

SECTION 03450 - ARCHITECTURAL PRECAST CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and any Specification Sections that relate to the architectural precast.

1.2 SUMMARY

- A. This Section may include any of the following, as required by the Contract Documents:

1. Architectural precast concrete cladding units / panels.
2. Architectural precast concrete trim units.
3. Architectural precast concrete brick-faced panels.
4. Architectural precast concrete stone-faced panels.
5. Architectural precast concrete site elements.
6. Architectural precast concrete restoration replications.

- B. Related Sections:

1. Division 03 Section "Cast-In-Place Concrete" for potential coordination of connection anchors in concrete, if required.
2. Division 04 Section "Cast Stone Masonry" for wet or dry cast stone trim and accessories, if required.
3. Division 04 Section "Unit Masonry" for anchoring materials and general installation requirements, if required.
4. Division 05 Section "Structural Steel Framing" for furnishing and installing connections attached to structural-steel framing, if required.
5. Division 05 Section "Metal Fabrications" for miscellaneous steel elements for precast anchoring, if required.

1.3 DEFINITIONS

- A. Architectural Precast Concrete: High quality concrete materials produced by an APA certified plant and precast is fabricated in accordance with industry standard (PCI MNL 117).
- B. Design Reference Sample: Sample of approved architectural precast concrete color, finish and texture, as approved by the Design Team.

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1.4 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide architectural precast concrete units and connections capable of withstanding the design loads provided on Structural Drawings and all applicable Codes:
- B. Provide the following test results to prove satisfactory strength & durability factors:
 - 1. Strength: Minimum 5,000 PSI at 28 days, average of two 4" or 6" diam. cylinder breaks, tested per ASTM C39.
 - 2. Absorption: No more than 6% by weight
 - 3. Air Content: 4% - 8%
 - 4. Freeze Thaw: No more than 2% weight loss after 300 cycles. Producer must have a typical mix design freeze/thaw test result on file, recent within 24 months.

1.5 PRODUCT SUBMITTALS

- A. LEED Submittals: Include recycled content, where applicable, and show documentation indicating percentages by weight of post-consumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content, if available.
- B. Mix Design(s): For each precast concrete mixture required. Include past compressive strength and water-absorption tests for the proposed color, if available.
 - 1. Cement(s) used for approved mix design, including material test results.
 - 2. Aggregates used for approved mix design, including material test results.
 - 3. Pigments used in proposed / approved mix design.
 - 4. Admixtures to be used in proposed / approved mix design
 - 5. Reinforcing Materials proposed for project.
- C. Qualification Data:
 - 1. Installer: At least five (5) years of experience with similar installations / assemblies.
 - 2. Testing Facility: Current CCRL Certification
 - 3. Precast Manufacturer:
 - a. Current APA Certification
 - b. QC Manual on file, available for review at the production facility upon request.
- D. Shop Drawings: Detail fabrication and installation of architectural precast concrete units. Indicate locations, plans, elevations, dimensions, shapes, and cross sections of each unit. Indicate joints, reveals, and extent and location of each surface finish. Indicate details at building corners & any transition locations.
 - 1. Indicate welded connections by AWS standard symbols, if required. Detail loose and cast-in hardware and connections.
 - 2. Indicate locations, tolerances, and details of anchorage devices to be embedded in or attached to structure or other construction.
 - 3. Indicate locations, extent, and treatment of dry joints if two-stage casting is proposed.
 - 4. Include plans and elevations showing unit location and sequence of erection (for special conditions).
 - 5. Indicate location of each architectural precast concrete unit by same identification mark placed on panel.
 - 6. Indicate relationship of architectural precast concrete units to adjacent materials.

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7. Indicate locations and details of brick units, including corner units and special shapes, and joint treatment, if required.
 8. Indicate locations and details of stone facings, anchors, and joint widths, if required.
 9. Design Modifications: If design modifications are proposed to meet performance requirements and field conditions, submit design calculations and Shop Drawings. Do not adversely affect the appearance, durability, or strength of units when modifying details or materials and maintain the general design concept.
 10. Provide a comprehensive engineering analysis for both reinforcement and anchoring that is stamped by a qualified professional engineer responsible for its preparation. Show governing panel types, connections, and types of reinforcement, including special reinforcement. Indicate location, type, magnitude, and direction of loads imposed on the building structural frame from the architectural precast concrete.
- E. Samples: Provide a standard range of precast samples for the Design Team's review. All options should provide an accurate representation of the color & finish of the materials, as required per contract documents. Additional samples may be requested by the Design Team, if necessary. Once a color is selected the Design team may request larger samples or mock-up piece (s).
1. Multiple colors may be required, if indicated on the contract drawings.
 2. Multiple finishes may be required, if indicated on the contract drawings.
 3. If applicable, samples for embedding items may be required (brick, stone, nosings etc.).
 4. Joint treatment samples required (by Installer):
 - a. Grout / Mortar.
 - b. Sealant / Caulking.
- F. Mock-Up Panel: Provide mock-up piece(s), as required per the contract documents.
- G. Welding certificates: Please provide welding cert., if applicable for this project.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: A precast concrete erector who has experience installing precast materials similar to this project. Design Team may require a "Certified Field Auditor" to conduct a field audit of a past project (in same category as this Project) before erection of precast concrete, in order to produce & submit an Erectors' Post-Audit Declaration.
- B. Testing Agency Qualifications: An independent testing agency qualified to perform the testing indicated according to ASTM C1077 & ASTM E329 and retains a current certification through CCRL.
- C. Fabricator Qualifications: A firm that assumes responsibility for drawing and manufacturing architectural precast concrete units that comply with performance requirements. This responsibility includes preparation of Shop Drawings and Comprehensive Engineering Analysis by a qualified professional engineer, if applicable.
1. Precast Producer must be in Good Standing with the APA and operate an APA Certified Plant for the Production of Architectural Precast Concrete Products.

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- D. Design Standards: Comply with ACI 318 and design recommendations of PCI MNL 120, "PCI Design Handbook - Precast and Prestressed Concrete," applicable to types of architectural precast concrete units indicated.
- E. 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."
- F. Welding: Qualify procedures and personnel according to AWS D1.1/D.1.1M, "Structural Welding Code - Steel"; and AWS D1.4, "Structural Welding Code - Reinforcing Steel."
- G. Mock-Up Sample Panel(s): After sample approval and before fabricating architectural precast concrete units, produce mock-up piece(s) for review by Design Team. Incorporate full-scale details of architectural features, finishes, textures, and transitions in sample panel, as required by the contract documents.
 - 1. Provide panels where indicated or, if not indicated, as directed by Architect.
 - 2. Approved mockups may become part of the completed Work if undamaged at time of Substantial Completion.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents unless such deviations are specifically approved by Architect in writing.
 - 4. If requested, damage part of an exposed-face surface for each finish, color, and texture, and perform a repair to demonstrate expectation of repairs on the project.
 - 5. Demolish and remove sample panels when directed.
- H. Pre-installation Conference: Conduct conference / meeting on site to discuss and confirm compliance with contract documents & project schedule.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver architectural precast concrete units in an organized, prioritized manner at such times to limit unloading requirements and increase efficiency on site.
- B. Support units during shipment on non-staining, shock-absorbing material, when possible.
- C. Palletize & store units with adequate dunnage / bracing and protect units to prevent staining, cracking, distortion, warping or other physical damage or aesthetic defects.
- D. Place stored units so identification marks are clearly visible, so units can be inspected and quantified.
- E. Unload, handle, store and transport units in a position consistent with their shape and design in order to avoid excessive stresses which would cause cracking or damage.
- F. Lift and support units in a manner that minimizes risk of cracking or damage.
- G. Remove steel banding from pallets while being stored, to reduce the risks of rust stains.

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- H. Cover Precast materials during storage to protect from staining & discoloration from weather and construction site debris / activity.

1.8 SEQUENCING

- A. Furnish all precast materials and any loose connection hardware and anchorage items without delaying the Work. Provide locations, setting diagrams, templates, instructions, and directions, as required, for installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Fabricators: Provide Architectural Precast products by one of the following:
 - 1. NORTHERN DESIGN: 51 International Drive Loudon, NH 03307 Ph: 603-783-8989
 - a. Basis of Design
 - 2. APPROVED EQUAL:
 - a. APA Certified Plant who is capable to provide the products required for project at hand.
 - b. Producer to submit product data & qualifications for preliminary approval.
 - c. Producer to provide a list of past projects for Design Team's review.

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. Mold-Release Agent: Commercially produced liquid-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.
- B. Form Liners: If required by contract documents, furnish form liners with manufacturer's recommended liquid-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.
- C. Surface Retarder: Chemical set retarder, capable of temporarily delaying final hardening of newly placed concrete mixture to depth of reveal specified.

2.3 REINFORCING MATERIALS

- A. Recycled Content of Steel Products: Post-consumer recycled content to be no less than 80% and pre-consumer recycled content to be no more than 20% percent.

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- B. Reinforcing Bars: ASTM A615 / A 615M, Grade 60, deformed.
- C. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.
- D. Epoxy Coated Bars: ASTM A615 / A 615M, Grade 60. ASTM A706 / A706M, deformed bars, ASTM A775 / A775M epoxy coated.
- E. Deformed-Steel Welded Wire Reinforcement: ASTM A1064 – 16, flat sheet 4 X 4 W4/W4.
- F. Epoxy-Coated-Steel Wire: WWR Grade 70 - ASTM A1064, flat sheet 4 X 4 W4/W4.
- G. 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 CONCRETE MATERIALS

- A. Portland Cement: ASTM C150, Type I White.
- B. Normal-Weight Aggregates: Except as modified by PCI MNL 117, ASTM C33. Stockpile coarse and fine aggregates from a single source (pit or quarry) for entire Project.
 - 1. Coarse Aggregates: Selected, consistent, hard, and durable; free of material that reacts with cement or causes staining;.
 - a. Size / Gradation: ½” diameter Ledge Rock -- 12.5 mm per ASTM C33
 - 2. Fine Aggregates: Selected, consistent, natural or manufactured sand of same material as coarse aggregate, unless otherwise approved by Architect.
 - a. Concrete Sand per ASTM C33
- C. Coloring Pigments: Provide per ASTM C979, synthetic or natural mineral-oxide pigments.
- D. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of concrete and complying with chemical limits of PCI MNL 117.
- E. Air-Entraining Admixture: ASTM C260, certified by manufacturer to be compatible with other required admixtures.
- F. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and to not contain calcium chloride, or more than 0.15 percent chloride ions or other salts by weight of admixture. Include product data for all admixtures that will be included in proposed mix design:
 - 1. Water-Reducing Admixtures: 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.

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6. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
7. Plasticizing Admixture: ASTM C 1017/C 1017M, Type I.
8. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
9. Corrosion Inhibiting Admixture: ASTM C 1582/C 1582M.

2.5 STEEL CONNECTION MATERIALS

- A. Carbon-Steel Shapes and Plates: ASTM A 36/A 36M.
- B. Carbon-Steel-Headed Studs: ASTM A 108, AISI 1018 through AISI 1020, cold finished, AWS D1.1/D1.1M, 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.
- 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.
- 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.
- J. Carbon-Steel Bolts and Studs: ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); carbon-steel, hex-head bolts and studs; carbon-steel nuts, ASTM A 563 (ASTM A 563M); and flat, unhardened steel washers, ASTM F 844.
- K. High-Strength Bolts and Nuts: ASTM A 325 (ASTM A 325M), Type 1, heavy hex steel structural bolts; heavy hex carbon-steel nuts, ASTM A 563 (ASTM A 563M); and hardened carbon-steel washers, ASTM F 436 (ASTM F 436M).
- L. Zinc-Coated Finish: For exterior steel items and items indicated for galvanizing, apply zinc coating by hot-dip process, according to ASTM A 123/A 123M or ASTM A 153/A 153M.
 1. For steel shapes, plates, and tubing to be galvanized, limit silicon content of steel to less than 0.03 percent or to between 0.15 and 0.25 percent or limit sum of silicon and 2.5 times phosphorous content to 0.09 percent.
 2. Galvanizing Repair Paint: High-zinc-dust-content paint with dry film containing not less than 94 percent zinc dust by weight, and complying with DOD-P-21035A or SSPC-Paint 20.
- M. 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.
- N. Welding Electrodes: Comply with AWS standards.

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2.6 STAINLESS-STEEL CONNECTION MATERIALS

- 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 antiseize thread lubricant during assembly.
- C. Stainless-Steel-Headed Studs: ASTM A 276, with minimum mechanical properties of PCI MNL 117, Table 3.2.3.

2.7 BEARING PADS

- A. Installer to provide bearing pads, as required by the shop drawings & engineered connections.
 - 1. Elastomeric Pads: AASHTO M 251, plain, vulcanized, 100 percent polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet, Type A durometer hardness of 50 to 70, ASTM D 2240, minimum tensile strength 2250 psi (15.5 MPa), ASTM D 412.
 - 2. Random-Oriented, Fiber-Reinforced Elastomeric Pads: Preformed, randomly oriented synthetic fibers set in elastomer. Type A durometer hardness of 70 to 90, 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 pad. Test one specimen for every 200 pads used in Project.
 - 3. Cotton-Duck-Fabric-Reinforced Elastomeric Pads: Preformed, horizontally layered cotton-duck fabric bonded to an elastomer; Type A durometer hardness of 80 to 100, ASTM D 2240; complying with AASHTO's "AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, Division II, Section 18.10.2, or with MIL-C-882E.
 - 4. Frictionless Pads: Tetrafluoroethylene (Teflon), glass-fiber reinforced, bonded to stainless or mild-steel plate, of type required for in-service stress.
 - 5. High-Density Plastic: Multimonomer, nonleaching, plastic strip.

2.8 ACCESSORIES

- A. Precast Accessories: Installer to provide strap anchors, screws, pins, clips, bolts, nuts, hangers, plastic shims and all other accessories required to install architectural precast concrete units.

2.9 GROUT MATERIALS

- 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 parts sand, by volume, with minimum water required for placement and hydration.
- B. Nonmetallic, Nonshrink Grout: Premixed, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, plasticizing

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and water-reducing agents, complying with ASTM C 1107, Grade A for drypack and Grades B and C for flowable grout and of 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 CONCRETE MIXTURES

- A. Prepare mix designs for each precast concrete color / sample required.
- B. Design mixtures to be prepared by APA Batch Plant Operator who is actively employed at architectural precast concrete fabricator's APA Certified facility.
- C. Limit water-soluble chloride ions to maximum percentage by weight of cement permitted by ACI 318 or PCI MNL 117 when tested according to ASTM C 1218/C 1218M.
- D. Normal-Weight Concrete Mixtures: Proportions confirmed by either laboratory trial batch or field test data methods according to ACI 211.1, with materials to be used on Project, to provide normal-weight concrete with the following properties:
 - 1. Compressive Strength (28 Days): 5000 psi (34.5 MPa) minimum.
 - 2. Maximum Water-Cementitious Materials Ratio: 0.45.
- E. Water Absorption: 6 percent by weight or 14 percent by volume, tested according to PCI MNL 117.
- F. 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.
- G. When included in design mixtures, add other admixtures to concrete mixtures according to manufacturer's written instructions.

2.11 MOLD FABRICATION

- A. Molds: Accurately construct molds, water tight, of sufficient strength to withstand pressures due to concrete-placement operations, material weight and temperature changes. Coat contact surfaces of molds with release agent before reinforcement is placed. Avoid contamination of reinforcement by release agent.
 - 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.

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2. Edge and Corner Treatment: Uniformly sealed, chamfered or radiused, as required by Contract Documents.

2.12 FABRICATION

- 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."
- B. Installer to furnish loose hardware items including steel plates, clip angles, seat angles, strap anchors, dowels, cramps, hangers, and other hardware shapes for securing architectural precast concrete units to supporting and adjacent construction.
- C. Cast-in reglets, slots, pin pockets, voids, and any other accessories in the architectural precast concrete units, as indicated on the Contract Drawings.
- D. Reinforcement: Comply with recommendations in PCI MNL 117 for fabricating, 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 reinforcement to maintain at least 3/4-inch (19-mm) minimum coverage. 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. Place reinforcing steel to maintain at least 3/4-inch (19-mm) minimum concrete cover. Increase cover requirements for reinforcing steel to 1-1/2 inches (38 mm) when units are exposed to corrosive environment or severe exposure conditions. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position while placing concrete, if necessary. Direct wire tie ends away from finished, exposed concrete surfaces.
 5. Install welded wire fabric in lengths as long as practical. 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.
- E. Reinforce architectural precast concrete units to resist handling, transportation, and erection stresses.
- F. 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.

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- G. Place face mixture to a minimum thickness after consolidation of the greater of 1 inch (25 mm) or 1.5 times the maximum aggregate size, but not less than the minimum reinforcing cover specified.
- H. Place concrete in a continuous operation to prevent seams or planes of weakness from forming in precast concrete units.
 - 1. Place backup concrete mixture to ensure bond with face-mixture concrete.
- I. Thoroughly consolidate placed concrete by internal and external vibration without dislocating or damaging reinforcement and built-in items, and minimize pour lines, honeycombing, or entrapped air on surfaces. Use equipment and procedures complying with PCI MNL 117.
 - 1. Place self-consolidating concrete without vibration according to PCI TR-6, "Interim Guidelines for the Use of Self-Consolidating Concrete in Precast/Prestressed Concrete Institute Member Plants."
- J. Comply with PCI MNL 117 for hot- and cold-weather concrete placement.
- K. 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.
- L. 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 compressive strength is high enough to ensure that stripping does not have an effect on performance or appearance of final product.
- M. Discard and replace architectural precast concrete units that do not comply with requirements, including structural, manufacturing tolerance, and appearance, unless repairs meet requirements in PCI MNL 117 and Architect's approval.

2.13 FABRICATION TOLERANCES

- A. Fabricate architectural precast concrete units straight and true to size and shape with exposed edges and corners precise and true so each finished panel complies with PCI MNL 117 product tolerances as well as position tolerances for cast-in items.
- B. Fabricate architectural precast concrete units straight and true to size and shape with exposed edges and corners precise and true so each finished panel complies with the following product tolerances:
 - 1. Overall Height and Width of Units, Measured at the Face Exposed to View: As follows:
 - a. 10 feet (3 m) or under, plus or minus 1/8 inch (3 mm).
 - b. 10 to 20 feet (3 to 6 m), plus 1/8 inch (3 mm), minus 3/16 inch (5 mm).
 - c. 20 to 40 feet (6 to 12 m), plus or minus 1/4 inch (6 mm).

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2. Overall Height and Width of Units, Measured at the Face Not Exposed to View: As follows:
 - a. 10 feet (3 m) or under, plus or minus 1/4 inch (6 mm).
 - b. 10 to 20 feet (3 to 6 m), plus 1/4 inch (6 mm), minus 3/8 inch (10 mm).
 - c. 20 to 40 feet (6 to 12 m), plus or minus 3/8 inch (10 mm).
 3. Total Thickness or Flange Thickness: Plus 1/4 inch (6 mm), minus 1/8 inch (3 mm).
 4. Rib Thickness: Plus or minus 1/8 inch (3 mm).
 5. Rib to Edge of Flange: Plus or minus 1/8 inch (3 mm).
 6. Distance between Ribs: Plus or minus 1/8 inch (3 mm).
 7. Variation from Square or Designated Skew (Difference in Length of the Two Diagonal Measurements): Plus or minus 1/8 inch per 72 inches (3 mm per 1830 mm) or 1/2 inch (13 mm) total, whichever is greater.
 8. Length and Width of Block-outs and Openings within One Unit: Plus or minus 1/4 inch (6 mm).
 9. Location and Dimension of Block-outs Hidden from View and Used for HVAC and Utility Penetrations: Plus or minus 3/4 inch (19 mm).
 10. Dimensions of Haunches: Plus or minus 1/4 inch (6 mm).
 11. Haunch Bearing Surface Deviation from Specified Plane: Plus or minus 1/8 inch (3 mm).
 12. Difference in Relative Position of Adjacent Haunch Bearing Surfaces from Specified Relative Position: Plus or minus 1/4 inch (6 mm).
 13. Bowing: Plus or minus L/360, maximum 1 inch (25 mm).
 14. Local Smoothness: 1/4 inch per 10 feet (6 mm per 3 m).
 15. Warping: 1/16 inch per 12 inches (1.5 mm per 300 mm) of distance from nearest adjacent corner.
 16. Tipping and Flushness of Plates: Plus or minus 1/4 inch (6 mm).
 17. Dimensions of Architectural Features and Rustications: Plus or minus 1/8 inch (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 inch (25 mm).
 2. Inserts: Plus or minus 1/2 inch (13 mm).
 3. Handling Devices: Plus or minus 3 inches (75 mm).
 4. Reinforcing Steel and Welded Wire Fabric: Plus or minus 1/4 inch (6 mm) where position has structural implications or affects concrete cover; otherwise, plus or minus 1/2 inch (13 mm).
 5. Reinforcing Steel Extending out of Member: Plus or minus 1/2 inch (13 mm) of plan dimensions.
 6. Tendons: Plus or minus 1/4 inch (6 mm), vertical; plus or minus 1 inch (25 mm), horizontal.
 7. Location of Rustication Joints: Plus or minus 1/8 inch (3 mm).
 8. Location of Opening within Panel: Plus or minus 1/4 inch (6 mm).
 9. Location of Flashing Reglets: Plus or minus 1/4 inch (6 mm).
 10. Location of Flashing Reglets at Edge of Panel: Plus or minus 1/8 inch (3 mm).
 11. Reglets for Glazing Gaskets: Plus or minus 1/8 inch (3 mm).
 12. Electrical Outlets, Hose Bibs: Plus or minus 1/2 inch (13 mm).
 13. Location of Bearing Surface from End of Member: Plus or minus 1/4 inch (6 mm).
 14. Allowable Rotation of Plate, Channel Inserts, and Electrical Boxes: 2-degree rotation or 1/4 inch (6 mm) maximum over the full dimension of unit.

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15. Position of Sleeve: Plus or minus 1/2 inch (13 mm).
16. Location of Window Washer Track or Buttons: Plus or minus 1/8 inch (3 mm).

2.14 FINISHES

- A. Standard Finishes: Exposed to view faces shall be free of joint marks, grain, and other obvious defects. All finished faces to be treated in a manner that creates consistency from face to face, piece to piece, day to day. All exposed-to-view surfaces of architectural precast concrete units to match approved sample and mock-up panel, if applicable. Potential design finish required are as follows:
1. Standard Light Etch Finish: Use adequate equipment and application techniques of acid and water to expose aggregate and surrounding matrix surfaces in a consistent manner. Thoroughly clean units from all acid residue.
 2. Exposed-Aggregate Finish – Post-Fabrication: Expose more aggregate by removing cream with sand blasting and acid etching. Provide samples to present different levels of aggregate exposure, limited to:
 - a. Light – Medium Aggregate Exposure
 - b. Medium Aggregate Exposure
 - c. Medium – Heavy Aggregate Exposure
 - d. Heavy Aggregate Exposure
 3. Exposed-Aggregate Finish – Pre-Fabrication: Expose more aggregate by removing cream with chemical retarding agents (applied to molds). Power wash exposed faces to expose aggregate immediately after stripping. Provide consistency with retarder application as well as timing of application, pouring, curing, stripping and washing. Provide samples to present different levels of aggregate exposure, limited to:
 - a. .25 Retarder Level (lighter aggregate exposure)
 - b. .50 Retarder Level (medium aggregate exposure)
 - c. .75 Retarder Level (heavier aggregate exposure)
 4. As-Cast / Form Finish: Post fabrication finishing not provided, surfaces may have air voids, streaks and / or other visual defects.
- B. Specialty Finishes: If Contract Documents refer to the following finishes, manufacturer shall include the added cost of said finish so there's no added cost to the owner.
1. Honed Finish: Use filling and rubbing procedures followed by continuous mechanical abrasion with fine grit until finished surfaces are smooth to the touch.
 2. Polished Finish: Use filling and rubbing procedures followed by continuous mechanical abrasion with fine grit until finished surfaces show sheen and reflect light.
 3. Textured-Surface Finish: Special textures are achieved with form liners within mold, if required by contract documents. This includes bush-hammered, lined, patterns and rock face textures etc.
- C. Finish all exposed surfaces of architectural precast concrete units to create an attractive, consistent appearance.
- D. One face is always troweled. If exposed, that surface must be steel troweled as smooth as possible and finished in a manner that minimizes the visual inconsistency of a trowel finish.
- E. All unexposed surfaces of architectural precast concrete units as “as cast”, no finishing.

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2.15 SOURCE QUALITY CONTROL

- A. Quality-Control Testing: Test and inspect precast concrete according to PCI MNL 117 requirements.
- B. If using self-consolidating concrete, test and inspect according to PCI TR-6, "Interim Guidelines for the Use of Self-Consolidating Concrete in Precast/Prestressed Concrete Institute Member Plants."
- C. Owner reserves the right to employ an 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, 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.
- D. Strength of precast concrete units will be considered deficient if units fail to comply with ACI 318 (ACI 318M) requirements for concrete strength.
- E. Testing: If there is evidence that strength of precast concrete units may be deficient or may not comply with ACI 318 (ACI 318M) requirements, precaster 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 3 cores will be considered satisfactory if average compressive strength is equal to at least 85 percent of 28-day design compressive strength and no single core is less than 75 percent of 28-day design compressive strength.
 - 4. 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. Test results to be on file at the Plant and made available to the Architect, Contractor, EOR and Owner upon request. 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.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Installer to examine supporting structural frame, foundation, back-up, opening sizes and location, bearing surfaces are true and level and any other conditions affecting the ability to install / erect with full compliance to contract documents.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Do not install precast concrete units until supporting cast-in-place building structural framing has attained minimum allowable design compressive strength or supporting steel or other structure is complete.

3.2 INSTALLATION

- A. Install clips, hangers, bearing pads, and other accessories required for connecting architectural precast concrete units to supporting members and backup materials.
- B. Erect architectural precast concrete level, plumb, and square within specified allowable tolerances. Provide temporary supports and bracing as required to maintain position, stability, and alignment as units are being permanently connected.
 - 1. Install temporary steel or plastic spacing shims or bearing pads 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 grout fill voids within recessed lifting devices flush with surface of adjacent precast surfaces when recess is exposed.
 - 4. Unless otherwise indicated, maintain uniform joint widths of 3/8 inch (10 mm).
- C. Connect architectural precast concrete units in position by bolting, welding, grouting, or as otherwise indicated on Shop Drawings. Remove temporary shims, wedges, and spacers as soon as practical after connecting and grouting are completed.
 - 1. Do not permit connections / anchors to disrupt continuity of flashing or jeopardizing the design team's waterproofing design efforts.
- D. Welding: Comply with applicable AWS D1.1/D1.1M and AWS D1.4 for welding, welding electrodes, appearance, quality of welds, and methods used in correcting welding work.
 - 1. Protect architectural precast concrete units and bearing pads from damage by field welding or cutting operations, and provide noncombustible shields as required.
 - 2. Welds not specified shall be continuous fillet welds, using no less than the minimum fillet as specified by AWS.
 - 3. Clean weld-affected metal surfaces with chipping hammer followed by brushing, and apply a minimum 4.0-mil- (0.1-mm-) thick coat of galvanized repair paint to galvanized surfaces according to ASTM A 780.

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4. Clean weld-affected metal surfaces with chipping hammer followed by brushing, and re-prime damaged painted surfaces.
 5. Remove, re-weld, or repair incomplete and defective welds.
- E. 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, verify 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 percent of bolts at random by calibrated torque wrench.
- F. Grouting Connections: Grout connections where required or indicated. Retain grout in place until hard enough to support itself. Pack spaces with stiff grout material, tamping until voids are completely filled. Place grout to finish smooth, level, and plumb with adjacent concrete surfaces. Keep grouted joints damp for not less than 24 hours after initial set. Promptly remove grout material from exposed surfaces before it affects finishes or hardens.

3.3 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.
- 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 inch (13 mm).
 2. Plan Location from Centerline of Steel: Plus or minus 1/2 inch (13 mm).
 3. Top Elevation from Nominal Top Elevation: As follows:
 - a. Exposed Individual Panel: Plus or minus 1/4 inch (6 mm).
 - b. Non-Exposed Individual Panel: Plus or minus 1/2 inch (13 mm).
 - c. Exposed Panel Relative to Adjacent Panel: 1/4 inch (6 mm).
 - d. Non-Exposed Panel Relative to Adjacent Panel: 1/2 inch (13 mm).
 4. Support Elevation from Nominal Support Elevation: As follows:
 - a. Maximum Low: 1/2 inch (13 mm).
 - b. Maximum High: 1/4 inch (6 mm).
 5. Maximum Plumb Variation over the Lesser of Height of Structure or 100 Feet (30 m): 1 inch (25 mm).
 6. Plumb in Any 10 Feet (3 m) of Element Height: 1/4 inch (6 mm).
 7. Maximum Jog in Alignment of Matching Edges: 1/4 inch (6 mm).
 8. Joint Width (Governs over Joint Taper): Plus or minus 1/4 inch (6 mm).
 9. Maximum Joint Taper: 3/8 inch (10 mm).
 10. Joint Taper in 10 Feet (3 m): 1/4 inch (6 mm).
 11. Maximum Jog in Alignment of Matching Faces: 1/4 inch (6 mm).
 12. Differential Bowing or Camber, as Erected, between Adjacent Members of Same Design: 1/4 inch (6 mm).

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13. Opening Height between Spandrels: Plus or minus 1/4 inch (6 mm).

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: Owner may choose to engage a qualified special inspector to perform the following special inspections and prepare reports:
1. Accurate erection of precast concrete members.
 2. Validate anchoring materials & execution.
- B. Testing Agency: Owner may choose to engage a qualified testing agency to perform tests, inspections and prepare reports.
- C. Field welds will be subject to visual inspections and nondestructive testing according to ASTM E 165 or ASTM E 709. High-strength bolted connections will be subject to inspections.
- D. Testing agency will report test results promptly and in writing to Contractor and Architect.
- E. Repair or remove and replace work where tests and inspections indicate that it does not comply with specified requirements.
- F. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.5 REPAIRS

- A. Repair architectural precast concrete in a durable manner that minimizes the visual impact of said damage. The Architect reserves the right to reject repairs that do not comply with requirements.
- B. Mix patching materials and repair units so cured patches blend with color, texture, and uniformity of adjacent exposed surfaces and show no apparent line of demarcation between original and repaired work, when viewed in typical daylight illumination from a distance of 20 feet (6 m).
- C. Prepare and repair damaged galvanized coatings with galvanizing repair paint according to ASTM A 780.
- D. Wire brush, clean, and paint damaged prime-painted components with same type of shop primer.
- E. Remove and replace damaged architectural precast concrete units when repairs do not comply with requirements.

3.6 CLEANING

- A. Clean surfaces of precast concrete units exposed to view.

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- B. Clean mortar, plaster, fireproofing, weld slag, and 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, other markings, dirt, and stains.
 - 1. Perform cleaning procedures according to precast concrete fabricator's recommendations. Clean soiled precast concrete surfaces with detergent and a hot power wash. Always use a fanned spray, no stream power washing that can leave a line on the finished product.
 - 2. Use a stiff fiber brush and / or sponge with clean water, if necessary. Protect other work from staining or damage due to cleaning operations.
 - 3. Use a masonry cleaning detergent with water, if necessary. Rinse heavily and continuously in order to avoid changing the finish of the finished product.

3.7 SEALERS

- A. Seal product after cleaning to protect precast products and slow down the effects of weathering:
 - 1. Installer to ensure that all product / entire precast concrete assembly is clean and consistent.
 - 2. Apply consistently throughout using a spray bottle or brush on technique.
 - 3. Use a penetrating sealer that is 100% Silane and does not effect color or appearance of the stone:
 - a. Recommended Sealer: BASF MasterProtect H 1000

END OF SECTION 03450