Asp Avenue Parking Facility Norman, Oklahoma; Architect: Frankfurt-Short-Bruza Associates.

CHAPTER SIX
GUIDE SPECIFICATION
FOR ARCHITECTURAL PRECAST CONCRETE

6.1 GENERAL

This chapter provides a basis for specifying in-plant fabrication, including product design not shown on contract drawings, and field erection of architectural precast concrete. It does not address structural precast concrete, coatings, or sealing the joints between units.

6.2 DRAWINGS AND SPECIFICATIONS

6.2.1 Drawings

The Architect's or Engineer's drawings should show panel locations and necessary sections and dimensions to define the size and shape of the architectural precast concrete units, indicate the location and size of reveals, bullnoses, and joints (both functional and aesthetic), and illustrate details between panels and adjacent materials. When more than one type of panel material or finish is used, indicate the extent and location of each type on the drawings. The location and details of applied and embedded items should be shown on the drawings. Plans should clearly differentiate between architectural and structural precast concrete if both are used on the same project. The details of corners of the structure and interfacing with other materials should be illustrated. The aesthetic requirements and design loads should be identified, and load support points and space allowed for connections should be indicated. The Engineer of Record needs to be aware of the magnitude and direction of all anticipated loads to be transferred from the architectural precast concrete components to the building structural framing and their points of application. These loads should be addressed in the bid documents. It is especially critical that the Engineer of Record make provisions for stiffeners and bracing required to transfer the architectural precast concrete loads to the structural frame.

There should be no gaps between the specifications and drawings nor should they overlap; the specifications and drawings should be complementary.

6.2.2 Specifications

The type and quality of the materials incorporated into the units, the design compressive strength of the concrete, the finishes, and the tolerances for fabrication and erection should be described. In the event a performance specification is used appropriate data should be included for the precaster to assess the scope and quality of the precast concrete units to be fabricated.

Specifiers should consider permitting variations in production methods, structural design, materials, connection and erection techniques to accommodate varying plant practices. Specifying the results desired without specifically defining the manufacturing procedures will ensure the best competitive bidding. Required submittals should also include range-bracketing samples for color and texture.

The availability, quantity, performance, cost and production considerations of each ingredient and finish of architectural precast concrete can have a large impact on a project's schedule and budget. Therefore, they should be determined and specified for each specific project before the project specifications are released. The time and expense required to develop samples and select concretee colors and textures can be considerable and should not be underestimated by the design team.

The specification section should include requirements for connection components embedded in the precast concrete, related loose connection hardware, and any special devices for lifting or erection, if required. Items to be specified in other sections include building frame support provisions required to support units, including portions of connectors attached to the structure, joint sealing and final cleaning, and protection of the architectural precast concrete.

6.2.3 Coordination

The responsibility for supply of precast concrete support items to be placed on or in the structure in order to receive the architectural precast concrete units depends on the type of structure and varies with local practice. Clearly specify responsibility for supply and installation of pre-erection hardware. If not supplied by the precast concrete fabricator, list supplier and installation requirements in related trade sections.

The type and quantity of hardware items required to be cast into precast concrete units for the use of other

trades should be clearly specified. Specialty items should be required to be detailed, and supplied to precaster in a timely manner by the trade requiring them. Verify that materials specified in the section on flashing are galvanically compatible with cast in reglets or counterflashing receivers. Check that concrete coatings, adhesives, and sealants specified in other sections are compatible with each other and with the form release agents and surfaces to which they are applied.

Items mentioned in the Guide Specification as supply and/or installation by others should be mentioned in the specifications covering the specific trades. Such items may include:

- Cost of additional inspection by an independent testing laboratory, if required.
- Hardware for interfacing with other trades (window, door, flashing, and roofing items).
- Placing of precast concrete hardware cast into or attached to the structure, including tolerances for such placing.
- Joint treatment for joints between precast concrete and other materials.
- Access to building and floors.
- Power and water supply.
- Cleaning.
- Water repellent coatings.
- Plant-installed facing materials such as natural stone and clay products.

6.2.4 Guide Specification Development:

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6.3 TYPES OF SPECIFICATIONS

The most common form of an architectural precast concrete specification is by performance. The principal advantage of performance specifying over prescriptive is that it allows precasters to combine economy and optimum quality, utilizing established tooling and production techniques not envisioned by the architect or specifier.

Performance specifications define the scope of work by the results desired. For example, architectural precast concrete performance specifications will establish: (1) drawings that govern the design and arrangement of the various wall components; (2) quality of materials and types of finishes; (3) the loads and forces the wall panels are required to support; and (4) insulating and permeability requirements. In other words, they cover the aesthetic, functional, and structural requirements and define all limiting factors.

Performance specifications can achieve good results as long as the architect identifies the purpose to be served. Performance specifications often include appropriate quality control safeguards such as pre-qualification of precasters, pre-bid approval of materials and samples, careful review of shop drawings, and architect's approval of initial production units.

An alternative form of specifying is the prescriptive method. Prescriptive specifications typically contain inflexible and too stringent requirements that can adversely affect a project's budget and delivery schedule. An example of prescriptive specifying would be pre-engineered cladding systems. In this example an owner will engage a design firm to engineer a cladding system in order to shorten the time period necessary to design and develop project shop drawings.

Performance specifications may create additional work for the architect at the design stage, because the end result must be clearly defined and frequently multiple bid proposals must be assessed. The accepted proposal will eventually become the standard for manufacturing. However, this additional work in the early stages is generally offset by time saved later in detailing in the architect's office.

Performance specifications should define the scope (statement of needs) and quality of the precast concrete at an early project stage. With performance specifications, the manufacturer is responsible for selecting means and methods to achieve satisfactory results.

Properly prepared performance specifications should conform to the following criteria:

1. They should clearly state all limiting factors such as minimum or maximum thickness, depth, weight, tolerances, and any other limiting dimensions. Acceptable limits for requirements not detailed should be clearly provided. These limits may cover insulation (thermal and acoustical), interaction with other materials, services, and appearance.

2. They should be written so that the scope is clearly defined. Items both included and not included under the scope of the precast concrete work must be identified and cross-referenced in the project documents.

3. The architect should request samples, design and detail submissions from prospective bidders, and make pre-bid approval of such submissions a prerequisite for bidding.

4. If such requests for pre-bid approvals form a part of the specifications, the architect should adhere to the following:

a. Sufficient time must be allowed for the precaster to prepare and submit samples or information for approval by the architect. Approval should be conveyed to the manufacturer in writing with sufficient time to allow completion of an estimate and submittal of a bid.

b. All proprietary pre-bid submittals should be treated in confidence and the individual precaster's original solutions or techniques protected both before and after bidding.

6.4 Guide Specification

This Guide Specification is intended to be used as a basis for the development of an office master specification or in the preparation of 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 or inclusion of additional appropriate requirements. Coordinate the specifications with the information shown on the Contract Drawings to avoid duplication or conflicts.

Shaded portions are Notes to the Specification Writer.

SECTION 034500

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

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section includes the performance criteria, materials, production, and erection of architectural precast concrete for the entire project. The work performed under this Section includes all labor, material, equipment, related services, and supervision required for the manufacture and erection of the architectural precast concrete work shown on the Contract Drawings.

Adjust list below to suit Project. Delete paragraph below if not listing type of units.

B. This Section includes the following:
1. Architectural precast concrete cladding **(and loadbearing**) units.
2. Insulated, architectural precast concrete units.
3. Clay product-faced, architectural precast concrete units.
4. Stone veneer-faced, architectural precast concrete units.

C. Related Sections include the following:

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

1. Division 03 Section "Cast-in-Place Concrete" for installing connection anchors in concrete.
2. Division 03 Section "Glass-Fiber-Reinforced Concrete (GFRC)."
3. Division 04 Section "Exterior Stone Cladding" for furnishing stone facings and anchorages.
4. Division 04 Section "Cast Stone Masonry" for wet or dry cast stone facings, trim, and accessories.
5. Division 04 Section "Unit Masonry Assemblies" for full-thickness brick facing, mortar, inserts, and anchorages.
6. Division 05 Section "Structural Steel Framing" for furnishing and installing connections attached to structural-steel framing.
7. Division 05 Section "Metal Fabrications" for furnishing and installing loose hardware items, kickers, and other miscellaneous steel shapes.
8. Division 07 Section "Water Repellents" for water-repellent finish treatments.
9. Division 07 Section "Sheet Metal Flashing and Trim" for flashing receivers and reglets.
10. Division 07 Section "Joint Sealants" for elastomeric joint sealants and sealant backings.
11. Division 08 Section "Aluminum Windows" for windows set into architectural precast concrete units.
12. Division 09 Section "Tiling" for ceramic tile setting materials and installation.
13. Division 11 Section "Window Washing Equipment" for tie-backs located in architectural precast concrete units.

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, finish and texture, preapproved by Architect.

1.4 PERFORMANCE REQUIREMENTS

Retain this Article if delegating design responsibility for architectural precast concrete units to Contractor. AIA Document A201 requires 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.

Retain paragraph above if design loads are shown on Drawings; delete subparagraph above and retain paragraph and applicable subparagraphs below if including design loads here. 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 7, 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.**>

Precast 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:

Indicate locations here or on Drawings if different element structural, shrinkage, creep or thermal movements are anticipated for different building elements. If preferred, change deflection limits in 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 **($^1/_2$ in. [13 mm]) ($^3/_4$ in. [19 mm]) (1 in. [25 mm])**.
   b. Overall building drift: <**Insert drift.**>
   c. Interstory building drift: <**Insert drift.**>

Temperature value in first subparagraph below is suitable for most of the U.S. 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 at www.ncdc.noaa.gov.

7. Thermal Movements: Provide for in-plane thermal movements resulting from annual ambient temperature changes of **(80 °F [26 °C])** <**Insert temperature range**>.

Delete subparagraph below if fire resistance rating is not 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 design drawings.

8. Fire Resistance Rating: Select material and minimum thicknesses to provide **(1)(2)** <**Insert number**> - hour fire rating.

Delete subparagraph below if window washing system is not required. Indicate design criteria here or on Drawings for window washing system, including material and equipment..

9. Window Washing System: Design precast concrete units supporting window washing system indicated to resist pull-out and horizontal shear 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 testing, in numbers, types, and locations required to satisfy specified performance criteria.

Delete subparagraph below if precast concrete units are not used in parking structure to resist impact load. Local codes may have requirements that vary from those listed.

11. Vehicular Impact Loads: Design spandrel beams acting as vehicular barriers for passenger cars to resist a single load of **(6,000 lb [26.7 kN])** <**Insert load**> service load and **(10,000 lb [44.5 kN])** <**Insert load**> ultimate load applied horizontally in any direction to the spandrel beam, with anchorages or attachments capable of transferring this load to the structure. Design spandrel beams, assuming the load to act at a height of 18 in. (457 mm) above the floor or ramp surface on an area not to exceed 1 ft^2 (0.09 m^2).

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Retain quality control records and certificates of compliance for 5 years after completion of structure.

B. LEED Submittals:

Retain subparagraph below if recycled content is required for LEED-NC or LEED-CI Credits MR 4.1 and MR 4.2. An alternative method of complying with Credit MR 4.1 and MR 4.2 requirements is to retain requirement in Division 01 SECTION "Sustainable Design Requirements" that gives Contractor the option and responsibility for determining how Credit MR 4.1 and MR 4.2 requirements will be met.

1. Product Data for Credit MR 4.1[**and Credit MR 4.2**]: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer (post-industrial) recycled content per unit of product.
   a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.
   b. Indicate 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, indicate the percentage of recycled content product in the assembly by weight.
   d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.
2. Product Data for Credit MR 5.1 **[and Credit MR 5.2]**: For local and regional material extracted/harvested and manufactured within a 500 mile radius from the project site.
   a. Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
   b. Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
   c. Indicate dollar value of product containing local/regional materials; include materials cost only.
   d. Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.

Retain subparagraph below if environmental data is required in accordance with Table 1 of ASTM E 2129. Concrete is relatively inert once cured. Admixtures, form release agents, and sealers may emit VOCs, especially during the curing process; however, virtually all emissions are eliminated before enclosing the building.

3. Include MSDS product information showing that materials meet any environmental performance goals such as biobased content.

4. For projects using FSC certified formwork, 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: Detail fabrication and installation of architectural precast concrete units. Indicate locations, plans, elevations, dimensions, shapes, and cross-sections of each unit. Indicate aesthetic intent including joints, rustications or reveals, and extent and location of each surface finish. Indicate details at building corners.

Delete subparagraphs below not applicable to Project.

1. Indicate separate face and backup mixture locations and thicknesses.
2. Indicate welded connections by AWS standard symbols and show size, length, and type of each weld. Detail loose and cast-in hardware and connections.
3. Indicate locations, tolerances, and details of anchorage devices to be embedded in or attached to structure or other construction.
4. Indicate locations, extent, and treatment of dry joints if two-stage casting is proposed.
5. Indicate plans and/or elevations showing unit location and dimensions, erection sequences, and bracing plan for special conditions.
6. Indicate location of each architectural precast concrete unit by same identification mark placed on unit.
7. Indicate relationship of architectural precast concrete units to adjacent materials.
8. Indicate locations and details of clay product units, including corner units and special shapes with dimensions, and joint treatment.
9. Indicate locations and details of stone veneer-facings, stone anchors, and joint widths.
10. Coordinate and indicate openings and inserts required by other trades.
11. Design Modifications: If design modifications are proposed to meet performance requirements and field conditions, notify the Architect and submit design calculations and Shop Drawings. Do not adversely affect the appearance, durability, or strength of units when modifying details or materials and maintain the general design concept.

Retain subparagraph below if retaining "Performance Requirements" Article. Delete or modify if Architect assumes or is required by law to assume design responsibility.

12. Comprehensive engineering design **(signed and sealed) (certified)** by qualified professional engineer responsible for its preparation licensed in the jurisdiction in which the project is located. Show governing panel types, connections, and types of reinforcement, including special reinforcement such as epoxy coated carbon fiber grid. Indicate location, type, magnitude, and direction of all loads imposed on the building structural frame by the architectural precast concrete.

Retain paragraph and subparagraphs below if finishes, colors, and textures are preselected, specified, or scheduled. Coordinate with sample panels and range samples in "Quality Assurance" Article.

E. Samples: Design reference samples for initial verification of design intent, approximately 12 x 12 x 2 in. (300 x 300 x 50 mm), representative of finishes, color, and textures of exposed surfaces of architectural precast concrete units.

1. When back face of precast concrete unit is to be exposed, include Samples illustrating workmanship, color, and texture of the backup concrete as well as facing concrete.

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

2. Samples for each brick unit required, showing full range of color and texture expected. Include Sample showing color, geometry, and texture of joint treatment.

Retain paragraph below if procedures for welder certification are retained in "Quality Assurance" Article.

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

Manufacturer should have a minimum of 2 years of production experience in architectural precast concrete work comparable to that shown and specified, in not less than three projects of similar scope with the Owner or Architect determining the suitability of the experience.

G. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include list of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

Delete test reports paragraph below if not required.

H. Material Test Reports: From an accredited testing agency, indicating and interpreting test results of the following, for compliance with requirements indicated:

Retain paragraph above or below.

I. Material Certificates. For the following items signed by manufacturers:

Retain list below with either paragraph above. Edit 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.

Retain paragraph below if Contractor is responsible for field quality-control testing. Retain option if Contractor is responsible for special inspections.

J. Field quality-control test [**and special inspections**] reports.

1.6 QUALITY ASSURANCE

Erector should have a minimum of 2 years of experience in architectural precast concrete work comparable to that shown and specified in not less than three projects of similar scope with the Owner or Architect determining the suitability of the experience. The inclusion of erection in the precast concrete contract should be governed by local practices. Visit the PCI website at www.pci.org for current listing of PCI- Qualified and Certified Erectors. Retain first paragraph below if PCI-Certified Erector is not available in project location.

A. Erector Qualification: A precast concrete erector with all erecting crews Qualified 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) (Category S2 [Complex Structural Systems] for load-bearing members)**.

B. Erector Certification: A precast concrete erector with erecting organization and all erecting crews 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) (Category S2 [Complex Structural Systems] for load-bearing members)**.

Retain first paragraph below if PCI-Qualified or Certified Erector is not available in Project location. Basis of audit is PCI MNL-127, *Erector's Manual – Standards and Guidelines for the Erection of Precast Concrete Products*.

C. Erector Qualifications: A precast concrete erector who has retained a "PCI-Certified Field Auditor", at erector's expense, to conduct a field audit of a project in the same category as this Project prior to start of erection and who can produce an Erector's Post Audit Declaration.

D. Fabricator Qualifications: A firm that complies with the following requirements and is experienced in producing architectural precast concrete units similar to those indicated for this Project and with a record of successful in-service performance.

1. Assumes responsibility for engineering architectural precast concrete units to comply with performance requirements. This responsibility includes preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.

Delete subparagraph above and below if Precaster is not required to engage the services of a qualified professional engineer and if submission of a comprehensive engineering analysis is not retained in "Submittals" Article.

2. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of architectural precast concrete that are similar to those indicated for this Project in material, design, and extent.
3. Participates in PCI's Plant Certification program (at the time of bidding) and is designated a PCI-Certified plant for Group A, Category A1- Architectural Cladding and Loadbearing Units.
4. Has sufficient production capacity to produce required units without delaying the Work.

Delete subparagraph below if fabricators are not required to be registered with and approved by authorities having jurisdiction. List approved fabricators in Part 2 if required.

5. Is registered with and approved by authorities having jurisdiction.

Retain first paragraph below if quality assurance testing in addition to that provided by the PCI Certification Program is required. Testing agency if required, is normally engaged by Owner.

E. Testing Agency Qualifications: An independent testing agency **(acceptable to authorities having jurisdiction)**, qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated.

F. Design Standards: Comply with ACI 318 (ACI 318M) and design recommendations of PCI MNL 120, *PCI Design Handbook – Precast and Prestressed Concrete*, applicable to types of architectural precast concrete units indicated.

G. Quality-Control Standard: 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 Production of Architectural Precast Concrete Products.*

Delete paragraph below if no welding is required. Retain "Welding Certificates" paragraph in "Submittals" Article if retaining below. 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.

H. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code – Steel"; and AWS D1.4, "Structural Welding Code – Reinforcing Steel."

Retain paragraph below if fire-rated units or assemblies are required. Select either PCI MNL 124 or ACI 216.1/TMS 0216.1 or retain both if acceptable to authorities having jurisdiction.

I. Fire Resistance: Where indicated, provide architectural precast concrete units whose fire resistance meets the prescriptive requirements of the governing code or has been calculated according to **(PCI MNL 124, *Design for Fire Resistance of Precast Prestressed Concrete) (ACI 216.1/TMS 0216.1, Standard Method for Determining Fire Resistance of Concrete and Masonry Construction Assemblies)*** and is acceptable to authorities having jurisdiction.

PCI recommends review of preproduction sample panels or first production unit. Revise size and number of sample panels in paragraph below to suit Project.

J. Sample Panels: After sample approval and before fabricating architectural precast concrete units, produce a minimum of **(two)** <**Insert number**> sample panels approximately **(16 ft² [1.5 m²])** <**Insert size**> in area for review by Architect. Incorporate full-scale details of architectural features, finishes, textures, and transitions in the sample panels.

1. Locate panels where indicated or, if not indicated, as directed by Architect.
2. Damage part of an exposed-face surface for each finish, color, and texture, and demonstrate adequacy of repair techniques proposed for repair of surface blemishes.
3. After acceptance of repair technique, maintain one sample panel at the manufacturer's plant and one at the Project site in an undisturbed condition as a standard for judging the completed Work.
4. Demolish and remove sample panels when directed.

PCI recommends production of finish and texture range samples when color and texture uniformity concerns could be an issue, Architect or precaster has not had previous experience with the specified mixture and finish, or a large project has multiple approving authorities.

K. Range Sample Panels: After sample panel approval and before fabricating architectural precast concrete units, produce a minimum of **(three)(five)** <**Insert number**>samples, approximately **(16 ft² [1.5 m²])** <**Insert number**> in area, representing anticipated range of color and texture on Project's units. Maintain samples at the manufacturer's plant as color and texture acceptability reference.

Delete paragraph and subparagraphs below if sample panels and range samples above will suffice and added expense of mockups is not required. If retaining, indicate location, size, and other details of mockups on Drawings or by inserts. Revise wording if only one mockup is required.

L. Mockups: 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 and to demonstrate aesthetic effects and set quality standards for materials and execution. Mockups to be representative of the finished work in all respects including **(glass, aluminum framing, sealants)** <**Insert construction type**> and architectural precast concrete complete with anchors, connections, flashings, and joint fillers as accepted on the final Shop 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 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 starting production fabrication of precast concrete units.
4. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
5. Demolish and remove mockups when directed.

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 Division 01 Section "Quality Requirements" for demolishing and removing mockups when directed, unless otherwise indicated.

6. Approved mockups may become part of the completed Work if undamaged at the time of Substantial Completion.
7. Approval of mockups does not constitute approval of deviations from the Contact Documents unless such deviations are specifically approved by Architect in writing.

Delete paragraph below if mockup above is to be used for 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. Requirements in paragraph below are limited to building a preconstruction testing mockup at a testing agency's facility.

M. Preconstruction Testing Mockup: Provide a full-size mockup of architectural precast concrete indicated on 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 with other Sections that include 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 Drawings including **[glass, aluminum framing, sealants,]** <**Insert construction**> and architectural precast concrete complete with anchors, connections, flashings, and joint fillers.
2. Build preconstruction testing mockup at testing agency facility.

Delete paragraph below if Work of this Section is not extensive or complex enough to justify a preinstallation conference. If retaining, coordinate with Division 01.

N. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

1.7 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Store units with adequate dunnage and bracing, and protect units to prevent contact with soil, to prevent staining, and to prevent cracking, distortion, warping, or other physical damage.

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

C. Deliver architectural precast concrete units in such quantities and at such times to ensure compliance with the agreed project schedule and proper setting sequence and also to limit unloading units temporarily on the ground or other rehandling.

D. Support units during shipment on non-staining shock-absorbing material.

E. Handle and transport units in a position consistent with their shape and design in order to avoid excessive stresses that could cause cracking or damage.

F. Lift and support units only at designated points indicated on Shop Drawings.

1.8 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 type of structure and varies with local practice. Clearly specify responsibility for supply and installation of hardware. If not supplied by precaster, supplier should be listed and requirements included in related trade sections. Ensure that type and quantity 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 in order not to delay the Work.

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 unless naming fabricators. See PCI's magazine *ASCENT* or visit PCI's website at www.pci.org for current PCI-Certified plant listings.

A. Available Fabricators: Subject to compliance with requirements, fabricators offering products that may be incorporated into the Work include, but are not limited to, the following:

Retain above for nonproprietary or below for semiproprietary specification. If above is retained, include procedure for approval of other fabricators in Instructions to Bidders. See Division 01 Section "Product Requirements."

B. Fabricators: Subject to compliance with requirements, provide products by one of the following:

1. <**Insert in separate subparagraphs, fabricators' names and product designations for acceptable manufacturers.**>

2.2 MOLD MATERIALS

A. Molds: Rigid, dimensionally stable, non-absorptive material, warp and buckle free, that will provide continuous and true precast concrete surfaces within fabrication tolerances indicated; nonreactive with concrete and suitable for producing required finishes.

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

Delete paragraph below if not using form liners. Form liners may be used to achieve a special off-the-form finish or to act as a template for thin or half-brick facings. Revise to add description of selected form liner, if required.

B. Form Liners: Units of face design, texture, arrangement, and configuration **(indicated) (to match those used for precast concrete design reference sample)**. Provide solid backing and form supports to ensure that form liners remain in place during concrete placement. Use manufacturer's recommended form-release agent that will not bond with, stain, or adversely affect precast concrete surfaces and 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.

C. Surface Retarder: Chemical set retarder, capable of temporarily delaying setting of newly placed concrete to depth of reveal specified.

2.3 REINFORCING MATERIALS

Retain first paragraph below if recycled content is required for LEED-NC or LEED-CI Credits MR 4.1 and MR 4.2. USGBC allows a default value of 25 percent to be used for steel, without documentation; higher percentages can be claimed if they are supported by appropriate documentation. The Steel Recycling Institute indicates that reinforcing bars are made by the electric arc furnace method, which typically has 67 percent post-consumer recycled content and 6.5 percent pre-consumer recycled content.

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

Select one or more of the paragraphs in this Article to suit steel reinforcement requirements. If retaining Part 1 "Performance Requirements" Article, consider reviewing selections with fabricators.

B. Reinforcing Bars: ASTM A 615/A 615M, 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 A 706/A 706M, deformed.

Retain galvanized reinforcement in paragraph below where corrosive environment or severe exposure conditions justify extra cost. The presence of chromate film on the surface of the galvanized coating is usually visible as a light yellow tint on the surface. ASTM B 201 describes a test method for determining the presence of chromate coatings.

D. Galvanized Reinforcing Bars: **(ASTM A 615/A 615M, Grade 60 [Grade 420]) (ASTM A 706/A 706M)**, deformed bars, ASTM A 767/A 767M Class II zinc-coated, hot-dip galvanized and chromate wash treated after fabrication and bending.

Consider using epoxy-coated reinforcement where corrosive environment or severe exposure conditions justify extra cost. In first paragraph below, retain ASTM A 775/A 775M for a bendable epoxy coating; retain ASTM A 934/A 934M for a nonbendable epoxy coating.

E. Epoxy-Coated Reinforcing Bars: **(ASTM A 615/A 615M, Grade 60 [Grade 420]) (ASTM A 706/A 706M)**, deformed bars, **(ASTM A 775/A 775M)** or **(ASTM A 934/A 934M)** epoxy coated.

F. Steel Bar Mats: ASTM A 184/A 184M, fabricated from **(ASTM A 615/A 615M, Grade 60 [Grade 420]) (ASTM A 706/A 706M)** 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 A 185, fabricated from **(as-drawn) (galvanized and chromate wash treated)** steel wire into flat sheets.

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

I. Epoxy Coated-Steel Welded Wire Reinforcement: ASTM A 884/A 884M Class A coated, **(plain) (deformed)**, flat sheet, Type **(1 bendable) (2 non-bendable)** coating.

J. Supports: Suspend reinforcement from back of mold or use bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place according to PCI MNL 117.

2.4 PRESTRESSING TENDONS

Retain this Article if precast concrete units will be prestressed, either pretensioned or post-tensioned. ASTM A 416/A 416M establishes low-relaxation strand as the standard.

A. Prestressing Strand: ASTM A 416/A 416M, Grade 270 (Grade 1860), uncoated, 7-wire, low-relaxation strand.

B. Unbonded Post-Tensioning Strand: ASTM A 416/A 416M with corrosion inhibitor coating conforming to ASTM D1743, Grade 270 (Grade 1860), 7-wire, low-relaxation strand with polypropylene tendon sheathing. Include anchorage devices.

C. Post-Tensioning Bars: ASTM A 722, uncoated high strength steel bar.

2.5 CONCRETE MATERIALS

Delete materials in this Arcticle that are not required; revise to suit Project.

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

Select portland cement color from options in subparagraph below. Mixing with white cement will improve color uniformity of gray cement. White cement has greater color consistency than gray cement and should be used for pastel colors. 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) (or) (white)**, of same type, brand, and mill source throughout the precast concrete production.

Delete subparagraphs below if only gray cement is selected in paragraph above. Retain below if face mixture uses white cement but gray cement will be permitted in backup mixture.

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

B. Supplementary Cementitious Materials.

Prior to selecting mineral or cementitious materials from four subparagraphs below consult local precasters. These materials may affect concrete appearance, set times and cost. Where appearance is an important factor, it is recommended that fly ash and gray silica fume not be permitted for exposed exterior surfaces. White silica fume is available.

1. Fly Ash: ASTM C 618, Class C or F with maximum loss on ignition of 3%.
2. Metakaolin: ASTM C 618, Class N.
3. Silica Fume: ASTM C 1240 with optional chemical and physical requirements.
4. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

ASTM C 33 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. Normalweight Aggregates: Except as modified by PCI MNL 117, ASTM C 33, with coarse aggregates complying with Class 5S. Provide and 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: Selected, hard, and durable; free of material that reacts with cement or causes staining; to match selected finish sample.

Retain one option from first 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: Selected, natural, or manufactured sand of a material compatible with coarse aggregate to match selected Sample finish.

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

3. Backup Concrete Aggregates: ASTM C 33 or C 330.

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

D. Lightweight Aggregates: Except as modified by PCI MNL 117, ASTM C 330 with absorption less than 11%.

Delete first paragraph below if coloring admixture is not required. Add color selection if known.

E. Coloring Admixture: ASTM C 979, synthetic or natural mineral–oxide pigments or colored water-reducing admixtures, temperature stable, and non-fading.

F. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of concrete and complying with ASTM C 1602/C 1602M and chemical limits of PCI MNL 117.

Delete paragraph below if air entrainment is not required. Air entrainment should be required to increase resistance to freezing and thawing where environmental conditions dictate.

G. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.

H. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and to not contain calcium chloride, or more than 0.15% chloride ions or other salts by weight of admixture.

Limit chemical admixture types if required.

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

2.6 STEEL CONNECTION MATERIALS

Edit this Article to suit Project. Add other materials as required.

A. Carbon-Steel Shapes and Plates: ASTM A 36/A 36M.

B. Carbon-Steel Headed Studs: ASTM A 108, Grades 1010 through 1020, cold finished, AWS D1.1/ D1.1 M, Type A or B, with arc shields and with minimum mechanical properties of PCI MNL 117, Table 3.2.3.

C. Carbon-Steel Plate: ASTM A 283/A 283M.

D. Malleable Iron Castings: ASTM A 47/A 47M, Grade 32510 or 35028.

E. Carbon-Steel Castings: ASTM A 27/A 27M, Grade 60-30 (Grade 415-205).

F. High-Strength, Low-Alloy Structural Steel: ASTM A 572/A 572M.

G. Carbon-Steel Structural Tubing: ASTM A 500, Grade B or C.

H. Wrought Carbon-Steel Bars: ASTM A 675/A 675M, Grade 65 (Grade 450).

I. Deformed-Steel Wire or Bar Anchors: ASTM A 496 or ASTM A 706/A 706M.

ASTM A 307 defines the term "studs" to include stud stock and threaded rods.

J. Carbon-Steel Bolts and Studs: ASTM A 307, Grade A or C (ASTM F 568M, Property Class 4.6) carbon-steel, hex-head bolts and studs; carbon-steel nuts (ASTM A 563/A 563M, Grade A); and flat, unhardened steel washers (ASTM F 844).

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 reduce effectiveness. ASTM A 490/A 490M bolts should not be galvanized.

K. High-Strength Bolts and Nuts: ASTM A 325/A 325M or ASTM A 490/A 490M, Type 1, heavy hex steel structural bolts, heavy hex carbon-steel nuts, (ASTM A 563/A 563M) and hardened carbon-steel washers (ASTM F 436/F 436M).

Structural plate and shape steel connection hardware enclosed in wall cavities is provided uncoated in non corrosive environments. Protection is required by painting or galvanizing on steel connection hardware when the corrosive environment is high or when connections are exposed to exterior weather conditions. 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 while 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 to in service.

L. Shop-Primed Finish: Prepare surfaces of nongalvanized steel items, except those surfaces to be embedded in concrete, according to requirements in SSPC-SP 3 and shop-apply **(lead- and chromate-free, rust–inhibitive primer, complying with performance requirements in MPI 79) (SSPC-Paint 25)** according to SSPC-PA 1.

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 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 A 123/A 123M, after fabrication, ASTM A 153/A 153M, or ASTM F 2329 as applicable) (electrodeposition according to ASTM B 633, SC 3, Type 1and 2 and F 1941 and F 1941M)**.

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: High zinc-dust-content paint with dry film containing not less than 94% zinc dust by weight, and complying with DOD-P-21035A or SSPC-Paint 20. Comply with manufacturer's requirements for surface preparation.

2.7 STAINLESS-STEEL CONNECTION MATERIALS

Delete this Article if not required. Retain when resistance to staining and corrosion merits extra cost in high moisture or corrosive areas.

A. Stainless-Steel Plate: ASTM A 666, Type 304, of grade suitable for application.

B. Stainless-Steel Bolts and Studs: ASTM F 593, alloy 304 or 316, 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 A 276 with the minimum mechanical properties for studs of PCI MNL 117, Table 3.2.3.

2.8 BEARING PADS AND OTHER ACCESSORIES

Delete this Article if not 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 M 251, plain, vulcanized, 100% polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet, 50 to 70 Shore A durometer according to ASTM D 2240, minimum tensile strength 2250 psi (15.5 MPa) per ASTM D 412.
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 D 2240. 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 the 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 D 2240. Conforming to Division II, Section 18.10.2 of AASHTO LRFD Bridge Design Specifications, or Military Specification, MIL-C-882E.
4. Frictionless Pads: Tetrafluoroethylene (Teflon), glass-fiber reinforced, 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 material from options in paragraph below or add another material to suit Project. Coordinate with counterflashing materials and details. It is preferable to use surface mounted reglets to avoid misalignment of reglets from panel to panel.

B. Reglets: **(PVC extrusions) (Stainless steel, Type 304) (Copper) (Reglets and flashing are specified in Division 07 Section "Sheet Metal Flashing and Trim")** felt- or fiber-filled or face opening of slots covered.

C. Precast Concrete 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.

2.9 GROUT MATERIALS

Add other proprietary grout systems to suit Project. Describe locations of each grout here or on Drawings if retaining more than one type. Indicate required strengths on Contract Drawings.

A. Sand-Cement Grout: Portland cement, ASTM C 150, Type I, and clean, natural sand, ASTM C 144 or ASTM C 404. Mix at ratio of 1 part cement to 2 1/2 to 3 parts sand, by volume, with minimum water required for placement.

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, packaged non-ferrous aggregate, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, plasticizing and water-reducing admixtures, complying with ASTM C 1107, Grade A for drypack and Grades B and C for flowable grout and of a consistency suitable for application within a 30-minute working time.

C. Epoxy-Resin Grout: Two-component, mineral-filled epoxy-resin: ASTM C 881/C 881M of type, grade, and class to suit requirements.

2.10 CLAY PRODUCT UNITS AND ACCESSORIES

Retain this Article if specifying thin veneer brick–faced precast concrete panels. PCI Standard for brick units features tighter dimensional tolerances than ASTM C 1088 or ASTM C 216, Type FBX. TBX or FBX brick units may be too dimensionally variable to fit securely within form liner 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 Division 04 Section "Unit Masonry Assemblies." The listed characteristics for thin brick units are included in PCI "Standard for Thin Brick".

A. Thin Brick Units: PCI Standard, not less than 1/2 in. (13 mm), nor more than 1 in. (25 mm) thick, with an overall tolerance of plus 0 in., minus 1/16 in. (+0 mm, -1.6 mm) for any unit dimension 8 in. (200 mm) or less and an overall tolerance of plus 0 in., minus 3/32 in. (+0 mm, -2.4 mm) for any unit dimension greater than 8 in. (200 mm) measured according to ASTM C 67.

1. Face Size: Modular, 2 1/4 in. (57 mm) high by 7 5/8 in. (190 mm) long.
2. Face Size: Norman, 2 1/4 in. (57 mm) high by 11 5/8 in. (290 mm) long.
3. Face Size: Closure Modular, 3 5/8 in. (90 mm) high by 7 5/8 in. (190 mm) long.
4. Face Size: Utility, 3 5/8 in. (90 mm) high by 11 5/8 in. (290 mm) long.

If approving a color range for brick, view 100 square feet (9.3 m^2) of loose bricks or a completed building. Edit to suit Project or delete if brick is specified by product name.

5. Face Size, Color, and Texture: **(Match Architect's samples) (Match existing color, texture, and face size of adjacent brickwork)**.
   a. <**Insert information on existing brick if known**>.

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

6. Special Shapes: Include corners, edge corners, and end edge corners.
7. Cold Water Absorption at 24 Hours: Maximum 6% when tested per ASTM C 67.
8. Efflorescence: Tested according to ASTM C 67 and rated "not effloresced."
9. Out of Square: Plus or minus $^{1}/_{16}$ in. (± 1.6 mm) measured according to ASTM C 67.
10. Warpage: Consistent plane of plus 0 in., minus $^{1}/_{16}$ in. (+0 mm, -1.6 mm).
11. Variation of Shape from Specified Angle: Plus or minus 1 degree.
12. Tensile Bond Strength: Not less than 150 psi (1.0MPa) when tested per modified ASTM E 488. Epoxy steel plate with welded rod on a single brick face for each test.
13. Freezing and Thawing Resistance: No detectable deterioration (spalling, cracking, or chafing) when tested in accordance with ASTM C 666 Method B.
14. Modulus of Rupture: Not less than 250 psi (1.7MPa) when tested in accordance with ASTM C 67.
15. Chemical Resistance: Provide brick that has been tested according to ASTM C 650 and rated "not affected."

Delete subparagraph below if surface-colored brick is not used.

16. Surface Coloring: Brick with surface coloring shall withstand 50 cycles of freezing and thawing per ASTM C 67 with no observable difference in applied finish when viewed from 20 ft (6 m).

Retain first subparagraph below, deleting inapplicable descriptions if required.

17. Back Surface Texture: scored, combed, wire roughened, ribbed, keybacked, or dovetailed.
18. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

Retain subparagraph above for nonproprietary or subparagraph below for semiproprietary Specification. Refer to Division 01 Section "Materials and Equipment."

19. Products: Subject to compliance with requirements, products that may be incorporated into the work include the following:
    a. <**Insert in separate subparagraphs, manufacturers' name and product name or designation.**>

Refer to American National Standards Institute (ANSI) A 137.1 for the commonly available sizes and shapes, physical properties, the basis for acceptance, and methods of testing.

B. Glazed and Unglazed Ceramic Tile Units: ANSI A 137.1 **(not less than $^{3}/_{8}$ in. [10 mm]).**
1. Body of glazed tile shall have a water absorption of less than 3% using ASTM C 373.
2. Manufacturer shall warrant materials as frost-resistant.
3. Glazed units shall conform to ASTM C 126.

C. Architectural Terra Cotta Units: Comply with requirements of the manufacturer of the selected Architectural Terra Cotta for the application indicated.

Retain paragraph below if mortar setting clay product unit joints before placing precast concrete mixture.

D. Sand-Cement Mortar: Portland cement, ASTM C 150, Type I, and clean, natural sand, ASTM C 144. Mix at ratio of 1 part cement to 4 parts sand, by volume, with minimum water required for placement.

Delete paragraph and subparagraphs below if not filling thin brick unit joints with pointing grout after precast concrete panel production.

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.

1. Dry-grout mixture, factory prepared, of portland cement, graded aggregate, and dry, redispersible, 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)**.

F. Setting Systems

Retain subparagraphs below if thin brick, ceramic tile, or full brick will be laid after casting of panel.

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])**
2. Full Brick Units: Install **(Galvanized)(Type 304 stainless steel**) dovetail slots in precast concrete: not less than $^{3}/_{16}$ in. (0.5 mm thick), felt- or fiber-filled or cover face opening of slots covered. Attach brick units with wire anchors, ASTM A 82 or B 227, Grade 30HS not less than $^{3}/_{16}$ in. (W2.8) in diameter and hooked on one end and looped through a $^{7}/_{8}$ in. (22 mm) wide, 12-gage (2.68 mm) steel sheet bent over the wire with dovetail on opposite end.

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 Division 04 Section "Exterior Stone Cladding." Replace first paragraph below with stone requirements, if preferred.

A. Stone facing for architectural precast concrete is specified in Division 04 Section "Exterior Stone Cladding."
1. Tolerance of length and width of +0, -$^{1}/_{8}$ in. (+0, -3 mm).

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

B. Anchors: Stainless steel, ASTM A 666, Type 304, of temper and diameter required to support loads without exceeding allowable design stresses.

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

1. Fit each anchor leg with 60 durometer 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.

C. Sealant Filler: ASTM C 920, low-modulus, multicomponent, nonsag polyurethane or silicone sealant complying with requirements in Division 07 Section "Joint Sealants" and that 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 C 881/C 881M, 100% solids, sand-filled non-shrinking, non-staining of type, class, and grade to suit application.

E. Bond Breaker: **(Preformed, compressible, resilient, non-staining, non-waxing, closed-cell polyethylene foam pad, nonabsorbent to liquid and gas, $^1/_8$ in. [3 mm] thick) (Polyethylene sheet, ASTM D 4397, 6 to 10 mil [0.15 to 0.25 mm] thick)**.

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 then one type, identify location of each on Drawings.

A. Expanded-Polystyrene Board Insulation: ASTM C 578, Type **(XI, 0.70 lb/ft³[12kg/m³]), (I, 0.90 lb/ft³ [15kg/m³])(VIII, 1.15 lb/ft³[18kg/m³])(II, 1.35 lb/ft³[22kg/m³])(IX, 1.80 lb/ft³[29 kg/m³])**; **(square)(ship-lap)** edges; with thickness of <**Insert dimension**>.

B. Extruded-Polystyrene Board Insulation: ASTM C 578, Type **(X, 1.30 lb/ft³[21kg/m³])(IV, 1.55 lb/ft³[25 kg/m³])(VI, 1.80 lb/ft³[29 kg/m³]) (VII, 2.20 lb/ft³[35 kg/m³])(V, 3.00 lb/ft³[48 kg/m³])**; **(square)(ship-lap)** edges; with thickness of <**Insert dimension**>.

C. Polyisocyanurate Board Insulation: Rigid, cellular polyisocyanurate thermal insulation complying with ASTM C 591; Grade 1, Type **(I, 1.8 lb/ft³[29kg/m³])(II, 2.5 lb/ft³[40kg/m³])(III, 3.0 lb/ft³[48kg/m³])**; square edged; unfaced; with thickness of <**Insert dimension**>.

Select wythe connectors from paragraph below.

D. Wythe Connectors: **(Glass-fiber and vinyl-ester polymer connectors), (Polypropylene pin connectors), (Stainless-steel pin connectors), (Bent galvanized reinforcing bars) (Galvanized welded wire trusses), (Galvanized bent wire connectors) (Epoxy coated carbon fiber grid)**, 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.

Revise subparagraph below if fly ash or gray silica fume are not permitted. Revise percentages to suit Project. White silica fume is available.

1. Limit use of fly ash to 20 to 40% replacement of portland cement by weight; ground granulated blast-furnace slag to 15 to 25% of portland cement by weight; and metakaolin and silica fume to 10% of portland cement by weight.

B. Design mixtures may be prepared by a qualified independent testing agency or by 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 C 1218/C 1218M.

Architectural precast concrete units may be 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. Normalweight Concrete Face and Backup Mixtures: Proportion mixtures by either laboratory trial batch or field test data methods according to ACI 211.1, with materials to be used on Project, to provide normalweight concrete with the following properties:

Retain subparagraph below or revise to suit Project. Higher-strength mixtures may be available; verify availability with fabricators.

1. Compressive Strength (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 usual for architectural precast concrete. Lower ratios may be possible with use of high-range water reducing admixtures. Revise ratio 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. 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 PCI MNL 117.

Lightweight backup mixtures must be compatible with normalweight face mixtures to minimize bowing or warping. Retain paragraph below if required or as an option, if satisfactory durability and in-service performance are verified by fabricator. Coordinate with selection of normalweight 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, with materials to be used on Project, to provide lightweight concrete with the following properties:

Retain subparagraph below or revise to suit Project. Higher-strength mixtures may be available; verify with fabricators.

1. Compressive Strength (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 normalweight aggregate in mixture will usually be heavier than unit weight below.

3. Unit Weight: Calculated equilibrium unit weight of 115 lb/ft^3 (1842 kg/m^3), where variations exceed plus or minus 5 lb/ft^3 (80 kg/m^3) adjust to plus or minus 3 lb/ft^3 (48 kg/m^3), according to ASTM C 567.

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 included in design mixtures, add other admixtures 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 form liners in subparagraph below unless needed to produce exposed surface finish.

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

B. Maintain molds to provide completed architectural precast concrete units of shapes, lines, and dimensions indicated, 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 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 facings on architectural precast concrete units.

A. Place form liner templates accurately to provide grid for brick facings. Provide solid backing and supports to maintain stability of liners while placing bricks and during concrete placement.

B. Match appearance of sample panel(s).

C. Securely place brick units face down into form liner 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 Division 04 Section "Exterior Stone Cladding".

A. Accurately position stone facings to comply with requirements and in locations indicated on Shop Drawings. Install anchors, supports, and other attachments indicated or necessary to secure stone in place. Maintain projection requirements of stone anchors into concrete substrate. Orient stone veining in direction indicated on Shop Drawings. Keep reinforcement a minimum of $^{3}/_{4}$ in. (19 mm) from the back surface of stone. Use continuous 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 Division 07 Section "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 two subparagraphs below if sealing dowel holes. Use sealant if a flexible filler is required; use epoxy if a rigid filler is required.

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

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

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

PCI recommends anchor spacing be determined prior to bidding. Retain below if precaster is to test stone anchors for shear and tension. ASTM E 488 is preferred as ASTM C 1354 does not include the influence of the precast concrete backup.

C. Stone Anchor Shear and Tensile Testing: Engage accredited testing laboratory acceptable to the 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 E 488 or ASTM C 1354 modified as follows:

1. Prior to testing, submit 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 E 488.

Retain subparagraph below and revise anchor spacing if required as a result of preconstruction testing of stone anchors for shear and tension specified in Division 04 Section "Exterior Stone Cladding."

D. Stone to Precast Concrete Anchorages: Provide anchors in numbers, types and locations required to satisfy specified performance criteria, but not less than two anchors per stone unit of less than 2 ft^2 (0.19 m^2) in area and four anchors per unit of less than 12 ft^2 (1.1 m^2) in area; and for units larger than 12 ft^2 (1.1 m^2) 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

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 for attachment of loose hardware and secure in place during precasting operations. Locate anchorage hardware where it does not affect position of main reinforcement or concrete placement.

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 Division 05 Section "Metal Fabrications" for furnishing and installing loose hardware items.

B. Furnish loose hardware items including steel plates, clip angles, seat angles, anchors, dowels, cramps, 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.

Delete first paragraph below if not applicable.

D. Cast in openings larger than 10 in. (250 mm) in any dimension. Do not drill or cut openings or prestressing strand without of 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 reinforcing exceeds limits specified in ASTM A 775/A 775M, repair 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 support devices to prevent exposure on finished surfaces.
3. Place reinforcing steel and prestressing tendon to maintain at least $^3/_4$ in. (19 mm) minimum concrete cover. Increase cover requirements for reinforcing steel to $1^1/_2$ 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, where required by design. 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 governs.

Delete first paragraph and subparagraphs below if prestressed architectural precast concrete units are not 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.

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

1. Delay detensioning or post-tensioning of precast, 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 member.
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 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 seams 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 "Interim Guidelines for the Use of Self-Consolidating Concrete."

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 with permanent markings, complying with markings indicated on Shop 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 is high enough to ensure that stripping does not have an effect on the performance or appearance of final product.

O. Repair damaged architectural precast concrete units to meet acceptability requirements in PCI MNL 117 and Architect's approval.

2.18 INSULATED PANEL CASTING

Delete this Article if integrally insulated panels are not required.

A. Cast and screed wythe supported by mold.

B. Place insulation boards, abutting edges and ends of adjacent boards. Insert wythe connectors through insulation, and consolidate concrete around connectors according to connector manufacturer's written instructions.

C. Cast and screed top wythe to meet required finish.

2.19 FABRICATION TOLERANCES

A. Fabricate architectural precast concrete units of shapes, lines and dimensions indicated, so each finished unit complies with PCI MNL 117 product tolerances as well as position tolerances for cast-in items.

Select paragraph above or first paragraph and subparagraphs below. Usually retain above unless tolerances for Project deviate from PCI recommendations. PCI MNL 117 product tolerances, referenced above and listed below, are standardized throughout the industry. For architectural trim units such as sills, lintels, coping, cornices, quoins, medallions, bollards, benches, planters, and pavers, tolerances are listed in PCI MNL 135, *Tolerance Manual for Precast and Prestressed Concrete Construction*.

B. Fabricate architectural precast concrete units of shapes, lines and dimensions indicated, so each finished unit complies with the following product tolerances.

1. Overall Height and Width of Units, Measured at the Face Exposed to View: As follows:
   a. 10 ft (3 m) or under, Plus or Minus $^1/_8$ in. (±3 mm).
   b. 10 to 20 ft (3 to 6 m), Plus $^1/_8$ in. (+3 mm), Minus $^3/_{16}$ in. (-5 mm).
   c. 20 to 40 ft (6 to 12 m), Plus or Minus $^1/_4$ in. (±6 mm).
   d. Each additional 10 ft (3 m), add Plus or Minus $^1/_{16}$ in. (±1.6 mm).
2. Overall Height and Width of Units, Measured at the Face Not Exposed to View: As follows:
   a. 10 ft (3 m) or under, Plus or Minus $^1/_4$ in. (±6 mm).
   b. 10 to 20 ft (3 to 6 m), Plus $^1/_4$ in. (+6 mm), Minus $^3/_8$ in. (-10 mm).
   c. 20 to 40 ft (6 to 12 m), Plus or Minus $^3/_8$ in. (±10 mm).
   d. Each additional 10 ft (3 m), add Plus or Minus $^1/_8$ in. (±3 mm).
3. Total Thickness or Flange Thickness: Plus $^1/_4$ in. (+6 mm), Minus $^1/_8$ in. (-3 mm).
4. Rib Width: Plus or Minus $^1/_8$ in. (±3 mm).
5. Rib to Edge of Flange: Plus or Minus $^1/_8$ in. (±3 mm).
6. Distance between Ribs: Plus or Minus $^1/_8$ in. (±3 mm).
7. Variation from Square or Designated Skew (Difference in Length of the Two Diagonal Measurements): Plus or Minus $^1/_8$ in. per 72 in. (±3 mm per 2 m) or $^1/_2$ in. (13 mm) total, whichever is greater.

8. Length and Width of Blockouts and Openings within One Unit: Plus or Minus 1/4 in. (±6 mm).
9. Location and Dimensions of Blockouts Hidden from View and Used for HVAC and Utility Penetrations: Plus or Minus 3/4 in. (±19 mm).
10. Dimensions of Haunches: Plus or Minus 1/4 in. (±6 mm).
11. Haunch Bearing Surface Deviation from Specified Plane: Plus or Minus 1/8 in. (±3 mm).
12. Difference in Relative Position of Adjacent Haunch Bearing Surfaces from Specified Relative Position: Plus or Minus 1/4 in. (±6 mm).
13. Bowing: Plus or Minus *L*/360, maximum 1 in. (25 mm).
14. Local Smoothness: 1/4 in. per 10 ft (6 mm per 3 m).
15. Warping: 1/16 in. per 12 in. (1.6 mm per 300 mm) of distance from the nearest adjacent corner.
16. Tipping and Flushness of Plates: Plus or Minus 1/4 in. (±6 mm).
17. Dimensions of Architectural Features and Rustications: Plus or Minus 1/8 in. (±3 mm).

C. Position Tolerances: For cast-in items measured from datum line location, as indicated on Shop Drawings.

1. Weld Plates: Plus or Minus 1 in. (±25 mm).
2. Inserts: Plus or Minus 1/2 in. (±13 mm).
3. Handling Devices: Plus or Minus 3 in. (±75 mm).
4. Reinforcing Steel and Welded Wire Reinforcement: Plus or Minus 1/4 in. (±6 mm) where position has structural implications or affects concrete cover; otherwise, Plus or Minus 1/2 in. (±13 mm).
5. Reinforcing Steel Extending out of Member: Plus or Minus 1/2 in. (±13 mm) of plan dimensions.
6. Tendons: Plus or Minus 1/4 in. (±6 mm), perpendicular to panel; Plus or Minus 1 in. (±25 mm), parallel to panel.
7. Location of Rustication Joints: Plus or Minus 1/8 in. (±3 mm).
8. Location of Opening within Panel: Plus or Minus 1/4 in. (±6 mm).
9. Location of Flashing Reglets: Plus or Minus 1/4 in. (±6 mm).
10. Location of Flashing Reglets at Edge of Panel: Plus or Minus 1/8 in. (±3 mm).
11. Reglets for Glazing Gaskets: Plus or Minus 1/8 in. (±3 mm).
12. Electrical Outlets, Hose Bibs: Plus or Minus 1/2 in. (±13 mm).
13. Location of Bearing Surface from End of Member: Plus or Minus 1/4 in. (±6 mm).
14. Allowable Rotation of Plate, Channel Inserts, Electrical Boxes: 2-degree rotation or 1/4 in. (6 mm) maximum measured at perimeter of insert.
15. Position of Sleeve: Plus or Minus 1/2 in. (±13 mm).
16. Location of Window Washer Track or Buttons: Plus or Minus 1/8 in. (±3 mm).

Delete paragraph below if brick faced architectural units are not used. The number of bricks allowed 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: 1/8 in. (3 mm).
   b. Alignment with Panel Centerline: Plus or Minus 1/8 in. (±3 mm).
2. Variation in Width of Exposed Mortar Joints: Plus or Minus 1/8 in. (±3 mm).
3. Tipping of Individual Bricks from the Panel Plane of Exposed Brick Surface: Plus 0 in. (+0 mm); Minus 1/4 in. (-6 mm) ≤ depth of form liner joint.
4. Exposed Brick Surface Parallel to Primary Control Surface of Panel: Plus 1/4 in. (+6 mm); Minus 1/8 in. (-3 mm).
5. Individual Brick Step in Face from Panel Plane of Exposed Brick Surface: Plus 0 in. (+0 mm); Minus 1/4 in. (-6 mm) ≤ depth of form liner joint.

Delete paragraph and subparagraphs below if stone veneer–faced architectural precast concrete units are not used.

E. Stone Veneer–Faced Architectural Precast Concrete Units.

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

1. Variation in Cross-Sectional Dimensions: For thickness of walls from dimensions indicated: Plus or Minus $^1/_4$ in. (±6 mm).
2. Variation in Joint Width: $^1/_8$ in. in 36 in. (3 mm in 900 mm) or a quarter of nominal joint width, whichever is less.

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

3. Variation in Plane between Adjacent Stone Units (Lipping): $^1/_{16}$ 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, straight, and sharp. Finish exposed-face surfaces of architectural precast concrete units to match approved **(design reference sample) (sample panels) (mockups)** and as follows:

This Article presumes Architect has preapproved one or more design reference samples. Include complete description of design reference sample here. If preapproving fabricators, coordinate with "Fabricators" Article. Revise if multiple samples are approved.

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

Delete subparagraph below if not required. PCI published numbered, color photographs of 428 precast concrete finishes. See PCI's website at www.pci.org for more information. If retaining, revise and add reference number. Add reference number combinations if more than one finish is required.

2. PCI's *Architectural Precast Concrete –Color and Texture Selection Guide*, of plate numbers indicated.

Select type of finish from subparagraphs below if needed. If more than one finish is required, add locations to finish descriptions or indicate on Drawings. Add more detailed descriptions of finishes outlined below if greater definition is required, such as (light), (medium), or (deep). Remove matrix to a maximum depth of one-third the average diameter of coarse aggregate but not more than one-half the diameter of smallest-sized coarse aggregate. See PCI MNL 117 for more information on finishes. An as-cast finish generally results in a mottled surface or non-uniform finish.

3. As-Cast Surface Finish: Provide surfaces free of excessive air voids, sand streaks, and honeycombs.
4. Textured-Surface Finish: Impart texture by form liners with surfaces free of excessive air voids, sand streaks, and honeycombs, with uniform color and texture.
5. Bushhammer Finish: Use power or hand tools to remove matrix and fracture coarse aggregates.
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.

7. Abrasive-Blast Finish: Use abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces.
8. Acid-Etched Finish: Use acid and hot-water solution, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces. Protect hardware, connections, and insulation from acid attack.
9. Honed Finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures.
10. Polished Finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures.
11. Sand-Embedment Finish: Use selected stones placed in a sand bed in bottom of mold, with sand removed after curing.
12. Thin Brick Facings: Refer to "Thin Brick Facings" Article.
13. Stone Veneer Facings: Refer to "Stone Veneer Facings" Article.

B. Finish exposed **(top) (bottom) (back)** surfaces of architectural precast concrete units to match face-surface finish.

Revise finish in paragraph below to light-broom, stippled, or float finish, if necessary. Upgrade to steel-trowel finish if surface is in contact with materials requiring a smooth finish.

C. Finish unexposed surfaces of architectural precast concrete units with as-cast finish.

Retain paragraph above or below if applicable. Revise below to float finish or light-broom finish if steel-trowel finish is unnecessary.

D. Finish unexposed surfaces **(top) (back)** of architectural precast concrete units by 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 requirements. If using self-consolidating concrete also test and inspect according to PCI TR-6 "Interim Guidelines for the Use of Self-Consolidating Concrete."

Delete first paragraph and subparagraph below if not required. PCI certification would normally be acceptable to authorities having jurisdiction without further monitoring of plant quality control and testing program by Owner.

B. In addition to PCI Certification, Owner will 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 will 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 will employ an independent testing agency to obtain, prepare, and test cores drilled from hardened concrete to determine compressive strength according to ASTM C 42/C 42M.

1. A minimum of three representative cores will be taken from units of suspect strength, from locations directed by Architect.
2. Cores will be tested in an air-dry condition.
3. Strength of concrete for each series of three cores will 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 will 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 with precast concrete mixture that has no coarse aggregate, and finish to match adjacent precast concrete surfaces.

F. Defective Work: Architectural precast concrete units that do not comply with acceptability requirements in PCI MNL 117, including concrete strength, manufacturing tolerances, and color and texture range are unacceptable. Chipped, spalled, or cracked units may be repaired, if repaired units match the visual mock-up. The Architect reserves the right to reject any unit if it does not match the accepted sample panel or visual mock-up. Replace unacceptable units with precast concrete units that comply with requirements.

PART 3 – EXECUTION

3.1 PREPARATION

A. Deliver anchorage devices for precast concrete units that are embedded in or attached to the building structural frame or foundation before start of such work. Provide locations, setting diagrams, and templates 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, true and level bearing surfaces, and other conditions affecting precast concrete performance.

B. Proceed with precast concrete installation only after unsatisfactory conditions have been corrected.

C. Do not install precast concrete units until supporting cast-in-place concrete building structural framing has 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 two paragraphs below

B. Structural steel fabricator to supply and install miscellaneous steel preweld connection hardware in the shop.

C. Precaster or erector to supply and install miscellaneous steel preweld connection hardware 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 steel or plastic spacing shims as precast concrete units are being erected. Tack 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 $^{3}/_{4}$ 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. Disruption of roof flashing continuity by connections is not permitted; concealment within roof insulation is acceptable.

F. Welding: Comply with applicable AWS D1.1/D1.1M and AWS D1.4 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. Welds not specified shall be continuous fillet welds, using not less than the minimum fillet as specified by AWS.
3. Clean weld-affected metal surfaces with chipping hammer followed by brushing and then reprime damaged painted surfaces in accordance with paint manufacturer's recommendations.

Retain last subparagraph above or first subparagraph below.

4. Clean weld-affected metal surfaces with chipping hammer followed by brushing and then apply a minimum 0.004-in.-thick (0.1 mm) coat of galvanized repair paint to galvanized surfaces in conformance with ASTM A 780.
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 lock washers, tack welding, or other approved means to prevent loosening of nuts after final adjustment.

1. Where slotted connections are used, check bolt position and tightness. For sliding connections, properly secure bolt but allow bolt to move within connection slot. For friction connections, apply specified bolt torque and check 25% of bolts at random by calibrated torque wrench.

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 strong enough to support itself. Alternatively pack spaces with stiff dry pack grout material, tamping until voids are completely filled. Place grout and finish smooth, level, and plumb with adjacent concrete surfaces. Promptly remove grout material from exposed surfaces before it affects finishes or hardens. Keep grouted joints damp for not less than 24 hours after initial set.

3.4 ERECTION TOLERANCES

A. Erect architectural precast concrete units level, plumb, square, true, and in alignment without exceeding the noncumulative erection tolerances of PCI MNL 117, Appendix I.

Select paragraph above or paragraph and subparagraphs below. Usually retain above unless tolerances for Project deviate from PCI recommendations. PCI MNL 117 erection tolerances are referenced above and are listed below. If tighter tolerances are required for Project, coordinate with fabrication tolerances for precast concrete as well as erection tolerances for supporting construction.

B. Erect architectural precast concrete units level, plumb, square, and true, without exceeding the following noncumulative erection tolerances.

1. Plan Location from Building Grid Datum: Plus or Minus 1/2 in. (±13 mm).
2. Plan Location from Centerline of Steel Support: Plus or Minus 1/2 in. (±13 mm).
3. Top Elevation from Nominal Top Elevation:
   a. Exposed Individual Panel: Plus or Minus 1/4 in. (±6 mm).
   b. Non-Exposed Individual Panel: Plus or Minus 1/2 in. (±13 mm).
4. Support Elevation from Nominal Support Elevation:
   a. Maximum Low: 1/2 in. (13 mm).
   b. Maximum High: 1/4 in. (6 mm).
5. Maximum Plumb Variation over the Lesser of Height of Structure or 100 ft (30 m): 1 in. (25 mm).
6. Plumb in Any 10 ft (3 m) of Element Height: 1/4 in. (6 mm).
7. Maximum Jog in Alignment of Matching Edges:
   a. Exposed Panel Relative to Adjacent Panel: 1/4 in. (6 mm).
   b. Non-Exposed Panel Relative to Adjacent Panel: 1/2 in. (13 mm).
8. Joint Width (Governs over Joint Taper): Plus or Minus 1/4 in. (±6mm).
9. Maximum Joint Taper: 3/8 in. (10 mm).
10. Joint Taper over 10 ft (3 m): 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: Plus or Minus 1/4 in. (± 6 mm).

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 opotion and retain option for submitting special inspection reports in Part 1 "Submittals" Article.

A. Special Inspections: [**Owner will engage**][**Contractor will engage**] a qualified special inspector to perform the following special inspections and prepare reports:
1. Erection of loadbearing 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 will engage accredited independent testing and inspecting agency to perform field tests and inspections and prepare reports.
1. Field welds will be subject to visual inspections and nondestructive testing in accordance with ASTM E165 or ASTM E 709.
2. Testing agency will 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, will 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 A 780.

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 shop primer.

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.

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.

END OF SECTION 034500