

## 6.4 Guide Specification – PCI Architectural Certification Category AA

This Guide Specification is intended to be used to develop an office master specification or prepare performance specifications for a particular project. **In either case, this Guide Specification must be edited to fit the conditions of use. Particular attention should be given to the deletion of inapplicable provisions and inclusion of additional appropriate requirements.** Coordinate the specifications with the information shown on the contract drawings to avoid duplication or conflicts.

All references to codes, manuals, standards, etc., refer to the most current versions unless noted otherwise

Boxed portions are notes to the specification writer.

### SECTION 03 45 00 AA PRECAST ARCHITECTURAL CONCRETE

This section uses the term “Architect.” Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions of the contract. Because section titles in the contract may not match those used in this Guide Specification, verify that section titles referenced in this section are correct for the project’s specifications.

#### PART 1 – GENERAL

##### 1.1 RELATED DOCUMENTS

- A. Contract drawings and general provisions of the contract, including General and Supplementary Conditions and Division 01 Specification Sections, shall apply to this section.

##### 1.2 SUMMARY

- A. This section covers the performance criteria, materials, design, production, and erection of architectural precast concrete for the **[entire project] [products listed in Section B below]**. The work performed under this section includes all labor, materials, equipment, related services, and supervision required for the manufacture and erection of the architectural precast concrete work shown on the contract drawings.

Delete the paragraph below if not listing type of units.

- B. This section includes the following:

List only those products that are included in PCI Architectural Certification Category AA. Revise this list to suit the project.

1. <List specific Category AA products or building areas.>

C. Related sections include the following:

List below only those products and construction that the reader might expect to find in this section but are specified elsewhere. Other sections of the specifications that are not referenced below also apply to the extent required for proper performance of this work.

1. Section 03 45 00 AB "Precast Architectural Concrete."
  2. Section 03 45 00 AC "Precast Architectural Concrete."
  3. Section 03 45 00 AD "Precast Architectural Concrete."
  4. Section 03 45 00 AT "Precast Architectural Concrete."
  5. Section 03 41 00 "Precast Structural Concrete" with an architectural finish.
  6. Section 03 30 00 "Cast-in-Place Concrete" for installing connection anchors in concrete.
  7. Section 03 49 00 "Glass-Fiber-Reinforced Concrete."
  8. Section 04 20 00 "Unit Masonry" for full-thickness brick facing, mortar, inserts, and anchorages.
  9. Section 04 42 00 "Dimension Stone Cladding" for furnishing stone facings and anchorages.
  10. Section 04 72 00 "Cast Stone Masonry" for wet- or dry-cast stone facings, trim, and accessories.
  11. Section 05 12 00 "Structural Steel Framing" for furnishing and installing connections attached to structural-steel framing.
  12. Section 05 50 00 "Metal Fabrications" for furnishing and installing loose hardware items, kickers, and other miscellaneous steel shapes.
  13. Section 07 19 00 "Water Repellents" for water-repellent finish treatments.
  14. Section 07 62 00 "Sheet Metal Flashing and Trim" for flashing receivers and reglets.
  15. Section 07 92 00 "Joint Sealants," for elastomeric joint sealants and sealant backings.
  16. Section 08 51 12 "Aluminum Windows" for windows set into architectural precast concrete units.
  17. Section 09 30 13 "Ceramic Tile" for ceramic tile setting materials and installation.
  18. Section 11 24 23 "Window Washing Equipment" for tiebacks located in architectural precast concrete units.
- D. The most current ASTM and ANSI standards for all materials shall govern unless otherwise noted.

### **1.3 DEFINITION**

Retain paragraph below if a design reference sample has been preapproved by Architect and is available for review.

- A. Design Reference Sample: Sample of approved architectural precast concrete color, form, and finish, preapproved by Architect.

#### **1.4 PERFORMANCE REQUIREMENTS**

Retain this Article if design responsibility for architectural precast concrete units is delegated to Contractor. The American Institute of Architects' "General Conditions of the Contract for Construction" (AIA A201), requires the Owner or Architect to specify performance and design criteria.

- A. Structural Performance: Provide architectural precast concrete units and connections capable of withstanding the following design loads within limits and under conditions indicated:
  - 1. Loads: As indicated on contract drawings.

Retain paragraph above if design loads are shown on contract drawings. If including design loads here, delete paragraph and subparagraph above, and retain paragraph and applicable subparagraphs below. Revise requirements below to suit project and add other performance and design criteria if applicable.

- B. Structural Performance: Provide architectural precast concrete units and connections capable of withstanding the following design loads within limits and under conditions indicated:

As a minimum, dead loads include panel weight and the weight(s) of the materials that bear on them.

- 1. Dead loads: **<Insert applicable dead loads.>**
- 2. Live loads: **<Insert applicable live loads.>**
- 3. Wind loads: **<Insert applicable 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 *Minimum Design Loads for Buildings and Other Structures*, including basic wind speed, importance factor, exposure category, and pressure coefficient.>**
- 4. Seismic loads: **<Insert applicable seismic design data, including seismic performance category, importance factor, use group, seismic design category, seismic zone, site classification, site coefficient, and drift criteria.>**

Project-specific loads may include blast loads.

- 5. Project-specific loads: **<Insert applicable loads.>**
- 6. Design precast concrete units 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 as follows:

If different movements are anticipated for different building elements, indicate locations here or on contract drawings. If preferred, change deflection limits in first subparagraph below to ratios such as  $L/300$  for floors and  $L/200$  for roofs. Verify all building frame movements with the Engineer of Record.

- a. Upward and downward movement of [**½ in. (13 mm)**] [**¾ in. (19 mm)**] [**1 in. (25 mm)**].
- b. Overall building drift: **<Insert drift.>**
- c. Interstory building drift: **<Insert drift.>**

The temperature value in first subparagraph below is suitable for most of the United States based on assumed design nominal temperature of 70°F (21°C). Revise subparagraph below to suit local conditions. Temperature data are available from National Oceanic and Atmospheric Administration ([www.ncdc.noaa.gov](http://www.ncdc.noaa.gov)).

7. Thermal movements: Provide for in-plane thermal movements resulting from annual ambient temperature changes of [**80°F (44°C)**] **<Insert temperature range>**.

Retain subparagraph below if fire resistance rating is required. Fire ratings depend on occupancy and building construction type, and are generally a building code requirement. When required, fire-rated products should be clearly identified on the contract drawings.

8. Fire resistance rating: Select material and minimum thicknesses to provide [**1-hour**] [**2-hour**] **<Insert number of hours>** fire rating.

Retain subparagraph below if window washing system is required. Indicate window washing system design criteria, including material and equipment, here or on contract drawings.

9. Window washing system: Design precast concrete units supporting window washing system indicated to resist forces transmitted from window washing equipment.

Retain subparagraph below if stone veneer–faced precast concrete units are used on project.

10. Stone–to–precast concrete anchorages: Provide anchors, as determined through Owner’s or stone supplier’s testing, in numbers, types, and locations required to satisfy specified performance criteria.

Retain subparagraph below if precast concrete units are used in a parking structure to resist impact load. Local code requirements may vary from those listed.

11. Vehicular impact loads: Design spandrel beams acting as vehicular barriers to resist the design load applied horizontally in any direction at the required height off finish floor, with anchorages or attachments capable of transferring this load to the structure.

### ***1.5 ACTION SUBMITTALS***

- A. Product Data: For each type of product indicated, retain quality control records and certificates of compliance for five years after completion of structure.
- B. LEED Submittals:

Retain subparagraph below if recycled content is required for an environmental rating system, architect to specify rating system and specific reporting requirements.

1. Product data for recycled content: For products having recycled content, document the following:
  - a. Percentages by weight of preconsumer (postindustrial) and postconsumer recycled content per unit of product.
  - b. Relative dollar value of recycled content product to total dollar value of product included in project.
  - c. If recycled content product is part of an assembly, percentage of recycled content product in the assembly by weight.
  - d. If recycled content product is part of an assembly, relative dollar value of recycled content product to total dollar value of assembly.
2. Product data regional materials: For local and regional material extracted/harvested and manufactured within a 500-mile radius from the project site, document the following:

If product components are sourced or manufactured in separate locations, provide location information for each component in subparagraphs below with the percentage by weight of each component per unit of product.

- a. Location of extraction, harvesting, and recovery, and distance between extraction, harvesting, and recovery and the project site.
- b. Location of manufacturing facility and distance between manufacturing facility and the project site.
- c. Dollar value of product containing local/regional materials (include materials cost only).

Retain subparagraph below if environmental data are required in accordance with Table 1 of ASTM E2129 *Standard Practice for Data Collection for Sustainability Assessment of Building Products*. Concrete is relatively inert once cured. Admixtures, form-release agents, and sealers may emit volatile organic compounds (VOCs), especially during the curing process; however, virtually all emissions are eliminated before the building is enclosed.

3. Include material safety data sheet (MSDS) product information showing that materials meet environmental performance goals, such as biobased content.
  4. For projects using formwork certified by the Forest Stewardship Council (FSC), include chain-of-custody documentation with certification numbers for all certified wood products.
  5. For projects using reusable formwork, include data showing how formwork is reused.
- C. Design Mixtures: For each precast concrete mixture, include results of compressive strength and water-absorption tests.
- D. Shop (Erection) Drawings:
1. Detail fabrication and installation of architectural precast concrete units.
  2. Indicate locations, plan views, elevations, dimensions, shapes, and cross sections of each unit.
  3. Indicate aesthetic intent, including joints, drips, chamfers, rustications, or reveals, and extent and location of each surface finish.
  4. Indicate details at building corners.

Retain only those subparagraphs below that are applicable to the project.

5. Indicate separate face and backup mixture locations and thicknesses.
6. Indicate welded connections, using American Welding Society (AWS) standard symbols, and show the size, length, and type of each weld.
7. Indicate locations, tolerances, and details of anchorage devices to be embedded in or attached to structure or other construction.
8. Indicate locations, extent, and treatment of dry joints if two-stage casting is proposed.
9. Indicate plan views and elevations showing unit locations and dimensions, erection sequences, and bracing plans for special conditions.
10. Indicate location of each architectural precast concrete unit by same identification mark placed on unit.
11. Indicate relationships of architectural precast concrete units to adjacent materials.
12. Indicate locations and details of clay product units, including corner units and special shapes with dimensions, and joint treatment.
13. Indicate locations and details of stone veneer facings, stone anchors, and joint widths.

14. Indicate multiple wythe connection details.
15. Coordinate and indicate openings and inserts required by other trades.
16. Indicate design modifications:
  - a. If design modifications are proposed to meet performance requirements and field conditions, notify the Architect, and submit design calculations along with the shop (erection) drawings.
  - b. Maintain the general design concept, and when modifying details of materials, do not adversely affect the appearance, durability, or strength of units.

Retain subparagraph below if requiring BIM drawing. Delete or modify subparagraph below if Architect requires shop (erection) drawing submittals in another format.

17. Provide shop (erection) drawings in building information modeling (BIM) level of development (LOD) [350] <Insert LOD> format.

Retain subparagraph below if retaining the “Performance Requirements” article. Delete or modify the subparagraph if Architect assumes, or is required by law to assume, design responsibility.

18. Provide comprehensive engineering design, signed and sealed by qualified professional engineer responsible for its preparation and licensed in the jurisdiction in which the project is located. This design shall show governing panel types, connections, concrete cover, and reinforcement types, including special reinforcement if required, and indicate the location, type, magnitude, and direction of loads imposed on the building’s structural frame by the architectural precast concrete.

Retain paragraph and subparagraphs below if finishes, colors, and textures are preselected, specified, or scheduled. Coordinate this information with sample panels and range samples in the “Quality Assurance” article.

- E. Samples: For initial verification of design intent, design reference samples approximately 12 × 12 × 2 in. (300 × 300 × 50 mm) in size that are representative of the finishes, colors, and textures of exposed surfaces of architectural precast concrete units.
  1. When precast concrete unit’s back face is to be exposed, include samples illustrating workmanship, color, and texture of the backup concrete as well as the facing concrete.

Retain subparagraph below if samples of thin brick facings are required.

2. Include samples for each required brick unit showing full range of colors and textures expected. Also include sample showing color, geometry, and texture of joint treatment.

## ***1.6 INFORMATIONAL SUBMITTALS***

Coordinate “Qualification Data” paragraph and subparagraphs below with qualification requirements in Section 01400, “Quality Requirements,” and any supplementary requirements in the “Quality Assurance” article.

A. Qualification Data:

1. Proof from precast concrete fabricator that they are a PCI-certified plant for Category AA in good standing at the time of project bid.
2. Proof from precast concrete erector that they are a PCI-certified erector for Category A at the time of project bid.

Retain paragraph below if procedures for welder certification are retained in the “Quality Assurance” article.

B. Welding Certificates: Copies of certificates for welding procedure specifications (WPS) and personnel certification.

Retain paragraph below if material test report submittal is required for aggregates.

C. Material Test Reports for Aggregates: Reports from an accredited testing agency that interpret test results and indicate compliance with project requirements.

Retain paragraph below to require submittal of material certificates from manufacturers.

D. Material Certificates: Certificates signed by manufacturers for the following items:

Edit items below to suit project.

1. Cementitious materials.
2. Reinforcing materials, including prestressing tendons.
3. Admixtures.
4. Bearing pads.
5. Structural-steel shapes and hollow structural-steel sections.
6. Insulation.
7. Clay product units and accessories.
8. Stone anchors.
9. Other components specified in contract documents with applicable standards.

Retain paragraph below if Contractor is responsible for field quality control testing. Retain the optional statement if Contractor is responsible for special inspections.

E. Field quality control test [**and special inspection**] reports.



## 1.7 QUALITY ASSURANCE

- A. Fabricator Qualifications: Fabricator shall be experienced in producing architectural precast concrete units similar to those indicated for this project, have a record of successful in-service performance, and comply with the following requirements:
1. Participates in PCI's Plant Certification program at the time of bidding and is designated a PCI-certified plant for Category AA.
  2. Has sufficient production capacity to produce required units without delaying the work.

Retain subparagraph below if fabricators are required to be registered with and approved by authorities having jurisdiction. List approved fabricators in Part 2 if required.

3. Is registered with and approved by authorities having jurisdiction.
4. Assumes responsibility for engineering architectural precast concrete units to comply with performance requirements. This responsibility includes preparation of shop (erection) drawings and comprehensive engineering analysis by a qualified professional engineer.

Retain subparagraphs above and below if fabricator is required to engage the services of a qualified professional engineer and if submission of a comprehensive engineering analysis is retained in the "Action Submittals" article.

5. Professional engineer qualifications: A professional engineer who is licensed in the jurisdiction where the project is located and who is experienced in providing engineering services of the kind indicated.

PCI Certification Category AA requires the use of a PCI-certified erector. See the PCI website ([pci.org](http://pci.org)) for current listing of PCI-certified erectors.

Inclusion of erection in the precast concrete contract should be governed by local practices.

- B. Erector Qualifications: A precast concrete erector whose erecting organization and all erecting crews are certified and designated, prior to beginning work at project site, by PCI's Certificate of Compliance to erect Category A (Architectural Systems) for non-load bearing members.
- C. Design Standards: Comply with the American Concrete Institute's *Building Code Requirements for Structural Concrete and Commentary* ACI 318 (ACI 318M) and design recommendations of PCI MNL-120, *PCI Design Handbook: Precast and Prestressed Concrete*, applicable to the types of architectural precast concrete units indicated.
- D. Quality Control Standards: For manufacturing procedures and testing requirements, quality control recommendations, and dimensional tolerances for types of units required, comply with PCI MNL-117, *Manual for Quality Control for Plants and*

Retain paragraph below if shop or field welding is required. If paragraph is retained, also retain “Welding Certificates” paragraph in the “Informational Submittals” article. AWS states that welding qualifications remain in effect indefinitely unless welding personnel have not welded for more than six months or there is a specific reason to question their ability.

- E. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, *Structural Welding Code - Steel*; AWS D1.4/D1.4M, *Structural Welding Code - Reinforcing Steel*; and AWS D1.6/D1.6M, *Structural Welding Code - Stainless*.

Retain paragraph below if fire-rated units or assemblies are required. Select either PCI 124 *Specification for Fire Resistance of Precast/Prestressed Concrete* or ACI 216.1/TMS 0216.1 *Code Requirements for Determining Fire Resistance of Concrete and Masonry Construction Assemblies*, or retain both, if acceptable to authorities having jurisdiction.

- F. Fire Resistance: Where indicated, provide architectural precast concrete units whose fire resistance satisfies the fire resistance ratings of the contract documents; units must also meet the prescriptive fire resistance requirements of the governing code or be calculated according to [PCI 124, *Specification for Fire Resistance of Precast/Prestressed Concrete*] [ACI 216.1/TMS 216.1, *Code Requirements for Determining Fire Resistance of Concrete and Masonry Construction Assemblies*], and be acceptable to authorities having jurisdiction.

PCI recommends review of preproduction sample panels or the first production unit. Review should evaluate all exposed-finish faces of panels, including the face, side, top, bottom, and backside of each panel, for conformance to the specification. Revise the number and size of sample panels in paragraph below to suit project.

- G. Sample Panels: After initial sample approval and before fabricating architectural precast concrete units, produce a minimum of [two] <Insert number> sample panels (not less than [16 ft<sup>2</sup> (1.5 m<sup>2</sup>)] <Insert dimensions>) in area for review by Architect. Incorporate full-scale details of architectural features, finishes, and transitions in sample panels.
1. Locate panels where indicated in the contract document or, if not indicated, as directed by Architect.
  2. Damage part of an exposed-face surface for each finish, color, and texture and then repair the damaged areas to demonstrate adequacy of repair techniques proposed for repair of surface blemishes.
  3. When unformed (backside) of panel is exposed to final view, damage and then repair part of the exposed unformed face surface for each finish, color, and texture to demonstrate adequacy of repair techniques proposed for repair of surface blemishes.

4. After acceptance of repair technique, maintain two sample panels in an undisturbed condition—one at the fabricator’s plant and one at the project site—as a standard for judging the completed work.
5. Demolish and remove sample panels when directed by Architect.

PCI recommends production of color and texture range samples when color and texture uniformity concerns could be an issue, Architect or fabricator does not have previous experience with the specified mixture and finish, or a large project has multiple approving authorities. Review of samples should include all exposed finish faces of panels, including the face, side, top, bottom, and backside of each sample panel for conformance to the specification.

H. Range Sample Panels:

1. After sample panel approval and before fabricating architectural precast concrete units, produce a minimum of [**three**][**five**] **<Insert number>** samples, approximately [**16 ft<sup>2</sup> (1.5 m<sup>2</sup>)**] **<Insert dimensions>** in area, representing the anticipated range of each color and texture on project’s units.
2. When unformed (back) side of panel is exposed to final view, produce a range of unformed (back) side samples to represent anticipated range of each color and texture on project’s units.
3. Maintain range samples at fabricator’s plant for reference regarding color and texture acceptability.

Retain paragraph and subparagraphs below if range samples specified above will not suffice and added expense of mockups is authorized. If retaining paragraph and subparagraphs below, indicate location, size, and other details of mockups on contract drawings or in inserts. Revise wording below if only one mockup is required.

- I. Mockup Panels: After sample panel [**and range sample**] approval but before production of architectural precast concrete units, construct full-sized mockups to verify selections made under sample submittals, demonstrate aesthetic effects, and set quality standards for materials and execution. Ensure that mockups are representative of the finished work, including all exposed-to-view finish faces of precast concrete elements. Mockups shall include [**aluminum framing, glass, sealants**] **<insert construction materials required to be included in mockup>** and architectural precast concrete complete with anchors, connections, flashings, and joint fillers as accepted on final shop (erection) drawings. Build mockups to comply with the following requirements, using materials indicated for the completed work:

Revise or delete subparagraphs below to suit project.

1. Build mockups in the location and of the size indicated in contract documents or, if not indicated, as directed by Architect.
2. Notify Architect in advance of dates and times when mockups will be constructed.
3. Obtain Architect’s approval of mockups before fabricating precast concrete units.

4. During construction, maintain mockups in an undisturbed condition as a standard for judging completed work.
5. Demolish and remove mockups when directed by Architect.

Retain first subparagraph below if mockups are erected as part of building, rather than separately, and the intention is to make an exception to the default requirement in Section 01400, "Quality Requirements," for demolishing and removing mockups.

6. Approved mockups may become part of the completed work if they are undamaged at the time of substantial completion.
7. Approval of mockups does not constitute approval of deviations from contract documents unless such deviations are specifically approved by Architect in writing.

Requirements in paragraph and subparagraphs below are limited to assembling a preconstruction testing mockup at a testing agency's facility. Delete paragraph and subparagraphs below if a mockup as described above is to be used as a testing mockup, or if testing is not required. If retaining paragraph and subparagraphs below, determine where preconstruction testing will be specified and include requirements in that section of the specification.

- J. Preconstruction Testing Mockup: Provide a full-size mockup of architectural precast concrete indicated on contract drawings for preconstruction testing. Refer to Division **[01][08]** <Insert Division number>, Section "<Insert Section title>," for preconstruction testing requirements.

Revise or delete subparagraphs below to suit project. Coordinate subparagraphs below with other sections that define extent of mockup construction to be included in a preconstruction testing mockup to clearly indicate extent of work required in this section.

1. Build preconstruction testing mockup as indicated on contract drawings, including all exposed-to-view finish faces of precast concrete elements; also include **[aluminum framing, glass, sealants]**, < insert construction materials required to be included in mockup > and architectural precast concrete complete with anchors, connections, flashings, and joint fillers.
2. Deliver and install preconstruction testing mockup at testing agency's facility.

Delete paragraph below if the work specified in this section is not extensive or complex enough to justify a preinstallation conference.

- K. Preinstallation Conference: Conduct conference at **[Project site]**, <Insert Location>, to comply with requirements in Section 01 31 00, "Project Management and Coordination."

## ***1.8 HANDLING, STORAGE, AND DELIVERY***

- A. Store units with adequate dunnage and bracing, and protect units to prevent contact with ground, prevent staining, and prevent cracking, distortion, warping, or other physical damage.
- B. Place stored units so identification marks are clearly visible, and units can be inspected.
- C. Handle and transport units in a manner that avoids excessive stresses capable of causing cracking or other damage.
- D. Lift and support units only at designated points indicated on shop (erection) drawings.
- E. Deliver architectural precast concrete units in such quantities and at such times to ensure compliance with the agreed-upon project schedule and setting sequence, and to limit unloading units temporarily on the ground or other rehandling.
- F. Support units during shipment on nonstaining, shock-absorbing material.

## **1.9 SEQUENCING**

Coordination and responsibility for supply of items to be placed on or in the structure to allow placement of precast concrete units depends on the type of structure, and varies with local practice. Responsibility for supply and installation of hardware should be clearly specified. If hardware is not supplied by the precaster, the supplier should be listed, and requirements included in related trade sections. To avoid work delays, ensure that the types and quantities of hardware items to be cast into precast concrete units for use by other trades are specified, or detailed in contract drawings, and furnished to precaster, with instructions, in a timely manner.

- A. Furnish loose connection hardware and anchorage items to be embedded in or attached to other construction without delaying the work. Provide locations, setting diagrams, templates, instructions, and directions, as required, for installation.

## **PART 2 – PRODUCTS**

### **2.1 FABRICATORS**

Delete this article if fabricators are not being named. See PCI’s website ([pci.org](http://pci.org)) for current listing of PCI-certified fabrication plants certified in Category AA.

The products described in this specification are Category AA products and must be produced by a producer with Category AA certification. If other products on this project are produced to comply with AB, AC, or AD certification category requirements, those products should be specified in their own specification section or sections.

- A. MPC Enterprises, Inc. (MPC Precast) Mount Pleasant, IA. (515)214-7771
- B. Fabricators: Ensure that products designated herein as AA products are provided by a firm that participates in the PCI Plant Certification program at the time of bidding and is designated a PCI-certified plant for Category AA.

Retain paragraph above for nonproprietary specification, or use paragraph below for semi proprietary specification. If paragraph above is retained, include procedure for approval of other fabricators in instructions to bidders. See Division 01 Section “Product Requirements.”

- C. Fabricators: Provide products by one of the following:
  - 1. **<Insert in separate subparagraphs the fabricators’ names and product designations for acceptable manufacturers.>**

## **2.2 MOLD MATERIALS**

- A. Molds: Rigid, dimensionally stable, nonabsorptive, and warp- and buckle-free material that will provide continuous and true precast concrete surfaces within fabrication tolerances indicated; nonreactive with concrete and suitable for producing required finishes.
- B. Form-release agent: Commercially produced form-release agent that will not bond with, stain, or affect hardening of precast concrete surfaces, and that will not impair subsequent surface or joint treatments of precast concrete.

Retain paragraph below if using formliners. Formliners may be used to achieve a special off-the-form finish or to act as a template for thin or half-brick facings. Revise paragraph below to add description of selected formliner, if required.

- C. Formliners: Units of face design, texture, arrangement, and configuration **[indicated [to match those used for precast concrete design reference sample].**
  - 1. Provide solid backing and form supports to ensure that formliners remain in place during concrete placement.
  - 2. Use a manufacturer-recommended form-release agent that will not bond with, stain, or adversely affect hardening of precast concrete surfaces, and that will not impair subsequent surface or joint treatments of precast concrete.

Retain paragraph below if surface retarder is applied to molds to help obtain exposed aggregate finish.

- D. Surface Retarder: Chemical set retarder, capable of temporarily delaying final hardening of newly placed concrete to depth of reveal specified.

## **2.3 REINFORCING MATERIALS**

Retain paragraph below if recycled content is required for environmental building rating system. Architect to specify specific rating system requirements.

- A. Recycled Content of Steel Products: Track the average recycled content of steel products used on project to ensure that the sum of postconsumer recycled steel meets the requirements of the **<insert specified rating system requirements>**.

Select one or more of the following paragraphs in this article to suit steel reinforcement requirements. Indicate locations of each type of reinforcement here or on contract drawings. If retaining Part 1 “Performance Requirements” article, consider reviewing selections with fabricators.

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

Retain paragraph below for reinforcement that is welded or if added ductility is sought.

C. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M, deformed.

Use epoxy-coated reinforcement or galvanized reinforcement when justified by corrosive environment or severe weather exposure conditions justify extra costs. In first paragraph below, retain ASTM A775/A775M for a bendable epoxy coating; retain ASTM A934/A934M for a non-bendable epoxy coating.

D. Epoxy-Coated Reinforcing Bars: **[ASTM A615/A615M, Grade 60 (Grade 420)] [ASTM A706/A706M]** deformed bars, **[ASTM A775/A775M] [ASTM A934/A934M]** epoxy coated.

E. Galvanized Reinforcing Bars: **[ASTM A615/A615M, Grade 60 (Grade 420)] [ASTM A706/A706M]** deformed bars, ASTM A767/A767M, Class II zinc-coated, hot-dip galvanized and chromate wash treated after fabrication and bending.

F. Steel Bar Mats: ASTM A184/A184M, fabricated from **[ASTM A615/A615M, Grade 60 (Grade 420)] [ASTM A706/A706M]** deformed bars, assembled with clips.

Select one or more of the paragraphs below to suit steel reinforcement requirements. If retaining Part 1 “Performance Requirements” article, consider reviewing selections with fabricators.

G. Plain-Steel Welded Wire Reinforcement: ASTM A1064/A1064M, fabricated from **[as-drawn] [galvanized and chromate wash–treated]** steel wire into flat sheets.

H. Deformed Steel Welded Wire Reinforcement: ASTM A1064/A1064M, flat sheet.

I. Epoxy Coated-Steel Welded Wire Reinforcement: ASTM A884/A884M, Class A coated, **[plain] [deformed]**, flat sheet, Type **[1 bendable] [2 nonbendable]** coating.

J. Supports: Suspend reinforcement from back of mold. Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place may only be used if they are not visible in the finished face.

## **2.4 PRESTRESSING TENDONS**

Retain this article if precast concrete units will be prestressed, either pretensioned or post-tensioned. ASTM A416/A416M establishes low-relaxation strand as the standard.

- A. Prestressing Strand: ASTM A416/A416M, Grade 270 (Grade 1860), uncoated, 7-wire, low-relaxation strand.
- B. Unbonded Post-Tensioning Strand: ASTM A416/A416M, Grade 270 (Grade 1860), 7-wire, low-relaxation strand with corrosion inhibitor coating conforming to ACI 423.7 *Specification for Unbonded Single-Strand Tendon Materials*, with polypropylene tendon sheathing. Include anchorage devices.
- C. Post-Tensioning Bars: ASTM A722/A722 M, uncoated high-strength steel bars.

## 2.5 CONCRETE MATERIALS

Retain materials in this article that are required; revise to suit project.

- A. Portland Cement: ASTM C150, Type I or III.

Select portland cement color from options in subparagraph below. White cement has greater color consistency than gray cement. Blending white and gray cement will improve the color uniformity of gray cement. For darker colors, the variations of gray cement have less effect on the final color hue.

- 1. For surfaces exposed to view in finished structure, use **[gray] [and/or] [white]** portland cement, of same type, brand, and mill source throughout the precast concrete production.

If only gray cement is selected in paragraph above, delete subparagraph below. If face mixture uses white cement but gray cement will be permitted in backup mixture, retain paragraph below.

- 2. Standard gray portland cement may be used for nonexposed backup concrete.

- B. Supplementary Cementitious Materials.

Consult with local fabricator prior to selecting mineral or cementitious materials from four subparagraphs below. These materials may affect concrete appearance, set times, and cost. If architectural face appearance is an important factor, it is recommended that fly ash and gray silica fume not be permitted for exposed exterior surfaces. White supplementary cementitious materials (SCMs), including metakaolin and white silica fume, are available.

- 1. Fly ash: ASTM C618, Class C or F, with maximum loss on ignition of 3%.
- 2. Metakaolin: ASTM C618, Class N.



3. Silica fume (white): ASTM C1240, with optional chemical and physical requirements.
4. Ground granulated blast furnace slag: ASTM C989, Grade 100 or 120.

ASTM C33 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-117 establishes stricter limits on deleterious substances for fine and coarse aggregates.

- C. Normal weight Aggregates: Except as modified by PCI MNL-117, use aggregates that comply with ASTM C33, with coarse aggregates complying with Class 5S. Stockpile fine and coarse aggregates for each type of exposed finish from a single source (pit or quarry) for project.

Revise subparagraph below and add descriptions of selected coarse- and fine-face aggregate colors, sizes, and sources if required.

1. Face-mixture coarse aggregates: Hard, and durable aggregates, free of material that reacts with cement or causes staining and matches selected sample finish(es).

Retain one option from subparagraph below, or insert gradation and maximum aggregate size if known. Fine and coarse aggregates are not always from same source.

- a. Gradation: **[Uniformly graded] [Gap-graded] [To match design reference sample]**.
2. Face-mixture fine aggregates: Natural or manufactured sand of a material compatible with coarse aggregate, and matches selected sample finish(es).

Delete subparagraph below when architectural requirements dictate that face mixture be used throughout.

3. Backup concrete aggregates: ASTM C33 or ASTM C330.

If face mixture will be exposed to weather, use of lightweight aggregates in the mixture is not recommended in cold or humid climates unless the aggregates' performance has been verified by tests or records of previous satisfactory usage in similar environments. If normal weight aggregates are used in face mixture, lightweight aggregates in the backup mixture are not recommended due to panel-bowing potential.

- D. Lightweight Aggregates: Meets ASTM C330 with absorption less than 11%, except as modified by PCI MNL-117.

Retain first paragraph below if coloring admixture is required. Add color selection if known.

- E. Coloring Admixture: ASTM C979, synthetic or natural mineral-oxide pigments that are temperature stable and nonfading.
- F. Water: Potable; free from or containing only trace amounts of deleterious material that may affect color stability, setting, or strength of concrete; and complying with chemical limits of PCI MNL-117.

Retain first paragraph below if air entrainment is required. Air entrainment should be required to increase resistance to freezing and thawing where environmental conditions dictate.

- G. Air-Entraining Admixture: ASTM C260, certified by manufacturer to be compatible with other required admixtures.
- H. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures; certified by manufacturer to not contain any calcium chloride or more than 0.15% chloride ions or other salts by weight of admixture.

If chemical admixtures are permitted, select one or more chemical admixtures with low VOC levels from the eight subparagraphs below; limit chemical admixture types if required. Water-reducing admixtures, Types A, E, and D, or high-range water-reducing admixture, Type F, predominantly used.

1. Water-reducing admixture: ASTM C494/C494M, Type A.
2. Retarding admixture: ASTM C494/C494M, Type B.
3. Water-reducing and retarding admixture: ASTM C494/C494M, Type D.
4. Water-reducing and accelerating admixture: ASTM C494/C494M, Type E.
5. High-range water-reducing admixture: ASTM C494/C494M, Type F.
6. High-range water-reducing and retarding admixture: ASTM C494/C494M, Type G.
7. Plasticizing admixture for flowable concrete: ASTM C1017/C1017M.
8. Corrosion-inhibiting admixture: ASTM C1582/C1582M.

## ***2.6 STEEL CONNECTION MATERIALS***

Edit this article to suit project. Add other materials as required. Select steel with a high percentage of post-consumer recycled content.

- A. Carbon Steel Shapes and Plates: ASTM A36/A36M.
- B. Carbon Steel Headed Studs: ASTM A108, Grades 1010 through 1020, cold finished, AWS D1.1/ D1.1 M, Type A or B, with arc shields and with the minimum mechanical properties specified in PCI MNL-117, Table 3.2.3.
- C. Carbon Steel Plate: ASTM A283/A283M, Grade C.
- D. Malleable Iron Castings: ASTM A47/A47M, Grade 32510 or 35028.
- E. Carbon Steel Castings: ASTM A27/A27M, Grade 60-30 (Grade 415-205).

- F. High-Strength, Low-Alloy Structural Steel: ASTM A572/A572M.
- G. Carbon Steel Structural Tubing: ASTM A500/A500M, Grade B or C.
- H. Wrought Carbon Steel Bars: ASTM A675/A675M, Grade 65 (Grade 450).
- I. Deformed-Steel Wire or Bar Anchors: ASTM A496/A496 M or ASTM A706/A706M.

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

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

High-strength bolts are used for friction-type connections between steel members and are not recommended between steel and concrete because concrete creep and crushing of concrete during bolt tightening reduces the effectiveness of the connection. ASTM A490/A490M bolts should not be galvanized.

- K. High-Strength Bolts and Nuts: ASTM A193/A198M, Grade B5 or B7, ASTM A325/A325M, or ASTM A490/A490M, Type 1, heavy hex steel structural bolts, heavy hex carbon steel nuts, (ASTM A563/A563M), and hardened carbon steel washers (ASTM F436/F436M).

Structural plate and shape steel connection hardware enclosed in wall cavities is provided uncoated in noncorrosive environments. When environment is highly corrosive or when connections are exposed to exterior weather conditions, steel connection hardware requires protection, which is achieved by painting or galvanizing the hardware. Retain paragraph below if shop-primed finish is required. Indicate locations of priming, if required. MPI 79 in first option below provides some corrosion protection whereas SSPC-Paint 25, without top coating, provides minimal corrosion protection. The need for protection from corrosion will depend on the actual conditions to which the connections will be exposed in service. Indicate locations of each finish. Select coatings that do not contain toxic chemicals and contain less than 250 grams VOC per liter.

- L. Shop-Primed Finish: Prepare surfaces of nongalvanized steel items, except those surfaces to be embedded in concrete, according to requirements in the Society for Protective Coatings SSPC-SP 3 standard *Power Tool Cleaning*, and shop-apply **[lead- and chromate-free, rust-inhibitive primer, complying with performance requirements in Master Painters Institute’s MPI 79] [SSPC-Paint 25]** according to SSPC-PA 1 *Shop, Field, and Maintenance Painting of Steel*.

Retain paragraph and subparagraph below if galvanized finish is required. Indicate locations of galvanized items if required. Field welding should generally not be permitted on galvanized elements, unless either the 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.

- M. Zinc-Coated Finish: For steel items in exterior walls and items indicated for galvanizing, apply zinc coating by **[hot-dip process according to ASTM A123/A123M, after fabrication, ASTM A153/A153M, or ASTM F2329 as applicable] [electrodeposition according to ASTM B633, SC 3, Type 1 or 2, and for bolts, ASTM F1941/F1941M]**.
1. For steel shapes, plates, and tubing to be galvanized, limit silicon content of steel to less than 0.03% or to between 0.15% and 0.25%, or limit sum of silicon content and 2.5 times phosphorous content to 0.09%.
  2. Galvanizing repair paint: Zinc paint with dry film containing not less than 94% zinc dust by weight and complying with DOD-P-21035B or SSPC-Paint 20. Comply with manufacturer's requirements for surface preparation.

## **2.7 STAINLESS STEEL CONNECTION MATERIALS**

Retain this article only when resistance to staining and corrosion merits extra investment in high-moisture or corrosive areas.

- A. Stainless Steel Plate: ASTM A666, Type 304, Type 316, or Type 201 of grade suitable for application.
- B. Stainless Steel Bolts and Studs: ASTM F593, alloy 304, 316, or 410, hex-head bolts and studs; stainless steel nuts; and flat, stainless steel washers.
  1. Lubricate threaded parts of stainless steel bolts with an anti-seize thread lubricant during assembly.
- C. Stainless Steel Headed Studs: ASTM A276 with the minimum mechanical properties for studs specified in PCI MNL-117, Table 3.2.3.

## **2.8 BEARING PADS AND OTHER ACCESSORIES**

Retain this article if applicable. Choice of bearing pad can usually be left to fabricator; coordinate selection with structural engineer if required.

- A. Provide one of the following bearing pads for architectural precast concrete units **[as recommended by precast concrete fabricator for application]**:
  1. Elastomeric pads: AASHTO M251, plain, vulcanized, 100% polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet. Surface hardness of 50 to 70 Shore A durometer according to ASTM D2240; minimum tensile strength 2250 psi (15.5 MPa) per ASTM D412.
  2. Random-oriented, fiber-reinforced elastomeric pads: Preformed, randomly oriented synthetic fibers set in elastomer. Surface hardness of 70 to 90 Shore A durometer according to 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 the pad. Test one specimen for each 200 pads used in project.
  3. Cotton-duck-fabric-reinforced elastomeric pads: Preformed, horizontally layered cotton-duck fabric bonded to an elastomer. Surface hardness of 80 to 100 Shore A durometer according to ASTM D2240. Conforming to Division II, Section 18.10.2

of the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*, or military specification MIL-C-882E.

4. Frictionless pads: Tetrafluoroethylene (Teflon), glass-fiber-reinforced pads bonded to stainless or mild-steel plates, or random-oriented, fiber-reinforced elastomeric pads, of type required for in-service stress.
5. High-density plastic: Multimonomer, nonleaching plastic strip capable of supporting loads with no visible overall expansion.

Select reglet materials from options in paragraph below or add another material to suit project. Coordinate material section here with counterflashing materials and details. It is preferable to use surface-mounted reglets to avoid misalignment of reglets from panel to panel.

- B. Reglets: Provide [**PVC extrusions reglets and flashing**] [**Stainless steel, Type 304 reglets and flashing**] [**Copper reglets and flashing**] [**Reglets and flashing as specified in Division 076200 Section "Sheet Metal Flashing and Trim"**], felt- or fiber-filled or face opening of slots covered.
- C. Erection Accessories: Provide clips, hangers, high-density plastic or steel shims, and other accessories required to install architectural precast concrete units.
- D. Welding Electrodes: Comply with AWS standards for steel type and/or alloy being welded.

## 2.9 GROUT MATERIALS

Add other proprietary grout systems to suit project. If retaining more than one grout type, indicate locations of each grout here or on contract drawings. Indicate required strengths on contract drawings.

- A. Sand-Cement Grout: Portland cement, ASTM C150, Type I, and clean, natural sand, ASTM C144 or ASTM C404. Mix at ratio of 1 part cement to 2½ to 3 parts sand, by volume, with minimum water required for placement and hydration. Water-soluble chloride ion content of grout shall be less than 0.06% chloride ion by weight of cement when tested in accordance with ASTM C1218/C1218M.

Retain first paragraph below if nonshrink grout is required or if cement-grout shrinkage could cause structural deficiency. For critical installations, require manufacturer to provide field supervision.

- B. Nonmetallic, Nonshrink Grout: Premixed, prepackaged nonferrous aggregate, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, and plasticizing and water-reducing admixtures; complying with ASTM C1107, 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 of grout shall be less than 0.06% chloride ion by weight of cement when tested in accordance with ASTM C1218/C 1218M.

- C. Epoxy-Resin Grout: Two-component, mineral-filled epoxy resin complying with ASTM C881/C881M, of type, grade, and class to suit requirements.

## 2.10 CLAY PRODUCT UNITS AND ACCESSORIES

Retain this article if specifying thin brick-faced precast concrete panels that require brick units with tighter dimensional tolerances than ASTM C1088, Type TBX, or ASTM C216, Type FBX. TBX or FBX brick units may be too dimensionally variable to fit securely within formliner templates. For economy, brick patterns should minimize cutting of brick. Select thin brick manufacturer and product prior to bid or establish cost allowance. If full-size brick units are required, delete this article and refer to Section 042000 "Unit Masonry Assemblies." The listed characteristics for thin brick units are included in PCI "Specification for Embedded Clay Thin Brick, May 4, 2016," and ACI's *Specifications for Concrete Construction* (ACI 301) Section 14.2. Verify availability of sizes and color.

A. Thin Brick Units:

1. Thickness: Not less than ½ in. (12.7 mm) but not more than 1 in. (25.4 mm).
2. Face size:
  - a. Modular: 2¼ in. (57.15 mm) high by 7⅝ in. (193.68 mm) long.
  - b. Norman: 2¼ in. (57.15 mm) high by 11⅝ in. (295.28 mm) long.
  - c. Closure modular: 3⅝ in. (92.08 mm) high by 7⅝ in. (193.68 mm) long.
  - d. Utility: 3⅝ in. (92.08 mm) high by 11⅝ in. (295.28 mm) long.

If approving a color range for brick, view 100 ft<sup>2</sup> (9.3 m<sup>2</sup>) of loose bricks or a completed building. Edit paragraph and subparagraphs below to suit project or delete them if brick is specified by product name. PCI recommends using current brick samples for initial selection and making final brick acceptance after brick has been cast into a precast concrete sample.

3. Face size, color, and texture:
  - a. **[Match Architect's samples] [Match existing color, texture, and face size of adjacent brickwork].**
  - b. **<Insert information on existing brick if known.>**

Show details of special conditions and shapes on contract drawings if required.

4. Special shapes: Include corners, edge corners, and end edge corners.
5. Back surface texture: Scored, combed, wire roughened, ribbed, key backed, or dovetailed.

B. Dimensional Tolerances: Measure in accordance with ASTM C67.

1. Thickness: +0 in. (+0 mm), -1/16 in. (-1.6 mm).
2. Face size:

- a. +0 in. (+0 mm), -1/16 in. (-1.6 mm) for dimensions 8 in. (200 mm) or less.
- b. +0 in. (+0 mm), -3/32 in. (-2.4 mm) for dimensions greater than 8 in. (200 mm).
- 3. Warpage:  $\leq 1/16$  in. (1.6 mm) either concave or convex from consistent plane.
- 4. Out of square:  $\pm 1/16$  in. ( $\pm 1.6$  mm).
- 5. Variation of shape from specified angle:  $\pm 1$  degree.

C. Properties:

- 1. Modulus of rupture:  $\geq 250$  psi (1.7 MPa) when tested in accordance with ASTM C67.

In subparagraph below, retain either first point for nonglazed thin brick or second point for glazed thin brick.

- 2. Cold water absorption at 24 hours:
  - a. Nonglazed thin brick: Maximum 6% when tested per ASTM C67.
  - b. Glazed thin brick: Maximum 5% when tested per ASTM C373.
- 3. Efflorescence: Rated “not effloresced” when tested in accordance with ASTM C67.
- 4. Freezing and thawing resistance:
  - a. Uncoated brick: No detectable deterioration (spalling, cracking, or breaking) after 300 cycles tested in accordance with ASTM C666 Method A or B on assembled specimens.
  - b. Surface coloring: No observable difference in the applied finish when viewed at a distance of 20 ft (6 m) after 50 cycles tested in accordance with ASTM C67. In addition, the brick shall undergo ASTM C666 test described above.
- 5. Pull-out strength:  $\geq 150$  psi (1.0 MPa) from base concrete before and after freeze-thaw testing when tested per modified ASTM E488.
- 6. Chemical resistance: Provide brick that has been tested according to modified ASTM C650 and rated “not affected.”

Select either first subparagraph below for nonproprietary specification or 2<sup>nd</sup> subparagraph below for semi proprietary specification. Refer to Division 01 Section “Materials and Equipment.”

- 7. Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to, the following:
- 8. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the work include, but are not limited to, the following]:**
  - a. **<Insert in separate subparagraphs, manufacturers’ names and product names or designations>.**

Retain paragraph and subparagraphs below only if specifying terra-cotta-faced precast concrete panels. Verify availability of sizes and color.

- D. Architectural Terra-Cotta Units: Not less than  $\frac{3}{4}$ -in.-thick (19-mm-thick) and not more than  $1\frac{1}{2}$ -in.-thick (38-mm-thick) surface to be embedded.
1. Dimensional tolerances:
    - a. Width:  $\pm 0.039$  in. (1 mm) for any length up to 60 in. (1524 mm).
    - b. Height:
      - i.  $\pm 1/16$  in. (1.6 mm) up to 10 in. (250 mm).
      - ii.  $\pm 3/32$  in. (2.4 mm) up to 15 in. (380 mm).
      - iii.  $\pm 1/8$  in. (3 mm) up to 20 in. (500 mm).
      - iv.  $\pm 5/32$  in. (4 mm) up to 24 in. (600 mm).
    - c. Thickness:  $\pm 1/16$  in. (1.6 mm).
  2. Warpage tolerances:
    - a. Straightness (sweep):  $\pm 0.25\%$  of length.
    - b. Diagonal flatness:  $\pm 0.25\%$  of diagonal.
    - c. Vertical flatness:  $\pm 1.0\%$  of height.
  3. Out of square:  $\pm 1/16$  in. (1.6 mm) when measured in accordance with ASTM C67.
  4. Comply with requirements of the manufacturer of the selected architectural terra-cotta for the application indicated.
    - a. Terra-cotta units: Face, size, color, and thickness **[Match Architect's samples]**  
**[Match existing color, texture, and face size of existing terra-cotta]**.
    - b. **<Insert information on existing terra-cotta if known.>**
  5. Special shapes: Include corners, returns, and other special-shape units as designated on architectural contract drawings.
  6. Variation of shape from specified angle:  $\pm 1$  degree.
  7. Cold water absorption at 24 hours: Maximum 7.5% when tested in accordance with ASTM C67.
  8. Efflorescence: Rated "not effloresced" when tested in accordance with ASTM C67.
  9. Tensile bond strength:  $\geq 150$  psi (1.0 MPa), before and after freeze-thaw testing, when tested in accordance with modified ASTM E488. Epoxy steel plate with welded rod on total terra-cotta surface for each test.
  10. Freeze-thaw resistance: No detectable deterioration (spalling, cracking, or chafing) after 300 cycles when tested in accordance with ASTM C666 Method A or B on assembled specimens.
  11. Modulus of rupture:  $\geq 1400$  psi (9.7 MPa) when tested in accordance with ASTM C67.
  12. Compressive strength:  $\geq 6000$  psi (41.4 MPa) when tested in accordance with ASTM C67.
  13. Chemical resistance: Rated "not affected" when tested in accordance with ASTM C126.
  14. Glaze resistance to crazing: Rated "not affected" when tested in accordance with ASTM C126.



15. Back surface: Dovetail.

Retain paragraph and subparagraphs below only if filling thin brick unit joints with pointing grout after precast concrete panel production. Paragraph and subparagraphs are not required when mortar joint is created by the formliner and architectural precast concrete face mixture serves as the mortar joint.

- E. Latex–Portland Cement Pointing Grout: ANSI A118.6 (included in ANSI A108.1) and as follows:

Select one or both types of grout from first two subparagraphs below. Specifier should request that pointing grout be represented in mockup panel(s).

1. Dry-grout mixture, factory prepared, of portland cement, graded aggregate, and dry, dispersible, ethylene-vinyl-acetate additive for mixing with water; uniformly colored.
2. Commercial portland cement grout, factory prepared, with liquid styrene-butadiene rubber or acrylic-resin latex additive; uniformly colored.
3. Colors: **[As indicated by manufacturer's designations] [Match Architect's samples] [As selected by Architect from manufacturer's full range].**
4. Tool joints to a slightly concave shape when pointing grout is thumbprint hard.

- F. Setting Systems:

Retain subparagraph below if thin brick or ceramic tile will be adhered to precast concrete panels after casting of panels using the thin-set or tile-set method.

1. Thin brick and ceramic tile units: **[Dry-set mortar: ANSI A118.1 (included in ANSI A108.1)] [Latex–portland cement mortar: ANSI A 118.4 (included in ANSI A108.1)].**

Retain subparagraph below if precast concrete panels will be used as a backup, lateral load–carrying system for full brick, where full brick will be laid up after panels are cast or installed.

2. Full brick units: Install **[galvanized] [Type 304 stainless steel]** dovetail slots in precast concrete,  $\geq 3/16$ -in.-thick (0.5-mm-thick), felt- or fiber-filled slots, or cover face opening of slots.

## ***2.11 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, “Dimension Stone Cladding.” Replace first paragraph below with stone requirements, if preferred.

- A. Stone facing for architectural precast concrete is specified in Section 044200, “Dimension Stone Cladding.”
  - 1. Tolerance of length and width of +0, - $\frac{1}{8}$  in. (+0, -3 mm).

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

- B. Anchors: Stainless steel, ASTM A666, Type 304 or Type 316, of temper and diameter required to support loads without exceeding allowable design stresses.
- C. Sealant Filler: ASTM C920, low-modulus, multicomponent, non-sag sealant that complies with requirements in Section 07 92 00, “Joint Sealants,” and is nonstaining to stone substrate.

Dowel hole filling is used to prevent water intrusion into stone and future discoloration at anchor locations. Retain paragraph above for a flexible filler or paragraph below for a rigid filler.

- D. Epoxy Filler: ASTM C881/C881M, 100% solids, sand-filled with a maximum sand-to-binder ratio between 6 and 9, nonshrinking, nonstaining of type, class, and grade to suit application.

Grommets will usually be required if filling dowel holes with rigid epoxy.

- 1. Fit each anchor leg with 60-durometer, ASTM D2240, neoprene grommet collar with a width at least twice the diameter of the anchor and a length at least five times the diameter of the anchor.

## 2.12 INSULATED PANEL ACCESSORIES

Retain this article if insulated, architectural precast concrete panels are required. Specify the required thickness for each insulation type allowed to achieve the desired aged *R*-value. Select insulation material from one of three paragraphs below; if using more than one type of insulation material, identify location of each type on contract drawings. Chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and other ozone-depleting substances should not be used or released during manufacture of insulation. **Note:** Type IV is the industry standard for extruded-polystyrene board insulation in most precast concrete applications—confirm with a local PCI producer.

- A. Expanded-Polystyrene (EPS) Board Insulation: ASTM C578, Type [XI, 0.70 lb/ft<sup>3</sup> (12 kg/m<sup>3</sup>)] [I, 0.90 lb/ft<sup>3</sup> (15 kg/m<sup>3</sup>)] [VIII, 1.15 lb/ft<sup>3</sup> (18 kg/m<sup>3</sup>)] [II, 1.35 lb/ft<sup>3</sup> (22 kg/m<sup>3</sup>)] [IX, 1.80 lb/ft<sup>3</sup> (29 kg/m<sup>3</sup>)]; square edged; with thickness of <Insert dimension>.

- B. Extruded-Polystyrene (XPS) Board Insulation: ASTM C578, Type [X, 1.30 lb/ft<sup>3</sup> (21 kg/m<sup>3</sup>)] [IV, 1.55 lb/ft<sup>3</sup> (25 kg/m<sup>3</sup>)] [VI, 1.80 lb/ft<sup>3</sup> (29 kg/m<sup>3</sup>)] [VII, 2.20 lb/ft<sup>3</sup> (35 kg/m<sup>3</sup>)] [V, 3.00 lb/ft<sup>3</sup> (48 kg/m<sup>3</sup>)]; square edged; with thickness of <Insert dimension>.
- C. Polyisocyanurate Board Insulation: Rigid, cellular polyisocyanurate thermal insulation complying with ASTM C591, Grade 1, or ASTM C1289 Type [I, 1.80 lb/ft<sup>3</sup> (29 kg/m<sup>3</sup>)] [II, 2.50 lb/ft<sup>3</sup> (40 kg/m<sup>3</sup>)] [(III, 3.00 lb/ft<sup>3</sup> (48 kg/m<sup>3</sup>))]; square edged; faced with <insert facing material> with thickness of <Insert dimension>.
- D. Producer to provide holes or other penetrations if required by connector system chosen.

Select wythe connectors from paragraph below. Specify thermal requirements of the wythe connector.

- E. Wythe Connectors: [Glass fiber in vinyl-ester polymer], [polypropylene pin], [stainless steel pin], [bent galvanized reinforcing bars] [galvanized welded wire trusses], [galvanized bent wire connectors] [epoxy-coated carbon fiber grid], [fiberglass truss] manufactured to connect wythes of precast concrete panels.

### 2.13 CONCRETE MIXTURES

- A. Prepare design mixtures to match Architect's sample or for each type of precast concrete required.

Delete subparagraph below if fly ash or gray silica fume are not permitted. Revise percentages to suit project. White supplementary cementitious materials (SCMs), including metakaolin and white silica fume, are available.

1. Permissible use of fly ash is between 15% and 20% replacement of portland cement by weight; permissible use of ground granulated blast furnace slag is between 15% and 20% of portland cement by weight; and permissible use of metakaolin and (white) silica fume is between 5% and 10% of portland cement by weight.
- B. Design mixtures may be prepared by either a qualified independent testing agency or qualified precast concrete plant personnel at architectural precast concrete fabricator's option.
- C. Limit water-soluble chloride ions to the maximum percentage by weight of cement permitted by ACI 318 (ACI 318M) or PCI MNL-117 when tested in accordance with ASTM C1218/C1218M.

Architectural precast concrete units are typically manufactured with a separate "architectural" face mixture and a "structural" backup mixture. Face and backup mixtures should have similar shrinkage and thermal coefficients of expansion. Similar water-cementitious materials ratios and cement-aggregate ratios are recommended to limit bowing or warping.

- D. Normal weight Concrete Face and Backup Mixtures: Proportion mixtures by either laboratory trial batch or field test data methods according to ACI 211.1 *Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete*, with materials to be used on project, to provide normal weight concrete with the following properties:

Retain first subparagraph below or revise it to suit project. Higher-strength mixtures may be available if required; verify availability with fabricators.

1. Compressive strength at 28 days: 5000 psi (34.5 MPa) minimum.
2. Release strength: As required by design.

A maximum water–cementitious materials ratio of 0.40 to 0.45 is typical for architectural precast concrete. Lower ratios may be possible with use of high-range water-reducing admixtures. Revise ratio in subparagraph below as required to suit project.

3. Maximum water–cementitious materials ratio: 0.45.

Water absorption indicates susceptibility to weather staining. The limit in paragraph below, corresponding to 6% by weight, is suitable for average exposures. Different parts of a single panel cannot be produced with different absorptions. Before specifying lower water absorption, verify that fabricator can produce units with lower water absorption because special consolidation techniques to increase concrete density are required.

- E. Water Absorption: 6% by weight or 14% by volume, tested according to ASTM C642, except for boiling requirement.

Lightweight backup mixtures must be compatible with normal weight face mixtures to minimize bowing or warping. If normal weight aggregates are used in face mixture, lightweight aggregates in the backup mixture are not recommended due to panel bowing potential. Retain paragraph below, if compatibility is verified by fabricator. Coordinate with selection of normal weight face mixture option above.

- F. Lightweight Concrete Backup Mixtures: Proportion mixtures by either laboratory trial batch or field test data methods according to ACI 211.2 *Standard Practice for Selecting Proportions for Structural Lightweight Concrete*, with materials to be used on project, to provide lightweight concrete with the following properties:

Retain first subparagraph below, or revise it to suit project. Higher-strength mixtures may be available if required; verify with fabricators.

1. Compressive strength at 28 days: 5000 psi (34.5 MPa) minimum.

2. Release strength: As required by design.

Increase or decrease unit weight in subparagraph below to suit project. Coordinate with lightweight aggregate supplier and architectural precast concrete fabricator. Lightweight concretes with combinations of lightweight and normal weight aggregates in mixture will usually be heavier than unit weight below.

3. Unit weight: Calculated equilibrium unit weight of 115 lb/ft<sup>3</sup> (1842 kg/m<sup>3</sup>), where variations exceed ±5 lb/ft<sup>3</sup> (±80 kg/m<sup>3</sup>) adjust to ±3 lb/ft<sup>3</sup> (±48 kg/m<sup>3</sup>), according to ASTM C567.
- G. 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-117.
  - H. When other admixtures are included in design mixtures, add them to concrete according to manufacturer's written instructions.

## **2.14 MOLD FABRICATION**

- A. Molds: Accurately construct molds, mortar tight, of sufficient strength to withstand pressures due to concrete placement and vibration 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.

Delete subparagraph below unless formliners are needed to produce exposed surface finish.

1. Place formliners accurately to provide finished surface texture indicated. Provide solid backing and supports to maintain stability of formliners during concrete placement. Coat formliner with form-release agent.
- B. Maintain molds to provide completed architectural precast concrete units of shapes, lines, and dimensions indicated in contract documents, within fabrication tolerances specified.
    1. Form joints are not permitted on faces exposed to view in the finished work.

Select one option from subparagraph below; show details on contract drawings, or revise description to add dimensions. Sharp edges or corners of precast concrete units are vulnerable to chipping.

2. Edge and corner treatment: Uniformly [**chamfered**] [**radiused**].

## **2.15 THIN BRICK FACINGS**

Retain this article if using thin brick or half-brick facings on architectural precast concrete units.

- A. Place formliner templates accurately to provide grid for brick facings. Provide solid backing and supports to maintain stability of formliners while placing bricks and during concrete placement.
- B. Match appearance of sample units.
- C. Securely place brick units face down into formliner pockets, and place concrete backing mixture.
- D. After stripping units, clean faces and joints of brick facing.

## **2.16 STONE VENEER FACINGS**

Retain this article if stone facing is required. Refer to Section 04 42 00, "Dimension Stone Cladding."

- A. Accurately position stone facings to comply with requirements and in locations indicated on shop (erection) drawings. Install anchors, supports, and other attachments indicated or necessary to secure stone in place. Maintain projection requirements of stone anchors into concrete substrate. Orient stone veining in direction indicated on shop (erection) drawings. Keep reinforcement a minimum of  $\frac{3}{4}$  in. (19 mm) from the back surface of stone. Use spacers to obtain uniform joints of widths indicated and with edges and faces aligned according to established relationships and indicated tolerances. Ensure no passage of precast concrete matrix to stone surface.
- B. See Section 07 92 00, "Joint Sealants," for furnishing and installing sealant backings and sealant into stone-to-stone joints and stone-to-concrete joints. Apply a continuous sealant bead along both sides and top of precast concrete panels at the stone–precast concrete interface, using the bond breaker as a joint filler backer. Do not seal panel bottom edge.

Retain one of the two subparagraphs below if sealing dowel holes. Use sealant subparagraph if a flexible filler is required; use epoxy subparagraph if a rigid filler is required.

- 1. Fill anchor holes with low-modulus sealant filler, and install anchors.
- 2. Fill anchor holes with epoxy filler, and install anchors with minimum  $\frac{1}{2}$  in. long (13mm long), 60 durometer elastomeric sleeve at the back surface of the stone.

Retain one of the two subparagraphs below. PCI recommends preventing bond between stone facing and precast concrete to minimize bowing, cracking, and staining of stone.

- 3. Install 6 mil to 10 mil thick (0.15 to 0.25mm thick) polyethylene sheet to prevent bond between back of stone facing and concrete substrate.
- 4. Install  $\frac{1}{8}$  in. thick (3mm thick) polyethylene-foam bond breaker to prevent bond between back of stone facing and concrete substrate.

Because of anchor testing lead times, PCI recommends anchor spacing be determined prior to bidding. Retain paragraph and subparagraphs below if precaster is to test stone anchors for shear and tension. ASTM E488 is preferred because ASTM C1354 does not include the influence of the precast concrete backup.

- C. Stone Anchor Shear and Tensile Testing: Engage accredited testing laboratory acceptable to Architect to evaluate and test the proposed stone anchorage system. Test for shear and tensile strength of proposed stone anchorage system in accordance with ASTM E488 or ASTM C1354 modified as follows:
1. Prior to testing, submit to Architect for approval a description of the test assembly (including pertinent data on materials), test apparatus, and procedures.
  2. Test 12 in. by 12 in. (300 mm by 300 mm) samples of stone affixed to testing apparatus through proposed anchorages. Provide 2 sets of 6 stone samples each (one set for shear load testing and the other set for tensile load testing).
  3. Test stone anchors of the sizes and shapes proposed for the installation.
    - a. Test the assembly to failure, and record the test load at failure. Record the type of failure, anchor pullout or stone breakage, and any other pertinent information, in accordance with the requirements of ASTM E488.

Revise anchor spacing if required as a result of preconstruction testing of stone anchors for shear and tension specified in Section 04 42 00 "Dimension Stone Cladding."

- D. Stone-to-Precast Concrete Anchorages: Provide anchors in numbers, types, and locations required to satisfy specified performance criteria; do not provide less than two anchors per stone unit equal to or less than 2 ft<sup>2</sup> (0.19 m<sup>2</sup>) in area, or less than four anchors per unit greater than 2 ft<sup>2</sup> (0.19 m<sup>2</sup>) in area or less than 12 ft<sup>2</sup> (1.1 m<sup>2</sup>) in area. For stone units larger than 12 ft<sup>2</sup> (1.1 m<sup>2</sup>) in area, provide anchors spaced not more than 24 in. (600 mm) on center both horizontally and vertically. Locate anchors a minimum of 6 in. (150 mm) from stone edge.

## **2.17 FABRICATION MATERIALS**

Coordinate with other trades for installation of cast-in items.

- A. 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 loose hardware and secure in place during casting operations. Locate anchorage hardware where it does not affect position of main reinforcement or concrete placement.
1. Weld headed studs and deformed bar anchors used for anchorage according to AWS D1.1/D1.1M and AWS C5.4, *Recommended Practices for Stud Welding*.

Coordinate paragraph below with Section 05 50 00 "Metal Fabrications," for furnishing and installing loose hardware items.

- B. Furnish loose hardware items, including steel plates, clip angles, seat angles, anchors, dowels, clamps, hangers, and other hardware shapes, for securing architectural precast concrete units to supporting and adjacent construction.
- C. Cast in reglets, slots, holes, and other accessories in architectural precast concrete units as indicated on contract drawings.

Retain first paragraph below if applicable.

- D. Cast in openings larger than 10 in. (250 mm) in any dimension. Do not drill or cut openings or prestressing strand without Architect's approval.
- E. Reinforcement: Comply with recommendations in PCI MNL-117 for fabrication, placing, and supporting reinforcement.
  - 1. 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 damage with patching material compatible with coating material and epoxy-coat bar ends after cutting.
  - 2. Accurately position, support, and secure reinforcement against displacement during concrete placement and consolidation operations. Completely conceal plastic chair support devices to prevent exposure on finished surfaces.
  - 3. Place reinforcing steel and prestressing tendon to maintain at least  $\frac{3}{4}$  in. (19 mm) minimum concrete cover. Increase cover requirements for reinforcing steel to  $1\frac{1}{2}$  in. (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.
  - 4. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh spacing, and wire tie laps. Offset laps of adjoining widths to prevent continuous laps in either direction.
- F. Reinforce architectural precast concrete units to resist handling, transportation, and erection stresses, and specified in-place loads, whichever govern.

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

- G. Prestress tendons for architectural precast concrete units by pretensioning or post-tensioning methods. Comply with PCI MNL-117.
  - 1. Delay detensioning or post-tensioning of prestressed architectural precast concrete units until concrete has reached its indicated minimum design release compressive



strength as established by test cylinders cured under the same conditions as concrete unit.

2. 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.
3. 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.
4. Protect strand ends and anchorages with bituminous, zinc-rich, or epoxy paint to avoid corrosion and possible rust spots.

- H. Comply with requirements in PCI MNL-117 and requirements 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 required or is permitted at fabricator's option.
---

- I. Place face mixture to a minimum thickness after consolidation of the greater of 1 in. (25 mm) or 1.5 times the nominal maximum aggregate size, but not less than the minimum reinforcing cover as indicated on contract drawings.
1. Use a single design mixture for those units in which more than one major face (edge) is exposed.
  2. Where only one face of unit is exposed, at the fabricator's option, either of the following mixture design/casting techniques may be used:
    - a. A single design mixture throughout the entire thickness of panel.
    - b. Separate mixtures for face and backup concrete, using cement and aggregates for each type, as appropriate, for consecutive placement in the mold. Use cement and aggregate specified for face mixture. Use cement and aggregate for backup mixture complying with specified criteria or as selected by the fabricator.
- J. Place concrete in a continuous operation to prevent pour lines, aggregate separation, cold joints, or planes of weakness from forming in precast concrete units.
1. Place backup concrete to ensure bond with face mixture concrete.
- K. Thoroughly consolidate placed concrete by internal and/or external 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-117.
1. Place self-consolidating concrete without vibration in accordance with PCI TR-6 *Guidelines for the Use of Self-Consolidating Concrete in Precast/Prestressed Concrete*. If face and backup concrete mixtures are used, ensure adequate bond between concrete mixtures.
- L. Comply with PCI MNL-117 procedures for hot- and cold-weather concrete placement.

- M. Identify pickup points of architectural precast concrete units and orientation in structure on shop (erection) drawings. Imprint or permanently mark casting date on each architectural precast concrete unit on a surface that will not show in finished structure.
- N. Cure concrete, according to requirements in PCI MNL-117, by moisture retention without heat or by accelerated heat curing using low-pressure live steam or radiant heat and moisture. Cure units until the compressive strength reaches the design stripping strength.
- O. Repair damaged architectural precast concrete units to meet acceptability requirements in PCI MNL-117 and Architect's approval.

## **2.18 INSULATED PANEL CASTING**

Retain this article if integrally insulated panels are required.

- A. Cast, screed, and consolidate bottom concrete wythe supported by mold.
- B. Place insulation boards, abutting edges, and ends of adjacent boards. Insert wythe connectors between insulation boards or through holes predrilled in insulation boards and consolidate concrete around connectors according to connector manufacturer's written instructions.
- C. Ensure bottom wythe or insulation layer are not disturbed after bottom wythe reaches initial set.
- D. Cast and screed top wythe to meet required finish.
- E. Maintain temperature in accordance with PCI MNL-117 requirements.

## **2.19 PRODUCT FABRICATION TOLERANCES**

- A. Fabricate architectural precast concrete units to the dimensional tolerances indicated and the shapes, lines, and features indicated, and position the cast-in items so each finished unit complies with PCI MNL-117, PCI MNL-135, and product tolerances as required by the Certification Category AA.

Select paragraph above or first paragraph and subparagraphs below. Paragraph above is usually retained unless tolerances for project deviate from PCI recommendations. PCI MNL-117 and PCI MNL-135 product tolerances, referenced above and listed below, are standardized throughout the industry.

- B. Fabricate architectural precast concrete units to shapes, lines, and dimensions indicated, so each finished unit complies with the following product tolerances, which reflect Certification Category AA tolerances.
  - 1. Overall height and width of units, measured at the face exposed to view, as follows:
    - a. 10 ft (3 m) or under:  $\pm 1/8$  in. ( $\pm 3$  mm).
    - b. 10 to 20 ft (3 to 6 m):  $+1/8$  in. ( $+3$  mm),  $-3/16$  in. ( $-5$  mm).
    - c. Greater than 20 ft (6 m):  $\pm 1/16$  in. per 10 ft ( $\pm 1.5$  mm per 3 m).

2. Overall height and width of units, measured at the face not exposed to view, as follows:
    - a. 10 ft (3 m) or under:  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm).
    - b. 10 to 20 ft (3 to 6 m):  $+\frac{1}{4}$  in. ( $+6$  mm),  $-\frac{3}{8}$  in. ( $-10$  mm).
    - c. Greater than 20 ft (6 m):  $\pm 1/16$  in. per 10 ft ( $\pm 1.5$  mm per 3 m).
  3. Total thickness or flange thickness:
    - a. Exposed edge:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
    - b. Nonexposed (hidden) edge:  $+\frac{1}{4}$  in. ( $+6$  mm),  $-\frac{1}{8}$  in. ( $-3$  mm).
  4. Rib width:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
  5. Rib to edge of flange:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
  6. Distance between ribs:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
  7. Variation from square or designated skew (difference in length of the two diagonal measurements — applies to panel and major openings in panel): Greater of  $\pm\frac{1}{8}$  in. per 72 in. ( $\pm 3$  mm per 2 m) and  $\pm\frac{1}{2}$  in. (13 mm).
  8. Length and width of blockouts and openings within one unit:
    - a. Maximum opening dimension  $\leq 10$  ft (3 m):  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
    - b. Maximum opening dimension  $> 10$  ft (3 m):  $+3/16$  in. ( $+5$  mm),  $-\frac{1}{8}$  in. ( $-3$  mm).
  9. Location and dimensions of blockouts hidden from view and used for HVAC and utility penetrations:  $\pm\frac{3}{4}$  in. ( $\pm 19$  mm).
  10. Dimensions of haunches:  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm).
  11. Haunch bearing surface deviation from specified plane:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
  12. Difference in relative position of adjacent haunch bearing surfaces from specified relative position:  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm).
  13. Bowing:  $\pm L/360$ , maximum 1 in. (25 mm).
  14. Local smoothness:  $\frac{1}{4}$  in. per 10 ft (6 mm per 3 m).
  15. Warping:  $1/16$  in. per 12 in. (1.5 mm per 0.3 m) of distance from the nearest adjacent corner.
  16. Tipping and flushness of plates:  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm).
  17. Dimensions of architectural features and rustications:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
  18. Location of rustication joints:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
- C. Position Tolerances: For cast-in items measured from datum line location, as indicated on shop (erection) drawings.
1. Weld plates:  $\pm 1$  in. ( $\pm 25$  mm).
  2. Inserts:  $\pm\frac{1}{2}$  in. ( $\pm 13$  mm).
  3. Handling devices:  $\pm 3$  in. ( $\pm 75$  mm).
  4. Reinforcing steel and welded wire reinforcement:  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm) where position has structural implications or affects concrete cover; otherwise,  $\pm\frac{1}{2}$  in. ( $\pm 13$  mm).
  5. Reinforcing steel extending out of member:  $\pm\frac{1}{2}$  in. ( $\pm 13$  mm) of plan dimensions.
  6. Prestressing reinforcement:  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm), perpendicular to panel;  $\pm 1$  in. ( $\pm 25$  mm), parallel to panel.
  7. Location of flashing reglets:  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm).
  8. Location of flashing reglets at edge of panel:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).

9. Reglets for glazing gaskets:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
10. Electrical outlets, hose bibs:  $\pm\frac{1}{2}$  in. ( $\pm 13$  mm).
11. Location of bearing surface from end of member:  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm).
12. Allowable rotation of plate, channel inserts, electrical boxes: 2-degree rotation or  $\frac{1}{4}$  in. (6 mm) maximum measured at perimeter of insert.
13. Position of sleeve:  $\pm\frac{1}{2}$  in. ( $\pm 13$  mm).
14. Location of window washer track or buttons:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).

Retain paragraph below if brick-faced architectural units are used. The number of bricks allowed in these misalignments should be limited to 2% of the bricks on the unit.

D. Brick-Faced Architectural Precast Concrete Units:

1. Alignment of mortar joints:
  - a. Jog in alignment:  $\frac{1}{8}$  in. (3 mm).
  - b. Alignment with panel centerline:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
2. Variation in width of exposed mortar joints:  $\pm\frac{1}{8}$  in. ( $\pm 3$  mm).
3. Tipping of individual bricks from the panel plane of exposed brick surface: +0 in. (+0 mm),  $-\frac{1}{4}$  in. ( $-6$  mm);  $\leq$  depth of form liner joint.
4. Exposed-brick surface parallel to primary control surface of panel:  $+\frac{1}{4}$  in. (+6 mm),  $-\frac{1}{8}$  in. ( $-3$  mm).
5. Individual brick step in face from panel plane of exposed brick surface: +0 in. (+0 mm);  $-\frac{1}{4}$  in. ( $-6$  mm); equal to or less than depth of formliner joint.

Retain paragraph and subparagraphs below if stone veneer-faced architectural precast concrete units are used.

E. Stone Veneer-Faced Architectural Precast Concrete Units:

Tolerances in subparagraphs below are generally appropriate for smooth-finished stone. Retain, delete, or revise subparagraphs to suit project.

1. Variation in cross-sectional dimensions: For thickness of walls from dimensions indicated,  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm).
2. Variation in joint width:  $\frac{1}{8}$  in. in 36 in. (3 mm in 900 mm), or one-fourth of nominal joint width, whichever is less.

Revise or delete paragraph below for natural-cleft, thermal, and similar finishes.

3. Variation in plane between adjacent stone units (lipping):  $\frac{1}{16}$  in. (1.6 mm) difference between planes of adjacent units.

## 2.20 FINISHES

- A. Exposed panel faces shall be free of joint marks, grain, and other obvious defects. Corners, including false joints shall be uniform and straight. Finish exposed-face surfaces of architectural precast concrete units to match approved **[design reference sample] [sample panels] [mockups]** and as follows:

PCI recommends that the architect use one or more preapproved design reference samples. Include complete description of design reference sample here. If preapproving fabricators, coordinate subparagraph with “Fabricators” article. Revise subparagraph if multiple samples are approved.

1. Design reference sample: **<Insert description and identify fabricator and code number of sample(s).>**

Retain subparagraph below only if design reference samples have not been established prior to bidding. PCI’s *Architectural Precast Concrete Color and Texture Selection Guide* provides numbered, color photographs of numerous precast concrete finishes. See PCI’s website (pci.org) for more information. If retaining subparagraph, revise it to include reference numbers. Add reference number combinations if more than one finish is required.

2. PCI’s *Architectural Precast Concrete Color and Texture Selection Guide*, **<Insert plate number(s).>**

Select type of finish from subparagraphs below, if needed. If more than one finish is required, add locations to finish descriptions or indicate on contract drawings. Add more detailed descriptions of finishes outlined below if greater definition is required, such as (light), (medium), or (deep). See PCI MNL-117 for more information on finishes. An as-cast finish generally results in a mottled surface and nonuniform finish.

3. As-cast surface finish: Provide surfaces to match accepted sample or mockup units for acceptable surface air voids, sand streaks, and honeycombs.
4. Abrasive-blast finish: Use abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces to match accepted sample or mockup units.
5. Acid-etched finish: Use acid and hot-water solution, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces to match accepted sample or mockup units. Protect hardware, connections, and insulation from acid attack.
6. Exposed aggregate finish: Use chemical retarding agents applied to molds, and washing and brushing procedures, to expose aggregate and surrounding matrix surfaces after form removal to match accepted sample or mockup units.
7. Textured-surface finish: Impart texture by formliners or inserts to match accepted sample or mockup units for acceptable surface air voids, sand streaks, and honeycombs, with uniform color and texture.
8. Thin brick facings: Refer to “Thin Brick Facings” article.

9. Stone veneer facings: Refer to “Stone Veneer Facings” article.
  10. Polished finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures, to match accepted sample or mockup units.
  11. Bush hammer finish: Use power or hand tools to remove matrix and fracture coarse aggregates to match accepted sample or mockup units.
  12. Honed finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures, to match accepted sample or mockup units.
  13. Sand-embedment finish: Use selected stones placed in a sand bed in bottom of mold, with sand removed after curing, to match accepted sample or mockup units.
- B. Finish exposed **[top] [bottom] [return]** surfaces of architectural precast concrete units to match face-surface finish or approved mockup.
  - C. Finish exposed back (non-formed) surfaces of architectural precast concrete units to match face-surface color with smooth, steel-trowel finish.
  - D. Finish unexposed surfaces of architectural precast concrete units with as-cast finish.

Architect to specify back of panel finish (face of panel not cast against a form) in paragraph below to light-broom, stippled, or float finish. Use steel-trowel finish if surface is in contact with materials requiring a smooth finish, or if surface will be exposed to view. Always require a sample of the unformed (back) finish if the back face will be exposed to view.

- E. Finish unexposed **[top in form] [back]** surfaces of architectural precast concrete units to achieve **[light-broom] [stippled] [float] [steel-trowel]** finish.

## ***2.21 SOURCE QUALITY CONTROL***

Always retain paragraph below because it establishes a minimum standard of plant testing and inspecting. PCI MNL-117 mandates source testing requirements and a plant “quality systems manual.” PCI certification also ensures periodic auditing of plants for compliance with requirements in PCI MNL-117.

- A. Quality Control Testing: Test and inspect precast concrete according to PCI MNL-117 and PCI MNL-135 requirements. If using self-consolidating concrete, also test and inspect according to PCI TR-6, *Guidelines for the Use of Self-Consolidating Concrete in Precast/Prestressed Concrete*, and ASTM C1611/C1611M, ASTM C1712, ASTM C1610/1610M, and ASTM C1621/C1621M.

Retain first paragraph and subparagraph below if owner provided testing is required. PCI certification is normally acceptable to authorities having jurisdiction without further plant quality control monitoring or owner provided third-party testing.

- B. In addition to PCI certification, Owner shall employ an accredited independent testing agency to evaluate architectural precast concrete fabricator’s quality control and testing methods.

1. Allow Owner's testing agency access to material storage areas, concrete production equipment, and concrete placement and curing facilities. Cooperate with Owner's testing agency and provide samples of materials and concrete mixtures as may be requested for additional testing and evaluation.
- C. Strength of precast concrete units shall be considered deficient if units fail to comply with ACI 318 (ACI 318M) concrete strength requirements.

Review testing and acceptance criteria with structural engineer. In first paragraph and subparagraphs below, add criteria for load tests, if required.
--

- D. Testing: If there is evidence that strength of precast concrete units may be deficient or may not comply with ACI 318 (ACI 318M) requirements, fabricator shall employ an independent testing agency to obtain, prepare, and test cores drilled from hardened concrete to determine compressive strength according to ASTM C42/C42M and ACI 318 (ACI 318M).
1. A minimum of three representative cores shall be taken from units of suspect strength, from locations directed by Architect.
  2. Cores shall be tested in an air-dry condition.
  3. Strength of concrete for each series of three cores shall be considered satisfactory if the average compressive strength is equal to at least 85% of the 28-day design compressive strength and no single core is less than 75% of the 28-day design compressive strength.
  4. Test results shall be reported in writing on the same day that tests are performed, with copies to Architect, Contractor, and precast concrete fabricator. Test reports will include the following:
    - a. Project identification name and number.
    - b. Date when tests were performed.
    - c. Name of precast concrete fabricator.
    - d. Name of concrete testing agency.
    - e. Identification letter, name, and type of precast concrete unit(s) represented by core tests; design compressive strength; type of break; compressive strength at breaks, corrected for length-diameter ratio; and direction of applied load to core in relation to horizontal plane of concrete as placed.
- E. Patching: If core test results are satisfactory and precast concrete units comply with requirements, clean and dampen core holes and solidly fill them with precast concrete mixture that has no coarse aggregate, and finish to match adjacent precast concrete surfaces.
- F. Acceptability: Architectural precast concrete units that do not comply with acceptability requirements in PCI MNL-117, PCI MNL-135, and PCI Certification Category AA, including concrete strength, manufacturing tolerances, and color and texture range, are unacceptable. Chipped, spalled, or cracked units may be repaired, with repaired units to match the visual mockup. Architect reserves the right to reject any unit if it does not

match the accepted sample panel or visual mockup. Replace unacceptable units with precast concrete units that comply with requirements.

## **PART 3 – FIELD EXECUTION**

### ***3.1 PREPARATION***

- A. Furnish anchorage devices for precast concrete units to be embedded in or attached to the building structural frame or foundation before start of such work. Provide locations, setting diagrams, templates, and instructions for the proper installation of each anchorage device.

### ***3.2 EXAMINATION***

- A. Examine supporting structural frame or foundation and conditions for compliance with requirements for installation tolerances, bearing surface tolerances, and other conditions affecting precast concrete performance.
- B. Proceed with precast concrete installation only after unsatisfactory conditions have been corrected.
- C. Prior to proceeding with installation, notify precast concrete erector in writing that supporting cast-in-place concrete foundation and building structural framing have attained minimum allowable design compressive strength, or supporting steel or other structure is structurally ready to receive loads from precast concrete units.

### ***3.3 ERECTION***

- A. Install loose clips, hangers, bearing pads, and other accessories required for connecting architectural precast concrete units to supporting members and backup materials.

Retain one of the next two paragraphs below.
--

- B. Structural steel fabricator shall supply miscellaneous steel preweld connection hardware and install it in the shop.
- C. Precaster or erector shall supply miscellaneous steel preweld connection hardware and install it in the field.
- D. Erect architectural precast concrete level, plumb, and square within the specified allowable erection tolerances. Provide temporary supports and bracing as required to maintain position, stability, and alignment of units until permanent connections are completed.
  - 1. Install temporary steel or plastic spacing shims as precast concrete units are being erected. Surface-weld steel shims to each other to prevent shims from separating.
  - 2. Maintain horizontal and vertical joint alignment and uniform joint width as erection progresses.
  - 3. Remove projecting lifting devices and use sand-cement grout to fill voids within recessed lifting devices flush with surface of adjacent precast concrete surfaces when recess is exposed.



4. Unless otherwise indicated, provide for uniform joint widths of  $\frac{3}{4}$  in. (19 mm).
- E. Connect architectural precast concrete units in position by bolting, welding, grouting, or as otherwise indicated on shop (erection) drawings. Remove temporary shims, wedges, and spacers as soon as practical after connecting and/or grouting are completed.
1. Do not allow connections to disrupt roof flashing continuity; concealment within roof insulation is acceptable.
- F. Welding: Comply with applicable AWS D1.1/D1.1M, AWS D1.4/D1.4M, and AWS D1.6/D1.6M requirements for welding, welding electrodes, appearance of welds, quality of welds, and methods used in correcting welding work.
1. Protect architectural precast concrete units and bearing pads from damage during field welding or cutting operations, and provide noncombustible shields as required.
  2. Welded connections should be clearly detailed to show the type, size, length, and location of all welds. If this information is not presented, the erector shall obtain necessary information from the specialty engineer.

Retain last subparagraph above or first subparagraph below.

4. For galvanized metal, clean weld-affected metal surfaces with chipping hammer followed by brushing or power-tool cleaning, and then apply a minimum 0.004-in.-thick (0.10-mm-thick) coat of galvanized repair paint to galvanized surfaces in conformance with ASTM A780/A780M.
  5. Visually inspect all welds critical to precast concrete connections. Visually check all welds for completion and remove, reweld, or repair all defective welds, if services of AWS-certified welding inspector are not furnished by Owner.
- G. At bolted connections, use upset threads, thread-locking compound, or other approved means to prevent loosening of nuts after final adjustment.
1. Where slotted connections are used, verify bolt position and tightness at installation. For sliding connections, properly secure bolt but allow bolt to move within connection slot.
  2. For slip critical connections, one of the following methods shall be used to ensure proper bolt pretension:
    - a. Turn-of-nut method, in accordance with American Institute of Steel Construction (AISC).
    - b. Calibrated wrench method, in accordance with AISC.
    - c. Twist-off tension control bolt method meeting ASTM F1852.
    - d. Direct-tension control bolt method meeting ASTM F1852.
  3. For slip-critical connections, the method to be used and the inspection procedure to be used shall be approved by Architect and coordinated with the inspection agency.

In paragraph below, revise locations and extent of grouting, if required.

- H. Grouting or Dry-Packing Connections and Joints: Indicate joints to be grouted and any critical grouting sequences on shop (erection) drawings. Grout connections where required or indicated on shop (erection) drawings. Retain flowable grout in place until it gains sufficient strength to support itself, or, 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. Promptly remove grout material from exposed surfaces before it affects finishes or hardens. Keep grouted joints damp for at least 24 hours after initial set.

### **3.4 ERECTION TOLERANCES**

- A. Erect architectural precast concrete units level, plumb, square, and in alignment, without exceeding the noncumulative erection tolerances listed in PCI MNL-135 or the tolerances listed in the most recently published *PCI Architectural Certification Program Supplemental Guide for Certification Category AA*.

Select paragraph above or paragraph and subparagraphs below. Paragraph above is usually retained unless tolerances for project deviate from PCI recommendations. PCI MNL-135 erection tolerances are referenced above and listed below. If tighter tolerances are required for project, coordinate fabrication tolerances for precast concrete as well as erection tolerances for supporting construction.

- B. Erect architectural precast concrete units level, plumb, square, and in alignment, without exceeding the following noncumulative erection tolerances:
1. Plan location from building grid datum\*:  $\pm\frac{1}{2}$  in. ( $\pm 13$  mm).
  2. Plan location from centerline of steel support<sup>†</sup>:  $\pm\frac{1}{2}$  in. ( $\pm 13$  mm).
  3. Top elevation from nominal top elevation:
    - a. Exposed individual panel:  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm).
    - b. Nonexposed individual panel:  $\pm\frac{1}{2}$  in. ( $\pm 13$  mm).
  4. Support elevation from nominal support elevation:
    - a. Maximum low:  $\frac{1}{2}$  in. (13 mm).
    - b. Maximum high:  $\frac{1}{4}$  in. (6 mm).
  5. Maximum plumb variation over the least of height of structure or 100 ft (30 m)\*: 1 in. (25 mm).
  6. Plumb in any 10 ft (3 m) of element height:  $\frac{1}{4}$  in. (6 mm).
    - a. Additionally, a maximum  $\frac{1}{2}$  in. (13 mm) over total height of the unit for vertical stacked panels.
  7. Maximum jog in alignment of matching edges:
    - a. Exposed panel relative to adjacent panel:  $\frac{1}{4}$  in. (6 mm).
    - b. Nonexposed panel relative to adjacent panel:  $\frac{1}{2}$  in. (13 mm).
  8. Joint width (governs over joint taper):
    - a. Joints  $\leq 10$  ft (3 m) in length:  $\pm\frac{3}{16}$  in. ( $\pm 5$  mm).
    - b. Joints  $> 10$  ft (3 m) in length:  $\pm\frac{1}{4}$  in. ( $\pm 6$  mm).

9. Joint taper exposed to view maximum:
  - a. Joints  $\leq$  10 ft (3 m) in length:  $\pm 3/16$  in. ( $\pm 5$  mm).
  - b. Joints  $>$  10 ft (3 m) in length:  $\pm 1/4$  in. ( $\pm 6$  mm).
10. Joint taper  $>$  10 ft (3 m) in length:  $1/4$  in. (6 mm).
11. Maximum jog in alignment of matching faces:  $1/4$  in. (6 mm).
12. Differential bowing or camber, as erected, between adjacent members of same design:  $1/4$  in. (6 mm).
13. Opening height between spandrels:  $\pm 1/4$  in. ( $\pm 6$  mm).

\*For precast concrete buildings  $>$  100 ft (30 m) tall, tolerances for items “1” and “5” above can increase at the rate of  $1/8$  in. (3 mm) per story to a maximum of 2 in. (50 mm).

†For precast concrete elements erected on a steel frame, the tolerance in item “2” takes precedence over tolerance dimension listed in item “1.”

### **3.5 FIELD QUALITY CONTROL**

Retain first option in paragraph below if Owner engages a special inspector. If authorities having jurisdiction permit Contractor to engage a special inspector, retain second option and retain option for submitting special inspection reports in Part 1 “Submittals” article.

- A. Special Inspections: **[Owner shall engage] [Contractor shall engage]** a qualified special inspector to perform the following special inspections and prepare reports:
  1. Erection of load-bearing precast concrete members.
  2. **<Insert special inspections.>**

Retain first paragraph below if field testing and inspecting are required, with or without paragraph above, to identify who shall perform tests and inspections. If retaining second option, retain requirement for field quality control test reports in Part 1 “Submittals” article.

- B. Testing: Owner shall engage accredited independent testing and inspecting agency to perform field tests and inspections and prepare reports.
  1. Field welds shall be subject to visual inspections and dye penetrant or magnetic particle testing in accordance with ASTM E165 or ASTM E1444 and ASTM E709. Testing agency shall be qualified in accordance with ASTM E543.
  2. Testing agency shall report test results promptly and in writing to Contractor and Architect.
- C. Repair or remove and replace work where tests and inspections indicate that it does not comply with specified requirements.
- D. Additional testing and inspecting, at erector’s expense, shall be performed to determine compliance of corrected work with specified requirements.

### **3.6 REPAIRS**

Production chips, cracks, and spalls should have been corrected at manufacturer's plant. Blemishes occurring after delivery are normally repaired before final joint sealing and cleaning as weather permits.

- A. Repairs will be permitted provided structural adequacy of units and appearance are not impaired.
- B. Repair damaged units to meet acceptability requirements of PCI MNL-117.

The precast concrete fabricator should develop appropriate repair mixtures and techniques during the production sample approval process.

- C. 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 ft (6 m).
- D. Prepare and repair damaged galvanized coatings with galvanizing repair paint according to ASTM A780/A780M.

Retain paragraph above if using galvanized anchors, connections, and other items; retain first paragraph below if items are prime painted.

- E. Wire-brush, clean, and paint damaged prime-painted components with same type of primer used in shop.
- F. Remove and replace damaged architectural precast concrete units when repairs do not comply with specified requirements.

### **3.7 CLEANING**

Specify whether erector or precaster does cleaning under the responsibility of General Contractor. Consider specifying use of biodegradable, biobased cleaning products.

- A. Clean all surfaces of precast concrete to be exposed to view, as necessary, prior to shipping.
- B. Clean mortar, plaster, fireproofing, weld slag, and any other deleterious material from concrete surfaces and adjacent materials immediately.
- C. Clean exposed surfaces of precast concrete units after erection and completion of joint treatment to remove weld marks, dirt, stains, and other markings.
  - 1. Perform cleaning procedures, if necessary, according to precast concrete fabricator's recommendations. Protect adjacent work from staining or damage due to cleaning operations.
  - 2. Do not use cleaning materials or processes that could change the appearance of exposed concrete finishes or damage adjacent materials.

### 3.8 SURVEYS

Specify surveys for all projects with 5000 ft<sup>2</sup> (464 m<sup>2</sup>) or more of architectural precast concrete; remove section for projects with less than 5000 ft<sup>2</sup> (464 m<sup>2</sup>) of architectural precast concrete.

- A. Architect Project Survey: The architect of record shall complete the PCI Architectural Certification Program form, “*Architect Project Survey*”, found in the PCI Architectural Certification Program Supplemental Conditions, that identifies their perceptions of the Category AA certified producer’s performance.
  
- B. General Contractor/Construction Manager Project Survey: The general contractor or construction manager shall complete the PCI Architectural Certification Program form “*General Contractor/Construction Manager Project Survey*”, found in the PCI Architectural Certification Program Supplemental Conditions, that identifies their perceptions the Category AA certified producer’s performance.

END OF SECTION 034500