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.

"Indigenous Materials" Paragraph below applies to IgCC; before retaining, verify availability of materials that comply.

1. Indigenous Materials: Concrete shall be manufactured within 500 miles (800 km) of Project site from aggregates [ **and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.

"Regional Materials" Paragraph below applies to ASHRAE 189.1; before retaining, verify availability of materials that comply.

1. Regional Materials: Concrete shall be manufactured within 500 miles (800 km) of Project site from aggregates [ **and cementitious materials]** that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
2. Source Limitations:

1. Obtain all concrete mixtures from a single ready-mixed concrete manufacturer for entire

Project.

1. Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant.
2. Obtain aggregate from single source.
3. Obtain each type of admixture from single source from single manufacturer.

G. Cementitious Materials:

Retain type and color of portland cement from options in "Portland Cement" Subparagraph below.

1. Portland Cement: ASTM C150/C150M, **[Type I] [Type II] [Type I/II] [Type III] [Type V], [gray] [white].**

Retain supplementary cementing materials in "Fly Ash" and "Slag Cement" subparagraphs below. Ready-mix-concrete manufacturer blends these materials with portland cement. Fly ash, slag cement, or pozzolanic materials may slow rate of concrete strengthening and affect color uniformity.

1. Fly Ash: ASTM C618, Class C or F.
2. Slag Cement: ASTM C989/C989M, Grade 100 or 120.

Retain "Blended Hydraulic Cement" Subparagraph below if factory-blended hydraulic cement is permitted; verify availability of options before specifying. Fly ash, slag cement, or pozzolanic materials in the nonportland cement part of blended hydraulic cement may slow rate of concrete strengthening and affect color uniformity. Insert ASTM C1157/C1157M if acceptable.

1. Blended Hydraulic Cement: ASTM C595/C595M, **[Type IS, portland blast-furnace slag] [Type IP, portland-pozzolan] [Type IL, portland-limestone] [Type IT, ternary blended]** cement.

Silica fume in "Silica Fume" Subparagraph below is most often used in high-strength concrete and in special applications, such as bridge decks and parking structures, to enhance durability by lowering permeability of concrete. Metakaolin provides similar benefits as silica fume, and because of its lighter color it is typically preferred in architectural concrete.

1. Silica Fume: ASTM C1240 amorphous silica.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; MasterLife SF 100 (Pre-2014: Rheomac SF100).

1. Metakaolin: ASTM C618, Class N.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterLife MK 828 .

Retain one or more options in "Performance-Based Hydraulic Cement" Paragraph below. For low reactivity with alkali-silica-reactive aggregates, add the optional suffix "(R)" to selected Type (e.g., Type MS(R). This option should only be specified for use with aggregates with known alkali-reactivity.

1. Performance-Based Hydraulic Cement: ASTM C1157/C1157M: **[Type GU, general use] [Type HE, high early strength] [Type MS, moderate sulfate resistance] [Type HS,**

**high sulfate resistance] [Type MB, moderate heat of hydration] [Type LH, low heat of hydration].**

Retain class of aggregate from options in "Normal-Weight Aggregates" Paragraph below or revise to suit Project. ASTM C33/C33M limits deleterious substances in coarse aggregate, depending on climate severity and in-service location of concrete. Classes in first set of options are ASTM C33/C33M default classes for concrete exposed to weather for Severe (S), Moderate (M), and Negligible (N) weathering regions, respectively. Revise first two options to "Class 4S" or "4M" if concrete is exposed to frequent wetting.

H. Normal-Weight Aggregates: ASTM C33/C33M, **[Class 3S] [Class 3M] [Class 1N] <Insert**

**class>** coarse aggregate or better, graded. Provide aggregates from a single source.

Retain "Alkali-Silica Reaction" Subparagraph below if damage caused by concrete expansion from alkali silica or alkali carbonate reactions is anticipated.

1. Alkali-Silica Reaction: Comply with one of the following:

1. Expansion Result of Aggregate: Not more than 0.04 percent at one-year when tested in accordance with ASTM C1293.
2. 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.
3. 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-SPEC-301 (ACI-SPEC-301M).

Retain coarse-aggregate size from three options in "Maximum Coarse-Aggregate Size" Subparagraph below; insert gradation requirements if preferred. Aggregate size limits relate to spacing of steel reinforcement, depth of slab, or thickness of concrete member.

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

Retain "Fine Aggregate" Subparagraph below if optional restriction for fine aggregate in ASTM C33/C33M is required.

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

Retain "Lightweight Aggregate" Paragraph below if using lightweight aggregate for structural lightweight concrete. Retain size limit from four options below.

I. Lightweight Aggregate: ASTM C330/C330M, **[1-inch (25-mm)] [3/4-inch (19-mm)] [1/2-inch (13-mm)] [3/8-inch (10-mm)]** nominal maximum aggregate size.

J. 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 admixtures containing intentionally added chlorides [ **in steel-reinforced concrete].**

1. Air-Entraining Admixture: ASTM C260/C260M.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; MasterAir Series (Pre-2014: Micro Air, MB-AE 90 and MB-VR) or comparable product.

1. Water-Reducing Admixture: ASTM C494/C494M, Type A. Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; MasterPozzolith Series (Pre-2014: Pozzolith Series) or comparable product.

1. Mid-Range, Water-Reducing Admixture: ASTM C494/C494M, Type A. Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements,

provide Master Builders Solutions; MasterPolyheed Series (Pre-2014: Polyheed Series)

or comparable product.

1. Retarding Admixture: ASTM C494/C494M, Type B. Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; **[MasterSet R Series (Pre-2014: Pozzolith R Series)] [MasterSet DELVO Series (Pre-2014: DELVO Series)]** or comparable product.

1. Accelerating Admixture: ASTM C494/C494M, Type C. Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; **[MasterSet AC 534 (Pre-2014: Pozzolith AC534)] [MasterSet FP 20 (Pre-2014: Pozzutec 20+)]** or comparable product.

1. Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type D. Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; **[MasterSet R Series (Pre-2014: Pozzolith R Series)] [MasterSet DELVO Series (Pre-2014: DELVO Series)]** or comparable product.

1. Hydration-Control Admixture: ASTM C494/C494M, Type D. Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; MasterSet DELVO Series (Pre-2014: DELVO Series) or comparable product.

1. Water-Reducing and -Accelerating Admixture: ASTM C494/C494M, Type E. Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; MasterSet FP 20 (Pre-2014: Pozzutec 20+) or comparable product.

1. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F. Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; **[MasterGlenium Series (Pre-2014: Glenium Series)] [MasterRheobuild 1000 (Pre-2014: Rheobuild 1000)]** or comparable product.

1. High-Range, Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type G.
2. Workability-Retaining Admixture: ASTM C494/C494M, Type S. Shall retain concrete workability without affecting time of setting or early-age strength development.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; MasterSure Z 60 (Pre-2014: RheoTEC Z-60) or comparable product.

1. Strength-Enhancing Admixture: ASTM C494/C494M, Type S, liquid crystalline CSH nanoparticle admixture that increases both early- and late-age strength development without affecting concrete setting time.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; Master X-Seed Series or comparable product.

Retain "Permeability-Reducing Admixture" Subparagraph below if required. Consider actual need, budget, and expected results. If retained, insert specific requirement for permeability-reducing admixture in applicable paragraph under "Concrete Mixtures" Article. See the Evaluations.

1. Permeability-Reducing Admixture:
2. Shall be a portland cement-based crystalline capillary waterproofing admixture

that reacts in concrete to form insoluble crystalline hydration products in the capillary pores of concrete.

1. Shall show a reduction in permeability of concrete compared with an identical concrete mixture without the admixture, when tested in accordance with CRD-C 48 at a pressure of 200 psi (1.4 MPa) [, **equivalent to 460 ft. (140 m) of head].**
2. Shall reduce or have no penetration of water compared with an identical concrete mixture without the admixture, when tested in accordance with DIN 1048 for a duration of 96 hours.

NSF certification may be required for potable water tanks; delete first subparagraph below if not required for Project.

1. NSF 61 certified.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterLife 300 Series (Pre-2014: Rheomac 300D) or comparable product.
2. 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.

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterLife CI 30 (Pre-2014 Rheocrete CNI) or comparable product by one of the following:

**1) <Insert manufacturer's name>.**

Retain "Non-Set-Accelerating Corrosion-Inhibiting Admixture" Subparagraph below if corrosion inhibitors that do not affect concrete setting time are required.

1. 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, complying with ASTM C494/C494M, Type S.

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

a. Basis-of-Design Product: Subject to compliance with requirements, Master Builders Solutions; MasterLife CI 222 (Pre-2014: Rheocrete 222+) or comparable product by one of the following:

**1) <Insert manufacturer's name>.**

Retain "Set-Accelerating Corrosion-Inhibiting Admixture" Subparagraph below if set-accelerating corrosion inhibitors are required. Set-accelerating products are usually calcium nitrite-based admixtures and comply with ASTM C494/C494M, Type C.

1. Shrinkage-Reducing Admixture: ASTM C494/C494M, Type S.

Master Builders Solutions' "MasterLife CRA 007" is also classified as a crack-reducing admixture, because it provides better performance under restrained shrinkage and results in smaller crack widths.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; **[MasterLife SRA Series] [MasterLife CRA 007]** or comparable product.

1. Viscosity-Modifying Admixture: ASTM C494/C494M, Type S. Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; MasterMatrix VMA Series (Pre-2014: Rheomac VMA Series) or comparable product.

1. Anti-Washout Admixture: CRD-C661.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; MasterMatrix UW450 (Pre-2014: Rheomac UW 450) or comparable product.

1. Alkali-Silica Reaction Inhibiting Admixture: ASTM C494/C494M, Type S. Shall contain a nominal lithium nitrate content of 30 percent.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Master

Builders Solutions; MasterLife ASR 30 (Pre-2014: ASRx 30 LN) or comparable product.

Retain "Color Pigment" Paragraph below for integrally colored concrete.

K. Color Pigment: ASTM C979/C979M. Colored water-reducing admixtures, color stable,[ **free of carbon black,]** nonfading, and resistant to lime and other alkalis.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product or a comparable product from manufacturers listed.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterColor or comparable product by one of the following:

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

Retain one of three options in "Color" Subparagraph below.

1. Color: **[As indicated by manufacturer's designation] [Match Architect's sample] [As selected by Architect from manufacturer's full range].**

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L. 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

Retain "Carbon-Steel-Wire Fiber" or "Carbon-Steel Cut Sheet Fiber" Paragraph below if using steel-fiber reinforcement. Retain length of fiber from first set of options and the ratio of length to effective diameter from second set of options for aspect ratio. When using steel-fiber reinforcement for minimum shear resistance, revise retained paragraph to ASTM C1116/C1116M wire with an aspect ratio of not less than 50 and not to exceed 100.

A. Carbon-Steel-Wire Fiber: ASTM A820/A820M, Type 1, cold-drawn wire, deformed, minimum of **1.5 inches** long, with a minimum aspect ratio of **45 <Insert ratio>,** for use in producing Type 1 Steel Fiber-Reinforced Concrete meeting the requirements of ASTM C1116/C1116M**.**

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Shall provide a minimum residual strength, , (or a minimum average flexural strength, ) of [ ] psi when tested in accordance with ASTM C1609/C1609M, using the roller support system described in ASTM C1812/C1812M.
2. Dosage shall be as recommended by the manufacturer, but not less than 25 lb/yd3 for composite metal deck floor slabs.
3. Manufacturers: Subject to compliance with requirements, provide products by one of the

following:

1. Master Builders Solutions; MasterFiber 510 or MasterFiber 515
2. **<Insert manufacturer's name>.**

If retaining "Carbon-Steel-Wire Fiber" Paragraph below, retain length of fiber from first set of options and the ratio of length to effective diameter from second set of options for aspect ratio. When using steel-fiber reinforcement for minimum shear resistance, revise paragraph to ASTM C1116/C1116M wire with an aspect ratio of not less than 50 and not to exceed 100.

B. Carbon-Steel Cut Sheet Fiber: ASTM A820/A820M, Type 2, cut sheet, deformed, minimum of **1 inch** long, and aspect ratio of **45 <Insert ratio>,** for use in producing Type 1 Steel Fiber-Reinforced Concrete meeting the requirements of ASTM C1116/C1116M**.**

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Shall provide a minimum residual strength, (or a minimum average flexural strength,  of [ ] psi when tested in accordance with ASTM C1609/C1609M, using the roller support system described in ASTM C1812/C1812M.
2. Dosage shall be as recommended by the manufacturer, but not less than 25 lb/yd3 for composite metal deck floor slabs.
3. Manufacturers: Subject to compliance with requirements, provide products by one of the

following:

1. Master Builders Solutions; MasterFiber 520 or MasterFiber 525
2. **<Insert manufacturer's name>.**

Retain "Synthetic Monofilament Micro -Fiber" or "Synthetic Fibrillated Micro -Fiber" paragraphs below if using synthetic micro-fiber reinforcement. Monofilament fibers help reduce plastic shrinkage cracking. Manufacturers claim fibrillated fibers also improve hardened concrete properties. While the dosage of monofilament fibers is based on the cracking reduction ratio desired, fibrillated fibers are used at a standard dosage of 1.5 lb/cu. yd. (0.9 kg/cu. m) to replace 6 by 6 W1.4 by W1.4 (152 by 152 MW9.1 by MW9.1) welded-wire reinforcement typically in slabs-on-ground.

1. Synthetic Monofilament Micro Fiber. ASTM D7508/D7508M, monofilament polypropylene micro-fibers engineered and designed for use in producing Type III Synthetic Fiber-Reinforced Concrete, complying with ASTM C1116/C1116M.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product or a comparable product from manufacturers listed.

1. Shall provide a minimum crack reduction ratio (CRR) of [40] [] percent when tested in

accordance with ASTM C1579.

1. Dosage shall be as recommended by the manufacturer.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Master Builders Solutions; MasterFiber M Series.
4. **<Insert manufacturer's name>.**
5. Synthetic Fibrillated Micro-Fiber: ASTM D7508/D7508M; ibrillated polypropylene micro-fibers engineered and designed for use in producing Type III Synthetic Fiber-Reinforced Concrete, complying with ASTM C1116/C1116M.

Retain "Basis-of-Design Product" Subparagraph below to identify a specific product or a comparable product from manufacturers listed.

1. Shall provide a minimum crack reduction ratio (CRR) of [40] [] percent when tested in

accordance with ASTM C1579.

1. Dosage shall be 1.5 lb/yd3.
2. Manufactures: Subject to compliance with requirements, provide products by one of the following:
3. Master Builders Solutions; MasterFiber F Series
4. **<Insert manufacturer's name>.**

Manufacturers claim macro-fiber reinforcement can be used for crack control and may substitute for welded-wire reinforcement and some light steel-reinforcement bar configurations in slabs-on-ground and composite slabs. The quantity of fiber required to be added to the concrete is calculated by a structural engineer, based on criteria furnished by fiber manufacturer. Master Builders Solutions provides assistance in calculating the dosage of macrosynthetic fibers required to replace conventional shrinkage and temperature reinforcement in slabs-on-ground and composite slabs.

1. Synthetic Macro-Fiber: ASTM D7508/D7508M, polypropylene macro-fibers engineered and designed for use in producing Type III Synthetic Fiber-Reinforced Concrete, complying with ASTM C1116/C1116MRetain "Basis-of-Design Product" Subparagraph below to identify a specific product or a comparable product from manufacturers listed.

.

1. Shall provide a minimum residual strength, , (or a minimum average equivalent

flexural strength, of [ ] psi when tested in accordance with ASTM C1609/

C1609M, using the roller support system described in ASTM C1812/C1812M.

1. Dosage shall be as recommended by the manufacturer, but not less than 4 lb/yd3 for

composite metal deck floor slabs.

1. Manufacturers: Subject to compliance with requirements, provide products by one of

following:

* 1. Master Builders Solutions; MasterFiber MAC Series
  2. **<Insert manufacturer's name>.**

2.4 VAPOR RETARDERS

Retain "Sheet Vapor Retarder Class A" or "Sheet Vapor Retarder Class C" Paragraph below if a nonbituminous water vapor retarder is required. Class A has the highest tensile strength and puncture resistance. Class C has the lowest. There are no manufactures of Class B vapor retarders.

Retain option and insert water-vapor permeance in "Sheet Vapor Retarder Class A" Paragraph below if requiring less than the 0.1 perms permitted by ASTM El 745. See the Evaluations. If inserting lower perm rating in option, coordinate with manufacturers and products selected.

A. Sheet Vapor Retarder, Class A: ASTM E1745, Class A [, **except with maximum water-vapor permeance of] <Insert rating>;** not less than 10 mils (0.25 mm) thick Include manufacturer's recommended adhesive or pressure-sensitive tape.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the

following:

1. Barrier-Bac; Inteplast Group, Ltd.
2. Fortifiber Building Systems Group.
3. ISI Building Products.
4. Poly-America, L.P.
5. Raven Industries, Inc.
6. Reef Industries, Inc.
7. Stego Industries, LLC.
8. Tex-Trude, LP.
9. W.R. Meadows, Inc.
10. **<Insert manufacturer's name>.**

Retain option and insert water-vapor permeance in "Sheet Vapor Retarder Class C" Paragraph below if requiring less than the 0.1 perms permitted by ASTM E1745. See the Evaluations. If inserting lower perm rating in option, coordinate with manufacturers and products selected.

B. Sheet Vapor Retarder, Class C: ASTM El 745, Class C [, **except with maximum water-vapor permeance of] <Insert rating>;** not less than 10 mils (0.25 mm) thick. Include manufacturer's recommended adhesive or pressure-sensitive joint tape.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the

following:

1. ISI Building Products.
2. Stego Industries, LLC.
3. Tex-Trude, LP.
4. **<Insert manufacturer's name>.**

Retain "Sheet Vapor Retarder/Termite Barrier" Paragraph below if vapor retarder/termite barrier is required.

C. Sheet Vapor Retarder/Termite Barrier: ASTM E1745, Class A, except with maximum water-vapor permeance of 0.03 perms; complying with ICC AC380. Include manufacturer's recommended adhesive or pressure-sensitive tape.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Polyguard Products, Inc.
2. **<Insert manufacturer's name>.**

2. Low-Temperature Flexibility: Pass at minus 15 deg F (minus 26 deg C); ASTM D146/D146M.

3. Puncture Resistance: 224 lbf (996 N) minimum; ASTM E154/E154M.

4. Water Absorption: 0.1 percent weight-gain maximum after 48-hour immersion at 70 deg F (21 deg C); ASTM D570.

5. Hydrostatic-Head Resistance: 231 ft. (70 m) minimum; ASTM D5385.

Retain "Bituminous Vapor Retarder" Paragraph below if bituminous vapor retarder is required.

D. Bituminous Vapor Retarder: ASTM E1993/E1993M, 110-mil- (2.8-mm-) thick, semiflexible, seven-ply sheet membrane, consisting of reinforced core and carrier sheet with fortified asphalt layers, protective weather coating, and removable plastic release liner. Furnish manufacturer's accessories, including bonding asphalt, pointing mastics, and self-adhering joint tape.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. W.R. Meadows, Inc.
2. **<Insert manufacturer's name>.**

2. Water-Vapor Permeance: 0.0011 grains/hx sq. ft. x inches Hg (0.063 ng/Pa x s x sq. m) when tested in accordance with ASTM E154/E154M.

3. Tensile Strength: 156 lbf/inch (27.35 kN/m) when tested in accordance with ASTM E154/E154M.

4. Puncture Resistance: 140 lbf (662N) when tested in accordance with ASTM E154/E154M.

2.5 FLOOR AND SLAB TREATMENTS

Retain this article if one or more floor and slab treatments are required.

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 **[3/8-inch (10-mm)] [No. 4 (4.75-mm)] [No. 8 (236-mm)] <Insert size or gradation>** sieve.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Anti-Hydro International, Inc.
2. Dayton Superior.
3. Lambert Corporation.
4. Laticrete International, Inc.
5. Metalcrete Industries.
6. **<Insert manufacturer's name>.**

B. Slip-Resistive Aluminum Granule Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of not less than 95 percent fused aluminum-oxide granules.

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterTop 120SR (Pre-2014: Frictex NS) or comparable product by one of the following:

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

C. Emery Dry-Shake Floor Hardener: **[Pigmented] [Unpigmented],** 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.

Retain one of three options in "Color" Subparagraph below if retaining first option in "Emery Dry-Shake Floor Hardener" Paragraph above.

1. Color: **[As indicated by manufacturer's designation] [Match Architect's sample] [As selected by Architect from manufacturer's full range].**

D. Metallic Dry-Shake Floor Hardener: **[Pigmented] [Unpigmented],** 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. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterTop 200 (Pre-2014: MasterPlate 200) or comparable product by one of the following:

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

Retain one of three options in "Color" Subparagraph below if retaining first option in "Metallic Dry-Shake Floor Hardener" Paragraph above.

1. Color: **[As indicated by manufacturer's designation] [Match Architect's sample] [As selected by Architect from manufacturer's full range].**
2. Unpigmented Mineral Dry-Shake Floor Hardener: Factory-packaged dry combination of portland cement, graded quartz aggregate, and plasticizing admixture.

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterTop 110ABR (Pre-2014: Maximent HD) or comparable product by one of the following:

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

Verify suitability of pigmented mineral dry-shake floor hardener with manufacturer if air content of concrete exceeds 3 percent.

1. 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.

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterTop 100 (Pre-2014: Mastercron) or comparable product by one of the following:

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

Retain one of three options in "Color" Subparagraph below.

1. Color: **[As indicated by manufacturer's designation] [Match Architect's sample] [As selected by Architect from manufacturer's full range].**

LIQUID FLOOR TREATMENTS

Penetrating liquid floor treatment in "Penetrating Liquid Floor Treatment" Paragraph below is commonly applied to harden and densify floors of warehouses and distribution facilities, imparting a clear satin sheen to finished floor. Pigmented products may also be available. Although formulations vary, manufacturers claim these nonfluosilicate liquids improve abrasion and chemical resistance and dustproof concrete surface. When approved by manufacturers, these products may be installed over mineral dry-shake floor hardeners or integrally colored concrete.

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

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterKure HB 200WB (Pre-2014: Kure-N-Harden) or comparable product by one of the following:

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

Subparagraph below applies to LEED 2009 for Schools, IEQc 4.3.

1. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

Subparagraph below applies to LEED v4.

1. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

Subparagraph below applies to IgCC.

1. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 16.5 meg/cu. m or 13.5 ppb, whichever is less.

Subparagraph below applies to Green Globes.

1. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.7 CURING MATERIALS

Evaporation retarders temporarily reduce 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 "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterKure ER 50 (Pre-2014: Confilm) or comparable product by one of the following:

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

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:

1. Ambient Temperature Below 50 deg F (10 deg C): Black.
2. Ambient Temperature between 50 deg F (10 deg C) and 85 deg F (29 deg C): Any color.
3. Ambient Temperature Above 85 deg F (29 deg C): White.

D. Curing Paper: Eight-feet- (2438-mm-) wide paper, consisting of two layers of fibered kraft paper laminated with double coating of asphalt.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. Fortifiber Building Systems Group.
2. **<Insert manufacturer's name>.**

E. Water: Potable or complying with ASTM C1602/C1602M.

Retain "Clear, Waterborne, Membrane-Forming, Dissipating Curing Compound" Paragraph below if a dissipating-type, waterborne, membrane-forming curing compound is required. Although the EPA mandates maximum VOC emissions of 350 g/L for curing compounds, verify VOC emission limits of authorities having jurisdiction. If slow breakdown of curing membrane could interfere with bonding of floor coverings, retain "Removal" Subparagraph in "Concrete Curing" Article in Part 3.

F. Clear, Waterborne, Membrane-Forming, Dissipating Curing Compound: ASTM C309, Type 1, Class B.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**

1. Anti-Hydro International, Inc.
2. ChemMasters, Inc.
3. Dayton Superior.
4. Euclid Chemical Company (The); an RPM company.
5. Kaufman Products, Inc.
6. Lambert Corporation.
7. Laticrete International, Inc.
8. Nox-Crete Products Group.
9. SpecChem, LLC.
10. TK Products.
11. Vexcon Chemicals Inc.

1. W.R. Meadows, Inc.

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

Retain "Clear, Waterborne, Membrane-Forming, Nondissipating Curing Compound" Paragraph below if a nondissipating-type, waterborne, membrane-forming curing compound with minimal solids content is required. Although the EPA mandates maximum VOC emissions of 350 g/L for curing compounds, verify VOC emission limits of authorities having jurisdiction. Retain option if applicable.

G. Clear, Waterborne, Membrane-Forming, Nondissipating Curing Compound: ASTM C309, Type 1, Class **B[, certified by curing compound manufacturer to not interfere with bonding of floor covering].**

Verify with manufacturer that retained products have been tested against interference with bonding of floor covering.

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterKure CC 160WB (Pre-2014: Kure-N-Seal WB) or comparable product by one of the following:

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

1. Clear, Waterborne, Membrane-Forming, Curing Compound: ASTM C309, Type 1, Class B, 18 to 25 percent solids, nondissipating[, **certified by curing compound manufacturer to not interfere with bonding of floor covering].**

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterKure CC 200WB (Pre-2014: Kure-N-Seal W) or comparable product by one of the following:

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

1. Clear, Solvent-Borne, Membrane-Forming, Curing and Sealing Compound: ASTM C1315, Type 1, Class A.

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterKure 300SB (Pre-2014: Kure-N-Seal 30) or comparable product by one of the following:

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

Subparagraph below applies to LEED 2009 for Schools, IEQc 4.3.

1. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

Subparagraph below applies to LEED v4.

1. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

Subparagraph below applies to IgCC.

1. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 16.5 mcg/cu. m or 13.5 ppb, whichever is less.

Subparagraph below applies to Green Globes.

1. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

Retain "Clear, Waterbome, Membrane-Forming, Curing and Sealing Compound" Paragraph below if a clear, nonyellowing, waterborne, membrane-forming, curing and sealing compound is required. Although the EPA mandates maximum VOC emissions of 700 g/L for curing and sealing compounds, verify VOC emission limits of authorities having jurisdiction.

J. Clear, Waterborne, Membrane-Forming, Curing and Sealing Compound: ASTM C1315,

Type 1, Class A.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the

following:

1. ChemMasters, Inc.
2. Concrete Sealers USA.
3. Dayton Superior.
4. Euclid Chemical Company (The); an RPM company.
5. Kaufman Products, Inc.
6. Lambert Corporation.
7. Laticrete International, Inc.
8. Metalcrete Industries.
9. Nox-Crete Products Group.
10. Right Pointe.
11. SpecChem, LLC.

1. TK Products.

1. Vexcon Chemicals Inc.
2. W.R. Meadows, Inc.
3. **<Insert manufacturer's name>.**

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed.

Verify suitability of unpigmented mineral dry-shake floor hardener with manufacturer if air content of concrete exceeds 3 percent.

Retain applicable curing aids and materials from remaining paragraphs.

Retain "Clear, Waterborne, Membrane-Forming, Nondissipating Curing Compound" Paragraph below if a nondissipating-type, waterborne, membrane-forming curing compound with minimal solids content is required. Although the EPA mandates maximum VOC emissions of 350 g/L for curing compounds, verify VOC emission limits of authorities having jurisdiction. Retain option if applicable.

2Retain "Clear, Waterborne, Membrane-Forming, Curing Compound" Paragraph below if a nondissipating-type, waterborne, membrane-forming, curing compound with a higher solids content is required. This product will partially seal the concrete. Although the EPA mandates maximum VOC emissions of 350 g/L for curing compounds, verify VOC emission limits of authorities having jurisdiction. Retain option if applicable.

Retain "Clear, Solvent-Borne, Membrane-Forming, Curing and Sealing Compound" Paragraph below if a clear, nonyellowing, solvent-borne, membrane-forming curing and sealing compound is required. Although the EPA mandates maximum VOC emissions of 700 g/L for curing and sealing compounds, verify VOC emission limits of authorities having jurisdiction.

Subparagraph below applies to LEED 2009 for Schools, IEQc 4.3.

1. Products shall comply with the requirements of the California Department of Public

Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

Subparagraph below applies to LEED v4.

3. Products shall comply with the requirements of the California Department of Public   
Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

Subparagraph below applies to IgCC.

4. Products shall comply with the requirements of the California Department of Public   
Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 16.5 meg/cu. m or 13.5 ppb, whichever is less.

Subparagraph below applies to Green Globes.

5. Products shall comply with the requirements of the California Department of Public   
Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.8 RELATED MATERIALS

Retain one or all options in "Expansion- and Isolation-Joint-Filler Strips" Paragraph below. Joint-filler strips are used in floor isolation joints.

A. Expansion- and Isolation-Joint-Filler Strips: **[ASTM D1751, asphalt-saturated cellulosic fiber] [or] [ASTM D1752, cork or self-expanding cork].**

Retain one of two options in "Semirigid Joint Filler" Paragraph below if semirigid joint filler is required to fill joints and support edges of trafficked control and construction joints.

B. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, **[epoxy resin with a Type A shore durometer hardness of 80] [aromatic polyurea with a Type A shore durometer hardness range of 90 to 95]** in accordance with ASTM D2240.

Bonding agent in "Bonding Agent" Paragraph below may be used directly from container or as an admixture in cement or sand-cement slurries and rubbing grout.

C. Bonding Agent: ASTM C1059/C1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.

D. 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:

Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterEmaco ADH (Pre-2014: Concresive Series).

Retain types from two options in subparagraph below, based on service loadings.

1. **[Types I and II, nonload bearing] [Types IV and V, load bearing],** for bonding hardened or freshly mixed concrete to hardened concrete.

Retain "Floor Slab Protective Covering" Paragraph below if required to protect concrete floor surfaces scheduled to be polished or other special floor finishes.

E. Floor Slab Protective Covering: Eight-feet- (2438-mm-) wide cellulose fabric.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the

following:

1. McTech Group, Inc.
2. **<Insert manufacturer's name>.**

2.9 REPAIR MATERIALS

Retain "Repair Underlayment" Paragraph below as a repair material for floor and slab areas beneath floor coverings.

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)] <Insert strength>** at 28 days when tested in accordance with ASTM C109/C109M.

Retain "Repair Overlayment" Paragraph below as a repair material for floor or slab areas remaining exposed and not receiving floor coverings.

B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch (6 mm) and that can be filled in over a scarified surface 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 topping manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by topping manufacturer.
4. Compressive Strength: Not less than **[5000 psi (34.5 MPa)] <Insert strength>** at 28 days when tested in accordance with ASTM C109/C109M.

2.10 CONCRETE MIXTURES, GENERAL

1. 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-SPEC-301 (ACI-SPEC-301M).

1. Use a qualified testing agency for preparing and reporting proposed mixture designs,

based on laboratory trial mixtures.

In "Cementitious Materials" Paragraph below, neither ACI-SPEC-301 (ACI-SPEC-301M) nor ACI-CODE-318 (ACI-CODE-318M) limit amount of cementitious materials that can replace portland cement unless concrete is exposed to deicing chemicals. Identify parts of building or structure affected by these limits unless extending them to all concrete.

1. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

Percentages in five subparagraphs below repeat ACI-SPEC-301 (ACI-SPEC-301M), Table 4.2.1.1(b) limits for concrete Exposure Class F3. Revise to suit Project.

1. Fly Ash or Other Pozzolans: 25 percent by mass.
2. Slag Cement: 50 percent by mass.

Limits of silica fume/metakaolin alone or in combination with other cementitious materials below are based on ACI-SPEC-301 (ACI-SPEC-301M) and ACI-CODE-318 (ACI-CODE-318M).

1. Silica Fume/Metakaolin: 10 percent by mass.
2. Total of Fly Ash or Other Pozzolans, Slag Cement, and Silica Fume/Metakaolin: 50 percent by mass, with fly ash or pozzolans not exceeding 25 percent by mass and silica fume/metakaolin not exceeding 10 percent by mass.
3. Total of Fly Ash or Other Pozzolans and Silica Fume/Metakaolin: 35 percent by mass with fly ash or pozzolans not exceeding 25 percent by mass and silica fume /metakaolin not exceeding 10 percent by mass.

C. Admixtures: Use admixtures in accordance with manufacturer's written instructions.

Use of chemical admixtures is typically the decision of the Contractor and concrete manufacturer. If any chemical admixture is required by the design team, consider inserting specific requirements in applicable paragraph in "Concrete Mixtures" Article.

Revise first four 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 accelerating or water-reducing and -accelerating admixture when required by low temperatures, or other adverse winter placement conditions.
4. 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].**

Insert locations and dosage of corrosion-inhibiting admixture in first subparagraph below if required.

1. Use corrosion-inhibiting admixture in concrete mixtures where indicated.

Insert locations and dosage of permeability-reducing admixture in subparagraph below if required.

1. Use permeability-reducing admixture in concrete mixtures where indicated.

Retain "Color Pigment" Paragraph below if integrally colored concrete is required, and indicate locations here or on Drawings.

D. 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.

2.11 CONCRETE MIXTURES

This article contains examples of building elements that often need different concrete mixtures. Revise, consolidate, or add other building elements if more concrete mixtures are required. ASTM C94/C94M

requires each "class" of concrete mixture be assigned a designation to facilitate identification of each concrete mixture delivered to the Project, and that this designation be identified on the delivery ticket. "Class" designations used below are examples only. Revise to suit Project. Do not duplicate "Class" designations used in Section 033300 "Architectural Concrete."

Consider inserting minimum cementitious material content for mix designs.

A. Class **[A] <Insert designation>:** Normal-weight concrete used for footings, grade beams, and

tie beams.

1. Exposure Class: ACI-CODE-318 (ACI-CODE-318M) **[F0] [Fl] [F2] [F3] [SO] [S1] [S2] [S3] [WO] [Wi] [CO] [C1] [C2].**

Retain strength from first five options in "Minimum Compressive Strength" Subparagraph below, or revise to suit Project. Coordinate compressive strength with w/cm if concrete is subject to special exposure conditions or sulfate exposure, as identified in ACI-CODE-318 (ACI-CODE-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)] [As indicated] <Insert strength>** at 28 days.

Retain one option in "Maximum w/cm" Subparagraph below, revise subparagraph to suit Project, or delete subparagraph if in-service durability conditions are benign and limits on w/cm are not required. Coordinate w/cm with compressive strength. See the Evaluations for discussion.

1. Maximum w/cm: **[0.50] [0.45] [0.40] <Insert number>.**

Consider deleting "Slump Limit" Subparagraph below and allow the Contractor to select a target slump based on ASTM C143/C143M, as permitted under ACI-SPEC-301. If retaining "Slump Limit" Subparagraph, retain slump limit from three options or revise to suit Project.

1. Slump Limit: **[4 inches (100 mm), plus or minus 1 inch (25 mm)] [5 inches (125 mm), plus or minus 1 inch (25 mm)] [8 inches (200 mm), plus or minus 1 inch (25 mm) for concrete with verified slump of 3 inches (75 mm), plus or minus 1 inch (25 mm)before adding high-range water-reducing admixture or plasticizing admixture at Project site] <Insert limits>.**

"Slump Flow Limit" Subparagraph below is for self-consolidating concrete. Consider deleting and allow the Contractor to select a target slump flow based on ASTM C1611/C1611M, as permitted under ACI-SPEC-301. If retaining "Slump Flow Limit" Subparagraph, retain slump flow limit from two options, or revise to suit Project.

1. Slump Flow Limit: **[22 inches (550 mm), plus or minus 1.5 inches (40 mm)] [30 inches (762 mm), plus or minus 2.5 inches (65 mm)] <Insert limits>.**
2. Air Content:

Options in first two subparagraphs below are examples only. Revise to suite Project. See ACI-SPEC-301 (ACI-SPEC-301M), Table 4.2.2.7(b)1 for air content for additional Exposure Classes and aggregate sizes.

a. Exposure Class Fl: **[5.0 percent, plus or minus 1.5 percent at point of delivery**

**for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-1/2-inch (38-mm) nominal maximum aggregate size].**

b. Exposure Classes F2 and F3: **[6 percent, plus or minus 1.5 percent at point of**

**delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [5.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-1/2-inch (38-mm) nominal maximum aggregate size].**

Retain appropriate option in subparagraph below for chloride limits. Percentages below repeat ACI-CODE-318 (ACI-CODE-318M) limits. First option is for Exposure Class CO; second option is for Exposure Class Cl; third option is for Exposure Class C2. ACI-SPEC-301 (ACI-SPEC-301M) and ACI-CODE-318 (ACI-CODE-318M) express this percentage by weight of cement, not cementitious material.

1. Limit water-soluble, chloride-ion content in hardened concrete to **[1.00] [0.30] [0.15] <Insert number>** percent by weight of cement.

B. Class **[B] <Insert designation>:** Normal-weight concrete used for foundation walls.

1. Exposure Class: ACI CODE-318 (ACI CODE-318M) **[F0] [Fl] [F2] [F3] [SO] [S1]** [S2] [S3] **[WO] [Wi] [CO] [C1] [C2].**

Retain strength from first five options in "Minimum Compressive Strength" Subparagraph below, or revise to suit Project. Coordinate compressive strength with w/cm if concrete is subject to special exposure conditions or sulfate exposure, as identified in ACI-CODE-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)] [As indicated] <Insert strength>** at 28 days.

Retain w/cm from three options in "Maximum w/cm" Subparagraph below, revise to suit Project, or delete if in-service durability conditions are benign and limits on w/c ratio are not required. Coordinate w/cm with compressive strength. See the Evaluations for discussion.

1. Maximum w/cm: **[0.50] [0.45] [0.40] <Insert number>.**

Consider deleting "Slump Limit" Subparagraph below and allow the Contractor to select a target slump based on ASTM C143/C143M, as permitted under ACI-SPEC-301. If retaining "Slump Limit" Subparagraph, retain slump limit from three options in, or revise to suit Project.

1. Slump Limit: **[4 inches (100 mm), plus or minus 1 inch (25 mm)] [5 inches (125 mm), plus or minus 1 inch (25 mm)] [8 inches (200 mm), plus or minus 1 inch (25 mm) for concrete with verified slump of 3 inches (75 mm), plus or minus 1 inch (25 mm),before adding high-range water-reducing admixture or plasticizing admixture at Project site] <Insert limits>.**

"Slump Flow Limit" Subparagraph below is for self-consolidating concrete. Consider deleting and allow the Contractor to select a target slump flow based on ASTM C1611/C1611M, as permitted under ACI-SPEC-301. If retaining "Slump Flow Limit" Subparagraph, retain slump flow limit from two options, or revise to suit Project.

1. Slump Flow Limit: **[22 inches (550 mm), plus or minus 1.5 inches (40 mm)] [30 inches (762 mm), plus or minus 2.5 inches (65 mm)] <Insert limits>.**
2. Air Content:

Options in first two subparagraphs are examples only. Revise to suite Project. See ACI-SPEC-301 (ACI-SPEC-301M), Table 4.2.2.7(b)1 for air content for additional Exposure Classes and aggregate sizes.

1. Exposure Class Fl: **[5.0 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing**

**inch (38-mm) nominal maximum aggregate size].**

1. Exposure Classes F2 and F3: **[6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-nun) nominal maximum aggregate size] [6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [5.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-1/2-inch (38-mm) nominal maximum aggregate size].**

Retain appropriate option in subparagraph below for chloride limits. Percentages below repeat ACI-CODE-318 (ACI-CODE-318M) limits. First option is for Exposure Class CO; second option is for Exposure Class Cl; third option is for Exposure Class C2. ACI-SPEC-301 (ACI-SPEC-301M) and ACI-CODE-318 (ACI-CODE-318M) express this percentage by weight of cement, not cementitious material.

7. Limit water-soluble, chloride-ion content in hardened concrete to **[1.00] [0.30] [0.15]**

**<Insert number>** percent by weight of cement.

C. Class **[C] <Insert designation>:** Normal-weight concrete used for interior slabs-on-ground.

1. Exposure Class: ACI CODE-318 (ACI CODE-318M) **[F0] [SO] [S1] [S2] [S3] [WO] [Wl] [CO] [C1] [C2].**

Retain strength from first five options in "Minimum Compressive Strength" 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)] [As indicated] <Insert strength>** at 28 days.

Retain w/cm from three options in "Maximum w/cm" Subparagraph below, revise to suit Project, or delete if in-service durability conditions are benign and limits on w/c ratio are not required. Coordinate w/cm with compressive strength. See the Evaluations for discussion.

1. Maximum w/cm: **[0.50] [0.45] [0.40] <Insert number>.**

Retain one of four options in "Minimum Cementitious Materials Content" Subparagraph below, or revise to suit Project. Options are based on minimum requirements set by ACI-SPEC-301 (ACI-SPEC-301M) for floors and relate to nominal maximum aggregate sizes 1-1/2 inches, 1 inch, 3/4 inch, and 3/8 inch (38, 25, 19 mm, and 10 mm), respectively.

1. Minimum Cementitious Materials Content: **[470 lb/cu. yd. (279 kg/cu. m)] [520 lb/cu. yd. (309 kg/cu. m)] [540 lb/cu. yd. (320 kg/cu. m)] [610 lb/cu. yd. (362 kg/cu. m)].**

Consider deleting "Slump Limit" Subparagraph below and allow the Contractor to select a target slump based on ASTM C143/C143M, as permitted under ACI-SPEC-301. If retaining "Slump Limit" Subparagraph, retain slump limit from three options, or revise to suit Project. Consider only including slump limits where slabs-on-ground are subject to special exposure conditions or injurious sulfate exposure.

1. Slump Limit: **[4 inches (100 mm), plus or minus 1 inch (25 mm)] [5 inches (125 mm), plus or minus 1 inch (25 nun)] [8 inches (200 mm), plus or minus 1 inch (25 mm) for concrete with verified slump of 3 inches (75 mm), plus or minus 1 inch (25**

**before adding high-range water-reducing admixture or plasticizing admixture at Project site] <Insert limits>.**

"Slump Flow Limit" Subparagraph below is for self-consolidating concrete. Consider deleting and allow the Contractor to select a target slump flow based on ASTM C1611/C1611M, as permitted under ACI-SPEC-301. If retaining "Slump Flow Limit" Subparagraph, retain slump flow limit from two options, or revise to suit Project.

1. Slump Flow Limit: **[22 inches (550 mm), plus or minus 1.5 inches (40 mm)] [30 inches (762 mm), plus or minus 2.5 inches (65 mm)] <Insert limits>.**
2. 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.

Retain appropriate option in first subparagraph below for chloride limits. Percentages below repeat ACI-CODE-318 (ACI-CODE-318M) limits. First option is for Exposure Class CO; second option is for Exposure Class Cl; third option is for Exposure Class C2. ACI-SPEC-301 (ACI-SPEC-301M) and ACI-CODE-318 (ACI-CODE-318M) express this percentage by weight of cement, not cementitious material.

1. Limit water-soluble, chloride-ion content in hardened concrete to **[1.00] [0.30] [0.15] <Insert number>** percent by weight of cement.

Retain "Steel-Fiber Reinforcement" Subparagraph below if steel-fiber reinforcement is used. Indicate location, on Drawings, of concrete using steel fiber. Revise application rate to suit Project.

1. 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)] <Insert weight>.**

Synthetic-micro-fiber dosage rates in "Synthetic Micro-Fiber" Subparagraph below reflect typical recommendations of manufacturers.

1. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of **[0.5 lb/cu. yd. (0.30 kg/cu. m)] [0.75 lb/cu. yd. (0.45 kg/cu. m)] [1.0 lb/cu. yd. (0.60 kg/cu. m)] [1.5 lb/cu. yd. (0.90 kg/cu. m)] <Insert dosage>.**

Synthetic-macro-fiber dosage rates in "Synthetic Macro-Fiber" Subparagraph below are examples only; verify minimum dosage rates with manufacturer.

1. Synthetic Macro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of **[3.0 lb/cu. yd. (1.8 kg/cu. m)] [4.0 lb/cu. yd. (2.4 kg/cu. m)] [5 lb/cu. yd. (3 kg/cu. m)] <Insert dosage>.**

Retain "Class D" Paragraph below if normal-weight concrete is used. Suspended slabs include formed concrete slabs, post-tensioned concrete slabs, and composite or non-composite concrete slabs on metal deck, classified by ACI-SPEC-302.1R as single-course floors or base slabs of two-course floors. If Project has more than one type of suspended slab with different properties, indicate location of each on Drawings.

D. Class **[D] <Insert designation>:** Normal-weight concrete used for interior suspended slabs.

1. Exposure Class: ACI CODE-318 (ACI CODE-318M) **[FO] [SO] [S1] [S2] [S3] [WO] [Wl] [CO] [C1]**

**[C2].**

Retain strength from first five options in "Minimum Compressive Strength" 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> [As indicated]** at 28 days.

Retain w/cm from three options in "Maximum w/cm" Subparagraph below, revise to suit Project, or delete if in-service durability conditions are benign and limits on w/cm are not required. Coordinate w/cm with compressive strength. See the Evaluations for discussion.

1. Maximum w/cm: **[0.50] [0.45] [0.40] <Insert number>.**

Retain one of four options in "Minimum Cementitious Materials Content" Subparagraph below, or revise to suit Project. Options are based on minimum requirements set by ACI-SPEC-301 (ACI-SPEC-301M) for floors and relate to nominal maximum aggregate sizes 1-1/2 inches, 1 inch, 3/4 inch, and 3/8 inch (38, 25, 19 mm, and 10 mm), respectively.

1. Minimum Cementitious Materials Content: **[470 lb/cu. yd. (279 kg/cu. m)] [520 lb/cu. yd. (309 kg/cu. m)] [540 lb/cu. yd. (320 kg/cu. m)] [610 lb/cu. yd. (362 kg/cu. m)].**

Consider deleting "Slump Limit" Subparagraph below and allow the Contractor to select a target slump based on ASTM C143/C143M, as permitted under ACI-SPEC-301. If retaining "Slump Limit" Subparagraph, retain slump limit from three options in, or revise to suit Project. Consider only including slump limits where suspended slabs are subject to special exposure conditions or injurious sulfate exposure.

1. Slump Limit: **[4 inches (100 mm), plus or minus 1 inch (25 mm)] [5 inches (125 mm), plus or minus 1 inch (25 mm)] [8 inches (200 mm), plus or minus 1 inch (25 mm) for concrete with verified slump of 3 inches (75 mm), plus or minus 1 inch (25 mm),before adding high-range water-reducing admixture or plasticizing admixture at Project site] <Insert limits>.**

"Slump Flow" Subparagraph below is for self-consolidating concrete. Consider deleting and allow the Contractor to select a target slump flow based on ASTM C1611/C1611M, as permitted under ACI-SPEC-301. If retaining "Slump Flow Limit" Subparagraph, retain slump flow limit from two options, or revise to suit Project.

1. Slump Flow Limit: **[22 inches (550 mm), plus or minus 1.5 inches (40 nun)] [30 inches (762 mm), plus or minus 2.5 inches (65 mm)] <Insert limits>.**
2. 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.

Retain appropriate option in first subparagraph below for chloride limits. Percentages below repeat ACI-CODE-318 (ACI-CODE-318M) limits. First option is for Exposure Class CO; second option is for Exposure Class Cl; third option is for Exposure Class C2. ACI-SPEC-301 (ACI-SPEC-301M) and ACI-CODE-318 (ACI-CODE-318M) express this percentage by weight of cement, not cementitious material.

1. Limit water-soluble, chloride-ion content in hardened concrete to **[1.00] [0.30] [0.15] <Insert number>** percent by weight of cement.

Retain "Steel-Fiber Reinforcement" Subparagraph below if steel-fiber reinforcement is used. Indicate location, on Drawings, of concrete using steel fiber. Revise application rate to suit Project.

1. 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)] <Insert weight>.**

Synthetic-micro-fiber dosage rates in "Synthetic Micro-Fiber" Subparagraph below reflect typical recommendations of manufacturers.

1. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of **[0.5 lb/cu. yd. (030 kg/cu. m)] [0.75 lb/cu. yd. (0.45 kg/cu. m)] [1.0 lb/cu. yd. (0.60 kg/cu. m)] [1.5 lb/cu. yd. (0.90 kg/cu. m)] <Insert dosage>.**

Synthetic-macro-fiber dosage rates in "Synthetic Macro-Fiber" Subparagraph below are examples only; verify minimum dosage rates by structural analysis and with manufacturer.

1. 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)] [5 lb/cu. yd. (3 kg/cu. m)] <Insert dosage>.**

Retain "Class E" Paragraph below if normal-weight structural concrete is used. Coordinate requirements with lightweight aggregate supplier, structural engineer, and, if applicable, UL design limits.

E. Class **[E] <Insert designation>:** Structural lightweight concrete used for interior suspended

slabs.

1. Exposure Class: ACI CODE-318 (ACI CODE-318M) **[F0] [SO] [S1] [S2] [S3] [WO] [Wl] [CO] [C1] [C2].**

Retain strength from first five options in "Minimum Compressive Strength" 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>** [As **indicated]** at 28 days.

Retain one of three options in "Calculated Density" Subparagraph below, or revise values or density terminology. "Calculated equilibrium density" is the basis preferred by the Expanded Shale Clay and Slate Institute rather than "oven dry density," which is included in ACI-SPEC-301 (ACI-SPEC-301M) for measuring unit weight.

1. Calculated Density: **[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 C567/C567M.

Consider deleting "Slump Limit" Subparagraph below and allow the Contractor to select a target slump based on ASTM C143/C143M, as permitted under ACI-SPEC-301. If retaining "Slump Limit" Subparagraph, retain slump limit from three options, or revise to suit Project.

1. Slump Limit: **[4 inches (100 mm), plus or minus 1 inch (25 mm)] [5 inches (125 mm), plus or minus 1 inch (25 mm)] [8 inches (200 mm), plus or minus 1 inch (25 mm) for concrete with verified slump of 3 inches (75 mm), plus or minus 1 inch (25 mm),before adding high-range water-reducing admixture or plasticizing admixture at Project site] <Insert limits>.**

"Slump Flow Limit" Subparagraph below is for self-consolidating concrete. Consider deleting and allow the Contractor to select a target slump flow based on ASTM C1611/C1611M, as permitted under ACI-SPEC-301. If retaining "Slump Flow Limit" Subparagraph, retain slump flow limit from two options, or revise to suit Project.

1. Slump Flow Limit: **[22 inches (550 mm), plus or minus 1.5 inches (40 mm)] [30 inches (762 mm), plus or minus 2.5 inches (65 mm)] <Insert limits>.**
2. 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.

Retain appropriate option in first subparagraph below for chloride limits. Percentages below repeat ACI-CODE-318 (ACI-CODE-318M) limits. First option is for Exposure Class CO; second option is for Exposure Class Cl; third option is for Exposure Class C2. ACI-SPEC-301 (ACI-SPEC-301M) and ACI-CODE-318 (ACI-CODE-318M) express this percentage by weight of cement, not cementitious material.

1. Limit water-soluble, chloride-ion content in hardened concrete to **[1.00] [0.30] [0.15] <Insert number>** percent by weight of cement.

Retain "Steel-Fiber Reinforcement" Subparagraph below if steel-fiber reinforcement is used. Indicate location, on Drawings, of concrete using steel fiber. Revise application rate to suit Project.

1. 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)] <Insert weight>.**

Synthetic-micro-fiber dosage rates in "Synthetic Micro-Fiber" Subparagraph below reflect typical recommendations of manufacturers.

1. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than a rate of **[0.5 lb/cu. yd. (0.30 kg/cu. m)] [0.75 lb/cu. yd. (0.45 kg/cu. m)] [1.0 lb/cu. yd. (0.60 kg/cu. m)] [1.5 lb/cu. yd. (0.90 kg/cu. m)] <Insert dosage>.**

Synthetic-macro-fiber dosage rates in "Synthetic Macro-Fiber" Subparagraph below are examples only; verify minimum dosage rates by structural analysis and with manufacturer.

1. 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)] [5 lb/cu. yd. (3 kg/cu. m)] <Insert dosage>.**

Retain "Class F" Paragraph below for concrete toppings or concrete underbeds on a base concrete slab or on structural precast concrete. For emery-aggregate and iron-aggregate concrete floor toppings, see Section 035300 "Concrete Topping."

F. Class **[F] <Insert designation>:** Normal-weight concrete used for concrete toppings.

1. Exposure Class: ACI-CODE-318 (ACI-CODE-318M) **[FO] [Fl] [F2] [F3] [SO] [S1] [S2] [S3] [WO] [Wl] [CO] [C1] [C2].**

Retain strength from first five options in "Minimum Compressive Strength" 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> [As indicated]** at 28 days.

Retain one of three options in "Minimum Cementitious Materials Content" Subparagraph below, or revise to suit Project. Options are based on minimum requirements set by ACI-SPEC-301 (ACI-SPEC-301M) for floors and relate to nominal maximum aggregate sizes 1-1/2 inches, 1 inch, and 3/4 inch (38, 25, and 19 mm), respectively.

3. Minimum Cementitious Materials Content: **[470 lb/cu. yd. (279 kg/cu. m)] [520 lb/cu.**

**yd. (309 kg/cu. m)] [540 lb/cu. yd. (320 kg/cu. m)].**

Consider deleting "Slump Limit" Subparagraph below and allow the Contractor to select a target slump based on ASTM C143/C143M, as permitted under ACI-SPEC-301. If retaining "Slump Limit" Subparagraph, retain slump limit from two options, or revise to suit Project.

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

5. Air Content:

Options in first two subparagraphs are examples only. Revise to suite Project. See ACI-SPEC-301 (ACI-SPEC-301M), Table 4.2.2.7(b)1 for air content for additional Exposure Classes and aggregate sizes.

1. Exposure Class Fl: **[5.0 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing**

**inch (38-mm) nominal maximum aggregate size].**

1. Exposure Classes F2 and F3: **[6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [5.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-1/2-inch (38-mm) nominal maximum aggregate size].**

Retain appropriate option in first subparagraph below for chloride limits. Percentages below repeat ACI-CODE-318 (ACI-CODE-318M) limits. First option is for Exposure Class CO; second option is for Exposure Class Cl; third option is for Exposure Class C2. ACI-SPEC-301 (ACI-SPEC-301M) and ACI-CODE-318 (ACI-CODE-318M) express this percentage by weight of cement, not cementitious material.

6. Limit water-soluble, chloride-ion content in hardened concrete to **[1.00] [0.30] [0.15]**

**<Insert number>** 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.

Retain "Steel-Fiber Reinforcement" Subparagraph below if steel-fiber reinforcement is used. Indicate location, on Drawings, of concrete using steel fiber. Revise application rate to suit Project.

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)] <Insert weight>.**

Synthetic-micro-fiber dosage rates in "Synthetic Micro-Fiber" Subparagraph below reflect typical recommendations of manufacturers.

8. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's   
recommended rate, but not less than a rate o f **[0.5 lb/cu. yd. (0.30 kg/cu. m)] [0.75 lb/cu. yd. (0.45 kg/cu. m)] [1.0 lb/cu. yd. (0.60 kg/cu. m)] [1.5 lb/cu. yd. (0.90 kg/cu. m)] <Insert dosage>.**

Synthetic-macro-fiber dosage rates in "Synthetic Macro-Fiber" Subparagraph below are examples only; verify minimum dosage rates with manufacturer.

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)] [5 lb/cu. yd. (3 kg/cu. m)] <Insert dosage>.**

G. Class **[G] <Insert designation>:** Normal-weight concrete used for building frame members.

1. Exposure Class: ACI-CODE-318 (ACI-CODE-318M) **[F0] [Fl] [F2] [F3] [SO] [S1] [S2] [S3] [WO] [Wl] [CO] [C1] [C2].**

Retain strength from first five options in "Minimum Compressive Strength" Subparagraph below, or revise to suit Project. Coordinate compressive strength with w/cm if concrete is subject to special exposure conditions or sulfate exposure, as identified in ACI-CODE-318 (ACI-CODE-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> [As indicated]** at 28 days.

Retain w/cm from three options in "Maximum w/cm" Subparagraph below, revise to suit Project, or delete if in-service durability conditions are benign and limits on w/cm are not required. Coordinate w/cm with compressive strength. See the Evaluations for discussion.

1. Maximum w/cm: **[0.50] [0.45] [0.40] <Insert number>.**

Consider deleting "Slump Limit" Subparagraph below and allow the Contractor to select a target slump based on ASTM C143/C143M, as permitted under ACI-SPEC-301. If retaining "Slump Limit" Subparagraph, retain slump limit from three options, or revise to suit Project.

1. Slump Limit: **[4 inches (100 mm), plus or minus 1 inch (25 mm)] [5 inches (125 nun), plus or minus 1 inch (25 mm)] [8 inches (200 mm), plus or minus 1 inch (25 mm) for concrete with verified slump of 3 inches (75 mm), plus or minus 1 inch (25 mm),before adding high-range water-reducing admixture or plasticizing admixture at Project site] <Insert limits>.**

"Slump Flow Limit" Subparagraph below is for self-consolidating concrete. Consider deleting and allow the Contractor to select a target slump flow based on ASTM C1611/C1611M, as permitted under ACI-SPEC-301. If retaining "Slump Flow Limit" Subparagraph, retain slump flow limit from two options, or revise to suit Project.

1. Slump Flow Limit: **[22 inches (550 nun), plus or minus 1.5 inches (40 mm)] [30 inches (762 mm), plus or minus 2.5 inches (65 mm)] <Insert limits>.**
2. Air Content:

Options in first two subparagraphs are examples only. Revise to suite Project. See ACI-SPEC-301 (ACI-SPEC-301M), Table 4.2.2.7(b)1 for air content for additional Exposure Classes and aggregate sizes.

1. Exposure Class Fl: **[5.0 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing**

**inch (38-mm) nominal maximum aggregate size].**

1. Exposure Classes F2 and F3: **[6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [5.5**

**percent, plus or minus 1.5 percent at point of delivery for concrete containing**

**1-1/2-inch (38-mm) nominal maximum aggregate size].**

Retain appropriate option in subparagraph below for chloride limits. Percentages below repeat ACI-CODE-318 (ACI-CODE-318M) limits. First option is for Exposure Class CO; second option is for Exposure Class Cl; third option is for Exposure Class C2. ACI-SPEC-301 (ACI-SPEC-301M) and ACI-SPEC-318 (ACI-SPEC-318M) express this percentage by weight of cement, not cementitious material.

1. Limit water-soluble, chloride-ion content in hardened concrete to **[1.00] [0.30] [0.15] <Insert number>** percent by weight of cement.

H. Class **[H] <Insert designation>:** Normal-weight concrete used for building walls.

1. Exposure Class: ACI CODE-318 (ACI CODE-318M) **[FO] [Fl] [F2] [F3] [SO] [S1] [S2] [S3] [WO] [Wl] [CO] [C1] [C2].**

Retain strength from first five options in "Minimum Compressive Strength" Subparagraph below, or revise to suit Project. Coordinate compressive strength with w/cm if concrete is subject to special exposure conditions or sulfate exposure, as identified in ACI-CODE-318 (ACI-CODE-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> [As indicated]** at 28 days.

Retain w/cm from three options in "Maximum w/cm" Subparagraph below, revise to suit Project, or delete if in-service durability conditions are benign and limits on w/cm are not required. Coordinate w/cm with compressive strength. See the Evaluations for discussion.

1. Maximum w/cm: **[0.50] [0.45] [0.40] <Insert number>.**

Consider deleting "Slump Limit" Subparagraph below and allow the Contractor to select a target slump based on ASTM C143/C143M, as permitted under ACI 301. If retaining "Slump Limit" Subparagraph, retain slump limit from three options, or revise to suit Project.

1. Slump Limit: **[4 inches (100 nun), plus or minus 1 inch (25 mm)] [5 inches (125 mm), plus or minus 1 inch (25 nun)] [8 inches (200 mm), plus or minus 1 inch (25 mm) for concrete with verified slump of 3 inches (75 mm), plus or minus 1 inch (25 mm),before adding high-range water-reducing admixture or plasticizing admixture at Project site] <Insert limits>.**

"Slump Flow Limit" Subparagraph below is for self-consolidating concrete. Consider deleting and allow the Contractor to select a target slump flow based on ASTM C1611/C1611M, as permitted under ACI 301. If retaining "Slump Flow Limit" Subparagraph, retain slump flow limit from two options, or revise to suit Project.

1. Slump Flow Limit: **[22 inches (550 mm), plus or minus 1.5 inches (40 mm)] [30 inches (762 mm), plus or minus 2.5 inches (65 mm)] <Insert limits>.**
2. Air Content:

Options in first two subparagraphs are examples only. Revise to suite Project. See ACI A301 (ACI 301M), Table 4.2.2.7(b)1 for air content for additional Exposure Classes and aggregate sizes.

a. Exposure Class Fl: **[5.0 percent, plus or minus 1.5 percent at point of delivery**

**for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete**

**containing 1-inch (25-mm) nominal maximum aggregate size] [4.5 percent,**

**plus or minus 1.5 percent at point of delivery for concrete containing**

**inch (38-mm) nominal maximum aggregate size].**

b. Exposure Classes F2 and F3: **[6 percent, plus or minus 1.5 percent at point of   
delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [5.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-1/2-inch (38-mm) nominal maximum aggregate size].**

Retain appropriate option in subparagraph below for chloride limits. Percentages below repeat ACI 318 (ACI 318M) limits. First option is for Exposure Class CO; second option is for Exposure Class Cl; third option is for Exposure Class C2. ACI 301 (ACI 301M) and ACI 318 (ACI 318M) express this percentage by weight of cement, not cementitious material.

7. Limit water-soluble, chloride-ion content in hardened concrete to **[1.00] [0.30] [0.15]**

**<Insert number>** percent by weight of cement.

I. Class **[I] <Insert designation>:** Normal-weight concrete used for interior metal pan stairs and

landings:

1. Exposure Class: ACI CODE-318 (ACI CODE-318M) **[FO] [Fl] [F2] [F3] [SO] [S1] [S2] [S3] [WO] [Wi] [CO] [C1] [C2].**
2. Minimum Compressive Strength: **[3000 psi (20.7 MPa)] <Insert strength> [As indicated]** at 28 days.

Retain w/cm from three options in "Maximum w/cm" Subparagraph below, revise to suit Project, or delete if in-service durability conditions are benign and limits on w/cm are not required. Coordinate w/cm with compressive strength. See the Evaluations for discussion.

1. Maximum w/cm: **[0.53] [0.45] [0.40] <Insert number>.**
2. Minimum Cementitious Materials Content: 470 lb/cu. yd. (279 kg/cu. m).
3. Maximum Size Aggregate: 1/2 inch (13 mm).

Retain slump limit from two options in "Slump Limit" Subparagraph below, or revise to suit Project.

1. Slump Limit: 3 inches (75 mm), plus 1 inch (25 mm) or minus 2 inches (50 mm).
2. Air Content: **[0] <Insert number>** percent, plus or minus 0.5 percent at point of delivery.

Retain appropriate option in first subparagraph below for chloride limits. Percentages below repeat ACI 318 (ACI 318M) limits. First option is for Exposure Class CO; second option is for Exposure Class Cl; third option is for Exposure Class C2. ACI 301 (ACI 301M) and ACI 318 (ACI 318M) express this percentage by weight of cement, not cementitious material.

1. Limit water-soluble, chloride-ion content in hardened concrete to **[1.00] [0.30] [0.15] <Insert number>** percent by weight of cement.
2. Retarding Admixture: Not allowed.
3. Accelerating Admixture: Not allowed.

J. Class **[J] <Insert designation>:** Normal-weight concrete used for exterior retaining walls.

1. Exposure Class: ACI CODE-318 (ACI CODE-318M) **[FO] [Fl] [F2] [F3] [SO] [S1] [S2] [S3] [WO]**

**[Wl] [CO] [C1] [C2].**

Retain strength from five options in "Minimum Compressive Strength" Subparagraph below, or revise to suit Project. Coordinate compressive strength with w/cm if concrete is 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> [As indicated]** at 28 days.

Retain w/cm from three options in "Maximum w/cm" Subparagraph below, revise to suit Project, or delete if in-service durability conditions are benign and limits on w/cm are not required. Coordinate w/cm with compressive strength. See the Evaluations for discussion.

1. Maximum w/cm: **[0.50] [0.45] [0.40] <Insert number>.**

Consider deleting "Slump Limit" Subparagraph below and allow the Contractor to select a target slump based on ASTM C143/C143M, as permitted under ACI 301. If retaining "Slump Limit" Subparagraph, retain slump limit from first three options, or revise to suit Project.

1. Slump Limit: **[4 inches (100 mm), plus or minus 1 inch (25 mm)] [5 inches (125 mm), plus or minus 1 inch (25 nun)] [8 inches (200 mm), plus or minus 1 inch (25 mm) for concrete with verified slump of 3 inches (75 mm), plus or minus 1 inch (25 mm),before adding high-range water-reducing admixture or plasticizing admixture at Project site] <Insert limits>.**

"Slump Flow Limit" Subparagraph below is for self-consolidating concrete. Consider deleting and allow the Contractor to select a target slump flow based on ASTM C1611/C1611M, as permitted under ACI 301. If retaining "Slump Flow Limit" Subparagraph, retain slump flow limit from two options, or revise to suit Project.

1. Slump Flow Limit: **[22 inches (550 mm), plus or minus 1.5 inches (40 mm)] [30 inches (762 mm), plus or minus 2.5 inches (65 mm)] <Insert limits>.**
2. Air Content:

Options in first two subparagraphs are examples only. Revise to suite Project. See ACI A301 (ACI 301M), Table 4.2.2.7(b)1 for air content for additional Exposure Classes and aggregate sizes.

1. Exposure Class Fl: **[5.0 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-1/2-inch (38-mm) nominal maximum aggregate size].**
2. Exposure Classes F2 and F3: **[6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 3/4-inch (19-mm) nominal maximum aggregate size] [6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch (25-mm) nominal maximum aggregate size] [5.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-1/2-inch (38-mm) nominal maximum aggregate size].**

Retain appropriate option in subparagraph below for chloride limits. Percentages below repeat ACI 318 (ACI 318M) limits. First option is for Exposure Class CO; second option is for Exposure Class Cl; third option is for Exposure Class C2. ACI 301 (ACI 301M) and ACI 318 (ACI 318M) express this percentage by weight of cement, not cementitious material.

7. Limit water-soluble, chloride-ion content in hardened concrete to **[1.00] [0.30] [0.15]**

**<Insert number>** percent by weight of cement.

2.12 CONCRETE MIXING

The slump/workability, air content, and temperature of freshly batched concrete can be maintained beyond the limits in ASTM C94/C94M through the use of hydration-controlling admixtures, workability-retaining admixtures, and other means as specified in ACI 305.1. Accordingly, the following note is provided in ASTM C94/C94M to make users of the standard aware of these technologies: "Depending on the project requirements the technology is available to the manufacturer to alter fresh concrete properties (such as setting time, slump or slump flow, air content, etc.). On some projects the manufacturer may request changes to certain fresh concrete properties due to the distance or projected transportation time between the batch plant and the point of delivery."

Since their introduction into the concrete industry, Master Builders Solutions' "MasterSet DELVO" hydration-controlling admixture and its "MasterSure Z 60" workability-retaining admixture have been used successfully to maintain the fivshproperties of concrete beyond the 1-1/2 hour limit for concrete discharge in ASTM C94/C94M.

Retain option in "Ready-Mixed Concrete" Paragraph below if steel or synthetic fibers are required.

1. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete in accordance with ASTM C94/C94M[ **and ASTM C1116/C1116M],** and furnish batch ticket information.

Retain "Project-Site Mixing" Paragraph below if Project-site mixing is permitted. ACI 301 (ACI 301M) applies measure ng, batching, and mixing requirements from ASTM C94/C94M to Project-site mixing.

1. 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.
2. 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.
3. 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).
4. 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

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.

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.

Retain applicable subparagraphs below, and insert others if required. Revise to suit Project.

1. 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 INSTALLATION OF VAPOR RETARDER

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder in accordance with ASTM E1643 and manufacturer's written instructions.

1. Install vapor retarder with longest dimension parallel with direction of concrete pour.
2. Face laps away from exposed direction of concrete pour.
3. Lap vapor retarder over footings and grade beams not less than 6 inches (150 mm), sealing vapor retarder to concrete.
4. Lap joints 6 inches (150 mm) and seal with manufacturer's recommended tape.
5. Terminate vapor retarder at the top of floor slabs, grade beams, and pile caps, sealing entire perimeter to floor slabs, grade beams, foundation walls, or pile caps.
6. Seal penetrations in accordance with vapor retarder manufacturer's instructions.
7. Protect vapor retarder during placement of reinforcement and concrete.

a. Repair damaged areas by patching with vapor retarder material, overlapping

damages area by 6 inches (150 mm) on all sides, and sealing to vapor retarder.

B. Bituminous Vapor Retarders: Place, protect, and repair bituminous vapor retarder in accordance with manufacturer's written instructions.

3.5 JOINTS

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

1. Construct joints true to line, with faces perpendicular to surface plane of concrete. Revise criteria for locating construction joints in "Construction Joints" Paragraph below to suit Project.
2. 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.

1. Continue reinforcement across construction joints unless otherwise indicated.
2. Do not continue reinforcement through sides of strip placements of floors and slabs.

Retain first subparagraph below if keyed joints are used. Keyed joints are used in walls and floors and between walls and slabs or footings. ACI 302.1R recommends limiting keyed joints to lightly trafficked floors, because keys may fail and lips may chip after concrete shrinks.

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.

Insert spacing of construction joints in first subparagraph below if preferred.

6. Space vertical joints in walls **[as indicated on Drawings] <Insert spacing>.** Unless otherwise indicated on Drawings, locate vertical joints beside piers integral with walls, near corners, and in concealed locations where possible.

Retain one of two subparagraphs below only if a bonding material is permitted. Verify acceptance of use with structural engineer.

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.

Insert spacing of control joints here or on Drawings if required. Control 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.

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

Retain type of joint-forming method from "Grooved Joints" and "Sawed Joints" subparagraphs below, or retain both subparagraphs as Contractor's option. Insert joint spacing if not indicated on Drawings.

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.

Retain "Sawed Joints" 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 are used within one to two hours of finishing concrete. To leave concrete undamaged from sawing, conventional saw cutting must be delayed, usually four to 12 hours, but not so long that uncontrolled cracking of concrete could occur.

1. 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.

Retain one or both of first two subparagraphs below. If both are required, indicate location of each on Drawings.

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 079200 "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.

Retain "Doweled Joints" Paragraph below if doweled control or expansion joints are used; revise if precoated dowels are required.

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.

Retain "Doweled Plates" Paragraph below if doweled control or expansion joints are used.

F. Dowel Plates: Install dowel plates at joints where indicated on Drawings.

3.6 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.

Retain one of first two paragraphs and associated subparagraphs below. ACI 301 (ACI 301M) permits water to be added to concrete mixture on-site to adjust slump, up to amount allowed in design mixture.

Use of a workability-retaining admixture, such as Master Builders Solutions' "MasterSure Z 60," will eliminate or minimize the need for field addition of water.

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.

Retain subparagraph below if high-range water-reducing admixtures are permitted.

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-SPEC-301 (ACI-SPEC-301M), but not to exceed the amount indicated on the concrete delivery ticket.

Retain subparagraph below if high-range water-reducing admixtures are permitted.

Use of a workability-retaining admixture, such as Master Builders Solutions' "MasterSure Z 60," will eliminate or minimize the need for field addition of water.

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-SPEC-301 (ACI-SPEC-301M).

a. Do not use vibrators to transport concrete inside forms.

1. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer.
2. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity.
3. 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.

3.7 FINISHING FORMED SURFACES

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

A. As-Cast Surface Finishes:

1. ACI-SPEC-301 (ACI-SPEC-301M) Surface Finish SF-1.0: As-cast concrete texture imparted by form-

facing material.

1. Patch voids larger than 1-1/2 inches (38 mm) wide or 1/2 inch (13 mm) deep.
2. Remove projections larger than 1 inch (25 mm).
3. Tie holes do not require patching.
4. Surface Tolerance: ACI-SPEC-117 (ACI-SPEC-117M) Class D.
5. Apply to concrete surfaces **[not exposed to public view] <Insert locations>.**

2. ACI-SPEC-301 (ACI-SPEC-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.

1. Patch voids larger than 3/4 inch (19 mm) wide or 1/2 inch (13 mm) deep.
2. Remove projections larger than 1/4 inch (6 mm).
3. Patch tie holes.
4. Surface Tolerance: ACI-SPEC-117 (ACI-SPEC-117M) Class B.

Revise locations in "Locations" Subparagraph below to suit Project or delete subparagraph and indicate locations on Drawings. Retain second option if additional finishing is required.

e. Locations: 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] <Insert locations>.**

3. ACI-SPEC-301 (ACI-SPEC-301M) Surface Finish SF-3.0:

1. Patch voids larger than 3/4 inch (19 mm) wide or 1/2 inch (13 mm) deep.
2. Remove projections larger than 1/8 inch (3 mm).
3. Patch tie holes.
4. Surface Tolerance: ACI-SPEC-117 (ACI-SPEC-117M) Class A.

Revise locations in "Locations" Subparagraph below to suit Project, or delete subparagraph and indicate locations on Drawings. Retain second option if additional finishing is required.

1. Locations: 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] <Insert locations>.**

If retaining "Rubbed Finish" Paragraph below, retain "ACI 301 (ACI 301M) Surface Finish SF-2.0" or "ACI 301 (ACI 301M) Surface Finish SF-3.0" subparagraphs above.

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

Retain one or more rubbed finishes in "Smooth-Rubbed Finish," "Grout-Cleaned Rubbed Finish," and "Cork-Floated Finish" subparagraphs below.

1. Smooth-Rubbed Finish:

1. Perform no later than one day after form removal.
2. Moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture.
3. 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.
4. Maintain required patterns or variances as indicated on Drawings or to match **[design reference sample] [field sample panels] [mockups].**

2. Grout-Cleaned Rubbed Finish:

1. Clean concrete surfaces after contiguous surfaces are completed and accessible.
2. Do not clean concrete surfaces as Work progresses.
3. 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.
4. Wet concrete surfaces.
5. 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.
6. Maintain required patterns or variances as indicated on Drawings or to match **[design reference sample] [field sample panels] [mockups].**

3. Cork-Floated Finish:

1. 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.
2. Mix 1 part portland cement and 1 part fine sand with sufficient water to produce a mixture of stiff gout. Add white portland cement in amounts determined by trial patches, so color of dry grout matches adjacent surfaces.
3. Wet concrete surfaces.
4. Compress grout into voids by grinding surface.
5. In a swirling motion, finish surface with a cork float.
6. Maintain required patterns or variances as indicated on Drawings or to match **[design reference sample] [field sample panels] [mockups].**

Retain "Scrubbed Finish" Subparagraph below if scrubbed finish, which is usually applied to surfaces treated with a surface retarder, is required.

4. Scrubbed Finish: After concrete has achieved a compressive strength of from 1000 to 1500 psi (6.9 to 10.3 MPa), apply scrubbed finish.

1. 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.
2. Rinse scrubbed surfaces with clean water.
3. Maintain continuity of finish on each surface or area of Work.
4. Remove only enough concrete mortar from surfaces to match **[design reference sample] [field sample panels] [mockups].**

Before retaining "Abrasive-Blast Finish" Paragraph below, consider Contractor's ability to comply with OSHA's "Respirable Crystalline Silica Standard for Construction."

C. Abrasive-Blast Finish: Apply the following to as-cast surface finishes where indicated on Drawings:

1. Perform abrasive blasting after compressive strength of concrete exceeds 2000 psi (13.8 MPa).

2. Coordinate with formwork removal to ensure that surfaces to be abrasive blasted are treated at the same age.

3. Surface Continuity:

1. Perform abrasive-blast finishing as continuous operation, maintaining continuity of finish on each surface or area of Work.
2. Maintain required patterns or variances in depths of blast to match **[design reference sample] [field sample panels] [mockups].**

4. Abrasive Blasting:

1. Abrasive-blast corners and edges of patterns carefully, using backup boards to maintain uniform corner and edge lines.
2. Determine type of nozzle pressure and blasting techniques required to match field sample.
3. Depth of Cut: Use an abrasive grit of proper type and gradation to expose aggregate and surrounding matrix surfaces to match field sample, as follows:

Texture in first four subparagraphs below is for example. Revise to suit Project.

1. Brush Texture: Remove cement matrix to dull surface sheen and expose face of fine aggregate, with no significant reveal.
2. Light Texture: Expose fine aggregate with occasional exposure of coarse aggregate and uniform color, with maximum reveal of 1/16 inch (1.5 mm).
3. Medium Texture: Expose coarse aggregate with slight reveal and with a maximum reveal of 1/4 inch (6 mm).
4. Heavy Texture: Expose and reveal coarse aggregate to a maximum projection of one-third its diameter, with reveal range of 1/4 to 1/2 inch (6 to 13 mm).

d. Maintain required patterns or variances in reveal projection to match **[design**

**reference sample] [field sample panels] [mockups].**

D. High-Pressure Water-Jet Finish: Apply the following to as-cast surface finishes where indicated on Drawings:

1. Perform high-pressure water jetting on concrete that has achieved a minimum compressive strength of 4500 psi (31 MPa).
2. Coordinate with formwork removal to ensure that surfaces to be high-pressure water jet finished are treated at same age for uniform results.
3. Surface Continuity: Perform high-pressure water-jet finishing in as continuous an operation as possible, maintaining continuity of finish on each surface or area of Work.
4. Maintain required patterns or variances in reveal projection to match **[design reference sample] [field sample panels] [mockups].**

Retain "Bushhammer Finish" Paragraph below if required. ACI 301 requires that concrete have a minimum compressive strength of 4500 psi (31 MPa). Before retaining, consider Contractor's ability to comply with OSHA's "Respirable Crystalline Silica Standard for Construction."

E. Bushhammer Finish: Apply the following to as-cast surface finishes where indicated on Drawings:

1. Perform bush-hammer finish to concrete that has achieved a minimum compressive strength of 4500 psi (31 MPa).

2. Surface Continuity:

a. Perform bush-hammer finishing in as continuous an operation as possible,

maintaining continuity of finish on each surface or area of Work.

3. Surface Cut:

1. Maintain required depth of cut and general aggregate exposure.
2. Use power tool with hammer attachments for large, flat surfaces, and use hand hammers for small areas, at corners and edges, and for restricted locations where power tools cannot reach.

4. Remove impressions of formwork and form facings with exception of tie holes.

5. Maintain required patterns or variances of cut as indicated on Drawings or to match **[design reference sample] [field sample panels] [mockups].**

6. Maintain control of concrete chips, dust, and debris in each Work area, limiting migration

of airborne materials and dust by use of tarpaulins, wind-breaks, or similar devices.

F. 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.

3.8 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.

Retain one or more of "Scratch Finish," "Float Finish," "Trowel Finish," "Trowel and Fine-Broom Finish," "Broom Finish," and "Slip-Resistive Finish" paragraphs below for types of slab finishes required. Coordinate slab finishes retained with finish schedule, or indicate location of each finish on Drawings.

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.

Revise locations of scratch finish in subparagraph below to suit Project, or delete subparagraph and indicate locations on Drawings.

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

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-SPEC-117 (ACI-SPEC-117M) tolerances for conventional concrete.

Revise locations of float finish in subparagraph below to suit Project or delete subparagraph and indicate locations on Drawings.

1. Apply float finish to surfaces **[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:

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.

Revise locations of trowel finish in first subparagraph below to suit Project, or delete subparagraph and indicate locations on Drawings.

1. 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] <Insert locations>.**
2. Finish surfaces to the following tolerances, in accordance with ASTM E1155 (ASTM E1155M), for a randomly trafficked floor surface:

a. Slabs on Ground:

ACI 301 (ACI 301M) suggests that all residential floors and nonresidential floors less than 10,000 sq. ft. (929 sq. m) be measured by straightedge method and that other nonresidential floors be measured by F-number system. Retain first subparagraph below for floor areas less than 10,000 sq. ft. (929 sq. m). Fourth option is requirement for gauged porcelain tile.

1. 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 mm)] [1/8 inch (3 mm) and)1/16 inch (1.6 mm) in 2 ft. (610 mm)].**

Retain first subparagraph below for floor areas 10,000 sq. ft. (929 sq. m) and larger. Retain floor flatness (FF) and floor levelness (FL) values required for Project from first five subparagraphs below, or revise values to suit type of floor. ACI 302.1R suggests values in first subparagraph be used for carpeted slabs; those in second for thin floor coverings; and those in third for very flat floors for high-speed forklifts, air pallets, and ice and roller rinks. Those in fourth subparagraph are common for polished concrete floors. Those in fifth subparagraph are common of wood flooring on sleepers.

1. Specified overall values of flatness, **FF** 25; and of levelness, FL 20; with minimum local values of flatness, **FF** 17; and of levelness, FL 15.
2. Specified overall values of flatness, **FF** 35; and of levelness, FL 25; with minimum local values of flatness, **FF** 24; and of levelness, FL 17.
3. Specified overall values of flatness, **FF** 45; and of levelness, FL 35; with minimum local values of flatness, **FF** 30; and of levelness, FL 24.
4. Specified Overall Value (SOV): **FF** 50 and FL 25 with minimum local value (MLV): **FF** 40 and FL 17.
5. Specified Overall Value (SOV): **FF** 25 and FL 20 with minimum local value (MLV): **FF** 17 and FL 15.

b. Suspended Slabs:

ACI 301 (ACI 301M) suggests that all residential floors and nonresidential floors less than 10,000 sq. ft. (929 sq. m) be measured by straightedge method and that other nonre sidential floors be measured by F-number system. Retain first subparagraph below for floor areas less than 10,000 sq. ft. (929 sq. m). Fourth option is requirement for gauged porcelain tile.

1. 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 mm)] [1/8 inch (3 mm) and)1/16 inch (1.6 mm) in 2 ft. (610 mm)].**

Retain first subparagraph below for floor areas 10,000 sq. ft. (929 sq. m) and larger. Retain floor flatness (FF) and floor levelness (FL) values required for Project from first three subparagraphs below, or revise values to suit type of floor. ACI 302.1R suggests values in first subparagraph be used for carpeted slabs; those in second for thin floor coverings; and those in third for very flat floors for high-speed forklifts, air pallets, and ice and roller rinks.

1. Specified overall values of flatness, **FF** 25; and of levelness, FL 20; with minimum local values of flatness, **FF** 17; and of levelness, FL 15.
2. Specified overall values of flatness, **FF** 35; and of levelness, FL 20; with minimum local values of flatness, **FF** 24; and of levelness, FL 15.
3. Specified overall values of flatness, **FF** 45; and of levelness, FL 35; with minimum local values of flatness, **FF** 30; and of levelness, FL 24.

E. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces **[indicated on Drawings] [where ceramic or quarry tile is to be installed by either thickset or thinset method].** 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.

Retain "Broom Finish" Paragraph below if applicable. Broom finish isused 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 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.

Retain "Slip-Resistive Finish" Paragraph below if applicable. This finish is used on interior and exterior concrete treads, platforms, and ramps subject to moderate foot traffic.

G. Slip-Resistive Finish: Before final floating, apply slip-resistive **[aggregate] [aluminum**

**granule]** finish to concrete stair treads, platforms, ramps as indicated on Drawings

1. Apply in accordance with manufacturer's written instructions and as follows:

1. Uniformly spread **[25 lb/100 sq. ft. (12 kg/10 sq. m)] <Insert rate>** of dampened slip-resistive **[aggregate] [aluminum granules]** over surface in one or two applications.
2. Tamp aggregate flush with surface, but do not force below surface.

Revise float finish in first subparagraph below to trowel finish if required.

1. After broadcasting and tamping, apply float finish.
2. After curing, lightly work surface with a steel wire brush or an abrasive stone and water to expose slip-resistive **[aggregate] [aluminum granules].**

Retain Dry-Shake Floor Hardener Finish Paragraph below if pigmented or unpigmented dry-shake floor hardener finish is required.

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:

Consult manufacturers and revise rate of application in first subparagraph below if required. This rate is usually recommended for light traffic.

1. Uniformly apply dry-shake floor hardener at a rate of **[100 lb/100 sq. ft. (49 kg/10 sq. m)] <Insert rate>** 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.

Coordinate selection of curing compounds for compatibility with dry-shake floor hardener, and revise lists of manufacturers in Part 2 accordingly if required.

1. After final floating, apply a trowel finish.
2. Cure concrete with curing compound recommended by dry-shake floor hardener manufacturer and apply immediately after final finishing.

3.9 INSTALLATION OF MISCELLANEOUS CONCRETE ITEMS   
This article is an example only. Insert, revise, or delete items to suit Project.

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.

C. Equipment Bases and Foundations:

1. Coordinate sizes and locations of concrete bases with actual equipment provided.

1. Construct concrete bases **[4 inches (100 mm)] [6 inches (150 mm)] [8 inches (200 mm)] <Insert dimension>** high unless otherwise indicated on Drawings and extend base not less than 6 inches (150 mm) in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated on Drawings, or unless required for seismic anchor support.
2. 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 value>** at 28 days.
3. 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.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete substrate.
5. Prior to pouring concrete, place and secure anchorage devices.
6. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Cast anchor-bolt insert into bases.
8. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items.

1. Cast-in inserts and accessories, as indicated on Drawings.
2. Screed, tamp, and trowel finish concrete surfaces.

3.10 CONCRETE CURING

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

1. Comply with ACI-SPEC-306.1 for cold weather protection during curing.
2. Comply with ACI-SPEC-305.1 (ACI-SPEC-305.1M) for hot-weather protection during curing.

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

ACI 305.1 recommends reviewing the 0.2 lb/sq. ft. x h (1 kg/sq. m x h) default value, which may be revised by Architect/Engineer, because concrete mixtures containing conventional or ultrafine pozzolan or other cementitious materials may require lower allowable evaporation rates.

1. Maintain moisture loss no more than 0.2 lb/sq. ft. x h (1 kg/sq. m x h), calculated in accordance with ACI-SPEC-305.1,) before and during finishing operations.

B. Curing Formed Surfaces: Comply with ACI-PRC-308.1 (ACI-PRC-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:

1. Continuous Fogging: Maintain standing water on concrete surface until final setting of concrete.
2. Continuous Sprinkling: Maintain concrete surface continuously wet.
3. Absorptive Cover: Pre-dampen absorptive material before application; apply additional water to absorptive material to maintain concrete surface continuously wet.
4. Water-Retention Sheeting Materials: Cover exposed concrete surfaces with sheeting material, taping, or lapping seams.
5. Membrane-Forming Curing Compound: Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's written instructions.
6. Recoat areas subject to heavy rainfall within three hours after initial application.
7. Maintain continuity of coating and repair damage during curing period.

C. Curing Unformed Surfaces: Comply with ACI-PRC-308.1 (ACI-PRC-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.

1. Lap edges and ends of absorptive cover not less than 12-inches (300-mm).
2. 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.

1. Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
2. 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:

1. Water.
2. 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.

1. Lap edges and ends of absorptive cover not less than 12 inches (300 mm).
2. 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.

1. Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
2. 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:

1. Water.
2. 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.

1. Lap edges and ends of absorptive cover not less than 12 inches (300 mm).
2. 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:

1. Water.
2. 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.

1. Install curing paper square to building lines, without wrinkles, and in a single length without end joints.
2. Butt sides of curing paper tight; do not overlap sides of curing paper.
3. 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.

Usually, delete "Floors to Receive Curing Compound" Subparagraph for floors scheduled to receive additional floor finishes. Consult with floor finish manufacturer before retaining.

f. Floors to Receive Curing Compound:

1. Apply uniformly in 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. Maintain continuity of coating, and repair damage during curing period.

Retain "Removal" Subparagraph below if requiring removal of curing compounds that may interfere with adhesion of floor coverings.

1. 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 does not interfere with bonding of floor covering used on Project].**

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

g. 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.

3.11 TOLERANCES

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

3.12 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.

Some manufacturers state that the penetrating liquid floor treatment also functions as a curing aid. If used as a cure, delete minimum age of concrete in first subparagraph below, and revise application method to follow manufacturer's written instructions. Coordinate with "Concrete Curing" Article.

1. Do not apply to concrete that is less than **[three] [seven] [14] [28]** days' old.
2. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing.
3. Rinse with water; remove excess material until surface is dry.
4. Apply a second coat in a similar manner if surface is rough or porous.

Usually, delete "Sealing Coat" Paragraph below if two coats of curing and sealing compound have already been applied during curing stage. Sealing coat may be used as turnover coat, independent of means of curing, to improve appearance of an exposed concrete floor at end of Project.

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.

3.13 JOINT FILLING

Retain this article if joint filling is required.

A. Prepare, clean, and install joint filler in accordance with manufacturer's written instructions.

ACI 302.1R recommends joint filling be deferred as long as possible in concrete floors. Use of polyurea joint fillers may allow joint filling to proceed earlier; verify minimum time period with manufacturer. Typically, up to 30 percent of concrete shrinkage takes place in first month, with 80 to 90 percent during first 12 months. Revise period in first subparagraph below if too short or too long. Joints must be filled before industrial floors can be placed in service.

1. Defer joint filling until concrete has aged at least **[one] [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.

3.14 CONCRETE SURFACE REPAIRS

This article provides basic applications for repairing concrete surfaces. Revise or delete to suit Project.

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.

Insert provision for testing repair technique on a mockup or surface to be concealed later, before repairing surfaces.

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.

1. Limit cut depth to 3/4 inch (19 mm).
2. Make edges of cuts perpendicular to concrete surface.
3. Clean, dampen with water, and brush-coat holes and voids with bonding agent.
4. Fill and compact with patching mortar before bonding agent has dried.
5. 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.

1. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching.
2. 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.

1. Correct low and high areas.
2. 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.

Retain one or both of first two subparagraphs below if applicable. First subparagraph uses an underlayment; second, a topping.

5. Correct other low areas scheduled to receive floor coverings with a repair underlayment.

1. Prepare, mix, and apply repair underlayment and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
2. Feather edges to match adjacent floor elevations.

6. Correct other low areas scheduled to remain exposed with repair topping.

1. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch (6 mm) to match adjacent floor elevations.
2. 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.

1. Remove defective areas with clean, square cuts, and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around.
2. Dampen concrete surfaces in contact with patching concrete and apply bonding agent.
3. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate.
4. Place, compact, and finish to blend with adjacent finished concrete.
5. 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.

1. Groove top of cracks and cut out holes to sound concrete, and clean off dust, dirt, and loose particles.
2. Dampen cleaned concrete surfaces and apply bonding agent.
3. Place patching mortar before bonding agent has dried.
4. Compact patching mortar and finish to match adjacent concrete.
5. 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.

3.15 FIELD QUALITY CONTROL

Retain "Special Inspections" or "Testing Agency" Paragraph below.

A. Special Inspections: Owner will engage a qualified special inspector to perform field tests and

inspections.

B. Testing Agency: **[Owner will engage] [Engage]** a qualified testing and inspecting agency to

perform tests and inspections.

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.
4. Test reports shall include reporting requirements of ASTM C31/C31M,

ASTM C39/C39M, and ACI-SPEC-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:

Retain first five subparagraphs below if special inspections are required. Items below are examples of special inspections and are based on IBC requirements; revise to insert other inspections or to suit requirements of other building codes.

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.
6. Batch Plant Inspections: On a random basis, as determined by Architect.

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:

Revise frequency in "Testing Frequency" Subparagraph below to suit Project.

1. Testing Frequency: Obtain one composite sample for each 150 cu. yd. (110 cu. m) or fraction thereof of each concrete mixture placed each day.

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:

1. 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.
2. Perform additional tests when concrete consistency appears to change.

Retain "Slump Flow" Subparagraph below for self-consolidating concrete.

3. Slump Flow: ASTM C1611/C1611M:

1. 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.
2. 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 deg F (27 deg C) and above, and one test for each composite sample.

Retain "Density" Subparagraph below if structural lightweight concrete is required.

6. Density: ASTM C138/C138M; density of freshly mixed concrete.

a. One test for each composite sample, but not less than one test for each day's pour

of each concrete mixture.

7. Compressive-Strength Test Specimens: ASTM C31/C31M:

1. Cast and laboratory cure a minimum of **[four 6- by 12-inch (150- by 300-mm)] [five 4- by 8-inch (100- by 200-mm)]** cylinder specimens for each composite sample.

Field-cured specimens in first subparagraph below may be required to verify adequacy of curing and protection of concrete, to verify strength for tilt-up concrete and post-tensioning concrete, or to verify strength for removal of shoring and reshoring in multistory construction. Revise number of test specimens if required.

1. Cast, initial cure, and field cure a minimum of **[four 6 by 12 inch (150 by 300 mm)] [five 4 by 8 inch (100 by 200 mm)]** cylinder specimens for each composite sample.

Coordinate the number of compression test specimens in last subparagraph above with number of compressive-strength tests in "Compressive-Strength Tests" Subparagraph below.

8. Compressive-Strength Tests: ASTM C39/C39M.

1. A compressive-strength test shall be the average compressive strength from a set of **[two 6 by 12 inch (150 by 300 mm)] [three 4 by 8 inch (100 by 200 mm)]** specimens obtained from same composite sample and tested at age indicated.
2. Test cylinders at **[3 days] [7 days] [28 days] [age indicated].**

Retain first subparagraph below if field-cured specimens are required.

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 *(f'c'),* and no compressive-strength test value falls below *fc* by more than 500 psi (3.4 MPa),when fc' is below 5000 psi (34 MPa) or by more than 0.1 *Ofc'* whenfc' is more than 5000 psi (34 MPa).

11. Nondestructive Testing: Rebound hammer, ultrasonic, 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:

1. 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.
2. 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-SPEC-301 (ACI-SPEC-301M), section 1.6.6.3.

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1. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
2. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

Retain paragraph below if measurements of floor flatness and levelness tolerances are required.

1. Measure floor and slab flatness and levelness in accordance with ASTM E1155 (ASTM E1155M) within **[24] [48] [72] <Insert number>** hours of completion of floor finishing and promptly report test results to Architect.
2. Prepare test and inspection reports.

3.16 **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.

Retain subparagraph below when Project includes concrete floors scheduled to receive surface hardener of polished concrete finish.

1. Protect concrete surfaces scheduled to receive surface hardener or polished concrete finish using Floor Slab Protective Covering.

END OF SECTION 033000

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