**SECTION 034100 - PRECAST STRUCTURAL CONCRETE**

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 : master-builders-solutions.com/en-us/architects-and-designers.

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:

Precast structural concrete.

Thin-b

rick-faced, precast structural concrete.

Stone-faced, precast structural concrete.

Precast structural concrete with commercial architectural finish.

* + - * 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" for [**concrete topping and**]placing connection anchors in concrete.

Section 051200 "Structural Steel Framing" for furnishing and installing connections attached to structural-steel framing.

Section 055000 "Metal Fabrications" for kickers and other miscellaneous steel shapes.

Section 071900 "Water Repellents" for water-repellent finish treatments.

* + - 1. ALLOWANCES

Retain products and Work included in this Section that are covered by cash or quantity allowance. Do not include amounts. Insert descriptions of items in Part 2 or 3 to provide information affecting the cost of the Work that is not included under the allowance.

* + - * 1. Thin brick is part of <**Insert name of allowance**>.

Retain paragraph below if testing is paid for by Contractor under an allowance.

* + - * 1. [**Preconstruction**] [**Source quality-control**] [**and**] [**field quality-control**] testing are part of testing and inspecting allowance.
      1. DEFINITIONS

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

Retain "Design Reference Sample" Paragraph below if a design reference sample has been preapproved by Architect for precast structural concrete units with architectural finish.

* + - * 1. Design Reference Sample: Sample of approved precast structural concrete color, finish, and texture, preapproved by Architect.
      1. PREINSTALLATION MEETINGS

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

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

If needed, insert list of conference participants not mentioned in Section 013100 "Project Management and Coordination."

* + - 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 2009, Materials and Resources Credit 5, "Regional Materials."

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.

"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.

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.

"Product Certificates" Subparagraph below applies to ASHRAE189.1, 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 ASHRAE189.1-2014, 9.4.1.2.

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 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.

* + - * 1. Design Mixtures: For each precast concrete mixture. Include compressive strength and, if required, water-absorption tests.
        2. Shop Drawings:

Include member locations, plans, elevations, dimensions, shapes and sections, openings, support conditions, and types of reinforcement, including special reinforcement.

Detail fabrication and installation of precast structural concrete units, including connections at member ends and to adjoining construction.

Retain subparagraphs below applicable to Project.

Indicate joints, reveals, drips, chamfers, and extent and location of each surface finish.

Indicate separate face and backup mixture locations and thicknesses.

Indicate type, size, and length of welded connections by AWS standard symbols.

Detail loose and cast-in hardware, lifting and erection inserts, connections, and joints.

Indicate locations, tolerances, and details of anchorage devices to be embedded in or attached to structure or other construction.

Include and locate openings larger than 10 inches (250 mm). Where additional structural support is required, include header design.

Indicate location of each precast structural concrete unit by same identification mark placed on panel.

Indicate relationship of precast structural concrete units to adjacent materials.

Indicate locations, dimensions, and details of thin-brick units, including corner units and special shapes, and joint treatment.

Indicate locations, dimensions, and details of stone facings, anchors, and joint widths.

Indicate estimated camber for precast floor slabs with concrete toppings.

Indicate shim sizes and grouting sequence.

If design modifications are proposed to meet performance requirements and field conditions, submit design calculations and Shop Drawings. Do not adversely affect the appearance, durability, or strength of units when modifying details or materials and maintain the general design concept.

Retain "Samples" Paragraph below for single-stage Samples, with a subordinate list if applicable.

* + - * 1. Samples:

Retain first subparagraph below if architectural finishes, colors, and textures are preselected, specified, or scheduled. Coordinate with sample panels in "Quality Assurance" Article.

For each type of finish indicated on exposed surfaces of precast structural concrete units with architectural finish, in sets of three, representative of finish, color, and texture variations expected; approximately 12 by 12 by 2 inches (300 by 300 by 50 mm).

Where other faces of precast concrete unit are exposed, include Samples illustrating workmanship, color, and texture of backup concrete as well as facing concrete.

Samples for each thin-brick unit required, showing full range of color and texture expected. Include Samples showing color and texture of joint treatment.

Retain one of or both "Grout Samples for Initial Selection" and "Grout Samples for Verification" subparagraphs below if joints for thin-brick facings are grouted.

Grout Samples for Initial Selection: Color charts consisting of actual sections of grout showing manufacturer's full range of colors.

Grout Samples for Verification: Showing color and texture of joint treatment.

Retain "Delegated-Design Submittal" Paragraph below if design services have been delegated to Contractor.

* + - * 1. Delegated-Design Submittal: For precast structural concrete indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

Show precast structural concrete unit types, connections, types of reinforcement, including special reinforcement, and concrete cover on reinforcement. Indicate location, type, magnitude, and direction of loads imposed on the building structural frame from precast structural concrete.

* + - 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**] [**fabricator**] [**testing agency**].

Retain "Welding certificates" Paragraph below if retaining "Welding Qualifications" Paragraph in "Quality Assurance" Article.

* + - * 1. Welding certificates.

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

* + - * 1. Material Certificates: For the following:

Cementitious materials.

Reinforcing materials and prestressing tendons.

Admixtures.

Bearing pads.

Insulation.

Structural-steel shapes and hollow structural sections.

Retain one or both subparagraphs below if thin-brick or stone facings are required.

Thin-brick units and accessories.

Stone anchors and accessories.

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

* + - * 1. Material Test Reports: For aggregates, by a qualified testing agency.

Retain first paragraph below if specifying preconstruction testing in "Preconstruction Testing" Article as Contractor's responsibility and submittal is required.

* + - * 1. Preconstruction test reports.
        2. Source quality-control reports.

Retain "Field quality-control( and special inspection) reports" Paragraph below if Contractor is responsible for field quality-control testing and inspecting. Retain option if Contractor is responsible for special inspections.

* + - * 1. Field quality-control[**and special inspection**] reports.
      1. QUALITY ASSURANCE
         1. Fabricator Qualifications: A firm that assumes responsibility for engineering precast structural concrete units to comply with performance requirements. Responsibility includes preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.

Usually retain first subparagraph below and retain a category to qualify a fabricator. A precast concrete plant certified to produce products in Category C2A, for example, is also certified to produce products in Categories C1, C1A, and C2 but not in Category C3, C3A, C4, or C4A. See the Evaluations for discussion of PCI's Group C and Group CA categories.

Designated as a PCI-certified plant as follows:

Retain first subparagraph and appropriate option if Group C products without architectural finishes are required. Retain second subparagraph and appropriate option if Group CA products with architectural finishes are required.

Group C, [**Category C1 - Precast Concrete Products (no prestressed reinforcement)**] [**Category C2 - Prestressed Hollowcore and Repetitively Produced Products**] [**Category C3 - Prestressed Straight Strand Structural Members**] [**Category C4 - Prestressed Deflected Strand Structural Members**].

Group CA, [**Category C1A - Precast Concrete Products (no prestressed reinforcement)**] [**Category C2A - Prestressed Hollowcore and Repetitively Produced Products**] [**Category C3A - Prestressed Straight-Strand Structural Members**] [**Category C4A - Prestressed Deflected-Strand Structural Members**].

Retain one of two "Installer Qualifications" paragraphs below if qualifying installers. Retain first paragraph if PCI-certified erector is required. See PCI's website, www.pci.org, for current listing of erectors.

* + - * 1. Installer Qualifications: A precast concrete erector qualified and designated by PCI's Certificate of Compliance, to erect [**Category S1 - Simple**] [**Category S2 - Complex**] Structural Systems.

Retain "Installer Qualifications" Paragraph below to qualify erector by PCI evaluation if PCI-certified erector is not required or is unavailable in Project location.

* + - * 1. Installer Qualifications: An experienced precast concrete erector who has retained a "PCI-Certified Field Auditor" to conduct a field audit of a project installed by erector in [**Category S1 - Simple**] [**Category S2 - Complex**] Structural Systems and who can produce an Erectors' Post Audit Declaration, in accordance with PCI MNL 127, "PCI Erector's Manual - Standards and Guidelines for the Erection of Precast Concrete Products."

Retain "Testing Agency Qualifications" Paragraph below if Contractor selects testing agency or if Contractor is required to provide the services of a qualified testing agency in "Field Quality Control" Article. Qualification requirements are in addition to those specified in Section 01400 "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.
        2. Quality-Control Standard: For manufacturing procedures, testing requirements, and quality-control recommendations for types of units required, comply with PCI MNL 116, "Manual for Quality Control for Plants and Production of Structural Precast Concrete Products."

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

* + - * 1. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

AWS D1.1/D1.1M, "Structural Welding Code - Steel."

AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

Consider retaining "Sample Panels" Paragraph below for precast structural concrete units with architectural finish or with thin-brick or stone facings. PCI recommends review of preproduction sample panels to establish range of finish, color, and texture to be expected. Revise number and size of sample panels in paragraph to suit Project.

* + - * 1. Sample Panels: After sample approval and before fabricating precast structural concrete units with [**architectural finish**] [**thin-brick facing**] [**stone facing**], produce a minimum of [**two**] <**Insert number**> sample panels approximately [**16 sq. ft. (1.5 sq. m)**] <**Insert dimensions**> in area for review by Architect. Incorporate full-scale details of architectural features, finishes, textures, and transitions in sample panels.

Locate panels where indicated or, if not indicated, as directed by Architect.

Damage part of an exposed-face surface for each finish, color, and texture, and demonstrate adequacy of repair techniques proposed for repair of surface blemishes.

After approval of repair technique, maintain one sample panel at fabricator's plant and one at Project site in an undisturbed condition as a standard for judging the completed Work.

Demolish and remove sample panels when directed.

Consider retaining "Mockups" Paragraph below for precast structural concrete units with architectural finish or with thin-brick or stone facings. Delete below if panels in "Sample Panels" Paragraph above suffice and added expense of mockups is not required.

* + - * 1. Mockups: After sample panel approval but before production of precast structural concrete units with [**architectural finish**] [**thin-brick facing**] [**stone facing**], construct full-sized mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and to set quality standards for materials and execution.

Revise or delete three subparagraphs below to suit Project.

Build mockup as indicated on Drawings including [**sealants**] <**Insert construction**> and precast structural concrete units with an architectural finish complete with anchors, connections, flashings, and joint fillers.

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

Retain this article for preconstruction stone anchor testing if stone facing is used and Contractor designs stone anchorage system.

* + - * 1. Preconstruction Stone Anchor Testing: Engage a qualified testing agency to perform preconstruction testing in accordance with ASTM C1354/C1354M or ASTM E488, modified as follows:

Furnish test specimens, including stone anchors, that are representative of materials proposed for incorporation into the Work.

Anchorage Tests: Test 12 inches (300 mm) square samples for[**each combination of**] stone variety, orientation of cut, finish, and anchor type proposed for use on Project. Test for shear and tensile strength of anchorage system.

* + - 1. COORDINATION
         1. Furnish loose connection hardware and anchorage items to be embedded in or attached to other construction before starting that Work. Provide locations, setting diagrams, templates, instructions, and directions, as required, for installation.
      2. DELIVERY, STORAGE, AND HANDLING
         1. Support units during shipment on nonstaining shock-absorbing material in same position as during storage.
         2. Store units with adequate bracing and protect units to prevent contact with soil, to prevent staining, and to prevent cracking, distortion, warping or other physical damage.

Store units with dunnage across full width of each bearing point unless otherwise indicated.

Place adequate dunnage of even thickness between each unit.

Place stored units so identification marks are clearly visible, and units can be inspected.

* + - * 1. Handle and transport units in a manner that avoids excessive stresses that cause cracking or damage.
        2. Lift and support units only at designated points indicated on Shop Drawings.

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. MANUFACTURERS

Retain "Manufacturers" Paragraph below and insert 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:

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

* + - 1. PERFORMANCE REQUIREMENTS

Retain "Delegated Design" Paragraph below if Contractor is required to assume responsibility for design.

* + - * 1. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design precast structural concrete units[**including stone facing system**].
        2. Design Standards: Comply with ACI CODE-318 (ACI CODE-318M) and with design recommendations in PCI MNL 120, "PCI Design Handbook - Precast and Prestressed Concrete," applicable to types of precast structural concrete units indicated.

Retain "Fire-Resistance Calculations" Paragraph below if required for units or assemblies. Retain either option below, or both, if acceptable to authorities having jurisdiction.

* + - * 1. Fire-Resistance Calculations: Where indicated, provide precast structural concrete units whose fire resistance meets prescriptive requirements of authorities having jurisdiction or has been calculated in accordance with [**ACI CODE-216.1 (ACI CODE-216.1M)**] [**PCI MNL 124, "Design for Fire Resistance of Precast Prestressed Concrete,"**] and is acceptable to authorities having jurisdiction.
        2. Structural Performance: Precast structural concrete units and connections shall withstand design loads indicated within limits and under conditions indicated.

Retain "Structural Performance" Paragraph below if including design loads here. See the Evaluations for discussion of loads. Revise requirements below to suit Project; insert other performance and design criteria if applicable.

* + - * 1. Structural Performance: Provide precast structural concrete units and connections capable of withstanding the following design loads within limits and under conditions indicated:

Dead Loads: <**Insert loads**>.

Concrete Topping Load: <**Insert load**>.

Live Loads: <**Insert loads**>.

Roof Loads: <**Insert loads**>.

Snow Loads: <**Insert loads**>.

Seismic Loads: <**Insert seismic design data including seismic performance category, importance factor, use group, seismic design category, seismic zone, site classification, site coefficient, and drift criteria**>.

Wind Loads: <**Insert wind loads or wind-loading criteria, positive and negative, for various parts of the building as required by applicable building code or ASCE/SEI 7, including basic wind speed, importance factor, exposure category, and pressure coefficient**>.

<**Insert loads or load combinations**>.

Indicate locations here or on Drawings if different movements are anticipated for different building elements. Specify deflection limits stricter than ACI CODE-318 (ACI CODE-318M).

Design precast structural concrete framing system and connections to maintain clearances at openings, to allow for fabrication and construction tolerances, to accommodate live-load deflection, shrinkage and creep of primary building structure, and other building movements. Maintain precast structural concrete deflections within limits of ACI CODE-318 (ACI CODE-318M).

Revise "Thermal Movements" Subparagraph below to suit exposure and local conditions. Temperature data are available from National Climatic Data Center, www.ncdc.noaa.gov.

Thermal Movements: Allow for in-plane thermal movements resulting from annual ambient temperature changes of [**minus 18 to plus 120 deg F (minus 10 to plus 67 deg C)**] [**120 deg F (67 deg C)**] <**Insert temperature**>.

Retain "Fire-Resistance Rating" Subparagraph below if required. Fire ratings depend on occupancy and building construction type and are generally a building code requirement.

Fire-Resistance Rating: Select material and minimum thicknesses to provide indicated fire rating.

Retain "Vehicular Impact Loads" Subparagraph below if precast units are used in parking structures to resist impact load. Revise loads to suit Project. Load is based on requirement in the International Building Code.

Vehicular Impact Loads: Design spandrel beams acting as vehicular barriers for passenger cars to resist a single [**6000-lbf (26.7-kN)**] <**Insert value**> load applied horizontally in any direction to the spandrel beam, with anchorages or attachments capable of transferring this load to the structure. Design spandrel beams assuming the load to act at a height of 18 or 27 inches (457 or 686 mm) above the floor or ramp surface, whichever is more severe, on an area not to exceed 1 sq. ft. (0.0929 sq. m).

* + - 1. MOLD MATERIALS
         1. Molds: Rigid, dimensionally stable, non-absorptive material, warp and buckle free, that provides continuous precast concrete surfaces within fabrication tolerances indicated; nonreactive with concrete and suitable for producing required finishes.

Mold-Release Agent: Commercially produced form-release agent that does not bond with, stain, or adversely affect precast concrete surfaces and does not impair subsequent surface or joint treatments of precast concrete.

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

Retain "Form Liners" Paragraph below if using form liners for precast structural concrete with architectural finish or thin-brick facings. Form liners may be used to achieve a special off-the-form finish or to act as a template for thin-brick facings. Revise to add description of selected form liner if required.

* + - * 1. Form Liners: Units of face design, texture, arrangement, and configuration [**indicated**] [**to match those used for precast concrete design reference sample**]. Furnish with manufacturer's recommended form-release agent that does not bond with, stain, or adversely affect precast concrete surfaces and does not impair subsequent surface or joint treatments of precast concrete.

Retain "Surface Retarder" Paragraph below if surface retarder is applied to molds to help obtain exposed-aggregate finish for precast structural concrete with architectural finish.

* + - * 1. Surface Retarder: Chemical set retarder, capable of temporarily delaying setting of newly placed concrete mixture to depth of reveal specified.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterFinish Series or comparable product.

* + - 1. REINFORCING MATERIALS

Retain one or more paragraphs in this article to suit steel reinforcement requirements. Distinguish locations of each type of reinforcement here or on Drawings. If retaining "Performance Requirements" Article, consider reviewing selections with fabricators.

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. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed.

Retain "Low-Alloy-Steel Reinforcing Bars" Paragraph below for reinforcement that is welded or if added ductility is sought.

* + - * 1. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M, deformed.

Retain "Galvanized Reinforcing Bars" Paragraph below where corrosive environment or severe exposure conditions justify extra cost. Presence of chromate film on the surface of galvanized coating is usually visible as light yellow tint on the surface. ASTM B201 describes a test method for determining presence of chromate coatings.

* + - * 1. Galvanized Reinforcing Bars: [**ASTM A615/A615M, Grade 60 (Grade 420)**] [**ASTM A706/A706M**], deformed bars, with ASTM A767/A767M, Class II zinc coating and chromate treatment.[**Galvanize after fabrication and bending.**]

Consider using epoxy coating where corrosive environment or severe exposure conditions justify extra cost. In "Epoxy-Coated Reinforcing Bars" Paragraph below, retain ASTM A775/A775M for a bendable epoxy coating; retain ASTM A934/A934M for a nonbendable epoxy coating.

* + - * 1. Epoxy-Coated Reinforcing Bars: [**ASTM A615/A615M, Grade 60 (Grade 420)**] [**ASTM A706/A706M**], deformed bars, [**ASTM A775/A775M**] [**or**] [**ASTM A934/A934M**] epoxy coated, with less than 2 percent damaged coating in each 12-inch (300-mm) bar length.
        2. Steel Bar Mats: ASTM A184/A184M, fabricated from [**ASTM A615/A615M, Grade 60 (Grade 420)**] [**ASTM A706/A706M**], deformed bars, assembled with clips.
        3. Plain-Steel Welded Wire Reinforcement: ASTM A1064/A1064M, fabricated from [**as-drawn steel**] [**galvanized-steel**] wire into flat sheets.
        4. Deformed-Steel Welded Wire Reinforcement: ASTM A1064/A1064M, flat sheet.
        5. Epoxy-Coated-Steel Wire: ASTM A884/A884M, Class A coated, [**plain**] [**deformed**], flat sheet, [**Type 1 bendable**] [**Type 2 nonbendable**] coating.
        6. Supports: Suspend reinforcement from back of mold or use bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place in accordance with PCI MNL 116.
      1. PRESTRESSING TENDONS

Retain this article if precast concrete units are prestressed, either pretensioned or post-tensioned.

* + - * 1. Pretensioning Strand: [**ASTM A416/A416M, Grade 250 (Grade 1720) or Grade 270 (Grade 1860), uncoated, seven-wire**] [**or**] [**ASTM A886/A886M, Grade 270 (Grade 1860), indented, seven-wire**], low-relaxation strand.
        2. Unbonded Post-Tensioning Strand: ASTM A416/A416M, Grade 270 (Grade 1860), uncoated, seven-wire, low-relaxation strand.

For aggressive climates, revise subparagraph below by adding an anchorage device encapsulation system consisting of caps and sleeves.

Coat unbonded post-tensioning strand with post-tensioning coating complying with ACI SPEC-423.7 and sheath with polypropylene tendon sheathing complying with ACI SPEC-423.7. Include anchorage devices and coupler assemblies.

* + - * 1. Post-Tensioning Bars: ASTM A722/A722M, uncoated high-strength steel bar.
      1. CONCRETE MATERIALS

Retain materials in this article as required; revise to suit Project.

"Regional Materials" Paragraph below applies to LEED 2009 NC, CS, and LEED 2009 for Schools Credit MR 5 and to LEED 2009 CI Credit MR 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 Credit MR 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.

* + - * 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.

"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. Portland Cement: ASTM C150/C150M, Type I or Type III, gray, unless otherwise indicated.

Retain subparagraph below if mixing white and gray cement improves color uniformity of precast structural concrete with architectural finish. White cement has greater color consistency than gray cement and can be used for pastel colors. For darker colors, variations of gray cement have less effect on final color hue.

For surfaces exposed to view in finished structure, use gray or white cement, of same type, brand, and mill source.

* + - * 1. Supplementary Cementitious Materials:

Retain mineral or cementitious admixtures in first four subparagraphs below. Because fly ash and gray silica fume affect color uniformity, they are not recommended by PCI where appearance is important. White silica fume is available. Slag cement and metakaolin are also white in color.

Fly Ash: ASTM C618, Class C or F, with maximum loss on ignition of 3 percent.

Metakaolin: ASTM C618, Class N.

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

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

Silica Fume: ASTM C1240, with optional chemical and physical requirement.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterLife SF 100 (Pre-2014: Rheomac SF100) or comparable product.

Slag Cement: ASTM C989, 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 other pozzolanic materials in the nonportland cement part of blended hydraulic cement may slow rate of concrete strengthening and affect color uniformity.

Blended Hydraulic Cement: ASTM C595/C595M, [**Type IS, portland blast-furnace slag**] [**Type IP, portland-pozzolan**] [**Type I (PM), pozzolan-modified portland**] [**Type I (SM), slag-modified portland**] cement.

ASTM C33/C33M limits deleterious substances in coarse aggregate depending on climate severity and in-service location of concrete. Class 5S is the most restrictive designation for architectural concrete exposed to severe weathering. PCI MNL 116 also establishes strict limits on deleterious substances for fine and coarse aggregates.

* + - * 1. Normal-Weight Aggregates: Except as modified by PCI MNL 116, ASTM C33/C33M, with coarse aggregates complying with [**Class 5S**] [**Class 5M**] [**Class 4S**] [**Class 4M**]. Stockpile fine and coarse aggregates for each type of exposed finish from a single source (pit or quarry) for Project.

Retain "Face-Mixture-Coarse Aggregates" and "Face-Mixture-Fine Aggregates" subparagraphs below for face mixtures for precast structural concrete with architectural finish. Revise to add descriptions of selected coarse- and fine-face aggregate colors and sources if required.

Face-Mixture-Coarse Aggregates: Selected, hard, and durable; free of material that reacts with cement or causes staining; to match selected finish sample.

Retain one option in "Gradation" Subparagraph below or insert gradation and maximum aggregate size if known. Fine and coarse aggregates are not always from same source.

Gradation: [**Uniformly graded**] [**Gap graded**] [**To match design reference sample**].

Face-Mixture-Fine Aggregates: Selected, natural or manufactured sand compatible with coarse aggregate to match approved finish sample.

Lightweight aggregates in a face mixture are not recommended by PCI in cold or humid climates (if exposed to the weather) unless their performance has been verified by tests or records of previous satisfactory usage in similar environments. If normal-weight aggregates are used in face mixture, PCI does not recommend lightweight aggregates in backup mixture due to bowing potential.

* + - * 1. Lightweight Aggregates: Except as modified by PCI MNL 116, ASTM C330/C330M, with absorption less than 11 percent.
        2. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of concrete and complying with chemical limits of PCI MNL 116.
        3. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and to not contain intentionally-added chlorides.

Retain one or more chemical admixtures in admixture subparagraphs below if chemical admixtures are permitted; limit chemical admixture types if required.

Air-Entraining Admixture: ASTM C260/C260M.

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

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.

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

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

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

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 a comparable product.

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

Retarding Admixture: ASTM C494/C494M, Type B.

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

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.

Accelerating Admixture: 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.

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.

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 a comparable product.

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.

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 a comparable product.

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; MasterSet FP 20 (Pre-2014: Pozzutec 20+) or comparable product.

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 a comparable product.

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.

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

Plasticizing Admixture: ASTM C1017/C1017M, Type I.

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

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.

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 a comparable product.

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

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; Master X-Seed Series or comparable product.

Permeability-Reducing Admixture:

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.

Shall show a reduction in permeability of concrete compared to 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 feet (140 m) of head**].

Shall reduce or have no penetration of water compared to 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.

Shall be certified to NSF/ANSI 61.

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

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

Corrosion-Inhibiting Admixture: ASTM C1582/C1582M.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; [**MasterLife CI 30 (Pre-2014 Rheocrete CNI)**] [**MasterLife CI 222 (Pre-2014 Rheocrete 222+)**] or comparable product.

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

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; [**MasterLife CRA** **007**] [**MasterLife SRA Series**] or comparable product.

Viscosity-Modifying Admixture: 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.

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

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

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 "Coloring Admixture" Subparagraph below if coloring admixture is required for precast structural concrete with architectural finish. Add color selection if known.

Coloring Admixture: ASTM C979/C979M, synthetic or natural mineral-oxide pigments or colored water-reducing admixtures, temperature stable, and nonfading.

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

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

* + - 1. STEEL CONNECTION MATERIALS

Revise this article to suit Project. Add other materials as required.

* + - * 1. Carbon-Steel Shapes and Plates: ASTM A36/A36M.
        2. Carbon-Steel-Headed Studs: ASTM A108, Grade 1010 through 1020, cold finished, AWS D1.1/D1.1M, Type A or B, with arc shields and with minimum mechanical properties of PCI MNL 116.
        3. Carbon-Steel Plate: ASTM A283/A283M, Grade C.
        4. Malleable-Iron Castings: ASTM A47/A47M, Grade 32510 or Grade 35028.
        5. Carbon-Steel Castings: ASTM A27/A27M, Grade 60-30 (Grade 415-205).
        6. High-Strength, Low-Alloy Structural Steel: ASTM A572/A572M.
        7. Carbon-Steel Structural Tubing: ASTM A500/A500M, Grade B or Grade C.
        8. Wrought Carbon-Steel Bars: ASTM A675/A675M, Grade 65 (Grade 450).
        9. Deformed-Steel Wire or Bar Anchors: ASTM A1064/A1064M or ASTM A706/A706M.

ASTM A307 defines the term "studs" to include stud stock and threaded rods.

* + - * 1. Carbon-Steel Bolts and Studs: ASTM A307, Grade A (ASTM F568M, Property Class 4.6); carbon-steel, hex-head bolts and studs; carbon-steel nuts, ASTM A563 (ASTM A563M); and flat, unhardened steel washers, ASTM F844.

High-strength bolts are used for friction-type connections between steel members and are not recommended by PCI between steel and concrete because concrete creep and crushing of concrete during bolt tightening reduce effectiveness.

* + - * 1. High-Strength Bolts, Nuts, and Washers: ASTM F3125/F3125M, Grade A325 (Grade A325M), Type 1, heavy-hex steel structural bolts; ASTM A563, Grade DH (ASTM A563M, Class 10S) heavy-hex carbon-steel nuts; and **ASTM F436/F436M**, Type 1, hardened carbon-steel washers.

Finish: [**Plain**] [**Hot-dip zinc coating**] [**Mechanically deposited zinc coating**].

* + - * 1. High-Strength Bolts, Nuts, and Washers: ASTM F3125/F3125M, Grade A490 (Grade A490M), Type 1, heavy-hex steel structural bolts; ASTM A563, Grade DH (ASTM A563M, Class 10S) heavy-hex carbon-steel nuts; and ASTM F436/F436M, Type 1, hardened carbon-steel washers; all with plain finish.

Retain "Zinc-Coated Finish" Paragraph below if galvanized finish is required. Revise locations of galvanized items if required. Field welding is generally not permitted on galvanized elements unless galvanizing is removed or acceptable welding procedures are submitted. Hot-dip galvanized finish provides greater corrosion resistance than electrodeposited zinc coating. Electrodeposition is usually limited to threaded fasteners.

* + - * 1. Zinc-Coated Finish: For exterior steel items[**, steel in exterior walls,**] and items indicated for galvanizing, apply zinc coating by [**hot-dip process in accordance with ASTM A123/A123M or ASTM A153/A153M**] [**electrodeposition in accordance with ASTM B633, SC 3, Types 1 and 2**].

For steel shapes, plates, and tubing to be galvanized, limit silicon content of steel to less than 0.03 percent or to between 0.15 and 0.25 percent or limit sum of silicon and 2.5 times phosphorous content to 0.09 percent.

Galvanizing Repair Paint: High-zinc-dust-content paint with dry film containing not less than 94 percent zinc dust by weight, and complying with DOD-P-21035B or SSPC-Paint 20.

Retain "Shop-Primed Finish" Paragraph below if required. Revise locations of priming if required. MPI 79 in first option below provides some corrosion protection, while SSPC-Paint 25, without topcoating, provides minimal corrosion protection.

* + - * 1. Shop-Primed Finish: Prepare surfaces of nongalvanized-steel items, except those surfaces to be embedded in concrete, in accordance with requirements in SSPC-SP 3, and shop apply [**lead- and chromate-free, rust-inhibitive primer, complying with performance requirements in MPI 79**] [**SSPC-Paint 25**] in accordance with SSPC-PA 1.
        2. Welding Electrodes: Comply with AWS standards.
        3. Precast Accessories: Provide clips, hangers, plastic or steel shims, and other accessories required to install precast structural concrete units.
      1. STAINLESS STEEL CONNECTION MATERIALS

Retain this article when resistance to staining merits extra cost in parking structures and other high-moisture or corrosive areas.

* + - * 1. Stainless Steel Plate: ASTM A240/A240M or ASTM A666, Type 304, Type 316, or Type 201.
        2. Stainless Steel Bolts and Studs: ASTM F593, Alloy Group 1 or 2 (ASTM F738M, Grade A1 or A4), hex-head bolts and studs; ASTM F594, Alloy Group 1 or 2 (ASTM F836M, Grade A1 or A4) stainless steel nuts; and flat, stainless steel washers.

Lubricate threaded parts of stainless steel bolts with an antiseize thread lubricant during assembly.

* + - * 1. Stainless Steel-Headed Studs: ASTM A276, Alloy 304 or 316, with minimum mechanical properties of PCI MNL 116.
      1. BEARING PADS

Retain this article if applicable. Coordinate selection of bearing pad with fabricator.

* + - * 1. Provide one of the following bearing pads for precast structural concrete units[**as recommended by precast fabricator for application**]:

Elastomeric Pads: AASHTO M 251, plain, vulcanized, 100 percent polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet, 50 to 70 Shore, Type A durometer hardness, ASTM D2240; minimum tensile strength 2250 psi (15.5 MPa), ASTM D412.

Random-Oriented-Fiber-Reinforced Elastomeric Pads: Preformed, randomly oriented synthetic fibers set in elastomer. 70 to 90 Shore, Type A durometer hardness, ASTM D2240; capable of supporting a compressive stress of 3000 psi (20.7 MPa) with no cracking, splitting, or delaminating in the internal portions of pad. Test one specimen for every 200 pads used in Project.

Cotton-Duck-Fabric-Reinforced Elastomeric Pads: Preformed, horizontally layered cotton-duck fabric bonded to an elastomer; 80 to 100 Shore, Type A durometer hardness, ASTM D2240; complying with AASHTO's "AASHTO LRFD Bridge Design Specifications," Division II, Section 18.10.2; or with MIL-C-882E.

Frictionless Pads: PTFE, glass-fiber reinforced, bonded to stainless or mild-steel plate, or random-oriented-fiber-reinforced elastomeric pads; of type required for in-service stress.

High-Density Plastic: Multimonomer, nonleaching, plastic strip.

* + - 1. ACCESSORIES

Retain one of two "Reglets" paragraphs below if applicable. Coordinate reglet material with counterflashing materials and details. Delete both paragraphs if specifying surface-applied reglets in Section 076200 "Sheet Metal Flashing and Trim," which avoids misalignment from one panel to the next.

* + - * 1. Reglets: Specified in Section 076200 "Sheet Metal Flashing and Trim."
        2. Reglets: [**PVC extrusions,**] [**Stainless steel, Type 302 or Type 304,**] [**Copper,**] felt or fiber filled, or with face opening of slots covered.
        3. Precast Accessories: Provide clips, hangers, high-density plastic or steel shims, and other accessories required to install structural precast concrete units.
      1. GROUT MATERIALS

Add other proprietary grout systems to suit Project. Indicate locations of each type of grout in this article or on Drawings if retaining more than one type. Sand-cement grout in "Sand-Cement Grout" Paragraph below is commonly used in keyed joints between hollow-core floor and roof slabs and wall units.

* + - * 1. Sand-Cement Grout: Portland cement, ASTM C150/C150M, Type I, and clean, natural sand, ASTM C144 or ASTM C404. Mix at ratio of 1 part cement to 2-1/2 to 3 parts sand, by volume, with minimum water required for placement and hydration. Water-soluble chloride ion content less than 0.06 percent by weight of cement when tested in accordance with ASTM C1218/C1218M.

Retain "Nonmetallic, Nonshrink Grout" Paragraph below if required or if cement-grout shrinkage could cause structural deficiency. For critical installations, require manufacturer to provide field supervision.

* + - * 1. Nonmetallic, Nonshrink Grout: Packaged, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, plasticizing and water-reducing agents, complying with ASTM C1107/C1107M, Grade A for dry pack and Grades B and C for flowable grout and of consistency suitable for application within a 30-minute working time. Water-soluble chloride ion content less than 0.06 percent by weight of cement when tested in accordance with ASTM C1218/C1218M.

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

If an early set time is desired, specify Master Builders Solutions’ "MasterFlow 713." If a longer working time is desired, specify "Masterflow 928." If a dry-pack consistency is desired, specify "MasterFlow 100."

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; [**MasterFlow 100 (Pre-2014: Construction Grout**] [**MasterFlow 713 (Pre-2014: MasterFlow 713 Plus)**] [**MasterFlow 928**] or comparable product.

* + - * 1. Nonmetallic, Nonshrink Grout for duct grouting applications of highly stressed steel: Packaged, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, plasticizing and water-reducing agents, complying with the compressive strength and settlement shrinkage requirements of ASTM C1107/C1107M and of a consistency suitable for application. [**Water soluble chloride ion content less than 0.06 percent by weight of cement when tested in accordance with ASTM C1218/C1218M**] [**Acid soluble chloride ion content less than 0.08 percent by weight of cement when tested in accordance with ASTM C1152/C1152M**]

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

Specify MasterFlow 1206 for vertical duct placements.

Basis-of-Design Product: Subject to compliance with requirements, provide Master Builders Solutions; [**MasterFlow 1205**] [**MasterFlow 1206 (Pre-2014: Masterflow 1341)**] or comparable product.

* + - * 1. Epoxy-Resin Grout: Two-component, mineral-filled epoxy resin; ASTM C881/C881M, of type, grade, and class to suit requirements.

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

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

* + - 1. THIN BRICK AND ACCESSORIES

Retain "Manufacturers" Paragraph below and insert 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:

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

Type TBX brick units feature the tightest dimensional tolerances but may be too dimensionally variable to fit securely within form-liner templates.

* + - * 1. Thin Brick: Thickness not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) thick, and as follows:

Thin-brick units that comply with ASTM C1088 Type TBX may be too dimensionally variable to fit securely within form liner templates. Tighter tolerances in "Dimensional Tolerances" Subparagraph below can be achieved by many thin-brick manufacturers.

Dimensional Tolerances: Plus 0 or minus 1/16 inch (0 or minus 1.6 mm) for any dimension 8 inches (203 mm) or less and plus 0 or minus 3/32 inch (0 or minus 2.4 mm) for any dimension more than 8 inches (203 mm).

Out-of-Square Tolerance: Plus or minus 1/16 inch (1.6 mm).

Warpage Tolerance: Plus 0 or minus 1/16 inch (0 or minus 1.6 mm).

Variation of Shape from Specified Angle: Plus or minus one degree.

Modulus of Rupture: Not less than 250 psi (1.7 MPa) when tested in accordance with ASTM C67.

Tensile Bond Strength: Not less than 150 psi (1.0 MPa) when tested before and after freeze-thaw test in accordance with ASTM E488 as modified. Adhere a steel plate with a welded rod on a single thin-brick face with epoxy for each test.

24-Hour Cold-Water Absorption: Not more than 6 percent when tested in accordance with ASTM C67.

Freeze-Thaw Resistance: No detectable disintegration or separation after 300 freezing-and-thawing cycles when tested in accordance with ASTM C666/C666M, Method B.

Chemical Resistance: Tested in accordance with ASTM C650 and rated "not affected."

Efflorescence: Tested in accordance with ASTM C67 and rated "not effloresced."

Retain "Surface Coating" Subparagraph below if surface-coated thin brick is used.

Surface Coating: Thin brick with colors or textures applied as coatings shall withstand 50 cycles of freezing and thawing; ASTM C67 with no observable difference in applied finish when viewed from 10 feet (3 m).

Retain "Back Surface Texture" Subparagraph below, deleting inapplicable descriptions if required.

Back Surface Texture: Scored, combed, wire roughened, ribbed, keybacked, or dovetailed.

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

* + - * 1. Regional Materials: Brick shall be manufactured within 500 miles (800 km) of Project site from 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, Credit MR 5, Option 1.

* + - * 1. Regional Materials: Brick shall be manufactured within 500 miles (800 km) of Project site.

"Regional Materials" Paragraph below applies to LEED v4.

* + - * 1. Regional Materials: Brick shall be manufactured within 100 miles (160 km) of Project site from 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: Brick shall be manufactured within 500 miles (800 km) of Project site from 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: Brick shall be manufactured within 500 miles (800 km) of Project site from 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.

Indicate details of special conditions and shapes on Drawings if required.

* + - * 1. Special Shapes: Include corners, edge corners, and end edge corners.
        2. Face Size: [**2-1/4 inches (57 mm) high by 7-5/8 inches (194 mm) long**] [**2-1/4 inches (57 mm) high by 11-5/8 inches (295 mm) long**] [**3-5/8 inches (92 mm) high by 7-5/8 inches (194 mm) long**] [**3-5/8 inches (92 mm) high by 11-5/8 inches (295 mm) long**] <**Insert dimensions**>.
        3. [**Where indicated to "match existing,"**]provide thin brick matching color, texture, and face size of existing adjacent brick work.

<**Insert information on existing brick if known**>.

Revise "Face Color and Texture" Paragraph below to suit Project or delete if thin brick is specified in last paragraph above by product name. If approving a color range for thin brick, view sufficient area of loose thin bricks or a completed building to make an informed determination.

* + - * 1. Face Color and Texture: [**Match Architect's samples**] <**Insert description**>.
        2. Sand-Cement Mortar: Portland cement, ASTM C150/C150M, Type I, and clean, natural sand, ASTM C144. Mix at ratio of 1 part cement to 4 parts sand, by volume, with minimum water required for placement.

Retain "Pointing Grout" Paragraph below if filling thin-brick joints with pointing grout after precast concrete panel production.

* + - * 1. Pointing Grout: Packaged, polymer-modified, sanded grout complying with ANSI A118.7.

Retain "Manufacturers" Subparagraph below and 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:

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

Polymer Type: Acrylic resin in [**dry, redispersible form, packaged with other dry ingredients**] [**liquid-latex form for adding packaged dry-grout mix**].

Colors: [**As indicated by manufacturer's designations**] [**Match Architect's samples**] [**As selected by Architect from manufacturer's full range**].

* + - 1. STONE MATERIALS AND ACCESSORIES

Retain this article if stone facing is required. Performance criteria, preconstruction material testing, material quality, fabrication, and finish requirements are usually specified in Section 044200 "Exterior Stone Cladding." Replace first paragraph below with stone requirements if preferred.

* + - * 1. Stone facing for precast structural concrete is specified in Section 044200 "Exterior Stone Cladding."

Anchors are generally supplied by stone fabricator or, in some cases, by precaster. Specify supplier. Anchors may be toe in, toe out, or dowels.

* + - * 1. Anchors: Stainless steel, ASTM A276, Type 304 or Type 316, of temper and diameter required to support loads without exceeding allowable design stresses.

Grommets are usually required if filling dowel holes with rigid epoxy.

Fit each anchor leg with neoprene grommet collar of width at least twice the diameter and of length at least five times the diameter of anchor.

Anchor hole filling is used to prevent water intrusion into stone and future discoloration at anchor locations. Retain one of two "Sealant Filler" paragraphs below for flexible filler.

Verify suitability of silicone sealant in first "Sealant Filler" Paragraph below before retaining. Silicone sealants often stain porous, light-colored stone.

* + - * 1. Sealant Filler: Chemically curing, elastomeric, single-component, nonsag, neutral-curing, silicone sealant; Class 25, Use NT (nontraffic), and Use M (masonry) that complies with applicable requirements in Section 079200 "Joint Sealants" and that does not stain stone:

Retain "Manufacturers" Subparagraph below and 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:

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

* + - * 1. Sealant Filler: Chemically curing, elastomeric, single-component, nonsag, urethane sealant; Class 25, Use T (traffic), and Use M (masonry) that complies with applicable requirements in Section 079200 "Joint Sealants" and that does not stain stone:

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; MasterSeal NP 1 (Pre-2014: Sonolastic NP1) or a comparable product by one of the following:

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

Retain "Epoxy Filler" Paragraph below for rigid filler.

* + - * 1. Epoxy Filler: ASTM C881/C881M, 100 percent solids, sand-filled nonshrinking, nonstaining of type, class, and grade to suit application.

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

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

Elastomeric Anchor Sleeve: 1/2 inch (13 mm) long; 60 Shore, Type A durometer hardness; ASTM D2240.

* + - * 1. Bond Breaker: [**Preformed, compressible, resilient, nonstaining, nonwaxing, closed-cell polyethylene foam pad, nonabsorbent to liquid and gas, 1/8 inch (3.2 mm) thick**] [**Polyethylene sheet, ASTM D4397, 6 to 10 mils (0.15 to 0.25 mm) thick**].
      1. INSULATED FLAT-WALL PANEL ACCESSORIES

Retain this article if insulated flat-wall panels are required. Retain insulation material in "Molded-Polystyrene Board Insulation," "Extruded-Polystyrene Board Insulation," or "Polyisocyanurate Board Insulation" Paragraph below; if using more than one type, identify location of each on Drawings.

* + - * 1. Molded-Polystyrene Board Insulation: ASTM C578, [**Type XI, 0.70 lb/cu. ft. (12 kg/cu. m)**] [**Type I, 0.90 lb/cu. ft. (15 kg/cu. m)**] [**Type VIII, 1.15 lb/cu. ft. (18 kg/cu. m)**] [**Type II, 1.35 lb/cu. ft. (22 kg/cu. m)**] [**Type IX, 1.80 lb/cu. ft. (29 kg/cu. m)**]; [**square**] [**ship-lap**] edges; with thickness of <**Insert dimension**>.
        2. Extruded-Polystyrene Board Insulation: ASTM C578, [**Type X, 1.30 lb/cu. ft. (21 kg/cu. m)**] [**Type IV, 1.55 lb/cu. ft. (26 kg/cu. m)**] [**Type VI, 1.80 lb/cu. ft. (29 kg/cu. m)**] [**Type VII, 2.20 lb/cu. ft. (35 kg/cu. m)**] [**Type V, 3.00 lb/cu. ft. (48 kg/cu. m)**]; [**square**] [**ship-lap**] edges; with thickness of <**Insert dimension**>.
        3. Polyisocyanurate Board Insulation: ASTM C591, [**Type I, 1.8 lb/cu. ft. (29 kg/cu. m)**] [**Type II, 2.5 lb/cu. ft. (40 kg/cu. m)**] [**Type III, 3.0 lb/cu. ft. (48 kg/cu. m)**] unfaced, with thickness of <**Insert dimension**>.

Retain one or more options in "Wythe Connectors" Paragraph below.

* + - * 1. Wythe Connectors: [**Glass-fiber-reinforced vinylester connectors**] [**Polypropylene pin connectors**] [**Stainless steel pin connectors**] [**Bent galvanized reinforcing bars**] [**Galvanized welded wire trusses**] [**Galvanized bent wire connectors**] [**Epoxy-coated carbon-fiber grid**] [**Fiberglass trusses**] manufactured to connect wythes of precast concrete panels.
      1. CONCRETE MIXTURES
         1. Prepare design mixtures for each type of precast concrete required.

Retain first subparagraph below if required for LEED-NC, LEED-CS, or LEED for Schools Credit ID 1.1. This credit can be achieved by replacing at least 40 percent of the portland cement, which would otherwise be used in concrete, with other cementitious materials. 40 percent replacement value applies to the average of all concrete used for Project; requirement below can be reduced if requirement for other concrete on Project is increased sufficiently to make up for the reduction.

Use fly ash, pozzolan, slag cement, and silica fume/metakaolin as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.

Retain subparagraph below if fly ash, slag cement, or metakaolin and silica fume are permitted. Percentages are PCI examples; revise to suit Project.

Limit use of fly ash to [**20**] [**35**] percent replacement of portland cement by weight and slag cement to [**20**] [**50**] percent of portland cement by weight; metakaolin and silica fume to 10 percent of portland cement by weight.

* + - * 1. Design mixtures may be prepared by a qualified independent testing agency or by qualified precast plant personnel at precast structural concrete fabricator's option.
        2. Limit water-soluble chloride ions to maximum percentage by weight of cement permitted by ACI CODE-318 (ACI CODE-318M) or PCI MNL 116 when tested in accordance with ASTM C1218/C1218M.

Precast structural concrete with architectural finish may be manufactured with a separate face mixture and a structural backup mixture. Face and backup mixtures require similar shrinkage and expansion coefficients. Similar water-cementitious materials ratios and cement-aggregate ratios are recommended by PCI to limit bowing or warping.

Retain first option in "Normal-Weight Concrete Mixtures" Paragraph below if lightweight backup concrete mix is required; second option if normal-weight face and backup mixtures are required; third option if full-depth, normal-weight mixture is required; or fourth option if choice of normal-weight face and backup mixtures or full-depth mixtures is fabricator's option.

* + - * 1. Normal-Weight Concrete Mixtures: Proportion [**face mixtures**] [**face and backup mixtures**] [**full-depth mixture**] [**face and backup mixtures or full-depth mixtures, at fabricator's option**] by either laboratory trial batch or field test data methods in accordance with ACI PRC-211.1, with materials to be used on Project, to provide normal-weight concrete with the following properties:

Retain "Compressive Strength (28 Days)" Subparagraph below or revise to suit Project. Higher-strength mixtures may be available; verify availability with fabricators.

Compressive Strength (28 Days): 5000 psi (34.5 MPa).

Water-cementitious materials ratio of 0.40 to 0.45 is usual for precast structural concrete. Lower ratios may be possible with use of high-range water reducers. Revise ratio in "Maximum Water-Cementitious Materials Ratio" Subparagraph below to suit Project.

Maximum Water-Cementitious Materials Ratio: 0.45.

Water absorption indicates susceptibility to weather staining. PCI states that limits in "Water Absorption" Paragraph below are suitable for average exposures. Different parts of a single panel cannot be produced with different absorptions. Verify that fabricators can produce units with lower water absorption because special consolidation techniques to increase concrete density are required.

* + - * 1. Water Absorption: For structural precast concrete with an architectural finish, limit water absorption to 6 percent by weight or 14 percent by volume, tested in accordance with ASTM C642, except for boiling requirement.

To minimize bowing or warping, PCI does not recommend lightweight backup mixtures with normal-weight face mixtures. Retain "Lightweight Concrete Backup Mixtures" Paragraph below if required or as an option if satisfactory durability and in-service performance are verified by fabricator. Coordinate with option retained in "Normal-Weight Concrete Mixtures" Paragraph.

* + - * 1. Lightweight Concrete Backup Mixtures: Proportion mixtures by either laboratory trial batch or field test data methods in accordance with ACI 211.2, with materials to be used on Project, to provide lightweight concrete with the following properties:

Retain "Compressive Strength (28 Days)" Subparagraph below or revise to suit Project. Higher-strength mixtures may be available; verify availability with fabricators.

Compressive Strength (28 Days): 5000 psi (34.5 MPa).

Increase or decrease weight in "Density" Subparagraph below to suit Project. Coordinate with lightweight-aggregate supplier and precast structural concrete fabricator. Lightweight concretes with lightweight and normal-weight aggregate in mixture are usually heavier than density below.

Density: Calculated equilibrium density of 115 lb/cu. ft. (1842 kg/cu. m), plus or minus 3 lb/cu. ft. (48 kg/cu. m), in accordance with ASTM C567/C567M.

* + - * 1. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content complying with PCI MNL 116.
        2. When included in design mixtures, add other admixtures to concrete mixtures in accordance with manufacturer's written instructions.
        3. Concrete Mix Adjustments: Concrete mix design adjustments may be proposed if characteristics of materials, Project conditions, weather, test results, or other circumstances warrant.
      1. MOLD FABRICATION
         1. Molds: Accurately construct molds, mortar tight, of sufficient strength to withstand pressures due to concrete-placement operations and temperature changes and for prestressing and detensioning operations. Coat contact surfaces of molds with release agent before reinforcement is placed. Avoid contamination of reinforcement and prestressing tendons by release agent.

Retain form liners in subparagraph below if needed to produce exposed surface finish on precast structural concrete with architectural finish.

Place form liners accurately to provide finished surface texture indicated. Provide solid backing and supports to maintain stability of liners during concrete placement. Coat form liner with form-release agent.

* + - * 1. Maintain molds to provide completed precast structural concrete units of shapes, lines, and dimensions indicated, within fabrication tolerances specified.

Retain first subparagraph below for precast structural concrete with architectural finishes.

Form joints are not permitted on faces of structural precast concrete with an architectural finish that is exposed to view in the finished work.

Retain one option from "Edge and Corner Treatment" Subparagraph below; indicate details on Drawings or revise description to add dimensions. Sharp edges or corners of precast concrete units are vulnerable to chipping.

Edge and Corner Treatment: Uniformly [**chamfered**] [**radiused**].

* + - 1. THIN-BRICK FACINGS

Retain this article if using thin-brick facings on precast structural concrete units.

* + - * 1. Place form-liner templates accurately to provide grid for thin-brick facings. Provide solid backing and supports to maintain stability of liners while placing thin bricks and during concrete placement.
        2. Securely place thin-brick units face down into form-liner pockets and place concrete backing mixture.

Delete first two paragraphs below if joint cavities are filled with concrete instead of using mortar or pointing grout.

* + - * 1. Completely fill joint cavities between thin-brick units with sand-cement mortar, and place precast concrete backing mixture while sand-cement mortar is still fluid enough to ensure bond.

Retain first paragraph below if pointing grouting is required. Delete if joints remain fully recessed as cast.

* + - * 1. Mix and install pointing grout in accordance with ANSI A108.10. Completely fill joint cavities between thin-brick units with pointing grout, and compress into place without spreading pointing grout onto faces of thin-brick units. Remove excess pointing grout immediately to prevent staining of thin brick.

Retain one or more joint profiles in subparagraph below or revise to suit Project. Joint shapes are listed in order of decreasing weathertightness in accordance with BIA Technical Note 21C.

Tool joints to a [**slightly concave**] [**V-**]shape when pointing grout is thumbprint hard.

* + - * 1. Clean faces and joints of thin-brick facing.
      1. STONE FACINGS

Retain this article if stone facing of precast structural concrete is required.

* + - * 1. Accurately position stone facings to comply with requirements and in locations indicated on Shop Drawings. Install anchors, supports, and other attachments indicated or necessary to secure stone in place. Keep concrete reinforcement a minimum of 3/4 inch (19 mm) from the back surface of stone. Use continuous spacers to obtain uniform joints of widths indicated and with edges and faces aligned in accordance with established relationships and indicated tolerances.

"Stone to Precast Anchorages" Subparagraph below is based on anchorage requirement in the International Building Code for slab-type exterior veneer panels not more than 20 sq. ft. (1.86 sq. m) in area; revise anchor spacing if required.

Stone to Precast Anchorages: Provide anchors in numbers, types and locations required to satisfy specified performance criteria, but not more than 24 inches (600 mm) o.c. around perimeter of stone facing panels with a minimum of four anchors per panel.

Retain one of two options in paragraph below if sealing dowel holes. Use sealant if flexible filler is required; use epoxy if rigid filler is required.

* + - * 1. Fill anchor holes with [**sealant filler and install anchors**] [**epoxy filler and install anchors with elastomeric anchor sleeve at back surface of stone**].

Retain one of two subparagraphs below. PCI recommends that stone facing not bond with precast concrete to minimize bowing, cracking, and staining of stone.

Install minimum 0.006-inch- (0.15-mm-) thick polyethylene sheet to prevent bond between back of stone facing and concrete substrate and to ensure no passage of precast matrix to stone surface.

Install 1/8-inch (3-mm) polyethylene-foam bond breaker to prevent bond between back of stone facing and concrete substrate and to ensure no passage of precast matrix to stone surface. Maintain minimum projection requirements of stone anchors into concrete substrate.

* + - 1. FABRICATION
         1. Cast-in Anchors, Inserts, Plates, Angles, and Other Anchorage Hardware: Fabricate anchorage hardware with sufficient anchorage and embedment to comply with design requirements. Accurately position for attachment of loose hardware, and secure in place during precasting operations. Locate anchorage hardware where it does not affect position of main reinforcement or concrete placement.

Weld-headed studs and deformed bar anchors used for anchorage in accordance with AWS D1.1/D1.1M and AWS C5.4, "Recommended Practices for Stud Welding."

Coordinate first paragraph below with Section 055000 "Metal Fabrications" for furnishing and installing loose hardware items.

* + - * 1. Furnish loose hardware items including steel plates, clip angles, seat angles, anchors, dowels, cramps, hangers, and other hardware shapes for securing precast structural concrete units to supporting and adjacent construction.
        2. Cast-in reglets, slots, holes, and other accessories in precast structural concrete units as indicated on the Contract Drawings.

Retain first paragraph below if applicable.

* + - * 1. Cast-in openings larger than 10 inches (250 mm) in any dimension. Do not drill or cut openings or prestressing strand without Architect's approval.
        2. Reinforcement: Comply with recommendations in PCI MNL 116 for fabricating, placing, and supporting reinforcement.

Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy the bond with concrete. When damage to epoxy-coated reinforcement exceeds limits specified in ASTM A775/A775M, repair with patching material compatible with coating material and epoxy coat bar ends after cutting.

Accurately position, support, and secure reinforcement against displacement during concrete-placement and consolidation operations. Completely conceal support devices to prevent exposure on finished surfaces.

Place reinforcing steel and prestressing strand to maintain at least 3/4-inch (19-mm) minimum concrete cover. Increase cover requirements for reinforcing steel to 1-1/2 inches (38 mm) when units are exposed to corrosive environment or severe exposure conditions. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position while placing concrete. Direct wire tie ends away from finished, exposed concrete surfaces.

Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh spacing and wire tie laps, where required by design. Offset laps of adjoining widths to prevent continuous laps in either direction.

* + - * 1. Reinforce precast structural concrete units to resist handling, transportation, and erection stresses and specified in-place loads.

Retain first paragraph below if precast, prestressed structural concrete units are required. Decision to prestress may be left to fabricator if objective is to aid handling and to control cracking of units during installation.

* + - * 1. Prestress tendons for precast structural concrete units by either pretensioning or post-tensioning methods. Comply with PCI MNL 116.

Revise release or post-tensioning strength in first subparagraph below to an actual compressive strength if required. Concrete strength in the range of 2500 to 4000 psi (17.2 to 27.6 MPa) at release does not appreciably affect bond transfer length.

Delay detensioning or post-tensioning of precast, prestressed structural concrete units until concrete has reached its indicated minimum design release compressive strength as established by test cylinders cured under same conditions as concrete unit.

Detension pretensioned tendons either by gradually releasing tensioning jacks or by heat cutting tendons, using a sequence and pattern to prevent shock or unbalanced loading.

If concrete has been heat cured, detension while concrete is still warm and moist to avoid dimensional changes that may cause cracking or undesirable stresses.

Protect strand ends and anchorages with bituminous, zinc-rich, or epoxy paint to avoid corrosion and possible rust spots.

Retain subparagraph below only when appearance of member ends is critical or when exposed to severe environment.

Protect strand ends and anchorages with a minimum of 1-inch- (25-mm-) thick, nonmetallic, nonshrink, grout mortar and sack rub surface. Coat or spray the inside surfaces of pocket with bonding agent before installing grout.

* + - * 1. Comply with requirements in PCI MNL 116 and in this Section for measuring, mixing, transporting, and placing concrete. After concrete batching, no additional water may be added.

Retain first paragraph below if a separate face mixture is proposed for precast structural concrete with architectural finish.

* + - * 1. Place face mixture to a minimum thickness after consolidation of the greater of 1 inch (25 mm) or 1.5 times the maximum aggregate size, but not less than the minimum reinforcing cover specified.
        2. Place concrete in a continuous operation to prevent cold joints or planes of weakness from forming in precast concrete units.

Retain subparagraph below if a separate face mixture is proposed for precast structural concrete with architectural finish.

Place backup concrete mixture to ensure bond with face-mixture concrete.

* + - * 1. Thoroughly consolidate placed concrete by vibration without dislocating or damaging reinforcement and built-in items, and minimize pour lines, honeycombing, or entrapped air voids on surfaces. Use equipment and procedures complying with PCI MNL 116.

Retain subparagraph below if permitting self-consolidating concrete.

Place self-consolidating concrete without vibration in accordance with PCI TR-6, "Interim Guidelines for the Use of Self-Consolidating Concrete in Precast/Prestressed Concrete Institute Member Plants." Ensure adequate bond between face and backup concrete, if used.

* + - * 1. Comply with PCI MNL 116 procedures for hot- and cold-weather concrete placement.
        2. Identify pickup points of precast structural concrete units and orientation in structure with permanent markings, complying with markings indicated on Shop Drawings. Imprint or permanently mark casting date on each precast structural concrete unit on a surface that does not show in finished structure.
        3. Cure concrete, in accordance with requirements in PCI MNL 116, by moisture retention without heat or by accelerated heat curing using live steam or radiant heat and moisture. Cure units until compressive strength is high enough to ensure that stripping does not have an effect on performance or appearance of final product.
        4. Discard and replace precast structural concrete units that do not comply with requirements, including structural, manufacturing tolerance, and appearance, unless repairs meet requirements in PCI MNL 116 and meet Architect's approval.
      1. CASTING INSULATED WALL PANELS

Retain this article if integrally insulated wall panels are required.

* + - * 1. Cast, screed, and consolidate wythe supported by mold.
        2. Place insulation boards abutting edges and ends of adjacent boards. Insert wythe connectors through insulation, and consolidate concrete around connectors in accordance with connector manufacturer's written instructions.
        3. Ensure bottom wythe and insulation layer are not disturbed after bottom wythe reaches initial set.
        4. Cast, screed, and consolidate top wythe to meet required finish.
        5. Maintain temperature below 150 deg F (65 deg C) in bottom concrete wythe.
      1. FABRICATION TOLERANCES
         1. Fabricate precast structural concrete units to shapes, lines, and dimensions indicated so each finished unit complies with PCI MNL 116 product dimension tolerances as well as position tolerances for cast-in items.

Retain "Thin-Brick-Faced Precast Structural Concrete Units" Paragraph below for thin-brick-faced precast structural concrete units. Tolerances are based on product tolerances of PCI MNL 117.

* + - * 1. Thin-Brick-Faced Precast Structural Concrete Units: Restrict the following misalignments to 2 percent of number of thin bricks in a unit:

Alignment of Mortar Joints:

Jog in Alignment: 1/8 inch (3 mm).

Alignment with Panel Centerline: Plus or minus 1/8 inch (3 mm).

Variation in Width of Exposed Mortar Joints: Plus or minus 1/8 inch (3 mm).

Tipping of Individual Thin Bricks from the Panel Plane of Exposed Thin-Brick Surface: Plus 0 inch (0 mm); minus 1/4 inch (6 mm) less than or equal to depth of form-liner joint.

Exposed Thin-Brick Surface Parallel to Primary Control Surface of Panel: Plus 1/4 inch (6 mm); minus 1/8 inch (3 mm).

Individual Thin-Brick Step in Face from Panel Plane of Exposed Thin-Brick Surface: Plus 0 inch (0 mm); minus 1/4 inch (6 mm) less than or equal to depth of form-liner joint.

Retain "Stone Veneer-Faced Precast Structural Concrete Units" Paragraph below if required. Tolerances are based on product tolerances of PCI MNL 117.

* + - * 1. Stone Veneer-Faced Precast Structural Concrete Units:

Tolerances in "Variation in Cross-Sectional Dimensions," "Variation in Joint Width," and "Variation in Plane between Adjacent Stone Units (Lipping)" subparagraphs below are generally appropriate for smooth-finished stone. Retain, delete, or revise below to suit Project.

Variation in Cross-Sectional Dimensions: For thickness of walls from dimensions indicated: Plus or minus 1/4 inch (6 mm).

Variation in Joint Width: 1/8 inch in 36 inches (3 mm in 900 mm) or a quarter of nominal joint width, whichever is less.

Revise or delete "Variation in Plane between Adjacent Stone Units (Lipping)" Subparagraph below for natural-cleft, thermal, and similar finishes.

Variation in Plane between Adjacent Stone Units (Lipping): 1/16-inch (1.6-mm) difference between planes of adjacent units.

* + - 1. COMMERCIAL FINISHES

Retain type of commercial structural finish, grouped by PCI as a "C" designation, in one or more of "Commercial Grade," "Standard Grade," "Grade B Finish," and "Grade A Finish" paragraphs below. If more than one finish is required, create a finish schedule, add locations to finish descriptions, or indicate on Drawings. Finishes below are in ascending order of finish quality and cost. Insert other specific finish requirements to suit Project.

Retain "Commercial Grade" Paragraph below when product is not visible in completed structure or when function of structure does not require an enhanced surface. This finish is essentially an "as-cast" one.

* + - * 1. Commercial Grade: Remove fins and protrusions larger than 1/8 inch (3 mm) and fill holes larger than 1/2 inch (13 mm). Rub or grind ragged edges. Faces must have true, well-defined surfaces. Air holes, water marks, and color variations are permitted. Limit form joint offsets to 3/16 inch (5 mm).

Retain "Standard Grade" Paragraph below where products are exposed to view but function of structure does not require a special finish. Surface is suitable for an applied textured coating, but not necessarily suitable for painting. This finish is typical for structural products.

* + - * 1. Standard Grade: Normal plant-run finish produced in molds that impart a smooth finish to concrete. Surface holes smaller than 1/2 inch (13 mm) caused by air bubbles, normal color variations, form joint marks, and minor chips and spalls are permitted. Fill air holes greater than 1/4 inch (6 mm) in width that occur more than once per 2 sq. in. (1300 sq. mm). Major or unsightly imperfections, honeycombs, or structural defects are not permitted. Limit joint offsets to 1/8 inch (3 mm).

Retain "Grade B Finish" Paragraph below for visually exposed structural members such as columns or walls.

* + - * 1. Grade B Finish: Fill air pockets and holes larger than 1/4 inch (6 mm) in diameter with sand-cement paste matching color of adjacent surfaces. Fill air holes greater than 1/8 inch (3 mm) in width that occur more than once per 2 sq. in. (1300 sq. mm). Grind smooth form offsets or fins larger than 1/8 inch (3 mm). Repair surface blemishes due to holes or dents in molds. Discoloration at form joints is permitted.

Retain "Grade A Finish" Paragraph below where surface is painted or coated with a textured or sanded coating; some surface blemishes are visible. If a surface with fewer imperfections than permitted Grade A finish is needed, retain a finish from "Commercial Architectural Finishes" Article. Grade A finish is not applicable to extruded precast structural concrete products using zero-slump concrete in their process.

* + - * 1. Grade A Finish: Repair surface blemishes and fill air holes with the exception of air holes 1/16 inch (1.6 mm) in width or smaller, and form marks where the surface deviation is less than 1/16 inch (1.6 mm). Float apply a neat cement-paste coating to exposed surfaces. Rub dried paste coat with burlap to remove loose particles. Discoloration at form joints is permitted. Grind smooth all form joints.

Retain one of first two paragraphs below. Screed or float finish in first paragraph is standard with PCI for unformed surfaces. Revise to describe extent to which float or trowel marks, variations of texture, or other surface blemishes are permitted. Require samples to establish acceptance criteria for any exposed finish. Revise finish below to light-broom or as-cast finish if float finish is unnecessary.

* + - * 1. Screed or float finish unformed surfaces. Strike off and consolidate concrete with vibrating screeds to a uniform finish. Hand screed at projections. Normal color variations, minor indentations, minor chips, and spalls are permitted. Major imperfections, honeycombing, or defects are not permitted.

Retain first paragraph below if upgrading unformed surfaces to smooth, steel trowel finish.

* + - * 1. Smooth, steel trowel finish unformed surfaces. Consolidate concrete, bring to proper level with straightedge, float, and trowel to a smooth, uniform finish.

Retain paragraph below if composite concrete topping is required.

* + - * 1. Apply roughened surface finish in accordance with ACI CODE-318 (ACI CODE-318M) to precast concrete units that receive concrete topping after installation.
      1. COMMERCIAL ARCHITECTURAL FINISHES

Retain this article if precast structural concrete receives an architectural finish. Indicate on Drawings which members require architectural finish.

* + - * 1. Manufacture member faces free of joint marks, grain, and other obvious defects with corners, including false joints, uniform and straight. Finish exposed-face surfaces of precast concrete units to match approved [**design reference sample**] [**sample panels**] [**mockups**] and as follows:

Retain "Design Reference Sample" Subparagraph below if Architect has preapproved one or more design reference samples. Include complete description of design reference sample here. If preapproving fabricators, coordinate with "Manufacturers" Article. Revise if multiple samples are approved.

Design Reference Sample: <**Insert description and identify fabricator and code number of sample**>.

Retain first subparagraph below if required. If retaining, revise and add reference number; PCI publishes numbered, color photographs of hundreds of precast concrete finishes; see PCI's Web site, www.pci.org. Add reference number combinations if more than one finish is required.

PCI's "Architectural Precast Concrete - Color and Texture Selection Guide," of plate numbers indicated.

Retain type of finish from first nine subparagraphs below if needed. If more than one finish is required, create a finish schedule, add locations to finish descriptions, or indicate on Drawings. Add more-detailed descriptions of finishes outlined below if greater definition, such as light, medium, or deep reveal to finishes that expose the aggregate, is required. See PCI MNL 117 for more information on architectural finishes.

Retain "Smooth-Surface Finish" Subparagraph below if a smooth-surface finish, an as-cast finish, which generally results in a mottled surface or non-uniform finish, is required.

As-Cast-Surface Finish: Provide surfaces to match approved sample or mockup for acceptable surface, air voids, sand streaks, and honeycomb.

Textured-Surface Finish: Impart by form liners or inserts.

Bushhammer Finish: Use power or hand tools to remove matrix and fracture coarse aggregates.

Exposed-Aggregate Finish: Use chemical-retarding agents applied to concrete molds and washing and brushing procedures to expose aggregate and surrounding matrix surfaces after form removal.

Abrasive-Blast Finish: Use abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces.

Acid-Etched Finish: Use acid and hot-water solution, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces. Protect hardware, connections, and insulation from acid attack.

Honed Finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures.

Polished Finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures.

Sand-Embedment Finish: Use selected stones placed in a sand bed in bottom of mold, with sand removed after curing.

Thin-Brick Facing: See "Thin-Brick Facings" Article.

Stone Facing: See "Stone Facings" Article.

* + - 1. SOURCE QUALITY CONTROL

Retain "Testing Agency" Paragraph below if required. PCI-plant certification may be acceptable to authorities having jurisdiction without further monitoring of plant's quality-control and testing program by Owner.

* + - * 1. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to evaluate precast structural concrete fabricator's quality-control and testing methods.

Allow testing agency access to material storage areas, concrete production equipment, concrete placement, and curing facilities. Cooperate with testing agency and provide samples of materials and concrete mixtures as may be requested for additional testing and evaluation.

Retain "Testing" Paragraph below if establishing a minimum standard of plant testing and inspecting. PCI MNL 116 mandates source testing requirements and a plant "Quality Systems Manual." PCI plant certification also ensures periodic auditing of plants complying with PCI MNL 116.

* + - * 1. Testing: Test and inspect precast structural concrete in accordance with PCI MNL 116 requirements and ASTM C1610/C1610M, ASTM C1611/C1611M, ASTM C1621/C1621M, and ASTM C1712.

Retain subparagraph below if permitting self-consolidating concrete.

Test and inspect self-consolidating concrete in accordance with PCI TR-6.

* + - * 1. Strength of precast structural concrete units is considered deficient if units fail to comply with ACI CODE-318 (ACI CODE-318M) requirements for concrete strength.

Revise testing and acceptance criteria in first paragraph below if required. Revise to add criteria for load tests if required.

* + - * 1. If there is evidence that the strength of precast concrete units may be deficient or may not comply with ACI CODE-318 (ACI CODE-318M) requirements, employ a qualified testing agency to obtain, prepare, and test cores drilled from hardened concrete to determine compressive strength in accordance with ASTM C42/C42M.

A minimum of three representative cores shall be taken from units of suspect strength, from locations directed by Architect.

Test cores in an air-dry condition or, if units are wet under service conditions, test cores after immersion in water in a wet condition.

PCI's recommendations in first subparagraph below are more stringent than ACI's.

Strength of concrete for each series of three cores is considered satisfactory if average compressive strength is equal to at least 85 percent of 28-day design compressive strength and no single core is less than 75 percent of 28-day design compressive strength.

Report test results in writing on same day that tests are performed, with copies to Architect, Contractor, and precast concrete fabricator. Test reports include the following:

Project identification name and number.

Date when tests were performed.

Name of precast concrete fabricator.

Name of concrete testing agency.

Identification letter, name, and type of precast concrete unit(s) represented by core tests; design compressive strength; type of failure; compressive strength at failure, corrected for length-diameter ratio; and direction of applied load to core in relation to horizontal plane of concrete as placed.

* + - * 1. Patching: If core test results are satisfactory and precast structural concrete units comply with requirements, clean and dampen core holes and solidly fill with same precast concrete mixture that has no coarse aggregate, and finish to match adjacent precast concrete surfaces.
        2. Defective Units: Discard and replace precast structural concrete units that do not comply with requirements, including strength, manufacturing tolerances, and color and texture range. Chipped, spalled, or cracked units may be repaired, subject to Architect's approval. Architect reserves the right to reject precast units that do not match approved samples, sample panels, and mockups. Replace unacceptable units with precast concrete units that comply with requirements.

1. EXECUTION
   * + 1. EXAMINATION
          1. Examine supporting structural frame or foundation and conditions for compliance with requirements for installation tolerances, bearing surface tolerances, and other conditions affecting performance of the Work.
          2. Proceed with installation only after unsatisfactory conditions have been corrected.
          3. Do not install precast concrete units until supporting, cast-in-place concrete has attained minimum allowable design compressive strength and until supporting steel or other structure is structurally ready to receive loads from precast concrete units.
       2. INSTALLATION
          1. Install clips, hangers, bearing pads, and other accessories required for connecting precast structural concrete units to supporting members and backup materials.
          2. Erect precast structural concrete level, plumb, and square within specified allowable tolerances. Provide temporary structural framing, shoring, and bracing as required to maintain position, stability, and alignment of units until permanent connections are complete.

Install temporary steel or plastic spacing shims or bearing pads as precast structural concrete units are being erected. Tack weld steel shims to each other to prevent shims from separating.

Maintain horizontal and vertical joint alignment and uniform joint width as erection progresses.

Remove projecting lifting devices and use plastic patch caps or sand-cement grout to fill voids within recessed lifting devices flush with surface of adjacent precast surfaces when recess is exposed.

Retain subparagraph below if voids of hollow-core slabs are used for electrical raceways or mechanical ducts.

For hollow-core slab voids used as electrical raceways or mechanical ducts, align voids between units and tape butt joint at end of slabs.

* + - * 1. Connect precast structural concrete units in position by bolting, welding, grouting, or as otherwise indicated on Shop Drawings. Remove temporary shims, wedges, and spacers as soon as practical after connecting and grouting are completed.

Do not permit connections to disrupt continuity of roof flashing.

* + - * 1. Field cutting of precast units is not permitted without approval of Architect.

"Fasteners" Paragraph below refers to fastening under the control of precast concrete erector. Coordinate with and repeat warning in other Sections if additional construction is fastened to precast, prestressed concrete units.

* + - * 1. Fasteners: Do not use drilled or powder-actuated fasteners for attaching accessory items to precast, prestressed concrete units.
        2. Welding: Comply with applicable requirements in AWS D1.1/D1.1M and AWS D1.4/D1.4M for welding, welding electrodes, appearance, quality of welds, and methods used in correcting welding work.

Protect precast structural concrete units and bearing pads from damage by field welding or cutting operations, and provide noncombustible shields as required.

Clean weld-affected steel surfaces with chipping hammer followed by brushing, and apply a minimum 4.0-mil- (0.1-mm-) thick coat of galvanized repair paint to galvanized surfaces in accordance with ASTM A780/A780M.

Retain subparagraph above or first subparagraph below.

Clean weld-affected steel surfaces with chipping hammer followed by brushing, and reprime damaged painted surfaces.

Visually inspect welds and remove, reweld, or repair incomplete and defective welds.

* + - * 1. At bolted connections, use lock washers, tack welding, or other approved means to prevent loosening of nuts after final adjustment.

Where slotted connections are used, verify bolt position and tightness. For sliding connections, properly secure bolt but allow bolt to move within connection slot.

For slip-critical connections, use one of the following methods to assure proper bolt pretension:

Turn-of-Nut: In accordance with RCSC's "Specification for Structural Joints Using ASTM A325 or A 490 Bolts."

Calibrated Wrench: In accordance with RCSC's "Specification for Structural Joints Using ASTM A325 or A 490 Bolts."

Twist-off Tension Control Bolt: ASTM F1852.

Direct-Tension Control Bolt: ASTM F1852.

For slip-critical connections, use method and inspection procedure approved by Architect and coordinated with inspection agency.

In "Grouting or Dry-Packing Connections and Joints" Paragraph below, revise locations and extent of grouting if required.

* + - * 1. Grouting or Dry-Packing Connections and Joints: Grout connections and joints and open spaces at keyways, connections, and joints where required or indicated on Shop Drawings. Retain flowable grout in place until hard enough to support itself. Alternatively, pack spaces with stiff dry-pack grout material, tamping until voids are completely filled.

Place grout and finish smooth, level, and plumb with adjacent concrete surfaces.

Fill joints completely without seepage to other surfaces.

Trowel top of grout joints on roofs smooth and uniform. Finish transitions between different surface levels not steeper than 1 to 12.

Retain first subparagraph below if end grouting hollow-core slabs is required.

Place grout end cap or dam in voids at ends of hollow-core slabs.

Promptly remove grout material from exposed surfaces before it affects finishes or hardens.

Keep grouted joints damp for not less than 24 hours after initial set.

* + - 1. ERECTION TOLERANCES
         1. Erect precast structural concrete units level, plumb, square, and in alignment without exceeding the noncumulative erection tolerances of PCI MNL 135.
         2. Minimize variations between adjacent slab members by jacking, loading, or other method recommended by fabricator and approved by Architect.
      2. FIELD QUALITY CONTROL

Retain first option in "Special Inspections" Paragraph below if Owner engages special inspector. Consider retaining second option if authorities having jurisdiction allow Contractor to engage special inspector. If retaining second option, retain "Field quality-control reports" Paragraph in "Informational Submittals" Article.

* + - * 1. Special Inspections: [**Owner will engage**] [**Engage**] a qualified special inspector to perform the following special inspections:

Erection of precast structural concrete members.

<**Insert special inspections**>.

Retain "Testing Agency" Paragraph below, with or without "Special Inspections" Paragraph above, to identify who shall perform tests and inspections. If retaining second option in "Testing Agency" Paragraph, 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.
        2. Visually inspect field welds and test in accordance with ASTM E165 or to ASTM E709 and ASTM E1444. High-strength bolted connections are subject to inspections.
        3. Testing agency will report test results promptly and in writing to Contractor and Architect.
        4. Repair or remove and replace work where tests and inspections indicate that it does not comply with specified requirements.
        5. Additional testing and inspecting, at Contractor's expense, shall be performed to determine compliance of replaced or additional work with specified requirements.
        6. Prepare test and inspection reports.
      1. REPAIRS

Blemishes occurring after delivery are normally repaired after erecting units. Repairs of production chips, cracks, and spalls take place at manufacturer's plant.

* + - * 1. Repair precast structural concrete units if permitted by Architect.

Repairs may be permitted if structural adequacy, serviceability, durability, and appearance of units have not been impaired.

Precast concrete manufacturer develops appropriate repair mixtures and techniques during production sample approval process.

* + - * 1. Mix patching materials and repair units so cured patches blend with color, texture, and uniformity of adjacent exposed surfaces and show no apparent line of demarcation between original and repaired work, when viewed in typical daylight illumination from a distance of 20 feet (6 m).

Retain first paragraph below if using galvanized anchors, connections, and other items.

* + - * 1. Prepare and repair damaged galvanized coatings with galvanizing repair paint in accordance with ASTM A780/A780M.

Retain first paragraph below if items are prime painted.

* + - * 1. Wire brush, clean, and paint damaged prime-painted components with same type of shop primer.
        2. Remove and replace damaged precast structural concrete units that cannot be repaired or when repairs do not comply with requirements as determined by Architect.
      1. CLEANING
         1. Clean mortar, plaster, fireproofing, weld slag, and other deleterious material from concrete surfaces and adjacent materials immediately.
         2. Clean exposed surfaces of precast concrete units after erection and completion of joint treatment to remove weld marks, other markings, dirt, and stains.

Perform cleaning procedures, if necessary, in accordance with precast concrete fabricator's written recommendations. Protect other work from staining or damage due to cleaning operations.

Do not use cleaning materials or processes that could change the appearance of exposed concrete finishes or damage adjacent materials.

END OF SECTION 034100