**SECTION 321313 - CONCRETE PAVING**

For more information, contact ***Master Builders Solutions***; 23700 Chagrin Blvd., Beachwood, OH 44122; Phone: (800) 628-9990; Website: [www.master-builders-solutions.com/en-us](http://www.master-builders-solutions.com/en-us);

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: <https://master-builders-solutions.com/en-us/specifications/>

1. GENERAL
   * + 1. RELATED DOCUMENTS
          1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
       2. SUMMARY
          1. Section includes concrete paving, including:

Driveways.

Roadways.

Parking lots.

Curbs and gutters.

Walks.

* + - * 1. Related Requirements:

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

[Section 033000 "Cast-in-Place Concrete"] [Section 033053 "Miscellaneous Cast-in-Place Concrete"] for general building applications of concrete.

Section 321316 "Decorative Concrete Paving" for stamped concrete other than stamped detectable warnings.

Section 321373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.

Section 321713 "Parking Bumpers."

Section 321723 "Pavement Markings."

Section 321726 "Tactile Warning Surfacing" for detectable warning [**tiles**] [**mats**] [**and**] [**pavers**].

Section 321729 "Manufactured Traffic-Calming Devices."

* + - 1. DEFINITIONS

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

Definition in "Cementitious Materials" Paragraph below refers to 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 blended hydraulic cement, fly ash, slag cement, and other pozzolans.
        2. w/cm: The ratio by mass of water to cementitious materials.
      1. PREINSTALLATION MEETINGS

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

* + - * 1. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

Retain first subparagraph below if additional requirements are necessary; include information about conference.

Review methods and procedures related to concrete paving, including but not limited to, the following:

Concrete mixture design.

Quality control of concrete materials and concrete paving construction practices.

<**Insert agenda item**>.

Retain first subparagraph below if additional requirements are necessary; include information about conference.

Require representatives of each entity directly concerned with concrete paving to attend, including the following:

Retain subparagraphs below for representatives required to be present.

Contractor's superintendent.

Independent testing agency responsible for concrete design mixtures.

Ready-mixed concrete manufacturer.

Concrete paving Subcontractor.

Manufacturer's representative of stamped concrete paving system used for stamped detectable warnings.

* + - 1. ACTION SUBMITTALS
         1. Product Data: For each type of product.
         2. Sustainable Design Submittals:

Retain "Product Data" Subparagraph below to require minimum recycled content for LEED 2009 MR Credit 2 - "Recycled Content."

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

"Product Certificates" Subparagraph below applies to LEED v4, Materials and Resources Credit "Building Product Disclosure and Optimization - Environmental Product Declarations, Option 2."

Product Certificates: For materials manufactured within 100 miles (160 km) of Project, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each raw material.

"Laboratory Test Reports" Subparagraph below applies to LEED v4 and IgCC.

Laboratory Test Reports: For concrete paving mixtures, documentation indicating that cured concrete complies with Solar Reflectance Index requirements.

Environmental Assessment Report: Submit for concrete mixture. Compare submitted concrete mixture to 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.

Retain "Samples for Initial Selection" and “Samples for Verification” paragraphs below for two-stage Samples.

* + - * 1. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.
        2. Samples for Verification: For each type of product or exposed finish, prepared as Samples of size indicated below:

Exposed Aggregate: [**10-lb (4.5-kg)**] <**Insert weight**> Sample of each mix.

* + - * 1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
      1. INFORMATIONAL SUBMITTALS

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

* + - * 1. Qualification Data: For [**Installer of stamped detectable warnings**] [**ready-mixed-concrete manufacturer**] [**and**] [**testing agency**].

Retain "Material Certificates" Paragraph below for material certificates from manufacturers.

* + - * 1. Material Certificates: For the following, from manufacturer:

Cementitious materials.

Steel reinforcement and reinforcement accessories.

Fiber reinforcement.

Admixtures.

Curing compounds.

Applied finish materials.

Bonding agent or epoxy adhesive.

Joint fillers.

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

* + - * 1. Material Test Reports: For each of the following:

Retain option in "Aggregates" Subparagraph below if retaining service-record data with "Normal-Weight Aggregates" Paragraph in "Concrete Materials" Article.

Aggregates:[**Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.**]

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

* + - * 1. Field quality-control reports.
      1. QUALITY ASSURANCE

Retain "Stamped Detectable Warning Installer Qualifications" Paragraph below if requirements in Section 014000 "Quality Requirements" are insufficient. Verify that manufacturers provide training and approval. Revise if installers are qualified by other means.

* + - * 1. Stamped Detectable Warning Installer Qualifications: An employer of workers trained and approved by manufacturer of stamped concrete paving systems.
        2. 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.

Manufacturer certified in accordance with NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

Retain "Testing Agency Qualifications" Paragraph below if Contractor or manufacturer selects testing agency or if Contractor is required to provide services of a qualified testing agency in "Field Quality Control" Article. Qualification requirements are in addition to those specified in Section 014000 "Quality Requirements," which also defines "NRTL" (nationally recognized testing laboratory).

* + - * 1. Testing Agency Qualifications: Qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.

Retain subparagraph below, which is required by ACI SPEC-301 (ACI SPEC-301M) and ASTM C31/C31M. ASTM C1077 notes that relevant field or laboratory technician certification by ACI, NRMCA, the Portland Cement Association (PCA), or the National Institute for Certification in Engineering Technologies may demonstrate evidence of competence.

Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, in accordance with ACI CP-1 or an equivalent certification program.

* + - * 1. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.

Build mockups of full-thickness sections of concrete paving to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship.

Build mockups of concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than [**96 inches (2400 mm) by 96 inches (2400 mm)**] <**Insert dimensions**>.[**Include full-size detectable warning.**]

Retain first subparagraph below if mockups are not only for establishing appearance factors.

Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

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.

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

* + - 1. PRECONSTRUCTION TESTING
         1. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.
      2. FIELD CONDITIONS
         1. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
         2. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

When air temperature has fallen to or is expected to fall below 40 deg F (4.4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.

Do not use frozen materials or materials containing ice or snow.

Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

* + - * 1. Hot-Weather Concrete Placement: Comply with ACI SPEC-305.1 (ACI SPEC-305.1M) and as follows when hot-weather conditions exist:

Cool ingredients before mixing to maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

Retain last subparagraph above and option in subparagraph below if steel reinforcement is required.

Fog-spray forms[**, steel reinforcement,**] and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

1. 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.

* + - 1. CONCRETE, GENERAL
         1. ACI Publications: Comply with ACI SPEC-301 (ACI SPEC-301M) unless otherwise indicated.
      2. FORMS
         1. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

Use flexible or uniformly curved forms for curves with a radius of 100 feet (30.5 m) or less. [**Do not use notched and bent forms.**]

* + - * 1. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterFinish Series (Pre-2014: Cast Off and Rheofinish Series) or comparable product.

* + - 1. STEEL REINFORCEMENT

Retain this article if steel reinforcement is required; revise to suit Project.

Retain "Recycled Content of Steel Products" Paragraph below to specify recycled content if required. An alternative method of requiring recycled content is to retain requirement in Project's Division 01 sustainable design requirements Section that gives Contractor the option and responsibility to determine how recycled content requirements will be met.

* + - * 1. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [**25**] [**60**] <**Insert number**> percent.
        2. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, fabricated from [**as-drawn**] [**galvanized-**]steel wire into flat sheets.
        3. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet.
        4. Epoxy-Coated Welded-Wire Reinforcement: ASTM A884/A884M, Class A, plain steel.
        5. Epoxy-Cementitious Rebar Repair Coating: Liquid, three-part epoxy cementitious bonding agent containing integral corrosion inhibitor used to coat/protect rebar.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterProtect P 8100AP or comparable product.

* + - * 1. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420); deformed.
        2. Galvanized Reinforcing Bars: ASTM A767/A767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A615/A615M, Grade 60 (Grade 420) deformed bars.
        3. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M or ASTM A934/A934M; with ASTM A615/A615M, Grade 60 (Grade 420) deformed bars.
        4. Steel Bar Mats: ASTM A184/A184M; with ASTM A615/A615M, Grade 60 (Grade 420) deformed bars; assembled with clips.
        5. Plain-Steel Wire: ASTM A1064/A1064M, [**as drawn**] [**galvanized**].
        6. Deformed-Steel Wire: ASTM A1064/A1064M.
        7. Epoxy-Coated-Steel Wire: ASTM A884/A884M, Class A; coated, [**plain**] [**deformed**].

Retain option in "Joint Dowel Bars" Paragraph below if required. Plastic-surfaced or reinforced-paper-covered dowels are available from proprietary sources. Indicate joint-dowel lengths on Drawings.

* + - * 1. Joint Dowel Bars: ASTM A615/A615M, Grade 60 (Grade 420) plain-steel bars[**; zinc coated (galvanized) after fabrication in accordance with ASTM A767/A767M, Class I coating**]. Cut bars true to length with ends square and free of burrs.
        2. Epoxy-Coated, Joint Dowel Bars: ASTM A775/A775M; with ASTM A615/A615M, Grade 60 (Grade 420) plain-steel bars.

Retain "Tie Bars" or "Hook Bolts" Paragraph below. Tie bars or hook bolts may be used for connection between new and existing paving and between paving and gutters.

* + - * 1. Tie Bars: ASTM A615/A615M, Grade 60 (Grade 420); deformed.
        2. Hook Bolts: ASTM A307, Grade A (ASTM F568M, Property Class 4.6), internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
        3. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports in accordance with CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

Retain or revise subparagraphs below to suit Project.

Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

* + - * 1. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.
        2. Zinc Repair Material: ASTM A780/A780M.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterProtect P 8100AP or comparable product.

* + - 1. CONCRETE MATERIALS

"Regional Materials" Paragraph below applies to LEED v4.

* + - * 1. 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.
        2. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:

Generally, retain first option in "Portland Cement" Subparagraph below unless concrete with lighter shades or brighter colors is required. See the Evaluations.

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

Retain one of or both "Fly Ash" and "Slag Cement" subparagraphs below if supplementary cementing materials are permitted. Generally, delete both subparagraphs if using white portland cement. Ready-mix plants blend these materials with portland cement. Fly ash and slag cement may slow rate of concrete strengthening and affect color uniformity. Use of Type C or Type F fly ash may be determined by regional availability as well as by properties cited in ASTM C618.

Fly Ash: ASTM C618, [**Class C**] [**or**] [**Class F**].

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. Insert target percentage or range of slag cement or pozzolan as a suffix to Type IS or Type IP designations if required; insert special properties if required. See the Evaluations. Fly ash, slag cement, or pozzolanic materials in the non-portland cement part of blended hydraulic cement may slow rate of concrete strengthening and affect color uniformity. Insert ASTM C1157 if acceptable.

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.

Retain one of first three 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 4S, 4M, and 1N apply to paving in Severe, Moderate, and Negligible weathering regions, respectively. Consider retaining last option below if damage caused by concrete expansion from alkali-silica or other chemical reactions is anticipated.

* + - * 1. Normal-Weight Aggregates: ASTM C33/C33M, [**Class 4S**] [**Class 4M**] [**Class 1N**] <**Insert class**>, uniformly graded. Provide aggregates from a single source[**with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials**].

Insert requirement for recycled content of coarse aggregate if required. Verify availability before specifying.

Retain one option in "Maximum Coarse-Aggregate Size" Subparagraph below; insert gradation requirements if preferred. PCA recommends maximum aggregate size of 3/4 inch (19 mm) in base slab if seeded exposed aggregate is paving finish.

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

Retain "Fine Aggregate" Subparagraph below to prohibit the exception in ASTM C33/C33M that allows using reactive fine aggregate if low-alkali cement or reaction-inhibiting admixture is also required.

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

Retain "Exposed Aggregate" Paragraph below if seeded or monolithic exposed-aggregate paving finish is required.

* + - * 1. Exposed Aggregate: Selected, hard, and durable; washed; free of materials with deleterious reactivity to cement or that cause staining; from a single source, with gap-graded coarse aggregate as follows:

Retain one option in "Aggregate Sizes" Subparagraph below or revise to include one size or a range of gradations if preferred. Coarse-aggregate sizes may range from 1/4 inch (6 mm) to more than 1-1/2 inches (38 mm).

Aggregate Sizes: [**3/4 to 1 inch (19 to 25 mm)**] [**1/2 to 3/4 inch (13 to 19 mm)**] [**3/8 to 5/8 inch (10 to 16 mm)**] <**Insert dimensions**> nominal.

Retain "Aggregate Source, Shape, and Color" Subparagraph below if a particular aggregate is required or to specify details of acceptable aggregates.

Aggregate Source, Shape, and Color: <**Insert requirements**>.

* + - * 1. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use admixtures containing intentionally added chlorides.

Retain one or more of first 18 subparagraphs below.

Air-Entraining Admixture: ASTM C260/C260M.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterAir Series (Pre-2014: Micro Air, MB-AE90 and MB-VR) or comparable product by one of the following:

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

Water-Reducing Admixture: ASTM C494/C494M, Type A.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterPozzolith Series (Pre-2014: Pozzolith Series) or comparable product by one of the following:

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

Mid-Range Water-Reducing Admixture: ASTM C494/C494M, Type A.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterPolyheed Series (Pre-2014: PolyHeed Series) or comparable product by one of the following:

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

Retarding Admixture: ASTM C494/C494M, Type B.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; [**MasterSet DELVO Series (Pre-2014: DELVO Series)**] [**MasterSet R Series (Pre-2014: Pozzolith R Series)**] or comparable product by one of the following:

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

Accelerating Admixture: ASTM C494/C494M, Type C.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; [**MasterSet AC 534** **(Pre-2014: Pozzolith NC534)**] [**MasterSet FP 20** **(Pre-2014: Pozzutec 20+)**] or comparable product by one of the following:

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

Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; [**MasterSet DELVO Series (Pre-2014: DELVO Series)**] [**MasterSet R Series (Pre-2014: Pozzolith R Series)**] or comparable product by one of the following:

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

Hydration-Control Admixture: ASTM C494/C 494M, Type D.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterSet DELVO Series (Pre-2014: DELVO Series) or comparable product by one of the following:

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

Water-Reducing and Accelerating Admixture: ASTM C494/C494M, Type E.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterSet FP20 (Pre-2014: Pozzutec20+) or comparable product by one of the following:

**Insert manufacturer's name>**.

High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.

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

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 by one of the following:

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

High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.

Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.

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 and list of manufacturers below to identify a specific product or comparable product from manufacturers listed.

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterSure Z60 (Pre-2014: RheoTEC Z-60) or comparable product by one of the following:

<**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 in accordance with ASTM C494/C494M, Type C.

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 in accordance with ASTM C494/C494M, Type C.

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterLife CI30 (Pre-2014: Rheocrete CNI) or comparable product by one of the following:

<**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.

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.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterLife CI222 (Pre-2014: Rheocrete222+) or comparable product by one of the following:

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

Shrinkage-Reducing Admixture: ASTMC494/C494M, TypeS.

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

Master Builders Solutions’ "MasterLife CRA007" is also classified as a crack-reducing admixture, because it provides better performance under restrained shrinkage resulting in smaller crack widths.

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; [**MasterLife CRA 007**] [**MasterLife SRA 035**] or comparable product by one of the following:

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

Viscosity-Modifying Admixture: ASTMC494/C494M, TypeS.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterMatrix VMA Series (Pre-2014: Rheomac VMA Series) or comparable product by one of the following:

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

Alkali-Silica Reaction Inhibiting Admixture: ASTMC494/C494M, TypeS, with nominal 30-percent lithium-nitrate content.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterLife ASR 30 (Pre-2014: ASRx30 LN) or comparable product by one of the following:

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

Retain "Color Pigment" Subparagraph below for integrally colored concrete paving.

Color Pigment: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable,[**free of carbon black,**] nonfading, and resistant to lime and other alkalis.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterColor (Pre-2014: RHEOCOLOR L) or comparable product by one of the following:

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

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

* + - * 1. Water: ASTM C1602/C1602M[**and potable**].
      1. FIBER REINFORCEMENT

Retain this article if fiber reinforcement is required; revise description and products if using polyester or nylon fibers. Monofilament fibers help reduce plastic shrinkage cracking.

* + - * 1. Synthetic Monofilament Micro-fiber: ASTM D7508/D7508M, monofilament polypropylene micro-fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, [**1/2 to 1-1/2 inches (13 to 38 mm)**] <**Insert dimensions**> long.

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

Shall provide a minimum crack reduction ratio (CRR) of [40] [] percent when tested in accordance with ASTM C1579.

Dosage shall be as recommended by the manufacturer.

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

Master Builders Solutions; MasterFiber M Series.

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

Manufacturers claim fibrillated fibers also improve hardened concrete properties.

* + - * 1. Synthetic Fibrillated Micro-fiber: Fibrillated polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, [**1/2 to 1-1/2 inches (13 to 38 mm)**] <**Insert dimensions**> long.

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

Shall provide a minimum crack reduction ratio (CRR) of [40] [] percent when tested in accordance with ASTM C1579.

Dosage shall be 1.5 lb/yd3.

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

Master Builders Solutions; MasterFiber F Series.

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

Synthetic macro-fiber reinforcement can be used for crack control and can be used to substitute for welded wire reinforcement and some light steel-reinforcement bar configurations in slabs-on-ground applications. Quantity of fiber is calculated by a structural engineer based on criteria furnished by fiber manufacturer. Master Builders Solutions provides assistance in calculating the dosage of synthetic macro-fibers required to replace conventional shrinkage and temperature reinforcement in slabs-on-ground applications.

* + - * 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/C1116M, [**1 to 2-1/4 inches (25 to 57 mm)**] <**Insert dimensions**> long.

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

Shall provide a minimum residual strength, , (or a minimum average equivalent flexural strength, ) of [ ] psi when tested in accordance with ASTM C1812/C1812M.

Dosage shall be as recommended by the manufacturer.

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

Master Builders Solutions; MasterFiber MAC Series.

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

* + - 1. CURING MATERIALS
         1. Absorptive Cover: AASHTO M 182, [**Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry**] [**or**] [**cotton mats**].
         2. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.
         3. Water: Potable.

Evaporation retarder in "Evaporation Retarder" Paragraph below temporarily reduces moisture loss from concrete surfaces awaiting finishing in hot, dry, and windy conditions. Evaporation retarders are not curing compounds or chemical surface retarders used to delay concrete setting.

* + - * 1. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.

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:

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

Retain "Clear, Waterborne, Membrane-Forming Curing Compound" Paragraph below if required. Although the EPA permits VOC emissions of up to 350 g/L for this product category, verify that product complies with curing compound VOC emission limits of authorities having jurisdiction. If appearance of paving is important before breakdown and disappearance of curing membrane, verify rate of dissipation with manufacturers.

* + - * 1. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B, dissipating.

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

Anti-Hydro International, Inc.

ChemMasters, Inc.

Dayton Superior.

Euclid Chemical Company (The); an RPM company.

Kaufman Products, Inc.

L&M Construction Chemicals, Inc.

Lambert Corporation.

Nox-Crete Products Group.

Right Pointe.

SpecChem, LLC.

TK Products.

Unitex by Dayton Superior.

Vexcon Chemicals Inc.

W. R. Meadows, Inc.

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

Retain "White, Waterborne, Membrane-Forming Curing Compound" Paragraph below if required. Retain if more reflectivity is required. Review product choices, because some dissipate and others are abraded by traffic. Although the EPA permits VOC emissions of up to 350 g/L for this product category, verify that product complies with curing compound VOC emission limits of authorities having jurisdiction.

* + - * 1. White, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 2, Class B, dissipating.

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

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

Anti-Hydro International, Inc.

ChemMasters, Inc.

Dayton Superior.

Euclid Chemical Company (The); an RPM company.

Kaufman Products, Inc.

L&M Construction Chemicals, Inc.

Lambert Corporation.

SpecChem, LLC.

Vexcon Chemicals Inc.

W. R. Meadows, Inc.

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

* + - 1. RELATED MATERIALS
         1. Joint Fillers: [**ASTM D1751, asphalt-saturated cellulosic fiber**] [**or**] [**ASTM D1752, cork or self-expanding cork**] in preformed strips.
         2. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or 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.

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

* + - * 1. Bonding Agent: ASTM C1059/C1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
        2. Epoxy-Bonding Adhesive: ASTM C881/C881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:

Retain one option in first subparagraph below based on service loading.

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

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

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

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

Retain "Chemical Surface Retarder" Paragraph below for exposed-aggregate finish requiring surface retarder; this is not an evaporation retarder.

* + - * 1. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch (3 to 6 mm).

Master Builders Solutions’ "MasterFinish EA" is a good solution for Residential, terraces, promenade and construction joint applications. For architectural precast applications, visit [https://www.master-builders-solutions.Master Builders Solutions.us/en-us/products/concrete-surface-treatment/surface-retarders](https://www.master-builders-solutions.basf.us/en-us/products/concrete-surface-treatment/surface-retarders) for more specific options in the MasterFinish Series.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterFinish EA (Pre-2014: MBT EAC-S) or comparable product by one of the following:

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

Pigmented mineral dry-shake hardener in "Pigmented Mineral Dry-Shake Hardener" Paragraph below is nonmetallic and used because of its nonrusting characteristics for frequently wet concrete.

* + - * 1. Pigmented Mineral Dry-Shake 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.

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

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

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

* + - * 1. Rock Salt: Sodium chloride crystals, kiln dried, coarse gradation with 100 percent passing 3/8-inch (9.5-mm) sieve and 85 percent retained on a No. 8 (2.36-mm) sieve.
      1. STAMPED DETECTABLE WARNING MATERIALS
         1. Detectable Warning Stamp: Semirigid polyurethane mats with formed underside capable of imprinting detectable warning pattern on plastic concrete; perforated with a vent hole at each dome.

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

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

ADA Solutions, Inc.

Advanced Surfaces Inc.

Butterfield Color.

Stampcrete International, Ltd.

Transpo Industries, Inc.

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

Retain "Size of Stamp" Subparagraph below if required; revise to suit Project.

Size of Stamp: One piece, [**matching detectable warning area shown on Drawings**] [**24 by 24 inches (610 by 610 mm)**] [**24 by 36 inches (610 by 914 mm)**] [**24 by 48 inches (610 by 1220 mm)**] [**26 by 26 inches (660 by 660 mm)**] [**26 by 36 inches (660 by 914 mm)**] <**Insert dimensions**>.

Liquid release agent in "Liquid Release Agent" Paragraph below is applied to paving before mat stamping to serve as a bond breaker and as an initial curing material without addition of color to surface. Pigmented release agents used for stamped concrete add a highlighting color, which is not uniform.

* + - * 1. Liquid Release Agent: Manufacturer's standard, clear, evaporating formulation designed to facilitate release of stamp mats.

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

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

[Advanced Surfaces Inc](http://www.specagent.com/Lookup?uid=123457048400).

Artcrete, Inc.

Bon Tool Co.

Brickform; a division of Solomon Colors.

Butterfield Color.

Decosup Inc.

Matcrete Inc.

Proline Concrete Tools, Inc.

QC Construction Products.

Scofield, L. M. Company.

Southern Color N.A., Inc.; a division of Rockwood Pigments.

Specialty Concrete Products, Inc.

Stampcrete International, Ltd.

SuperStone, Inc.

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

Insert requirements for concrete stain, pigmented sealer, or pigmented curing and sealing compound if pigment is required. Pigmented mineral dry-shake hardener is not used for stamped detectable warnings.

* + - 1. CONCRETE MIXTURES

Some authorities having jurisdiction prescribe concrete mixture requirements; revise this article to suit those requirements if any.

* + - * 1. Prepare design mixtures, proportioned in accordance with ACI SPEC-301 (ACI SPEC-301M), for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.

Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.

Retain subparagraph below if automatic machine placement is used for placing paving or curbs and gutters.

When automatic machine placement is used, determine design mixtures and obtain laboratory test results that comply with or exceed requirements.

Retain "Cementitious Materials" Paragraph below if applicable. ACI SPEC-301 (ACI SPEC-301M) sets no limits on amounts of cementitious or mineral admixtures that can replace portland cement unless concrete is exposed to deicing chemicals. Retain first option below if replacing part of the portland cement, which would otherwise be used in concrete, with other cementitious materials. Retain second option if limiting percentage of cementitious materials that can replace portland cement.

* + - * 1. Cementitious Materials: [**Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.**][**Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:**]

Delete "Fly Ash or Pozzolan," "Slag Cement," and "Combined Fly Ash or Pozzolan, and Slag Cement" subparagraphs below if retaining first option in "Cementitious Materials" Paragraph above. If retaining second option above, revise percentages below to suit Project. Percentages are ACI SPEC-301 (ACI SPEC-301M) limits for concrete exposed to deicing chemicals.

Retain first subparagraph below if either fly ash or blended Type IP hydraulic cement is specified. Retain second subparagraph if either slag cement or blended Type IS hydraulic cement is specified. Retain third subparagraph if fly ash or blended Type IP hydraulic cement is specified with slag cement or blended Type IS hydraulic cement.

Fly Ash or Pozzolan: 25 percent.

Slag Cement: 50 percent.

Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

Retain first paragraph below if concrete paving will be exposed to freeze-thaw cycling or deicing chemicals or if other beneficial effects of air entrainment, such as workability or cohesion of concrete mixture, are required.

* + - * 1. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

Optional percentages in three "Air Content" subparagraphs below are based on ACI SPEC-301 (ACI SPEC-301M) for exposure severity and aggregate size. Retain first option in each subparagraph for severe exposure, second option for moderate exposure, and third option for mild exposure. See the Evaluations for exposure definitions.

Air Content: [**5-1/2**] [**4-1/2**] [**2-1/2**] percent plus or minus 1-1/2 percent for 1-1/2-inch (38-mm) nominal maximum aggregate size.

Air Content: [**6**] [**4-1/2**] [**3**] percent plus or minus 1-1/2 percent for 1-inch (25-mm) nominal maximum aggregate size.

Air Content: [**6**] [**5**] [**3-1/2**] percent plus or minus 1-1/2 percent for 3/4-inch (19-mm) nominal maximum aggregate size.

Retain first option in first paragraph below if reinforced concrete paving will be exposed to chlorides in service; retain second option for reinforced concrete paving that will not be exposed to chlorides but will be exposed to moisture in service. Percentages are derived from ACI SPEC-301 (ACI SPEC-301M).

* + - * 1. Limit water-soluble, chloride-ion content in hardened concrete to [**0.15**] [**0.30**] percent by weight of cement.
        2. Chemical Admixtures: Use admixtures in accordance with manufacturer's written instructions.

Retain three subparagraphs below if required; revise to suit Project.

Use [**water-reducing admixture**] [**high-range, water-reducing admixture**] [**high-range, water-reducing and retarding admixture**] [**plasticizing and retarding admixture**] in concrete as required for placement and workability.

Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

Use accelerating or water-reducing and -accelerating admixture when required by low temperatures, or other adverse winter placement conditions.

Synthetic-fiber dosage rates in "Synthetic Micro-fiber" Paragraph below reflect typical recommendations of manufacturers. Retain first option below for synthetic fiber used for reducing plastic shrinkage cracking; retain second option for synthetic fiber used for improving hardened concrete properties. Revise dosage if required.

* + - * 1. Synthetic Micro-fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than [**1.0 lb/cu. yd. (0.60 kg/cu. m)**] [**1.5 lb/cu. yd. (0.90 kg/cu. m)**] <**Insert requirement**>.
        2. 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)]** <**Insert dosage**>.

"Re,3" in subparagraph below is the "equivalent flexural strength ratio" determined in accordance with ASTM C1609/C1609M.

Submit fiber manufacturer's documentation showing that proposed fiber dosage will provide a minimum Re,3 value of **<Insert number>** percent or of [ ] psi when tested in accordance with ASTM C1609/C1609M.

* + - * 1. 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. Concrete Mixtures: Normal-weight concrete.

Higher strengths than those in options in "Compressive Strength (28 Days)" Subparagraph below may be needed for durability in severe exposure conditions. Consult concrete paving contractors for regional practices.

Compressive Strength (28 Days): [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] <**Insert strength**>.

Insert another subparagraph for flexural strength if required.

Generally, retain first option in "Maximum w/cm at Point of Placement" Subparagraph below if concrete paving will be exposed to deicers or subject to freezing and thawing while moist; retain second option for concrete required to have low water permeability; insert another ratio to suit Project.

Maximum w/cm at Point of Placement: [**0.45**] [**0.50**] <**Insert ratio**>.

Slump Limit: [**4 inches (100 mm)**] [**5 inches (125 mm)**] [**8 inches (200 mm)**] <**Insert dimension**>, plus or minus 1 inch (25 mm).

"Solar Reflectance (SR)" Subparagraph below applies to LEED v4.

Solar Reflectance (SR): Three-year-aged SR value of at least 0.28 or initial SR of at least 0.33.

* + - 1. CONCRETE MIXING

Retain option in "Ready-Mixed Concrete" Paragraph below if synthetic-fiber reinforcement is required.

* + - * 1. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete in accordance with ASTM C94/C94M[**and ASTM C1116/C1116M**]. Furnish batch certificates for each batch discharged and used in the Work.

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

The slump/workability, air content, and temperature of freshly batched concrete can be maintained beyond the limits provided in ASTM C94/C94M through the use of hydration-controlling admixtures, workability-retaining admixtures, and other means in accordance with ACI SPEC-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 "MasterSure Z 60" workability-retaining admixture have been used successfully to maintain the fresh properties of concrete beyond the 1-1/2-hour limit for concrete discharge provided in ASTM C94/C94M.

Retain "Project-Site Mixing" Paragraph below if permitted. ACI SPEC-301 (ACI SPEC-301M) applies requirements in ASTM C94/C94M to site-produced concrete.

* + - * 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.

For concrete batches of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.

For concrete batches 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).

Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

1. EXECUTION
   * + 1. EXAMINATION
          1. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

If concrete walks or similar lightly loaded paving does not require proof-rolling to the degree described in first paragraph below, revise requirements in paragraph to suit Project.

* + - * 1. Proof-roll prepared subbase surface below [**concrete paving**] <**Insert locations**> to identify soft pockets and areas of excess yielding.

Completely proof-roll subbase in one direction [**and repeat in perpendicular direction**]. Limit vehicle speed to 3 mph (5 km/h).

Revise minimum weight or type of vehicle in first subparagraph below if required.

Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).

Correct subbase with soft spots and areas of pumping or rutting exceeding depth of [**1/2 inch (13 mm)**] <**Insert dimension**> in accordance with requirements in Section 312000 "Earth Moving."

* + - * 1. Proceed with installation only after unsatisfactory conditions have been corrected.
      1. PREPARATION
         1. Remove loose material from compacted subbase surface immediately before placing concrete.
      2. EDGE FORMS AND SCREED CONSTRUCTION
         1. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
         2. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.
      3. STEEL REINFORCEMENT INSTALLATION

Retain this article if steel-reinforced concrete paving is required; revise to suit Project.

* + - * 1. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
        2. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
        3. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
        4. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

Retain "Zinc-Coated Reinforcement" Paragraph below if required.

* + - * 1. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.

Retain "Epoxy-Coated Reinforcement" Paragraph below if required.

* + - * 1. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating in accordance with ASTM D3963/D3963M.
        2. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch (50-mm) overlap of adjacent mats.
      1. JOINTS

Coordinate joint types, descriptions, and locations with Drawings. Construction, isolation, and contraction joints and edging have been consolidated in this article for consistency rather than for strict sequence of installation.

* + - * 1. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

* + - * 1. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

Retain first two subparagraphs below if steel reinforcement is required; revise to suit Project.

Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.

Provide tie bars at sides of paving strips where indicated.

Retain one or more "Butt Joints," "Keyed Joints," and "Doweled Joints" subparagraphs below. Consider butt joints for joints not subject to traffic.

Butt Joints: Use [**bonding agent**] [**epoxy-bonding adhesive**] at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

Retain "Keyed Joints" Subparagraph below for low-traffic areas if applicable. Keyed joints are incapable of significant load transfer at joint and are not recommended by ACI PRC-302.1R for concrete less than 6 inches (150 mm) thick.

Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.

Retain "Doweled Joints" Subparagraph below for load-transfer doweled joints. Revise if precoated dowels are required.

Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

* + - * 1. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

Expansion joints are types of isolation joints. Revise spacing in first subparagraph below to suit Project or delete if not required.

Locate expansion joints at intervals of [**50 feet (15.25 m)**] <**Insert dimension**> unless otherwise indicated.

Extend joint fillers full width and depth of joint.

Terminate joint filler not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished surface if joint sealant is indicated.

Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.

Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.

During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

Terms "contraction joint" and "control joint" have been used interchangeably in the past. ACI documents use the term "contraction joint." Revise description in "Contraction Joints" Paragraph below if the term "control joint" is preferred.

* + - * 1. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows[**, to match jointing of existing adjacent concrete paving**]:

Retain "Grooved Joints" or "Sawed Joints" Subparagraph below for joint-forming method; retain both if joint-forming method is Contractor's option. Insert joint spacing if not indicated on Drawings.

Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a [**1/4-inch (6-mm)**] [**3/8-inch (10-mm)**] radius. Repeat grooving of contraction joints after applying surface finishes. [**Eliminate grooving-tool marks on concrete surfaces.**]

Retain "Tolerance" Subparagraph below if doweled contraction joints are required and if tolerance, coordinated with dowel length, is not indicated on Drawings. See the Evaluations.

Tolerance: Ensure that grooved joints are within [**3 inches (75 mm)**] <**Insert dimension**> either way from centers of dowels.

Retain "Sawed Joints" Subparagraph below if saw cutting is permitted. Timing is critical for sawed joints. Widen top portion of sawed joint if joint sealants are required. Description below allows conventional wet- and dry-cut saws and if required depth of cut can be achieved, early-entry dry-cut saws.

Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

Retain "Tolerance" Subparagraph below if doweled contraction joints are required and if tolerance, coordinated with dowel length, is not indicated on Drawings. See the Evaluations.

Tolerance: Ensure that sawed joints are within [**3 inches (75 mm)**] <**Insert dimension**> either way from centers of dowels.

Retain "Doweled Contraction Joints" Subparagraph below with either grooved joints or sawed joints if doweled contraction or expansion joints are required; revise if precoated dowels are required.

Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

Edging is included in this article because of its similarity to jointing. Timing of edging after initial floating is critical.

* + - * 1. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a [**1/4-inch (6-mm)**] [**3/8-inch (10-mm)**] radius. Repeat tooling of edges after applying surface finishes [**Eliminate edging-tool marks on concrete surfaces.**]
      1. CONCRETE PLACEMENT

Retain options in first two paragraphs below if steel reinforcement is required.

* + - * 1. Before placing concrete, inspect and complete formwork installation [**, steel reinforcement,**] and items to be embedded or cast-in.
        2. Remove snow, ice, or frost from subbase surface [**and steel reinforcement**] before placing concrete. Do not place concrete on frozen surfaces.
        3. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
        4. Comply with ACI SPEC-301 (ACI SPEC-301M) requirements for measuring, mixing, transporting, and placing concrete.

Retain first paragraph below if adding water is not permitted after batch mixing. ACI SPEC-301 (ACI SPEC-301M) and ASTM C94/C94M permit water to be added to concrete mixture on-site to adjust slump, up to amount allowed in design mixture, with some limitations.

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

* + - * 1. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
        2. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
        3. Consolidate concrete in accordance with ACI SPEC-301 (ACI SPEC-301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

Retain options in subparagraph below if steel reinforcement is required.

Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies [**reinforcement,**] or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating [**reinforcement**] [**dowels**] [**and**] joint devices.

* + - * 1. Screed paving surface with a straightedge and strike off.

Initial floating stage between screeding and final float finish is included in this article rather than in "Concrete Protection and Curing" Article.

* + - * 1. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

Retain "Curbs and Gutters" Paragraph below if machine-placed curbs and gutters are permitted.

* + - * 1. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

Retain "Slip-Form Paving" Paragraph below if machine-placed paving is acceptable.

* + - * 1. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.

Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

* + - 1. FLOAT FINISHING

Retain "General" Paragraph below. Some floating and troweling machines have watering attachments. Adding water weakens the concrete surface and can cause dusting and scaling.

* + - * 1. General: Do not add water to concrete surfaces during finishing operations.

Initial floating operation is included in "Concrete Placement" Article.

* + - * 1. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

Retain one or more "Burlap Finish," "Medium-to-Fine-Textured Broom Finish," and "Medium-to-Coarse-Textured Broom Finish" subparagraphs below or revise to suit Project. If retaining more than one subparagraph, indicate locations of each on Drawings.

Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.

Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.

Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to 3 mm) deep with a stiff-bristled broom, perpendicular to line of traffic.

* + - 1. SPECIAL FINISHES

Retain one or more "Monolithic Exposed-Aggregate Finish," "Seeded Exposed-Aggregate Finish," "Slip-Resistive Aggregate Finish," "Rock-Salt Finish," and "Pigmented Mineral Dry-Shake Hardener Finish" paragraphs in this article. If retaining more than one finish, indicate locations of each on Drawings. Retain one of first two paragraphs for exposed-aggregate finish. Retain first paragraph if coarse aggregate in concrete mixture will be exposed on paving surface. Retain second paragraph if exposed aggregate will be spread onto the surface of plastic concrete.

* + - * 1. Monolithic Exposed-Aggregate Finish: Expose coarse aggregate in paving surface as follows:

Immediately after float finishing, spray-apply chemical surface retarder to paving in accordance with manufacturer's written instructions.

Cover paving surface with plastic sheeting, sealing laps with tape, and remove when ready to continue finishing operations.

Without dislodging aggregate, remove mortar concealing the aggregate by lightly brushing surface with a stiff, nylon-bristle broom. Do not expose more than one-third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate.

Fine-spray surface with water and brush. Repeat cycle of water flushing and brushing until cement film is removed from aggregate surfaces to depth required.

* + - * 1. Seeded Exposed-Aggregate Finish: Immediately after initial floating, spread a single layer of aggregate uniformly on paving surface. Tamp aggregate into plastic concrete and float finish to entirely embed aggregate with mortar cover of 1/16 inch (1.6 mm).

Spray-apply chemical surface retarder to paving in accordance with manufacturer's written instructions.

Cover paving surface with plastic sheeting, sealing laps with tape, and remove sheeting when ready to continue finishing operations.

Without dislodging aggregate, remove mortar concealing the aggregate by lightly brushing surface with a stiff, nylon-bristle broom. Do not expose more than one-third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate.

Fine-spray surface with water and brush. Repeat cycle of water flushing and brushing until cement film is removed from aggregate surfaces to depth required.

* + - * 1. Slip-Resistive Aggregate Finish: Before final floating, spread slip-resistive aggregate finish on paving surface in accordance with manufacturer's written instructions and as follows:

Uniformly spread [**25 lb/100 sq. ft. (12 kg/10 sq. m)**] [**40 lb/100 sq. ft. (19.5 kg/10 sq. m)**] [**60 lb/100 sq. ft. (29 kg/10 sq. m)**] <**Insert rate of application**> of dampened, slip-resistive aggregate over paving surface in two applications. Tamp aggregate flush with surface using a steel trowel, but do not force below surface.

Uniformly distribute approximately two-thirds of slip-resistive aggregate over paving surface with mechanical spreader, allow to absorb moisture, and embed by power floating. Follow power floating with a second slip-resistive aggregate application, uniformly distributing remainder of material at right angles to first application to ensure uniform coverage, and embed by power floating.

Coordinate curing compounds retained in Part 2 for compatibility with slip-resistive aggregate and, if required, revise lists of manufacturers accordingly. Special curing compounds may be required.

Cure concrete with curing compound recommended by slip-resistive aggregate manufacturer. Apply curing compound immediately after final finishing.

After curing, lightly work surface with a steel-wire brush or abrasive stone and water to expose nonslip aggregate.

Retain "Rock-Salt Finish" Paragraph below if required. Avoid this finish if water may be trapped and frozen in pitted surface. Revise weight of salt and procedure in accordance with texture desired. Verify weight of salt on Project mockup if necessary.

* + - * 1. Rock-Salt Finish: After initial [**floating**] [**troweling**] [**brooming**], uniformly spread rock salt over paving surface at the rate of 5 lb/100 sq. ft. (0.2 kg/10 sq. m).

Embed rock salt into plastic concrete with [**roller**] [**or**] [**magnesium float**] <**Insert tool**>.

Retain first subparagraph below if polyethylene will not smother other textures previously applied to concrete.

Cover paving surface with 1-mil- (0.025-mm-) thick polyethylene sheet and remove sheet when concrete has hardened and seven-day curing period has elapsed.

After seven-day curing period, saturate concrete with water and broom-sweep surface to dissolve remaining rock salt, thereby leaving pits and holes.

Retain "Pigmented Mineral Dry-Shake Hardener Finish" Paragraph below if required. Use compatible curing compounds in lieu of moisture curing to prevent discoloration and staining.

* + - * 1. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to paving surface in accordance with manufacturer's written instructions and as follows:

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

Uniformly spread dry-shake hardener at a rate of [**100 lb/100 sq. ft. (49 kg/10 sq. m)**] <**Insert rate of application**> unless greater amount is recommended by manufacturer to match paving color required.

Uniformly distribute approximately two-thirds of dry-shake hardener over the concrete surface with mechanical spreader; allow hardener to absorb moisture and embed it by power floating. Follow power floating with a second application of pigmented mineral dry-shake hardener, uniformly distributing remainder of material at right angles to first application to ensure uniform color, and embed hardener by final power floating.

After final power floating, apply a hand-troweled finish followed by a broom finish.

Coordinate curing compounds retained in Part 2 for compatibility with pigmented mineral dry-shake hardener and, if required, revise list of manufacturers accordingly. Special curing compounds may be required.

Cure concrete with curing compound recommended by dry-shake hardener manufacturer. Apply curing compound immediately after final finishing.

* + - 1. DETECTABLE WARNING INSTALLATION

Retain "Blockouts," "Cast-in-Place Detectable Warning Tiles," or "Stamped Detectable Warnings" Paragraph below if detectable warnings are required. Retain first paragraph for detectable paving units set in mortar or adhesive in blockouts in concrete paving; retain second paragraph for paving units cast into concrete; retain third paragraph for stamped detectable warnings.

* + - * 1. Blockouts: Form blockouts in concrete for installation of detectable paving units specified in Section 321726 "Tactile Warning Surfacing."

Tolerance for Opening Size: [**Plus 1/4 inch (6 mm), no minus**] <**Insert requirement**>.

* + - * 1. Cast-in-Place Detectable Warning Tiles: Form blockouts in concrete for installation of tiles specified in Section 321726 "Tactile Warning Surfacing." Screed surface of concrete where tiles are to be installed to elevation, so that edges of installed tiles will be flush with surrounding concrete paving. Embed tiles in fresh concrete to comply with Section 321726 "Tactile Warning Surfacing" immediately after screeding concrete surface.
        2. Stamped Detectable Warnings: Install stamped detectable warnings as part of a continuous concrete paving placement and in accordance with stamp-mat manufacturer's written instructions.

Before using stamp mats, verify that the vent holes are unobstructed.

Apply liquid release agent to the concrete surface and the stamp mat.

Stamping: [**While initially finished concrete is plastic**] [**After application and final floating of pigmented mineral dry-shake hardener**], accurately align and place stamp mats in sequence. Uniformly load, gently vibrate, and press mats into concrete to produce imprint pattern on concrete surface. Load and tamp mats directly perpendicular to the stamp-mat surface to prevent distortion in shape of domes. Press and tamp until mortar begins to come through all of the vent holes. Gently remove stamp mats.

Trimming: After [**24**] <**Insert number**> hours, cut off the tips of mortar formed by the vent holes.

Revise minimum time period in subparagraph below if required. The recommended time period to wait before removing residual release agent varies from 2 to 10 days among manufacturers. Concrete must be strong enough to not be damaged.

Remove residual release agent in accordance with manufacturer's written instructions, but no fewer than three days after stamping concrete. High-pressure-wash surface and joint patterns, taking care not to damage stamped concrete. Control, collect, and legally dispose of runoff.

Insert requirements for concrete stain, pigmented sealer, or pigmented curing and sealing compound if pigment is required. Pigmented mineral dry-shake hardener is not used for stamped detectable warnings.

* + - 1. CONCRETE PROTECTION AND CURING
         1. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
         2. Comply with ACI SPEC-306.1 for cold-weather protection.

If evaporation rate in "Evaporation Retarder" Paragraph below is exceeded, ACI PRC-305 states that plastic shrinkage cracking is probable. See manufacturers' literature or ACI PRC-305 for estimated moisture-loss chart that relates relative humidity, air and concrete temperature, and wind velocity to rate of evaporation.

ACI SPEC-305.1 recommends that the 0.2 lb/sq. ft. x h (1 kg/sq. m x h) default value may be revised by Architect/Engineer, as concrete mixtures containing conventional or ultra-fine pozzolan or other cementitious materials may require lower allowable evaporation rates. Further guidance is available in ACI 305R.

* + - * 1. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply in accordance with manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.
        2. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

Retain one or more options in "Curing Methods" Paragraph below. Do not use curing compound on surfaces to be covered by unit pavers, tiles, or other materials set in mortar.

* + - * 1. Curing Methods: Cure concrete by [**moisture curing**] [**moisture-retaining-cover curing**] [**curing compound**] [**or**] [**a combination of these**] as follows:

Retain one or more "Moisture Curing," "Moisture-Retaining-Cover Curing," and "Curing Compound" subparagraphs below to suit Project. If retaining more than one, indicate locations of each curing method on Drawings.

Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

Retain first three subparagraphs below as Contractor's options unless unsuited for Project.

Water.

Continuous water-fog spray.

Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.

Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period, using cover material and waterproof tape.

Do not use curing compound in "Curing Compound" Subparagraph below on surfaces to be covered by unit pavers, tiles, or other materials set in mortar.

Curing Compound: Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

* + - 1. PAVING TOLERANCES
         1. Comply with tolerances in ACI SPEC-117 (ACI SPEC-117M) and as follows:

ACI SPEC-117 (ACI SPEC-117M) establishes few paving tolerances; those in subparagraphs below are based on ACI 330.1. Revise to suit Project.

Elevation: 3/4 inch (19 mm).

Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).

Surface: Gap below 10-feet- (3-m-) long; unleveled straightedge not to exceed 1/2 inch (13 mm).

Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches (13 mm per 300 mm) of tie bar.

Lateral Alignment and Spacing of Dowels: 1 inch (25 mm).

Vertical Alignment of Dowels: 1/4 inch (6 mm).

Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches (6 mm per 300 mm) of dowel.

Joint Spacing: 3 inches (75 mm).

Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.

Joint Width: Plus 1/8 inch (3 mm), no minus.

* + - 1. FIELD QUALITY CONTROL

Retain "Testing Agency" Paragraph below to identify who shall perform tests and inspections. If retaining second option, retain "Field quality-control reports" Paragraph in "Informational Submittals" Article.

* + - * 1. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

Retain "Testing Services" Paragraph below to suit Project; delete if not required for small work.

* + - * 1. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained in accordance with ASTM C172/C172M shall be performed in accordance with the following requirements:

Revise "Testing Frequency" Subparagraph below to suit Project. First option is based on ACI SPEC-301 (ACI SPEC-301M), second on ACI CODE-318 (ACI CODE-318M) for slabs.

Testing Frequency: Obtain at least one composite sample for each [**150 cu. yd. (110 cu. m)**] [**5000 sq. ft. (465 sq. m)**] or fraction thereof of each concrete mixture placed each day.

Retain first subparagraph below with either option in "Testing Frequency" Subparagraph above.

When frequency of testing will provide 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.

Slump: ASTM C143/C143M; 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. Perform additional tests when concrete consistency appears to change.

Air Content: ASTM C231/C231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.

Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when it is 80 deg F (27 deg C) and above, and one test for each composite sample.

Revise number of laboratory- or field-cured test specimens in "Compression Test Specimens" Subparagraph below if required.

Compression Test Specimens: ASTM C31/C31M; cast and laboratory cure [**four 6- by 12-inch (150- by 300-mm)**] [**five 4- by 8-inch (100- by 200-mm)**] <**Insert requirement**> cylinder specimens for each composite sample.

Coordinate number of compression test specimens in "Compression Test Specimens" Subparagraph above with number of compressive-strength tests in "Compressive-Strength Tests" Subparagraph below.

Compressive-Strength Tests: ASTM C39/C39M.

A compressive-strength test shall be the average compressive strength from [**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.

Test cylinders at [**three days**] [**seven days**] [**28 days**] [**days indicated**].

* + - * 1. Strength of each concrete mixture will be satisfactory if average of any three-consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).
        2. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, specified compressive strength at 28 days, concrete mixture proportions and materials, compressive strength, and type of failure for [**both 7- and 28-day**] [**age indicated**] tests.
        3. 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.
        4. Additional Tests: 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.
        5. Concrete paving will be considered defective if it does not pass tests and inspections.
        6. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
        7. Prepare test and inspection reports.
      1. REPAIR AND PROTECTION
         1. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
         2. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.
         3. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
         4. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313