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**GUIDE SPECIFICATION
FOR
STRUCTURAL PRECAST CONCRETE AND STRUCTURAL PRECAST
CONCRETE WITH COMMERCIAL ARCHITECTURAL FINISH (CA)**

This Guide Specification is intended for the use of professional personnel competent to evaluate the significance and limitations of its contents, and who will accept responsibility for the application of the material it contains. It is to be used as a basis for the development of an office master specification or in the preparation of 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 appropriate requirements. Coordinate the specifications with the information shown on the contract drawings to avoid duplication or conflicts.
These guide specifications are subject to change without notice.

Highlighted portions are Notes to the Specification Writer.

**SECTION 034100
STRUCTURAL PRECAST CONCRETE AND STRUCTURAL PRECAST CONCRETE WITH
COMMERCIAL ARCHITECTURAL FINISH (CA)**

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 structural 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 structural precast concrete work shown on the Contract Drawings.

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

B. This Section includes the following:

1. Beams, columns, double tees.
2. Walls.
3. Spandrels.
4. Insulated, precast concrete units.
5. **<Insert other applicable members>**

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, shall also apply to the extent required for proper performance of this work. Some items such as precast, prestressed wall panels could be included in either this section or the section "Architectural Precast Concrete," depending on the desired finish and tolerance expectation.

1. Division 03 Section "NiCore™ Plank (Hollow-core slabs)".
2. Division 03 Section "Architectural Precast Concrete."
3. Division 03 Section "Cast-in-Place Concrete" for installing connection anchors in concrete and structural topping.
4. Division 03 Section "Precast Post-Tensioned Concrete" for connecting precast units.
5. Division 03 Section "Cementitious Floor Underlayment" for floor and roof deck fill.
6. Division 04 Section "Unit Masonry Assemblies" for inserts or anchorages required for slab connections.
7. Division 05 Section "Structural Steel Framing" for structural steel framing and for furnishing and installing connections attached to structural-steel framing.
8. Division 05 Section "Metal Fabrications" for furnishing and installing loose hardware items.
9. Division 07 Section "Through Penetration Firestopping Systems" for joint filler materials for fire-resistance-rated construction.
10. Division 07 Section "Water Repellents" for water-repellent finish treatments.
11. Division 07 Section "Sheet Metal Flashing and Trim" for flashing receivers and reglets.
12. Division 07 Section "Joint Sealants" for elastomeric joint sealants and sealant backings between slab edges at exposed underside of floor and roof members and/or perimeter of members.
13. Division 07 Section "Roof and Deck Insulation" for insulation to meet energy code.
14. Division 09 Section "Carpet and Carpet Cushion" for covering on flooring members.
15. Division 09 Section "Exterior Paints."

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 structural precast concrete color, finish and texture, preapproved by Architect.

1.4 PERFORMANCE REQUIREMENTS

Retain this Article and applicable subparagraphs below if delegating design responsibility for

structural precast concrete members to contractor. AIA Document A201 requires Owner or Architect to specify performance and design criteria. Revise requirements below to suit Project, and add other performance and design criteria, if applicable.

- A. Structural Performance: Provide structural precast concrete members and connections capable of withstanding the following design loads within limits and under conditions indicated:

For members that are to receive concrete topping, state whether all superimposed dead and Live loads on structural precast concrete members do or do not include the weight of the concrete topping. It is best to list the live load, superimposed dead load, topping weight, and weight of the member, all as separate loads. Where there are two different live loads (e.g., roof level of a parking structure) indicate how they are to be combined. Show hanging utility support loads in addition to loads indicated on drawings.

Most precast, prestressed concrete is cast in continuous steel forms. Therefore, connection devices on the formed surfaces must be contained within the member since penetration of the form is impractical.

Camber will generally occur in prestressed concrete members due to eccentricity of the stressing force. If camber considerations are important, check with local prestressed concrete fabricator to secure estimates of the amount of camber and of camber movement with time and temperature change.

Design details must recognize the existence of camber and camber movement in connection with:

1. Closures to interior non-load bearing partitions.
2. Closures parallel to prestressed concrete members (whether masonry, windows, curtain walls or others) must be properly detailed for camber.
3. Floor slabs receiving cast-in-place topping. The elevation of top of floor and amount of concrete topping must allow for camber of precast, prestressed concrete members. Specifications must not be written for prestressed concrete members to be flat under their self-weight.

1. Dead Loads: **<Insert applicable dead loads>**
2. Live Loads: **<Insert applicable live loads>**
3. Concrete Topping Thickness: **<Insert applicable thickness>**
4. Basic Ground Snow Load & Flat Roof Snow Load: **<Insert applicable snow loads>**
5. Wind Loads: **<Insert applicable wind loads>**
6. Seismic Loads: **<Insert applicable seismic loads>**

Precast concrete specific load may include blast loads.

7. Project Specific Loads: **<Insert applicable loads.>**

Indicate locations here or on Drawings if different movements are anticipated for different building elements. If deflection limits stricter than ACI 318 are required, the limits must be specified.

- B. Design framing system and connections to maintain clearances at openings, to allow for fabrication and construction tolerances, to accommodate live-load deflection, shrinkage and creep of primary building structure, and other building movements. Member deflections shall meet the limits of ACI 318.

Differential values in first subparagraph below are applicable to members exposed to the sun on one face. Insert the temperature range to suit local conditions. Temperature data is available from National Oceanic and Atmospheric Administration at www.ncdc.noaa.gov.

C. Thermal Movements: Provide for thermal movements noted.

1. The precast system design shall consider the maximum seasonal climatic temperature change.
2. In-plane thermal movements of individual members directly exposed to the sun shall consider a temperature range of **<Insert temperature range>**.
3. Member and connection design shall consider through thickness thermal gradients as appropriate.

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.

D. Fire Resistance Rating: The fire resistance rating for the structural precast concrete members is calculated by IBC code-compliant rational means in lieu of U.L. testing and labels. Fire proofing of joints and annular spaces at penetrations is by a different trade contractor. Provide components to meet the following fire ratings:

1. Roof: **<Insert rating>**
2. Floors: **<Insert rating>**
3. Columns: **<Insert rating>**
4. Exterior Walls: **<Insert rating>**
5. **<Insert additional elements or special occupancy separations>**

Retain subparagraph below only if stone veneer-faced precast concrete are used on project.

E. 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 members are not used in parking structure to resist impact load. Local codes may have requirements that vary from those listed.

F. Vehicular Impact Loads: Design spandrel beams acting as vehicular barriers for passenger cars to resist a single load of **6,000 lb <Insert load>** service 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 and 27 in above the floor or ramp surface on an area not to exceed 1 ft².

1.5 SUBMITTALS

A. Product Data: For each type of structural precast concrete product indicated. Retain quality control records and certificates of compliance for 5 years or period of warranty, whichever is greater.

B. LEED Submittals

Retain subparagraph below if recycled content is required for LEED. Use products that meet at least 25% by cost of the total value of permanent building products on the project. Recycled content is the sum of post-consumer plus one-half of the pre-consumer recycled contents, based on cost. Products meeting recycled content are valued at 100% of their

cost for the purpose of credit achievement calculation. Furthermore, products sourced (extracted, manufactured, and purchased) within 100 miles of the project site are valued at 200% of their base contributing cost. For credit achievement calculation, the base contributing cost of individual products compliant with multiple responsible extraction criteria is not permitted to exceed 100% of its total cost (before regional multipliers) and double counting of single product components compliant with multiple responsible extraction criteria is not permitted and in no case is a product permitted to contribute more than 200% of its total actual cost. Structure and enclosure materials may not constitute more than 30% of the value of compliant building products.

An alternative method of complying with the recycled content credit is to retain requirement in Division 01 SECTION "Sustainable Design Requirements" that gives the Contractor the option and responsibility for determining how requirements will be met.

1. Submit documentation conforming with LEED BD+C: New Construction v4 dated July 1, 2015 for the MR Credit: Building Product Disclosure and Optimization - Sourcing of Raw Materials, Option 2 (leadership extraction practices).
 - a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product based on availability of materials such as fly ash.
 - 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.
 - e. Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
 - f. Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
 - g. Indicate dollar value of product containing local/regional materials; include materials cost only.
 - h. 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 bio-based 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 structural precast concrete product mixture. Include compressive strength and water-absorption tests, if required.

- D. Shop (Erection) Drawings: Detail fabrication and installation of structural precast concrete members. Indicate member locations, plan views, elevations, dimensions, shapes, cross sections, openings, extent and location of each finish, connections, edge conditions, support conditions, types of reinforcement, including special reinforcement, and sequence of completing connections.

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, lifting and erection inserts, connections, and joints.
 3. Indicate locations, tolerances and details of anchorage devices to be embedded in or attached to structure or other construction.
 4. Indicate plan views and/or elevations showing member locations with all openings 10" x 10" or larger shown and located. Where additional structural support is required for openings include header design.
 5. Coordinate and indicate openings and inserts required by other trades.
 6. Indicate location of each structural precast concrete member by same identification mark placed on unit.
 7. Indicate relationship of structural precast concrete members to adjacent materials.
 8. Indicate locations and details of thin, half and full brick units and joint treatment.
 9. Indicate locations and details of stone veneer-facings, stone anchors, and joint widths.
 10. Indicate areas receiving toppings and magnitude of topping thickness.
 11. Indicate estimated cambers for structural precast concrete receiving cast-in-place topping.
 12. Indicate shim sizes and grouting sequence.
 13. 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 affect the appearance, durability or strength of members when modifying details or materials. Maintain the general design concept when altering size of members and alignment.
- E. Provide handling procedures and erection sequences/bracing plans for special conditions.
- F. Comprehensive engineering design (signed and sealed) by a licensed design professional responsible for its preparation licensed in the jurisdiction in which the project is located.

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

- G. Samples: Design reference samples for initial verification of design intent, approximately 12" x 12" x 2" representative of finishes, colors, and textures of exposed surfaces of structural precast concrete members.
1. When back face of structural precast concrete member is to be exposed, include Samples illustrating workmanship, color, and texture of the concrete.

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

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

Retain subparagraph below if thin or half brick facings are used and joints are grouted.

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

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

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

Fabricator should have a minimum of 2 years of production experience in structural 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.

- I. 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, engineers and owners, and other information specified.

Delete test reports below if not required.

- J. Material Test Reports: Reports on the following, for compliance with requirements indicated upon request.

Retain paragraph above or below.

- K. Material Certificates: Material certificates signed by manufacturers or suppliers upon request certifying that each of the following items complies with requirements.

Retain list below with either paragraph above. Edit to suit Project.

1. Cementitious materials.
2. Concrete aggregates.
3. Reinforcing materials and prestressing strands.
4. Admixtures.
5. Bearing pads.
6. Structural-steel shapes and hollow structural sections.
7. Insulation.
8. Clay product units and accessories.
9. Stone anchors.

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

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

1.6 QUALITY ASSURANCE

Erector should have a minimum of 2 years of experience in structural 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- Certified Erectors.

- A. 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 S1 (Simple Structural Systems) for horizontal decking members and single-lift wall panels] (Category S2) [Complex Structural Systems] for load-bearing members).**

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

- B. 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. Submits Erectors' Post Audit Declaration.
- C. Fabricator Qualifications: A firm that complies with the following requirements and is experienced in producing structural precast concrete units similar to those indicated for this Project and with a record of successful in-service performance.
1. Assumes responsibility for engineering structural precast concrete units to comply with performance requirements. This responsibility includes preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.
 2. Professional Engineer Qualifications: A professional engineer licensed in 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 structural precast concrete that are similar to those indicated for this Project in material, design, and extent.

Affix the suffix A to the product group and category, e.g., C3A, if the structural product requires The application of an architectural finish produced by a fabricator with special architectural qualifications. Structural precast members must meet the requirements of PCI Manual, MNL-116. These members should not be expected to meet the requirements of MNL-117 for architectural precast concrete products. However, the structural members may have the application of architectural finishes included in the provisions of MNL-116. Fabricators that have certified architectural qualifications to apply these finishes have the suffix A added to their certification listing.

4. Participates in PCI's Plant Certification program **[at the time of bidding]** and is designated a PCI-certified plant for Group C or CA, Category **[C1 or C1A – Precast Concrete Products (no prestressed reinforcement)] [C2 or C2A – Prestressed Hollow-Core and Repetitive Products] [C3 or C3A – Prestressed Straight-Strand Structural Members] [C4 or C4A - Prestressed Deflected-Strand Structural Members]**
5. Has sufficient production capacity to produce required members 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.

6. 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.

- D. 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.
- E. Design Standards: Comply with ACI 318 and the design recommendations of PCI MNL 120, "PCI Design Handbook – Precast and Prestressed Concrete," applicable to types of structural precast concrete members indicated.
- F. Quality-Control Standard: For manufacturing procedures and testing requirements and quality control recommendations for types of members required, comply with PCI MNL 116, "Manual for Quality Control for Plants and Production of Structural Concrete Products."
 1. Comply with camber and dimensional tolerances of PCI MNL 135, "Tolerance Manual for Precast and Prestressed Concrete Construction."

Retain paragraph below to allow drawing details based on one fabricator's product to establish requirements. Exact cross section of precast, prestressed concrete members may vary from Producer to producer. Revise below to identify specific proprietary system or indicate on Drawings. Correlate with Division 1 requirements.

- G. Product Options: Drawings indicate size, profiles and dimensional requirements of structural precast concrete members and are based on the specific types of members indicated. Other fabricators' structural precast concrete members complying with requirements may be considered. Refer to Division 1 Section "Substitutions."
- H. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code – Steel"; and AWS D1.4, "Structural Welding Code – Reinforcing Steel."
- I. Fire Resistance: Where indicated, provide structural precast concrete members 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,"

PCI recommends review of preproduction sample units for CA structural precast concrete members to establish the range of acceptable finish, color, and texture to be expected.

- J. Sample Units: After sample approval and before fabricating CA structural precast concrete members, produce mock-up units to establish the approved range of selections made under sample Submittals. Produce a minimum of six (6) sample units approximately 4' x 5' and incorporating full scale details of architectural features to demonstrate the expected range of finish, color, and texture variations.
 1. Locate units where indicated in Contract Documents 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 repairs of surface blemishes.

3. After acceptance of repair technique, maintain three (3) sample units at the manufacturer's plant in an undisturbed condition as a standard for judging the completed Work.
4. Demolish and remove sample units when directed.

1.7 PRODUCT STORAGE, DELIVERY AND HANDLING

- A. Store structural precast concrete members with adequate dunnage and bracing, and protect units to prevent contact with soil, to prevent staining, and to control cracking, distortion, warping or other physical damage.
- B. Unless otherwise specified or shown on Shop Drawings, store structural precast concrete members with dunnage across full width of each bearing point.
- C. Place stored structural precast concrete members so identification marks are clearly visible, and units can be inspected.
- D. Place dunnage of even thickness between each structural precast concrete member.
- E. Deliver all structural precast concrete members in such quantities and at such times to assure compliance with the agreed upon project schedule and setting sequence to ensure continuity of installation.
- F. Handle and transport structural precast concrete members in a position consistent with their shape and design in order to avoid excessive stresses that could cause cracking or other damage.
- G. Lift and support structural precast concrete members only at designated points indicated on the 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 depends on type of structure and varies with local practice. Clearly specify responsibility for supply and installation of hardware. If not supplied by precast concrete fabricator, 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 members for use by other trades are specified or detailed in Contract Drawings and furnished to fabricator, 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

- A. Fabricators: Subject to compliance with requirements, provide products by Nitterhouse Concrete Products, Inc. in Chambersburg, PA

2.2 FORM MATERIALS

- A. Formwork: Rigid, dimensionally stable, nonabsorptive 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 finish surfaces.
1. Form-Release Agent: Commercially produced biobased oil form-release agent that will not bond with, stain or affect hardening of precast concrete surfaces and will not impair subsequent surface or joint sealants (if applicable) of structural precast concrete.

Delete 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 if particular form liner is selected.

- 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 the manufacturer's recommended form-release agent that will not bond with, stain, or adversely affect hardening of precast concrete surfaces and will not impair subsequent surface or joint sealants (if applicable) of precast concrete.

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

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

2.3 REINFORCING MATERIALS

Retain first paragraph below only if recycled content is required for LEED. Most of our cement and aggregates are produced locally within a 500-mile radius, and up to 60% of the prestressing strand may be composed of recycled steel for the precast to contribute to LEED participation.

- A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so post-consumer recycled content plus one-half of pre-consumer recycled content is not less than **[25][60] <Insert number>** percent.
- B. Reinforcing Bars: ASTM A 615, Grade 60 deformed.
- C. Low-Alloy-Steel Reinforcing Bars: ASTM A 706 deformed when welded to hardware assemblies.

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, Grade 60 or ASTM A 706 deformed bars, ASTM A 767, 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 for a bendable epoxy coating; retain ASTM A 934 for a non-bendable epoxy coating. ASTM A 775 is to be applied to straight rebars since they have the potential to be cut and bent at a later time. ASTM A 934 may be applied to rebars that are already bent.

- E. Epoxy-Coated Reinforcing Bars: ASTM A 615, Grade 60 or ASTM A 706 deformed bars, ASTM A 775 or ASTM A 934 epoxy coated.
- F. Steel Bar Mats: ASTM A 184 fabricated from ASTM A 615, Grade 60 or ASTM A 706 deformed bars, assembled with clips.
- 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, flat sheet.
- I. Epoxy-Coated-Steel Welded Wire Reinforcement: ASTM A 884 Class A coated, [plain] [deformed], flat sheet, Type (1 bendable coating) (2 non-bendable coating).
- J. Supports: Use bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place according to PCI MNL 116.

2.4 PRESTRESSING STRANDS

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

- A. Prestressing Strand: ASTM A 416, Grade 270, uncoated, 7-wire, low-relaxation strand.
- B. Unbonded Post-Tensioning Strand: ASTM A 416, Grade 270, 7-wire, low-relaxation strand with corrosion inhibitor conforming to ACI 423.7, with polypropylene tendon sheathing. Include anchorage devices.

2.5 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, 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 will have less effect on the final color hue.

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

Delete subparagraph 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 nonexposed backup concrete.

B. Supplementary Cementitious Materials

Prior to selecting mineral or cementitious materials from four subparagraphs below consult local fabricators. 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 (as available): 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.

Revise class of aggregate in paragraph below to suit Project. ASTM C 33 limits deleterious substances in coarse aggregate depending on climate severity and in-service location of concrete. Severe (S) weathering classifications range from Class 1S for protected substructure, beam, and column elements, and floor slabs to be given coverings, to Class 5S for exposed architectural concrete. Moderate (M) weathering classifications similarly range from Classes 1M to 5M. There are two negligible (N) weathering classifications. Class 1N is for slabs subject to abrasion, bridge decks, floors, sidewalks, and pavements; Class 2N is for other concrete. PCI MNL 116 establishes stricter limits on deleterious substances for fine and coarse aggregates.

- C. Normal Weight Aggregates: Except as modified by PCI MNL 116, ASTM C 33, with coarse, non-reactive aggregates complying with **Class [4S] [4M] [5S] [5M]**. Provide and stockpile fine and coarse aggregates for each type of exposed finish from a single source (pit or quarry) for entire 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 paragraph below when architectural requirements dictate that face-mixture be used throughout.

- D. 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 normal weight aggregates are used in the face mixture, lightweight aggregates in the backup mix are not recommended due to bowing potential.

- E. Lightweight Aggregates: Except as modified by PCI MNL 116, ASTM C 330 with absorption less than 11 percent.

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

- F. Coloring Admixture: ASTM C 979, synthetic or natural mineral-oxide pigments or liquid coloring admixtures, temperature stable and non-fading.

- G. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of concrete and complying with chemical limits of PCI MNL 116.

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.

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

- I. 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.

Select one or more chemical admixtures with low levels of volatile organic compounds (VOC) from seven subparagraphs below if chemical admixtures are permitted; limit chemical admixture types if required. Water-reducing admixtures, Types A, E, and D, or a high-range water reducer, Type F, predominate.

1. Water-Reducing Admixture: ASTM C 494, Type A.
2. Retarding Admixture: ASTM C 494, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494, Type G.
6. Plasticizing Admixture for Flowable Concrete: ASTM C 1017.
7. Corrosion Inhibiting Admixture: ASTM C 1582.

2.6 STEEL CONNECTION MATERIALS

- A. Carbon-Steel Shapes and Plates: ASTM A 36
- B. Carbon-Steel Headed Studs: ASTM A 108, Grades 1010 through 1020, cold finished, AWS D1.1, Type A or B, with arc shields and with the minimum mechanical properties of PCI MNL 116, Table 3.2.3.
- C. Carbon-Steel Plate: ASTM A 283, Grade C.
- D. Malleable Iron Castings: ASTM A 47. Grade 32510 or 35028.
- E. Carbon-Steel Castings: ASTM A 27, Grade 60-30 (Grade 415-205).
- F. High-Strength, Low-Alloy Structural Steel: ASTM A 572.

- G. Carbon-Steel Structural Tubing: ASTM A 500, Grade B or C.
- H. Wrought Carbon-Steel Bars: ASTM A 675, Grade 65.
- I. Deformed-Steel Wire or Bar Anchors: ASTM A 496 or ASTM A 706.

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, 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 bolts should not be galvanized.

- K. High-Strength Bolts and Nuts: ASTM A193, Grade B5 or B7, ASTM A 325, or ASTM A 490, Type 1, heavy hex steel structural bolts, heavy hex carbon-steel nuts (ASTM A 563), and hardened carbon-steel washers (ASTM F 436).

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. Select coatings that do not contain toxic chemicals and with less than 250 g/l VOCs.

- 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 exterior steel items and items indicated for galvanizing, apply zinc coating by hot-dip process according to ASTM A 123 after fabrication, or ASTM A 153 as applicable (electrodeposition according to ASTM B 633, SC 3, Type 1).
 - 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 content and 2.5 times phosphorous content to 0.09 percent.
 - 2. Galvanizing Repair Paint: Zinc paint with dry film containing not less than 94 percent zinc dust by weight, and complying with DOD-P-21035A or SSPC-Paint 20.

Retain paragraph below when more protection than a paint finish is required,
but galvanizing is not required.

- N. Galvanizing Paint: Zinc paint with dry film containing not less than 94 percent 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. Use when resistance to staining
merits extra cost in high moisture or corrosive environments.

- A. Stainless-Steel Plate: ASTM A 666, Type 304, Type 316, or Type 201, of grade suitable for application. Exception: Vector Connectors by JVI, Inc. for double tee flange connections are fabricated using Type 201L stainless steel.
- 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 minimum mechanical properties for studs as indicated under MNL 116, 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 for bearing loads and rotation requirements.

- A. Provide one of the following bearing pads for structural precast concrete members [**as recommended by precast fabricator for application**]:
1. Elastomeric Pads: AASHTO M 251, plain, vulcanized, 100 percent polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet, 50 to 70 Shore A durometer according to ASTM D 2240, minimum tensile strength 2250 psi 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 D2240. Capable of supporting a compressive stress of 3000 psi 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: Polytetrafluoroethylene (PTFE), glass-fiber reinforced, bonded to stainless or mild-steel plates, or random-oriented, fiber-reinforced elastomeric pads, of type required for in-service stress.

Plastic pads are widely used with slabs and other lightly loaded members. Compression stress in use is not normally over a few hundred psi and proof testing is not considered necessary. No standard guide specifications are available.

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.

- 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 face opening of slots covered.
- C. Erection Accessories: Provide clips, hangers, high density plastic or steel shims, and other accessories required to install structural precast concrete members.
- D. Welding Electrodes: Comply with AWS standards for steel type and/or alloy being welded.

2.9 GROUT MATERIALS

Add other proprietary grout systems to suit Project. Show locations of each grout here or on Drawings if retaining more than one type. Sand-cement grout in paragraph below is commonly used in keyed joints between solid slab floor and roof members. 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. Typically mix at ratio of 1 part cement to 2 ½ to 3 parts sand, by volume, with minimum water required for placement and hydration. Water-soluble chloride ion content of grout less than 0.06% chloride ion by weight of cement when tested in accordance with ASTM C 1218. Grouting of solid slab topside, butt & end joints with a grout mixture having sufficient consistency to not require end core dams a having a minimum 28-day compressive strength of 3,500 psi. Furthermore, consistency shall be such that joints can be substantially filled, but without seepage over adjacent surfaces. Any grout that seeps from the joint shall be completely removed before it hardens. The ambient temperature must be at least 40°F and rising for the grouting operation. Alternatively, the structural precast needs to be at least 32°F and held above freezing for a minimum of 24 hours. It is permissible to grout in ambient temperatures below 40°F if this is achieved by the general contractor heating the units and blanketing the grouted joints to assure the grout is not subjected to freezing for a 24 hour period, all other weather conditions permitting.

Retain first paragraph below if nonshrink grout is required or if cement-grout shrinkage could cause structural deficiency. For critical installations, field installation procedures should be developed and the manufacturer's instructions should be followed. Non-ferrous grouts with a gypsum base should not be exposed to moisture. Ferrous grouts should not be used where possible staining would be undesirable or where the grout is not confined. Non-shrink grouts are not used in the keyed joints between solid slab or hollow-core floor and roof members.

- B. Nonshrink Grout: Premixed, packaged ferrous and non-ferrous aggregate shrink-resistant grout containing selected silica sands, portland cement, shrinkage-compensating agents, plasticizing 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 with a 30-minute working time. Water-soluble chloride ion content of grout less than 0.06% chloride ion by weight of cement when tested in accordance with ATM C1218.

- C. Epoxy-resin grout: Two-component mineral-filled epoxy-resin: ASTM C 881 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 members. 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 $\frac{1}{2}$ in., nor more than 1 in. thick, with an overall tolerance of plus 0 in, minus $\frac{1}{16}$ in. for any unit dimension 8 in. or less and an overall tolerance of plus 0 in., minus $\frac{3}{32}$ in. or any unit dimension greater than 8 in. measured according to ASTM C 67.
1. Face Size Modular, $2\frac{1}{4}$ in. high by $7\frac{5}{8}$ in. long.
 2. Face Size Norman, $2\frac{1}{4}$ in. high by $11\frac{5}{8}$ in. long.
 3. Face Size Closure Modular, $3\frac{5}{8}$ in. high by $7\frac{5}{8}$ in. long.
 4. Face Size Utility, $3\frac{5}{8}$ in. high by $11\frac{5}{8}$ in. long.

If approving a color range for brick, view 100 square feet 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 $\frac{1}{16}$ in. measured according to ASTM C 67.
10. Warpage: Consistent plane of plus 0 in, minus $\frac{1}{16}$ in.
11. Variation of Shape from Specified Angle: Plus or minus 1 degree.
12. Tensile Bond Strength: Not less than 150 psi 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.
14. Modulus of Rupture: Not less than 250 psi 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 other than flashed or sand-finished units shall withstand 50 cycles of freezing and thawing per ASTM C 67 with no observable difference in applied finish when viewed from 20 ft

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: **<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 ceramic tile units.

B. Glazed and Unglazed Ceramic Tile Units: ANSI A 137.1 **[not less than 3/8 inch]**

1. Body of glazed tile shall have a water absorption of less than 3 percent using ASTM C373.
2. Manufacturer shall warrant materials as frost-resistant.
3. Glazed units shall conform to ASTM C126.

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

D. Setting Systems

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

1. Thin brick and Ceramic Tile Units: **(Dry-Set Mortar: ANSI A118.1 [included in ANSI A 08.1]) (Latex-Portland Cement Mortar: ANSI A 118.4 [included in ANSI A 108.1])**
2. Full Brick Units: Install (Galvanized) (Type 304 stainless steel) dovetail slots in precast concrete: not less than $\frac{3}{16}$ in. thick, felt or fiber filled slots or cover face opening of slots. Attach brick units with wire anchors, ASTM A 82 or B 227, Grade 30HS not less than $\frac{3}{16}$ inch (W2.8) in diameter and hooked on one end and looped through a $\frac{7}{8}$ in. wide, 12-gage steel sheet bent over the wire with dovetail on other 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 structural precast concrete is specified in Division 04 Section "Exterior Stone Cladding."

1. Tolerance of length and width of +0, -1/8 inch.

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

B. Anchors: Stainless steel, ASTM A 666, Type 304 or Type 316, 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 of 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 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 percent solids, sand-filled non-shrinking, non-staining of type, class, and grade to suit application.

E. Bond Breaker: **[Preformed, compressible, resilient, nonstaining, nonwaxing, closed-cell polyethylene foam pad, nonabsorbent to liquid and gas, 1/8 inch thick] (Polyethylene sheet, ASTM D4397, 6 to 10 mil thick).**

2.12 INSULATED PANEL ACCESSORIES

If insulated structural precast concrete members are required, retain one or more of the following insulation paragraphs. State the required thickness for each type of insulation allowed to achieve the desired minimum aged R-value. CFCs, HCFCs and other ozone-depleting substances should not be used or released during manufacture of insulation.

- A. Expanded Polystyrene Board Insulation: ASTM C 578, Type **(XI, 0.70 lb/ft³), (I, 0.90 lb/ft³), (VIII, 1.15 lb/ft³), (II, 1.35 lb/ft³), (IX, 1.80 lb/ft³) (square)(ship-lap)** edges; with thickness of **<Insert dimension>**.
- B. Extruded-Polystyrene Board Insulation: ASTM C 578, Type **(X, 1.30 lb/ft³), (IV, 1.55 lb/ft³), (VI, 1.80 lb/ft³), (VII, 2.20 lb/ft³), (V, 3.00 lb/ft³) (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, or ASTM C 1289 Type **(I, 1.8 lb/ft³), (II, 2.5 lb/ft³), (III, 3.0 lb/ft³)**; square edged; unfaced; with thickness of **<Insert dimension>**.

Select wythe connectors from paragraph below.

- D. Wythe Connectors: **(Glass-fiber in vinyl-ester polymer) (Polypropylene pin) (Stainless-steel pin) (Bent galvanized reinforcing bars) (Galvanized welded wire trusses) (Galvanized bent**

wire connectors) (Epoxy coated carbon fiber grid) (fiberglass truss) manufactured to connect wythes of precast concrete members.

1. If punch-thru wythe connectors are not used, provide holes in insulation for connector placement at least 4 in. and no more than 12 in. from edges of member or openings.

2.13 CONCRETE MIXTURES

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

Delete subparagraph below if fly ash, blast furnace slag, or silica fume are not permitted. Revise percentage to suit Project.

1. Permissible use of fly ash is between 15 to 25 percent replacement of Portland cement by weight as available; ground granulated blast-furnace slag is between 25 to 50 percent of Portland cement by weight; and metakaolin and silica fume is between 5 to 15 percent of Portland cement by weight as available.
- B. Design mixtures may be prepared by a qualified independent testing agency or by qualified precast plant personnel at structural precast concrete fabricator's option.
- C. Limit water-soluble chloride ions to maximum percentage by weight of cement permitted by ACI 318 or PCI MNL 116 when tested in accordance with ASTM C 1218.

Structural precast concrete members may be fabricated with a separate "architectural" face mixture and a "structural" backup mixture. Face and backup mixtures should have similar shrinkage and expansion coefficients. 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, 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 mixes may be available; verify availability with fabricators.

1. Compressive Strength (28 Days): As required by design; 5,000 psi minimum.
2. Release Strength: As required by design; 3,000 psi minimum

A maximum water-cementitious materials ratio of 0.40 to 0.45 is usual for Structural 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.

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.

- E. Lightweight Concrete Backup Mixtures: Proportion mixtures by either laboratory trial batch or field test data methods according to ACI 211, 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): As required by design; 5,000 psi minimum.
2. Release Strength: As required by design; 3,000 psi minimum

Increase or decrease unit weight in subparagraph below to suit Project. Coordinate with lightweight-aggregate supplier and structural precast concrete fabricator.

Lightweight concretes with combinations of lightweight and normalweight aggregate in mixture will usually be heavier than unit weight below.

3. Density (Unit Weight): Calculated equilibrium density of 115 lb/ft.³, ± 5 lb/ft.³ adjust to ± 3 lb./ft.³, when tested in accordance with ASTM C 567.

- 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 116.

- G. When included in design mixtures, add other admixtures to concrete mixtures according to manufacturer's written instructions.

- H. Concrete Mixture Adjustments: Concrete mixture design adjustments may be proposed if Characteristics of materials, Project conditions, weather, test results, or other circumstances warrant.

2.14 FORM FABRICATION

- A. Form: Accurately construct forms, 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 forms 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 forms to provide completed structural precast concrete members of shapes, lines, and dimensions indicated, within fabrication tolerances specified.

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

1. Edge and Corner Treatment: Uniformly **[chamfered]** **[radiused]** or as built-in on standard forms.

2.15 THIN AND HALF BRICK FACINGS

Retain this Article if using thin or half brick facings on structural precast concrete members.

- 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. Securely place brick units face down into form liner pockets and place concrete backing mixture.
- C. Match appearance of sample units.
- 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 inch 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 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 members at the stone/precast concrete interface using the bond breaker as joint filler backer. Do not seal 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 sealant filler and install anchors.
- 2. Fill anchor holes with epoxy filler and install anchors with 1/2 inch long, 60 durometer elastomeric sleeves 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 mil to 10 mil thick polyethylene sheet to prevent bond between back of stone facing and concrete substrate.
- 4. Install 1/8 inch 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 fabricator is to test stone anchors for shear and tension. ASTM E488 is preferred as ASTM C1354 does not include the influence of the precast concrete backup.

- C. Stone Anchor Shear and Tensile Testing: Engage accredited testing laboratory acceptable to 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" x 12" 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 in area and four anchors per unit of less than 12 ft.² in area; and for units larger than 12 ft.² in area, provide anchors spaced not more than 24 in. on center both horizontally and vertically. Locate anchors a minimum of 6 in. from stone edge.

2.17 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. Do not relocate bearing plates in members unless approved by Architect.
1. Weld headed studs and deformed bar anchors used for anchorage according to AWS D1.1 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 structural precast concrete members to supporting and adjacent construction.
- C. Cast-in reglets, slots, and other accessories in structural precast concrete members as indicated on Contract Drawings.

Delete first paragraph below if not applicable or if all openings are clearly detailed. Coordinate with other Specification Sections.

- D. Cast-in openings 10" x 10" or larger. Do not drill or cut openings or prestressing strand without Engineer's approval.

- E. Reinforcement: Comply with recommendations in PCI MNL 116 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, 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. Locate and support reinforcement by metal or plastic chairs, runners, bolsters, spacers, hangers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place according to PCI MNL 116.
 3. Place reinforcing steel and prestressing strands to maintain at least $\frac{3}{4}$ in. minimum concrete cover. Provide cover requirements in accordance with ACI 318 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 structural precast concrete members to resist handling, transportation, and erection stresses, and specified in-place loads, whichever governs.

Delete paragraph and subparagraph below if precast prestressed concrete Members are not required. Option to prestress may be left to fabricator if objective is to aid handling and to control cracking of units during installation.

- G. Prestress strands for structural precast concrete members by either pretensioning or post-tensioning methods. Comply with PCI MNL 116.

Revise release or post-tensioning strength in subparagraph below to an actual compressive strength, if required. A concrete strength in the range of 2,500 psi to 4,000 psi at release does not appreciably affect bond transfer length.

1. Delay detensioning or post-tensioning of precast prestressed concrete members 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 strands by cutting them 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.

Retain the following subparagraph only when appearance of member ends is critical.

4. Recess strand ends and anchorages exposed to view a minimum of 1 inch, fill with non-metallic, non-shrink grout and sack rub surface. Coat or spray inside surfaces of pocket with latex or epoxy bonding agent before installing grout.

Retain the following subparagraph only when exposed to severe environment.

5. Protect strand ends and anchorage exposed to severe environments with bitumastic, zinc-rich, or epoxy paint.
- H. Comply with requirements in PCI MNL 116 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 inch 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 members in which more than one major face (edge) is exposed.
 2. Where only one face of unit is exposed and 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 member.
 - b. Design mixtures for facing and backup; using cement and aggregates for each type as appropriate, for consecutive placement in the form. Use cement and aggregate specified for facing 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 structural precast concrete members.
 1. Place backup concrete to ensure bond with face-mixture concrete.
- K. Thoroughly consolidate placed concrete by 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 116.
 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 116 procedures for hot and cold-weather concrete placement.
- M. Identify pickup points of structural precast concrete members and orientation in structure with permanent markings, complying with markings indicated on Shop Drawings. Imprint or permanently mark the Mark Number and I.D. Number on each precast concrete member on a surface that will not show in finished structure.
- N. Cure concrete, according to requirements in PCI MNL 116, by moisture retention without heat or by accelerated heat curing using radiant heat. Cure members until compressive strength is high enough to ensure that stripping does not have an effect on performance or appearance of final product.

2.18 INSULATED PANEL CASTING

Delete this Article if integrally insulated members are not required.

- A. Cast, screed and consolidate bottom concrete wythe supported by form.
- B. Place insulation boards, abutting edges and ends of adjacent boards. Stagger end joints between rows to minimize cold joints. Stagger joints of insulation layers one-half board apart. Insert wythe connectors through insulation holes, and consolidate concrete around connectors according to connector manufacturer's written instructions.
- C. Ensure bottom wythe or insulation layer are not disturbed after bottom wythe reaches initial set.
- D. Cast and screed top wythe and apply required finish.
- E. Maintain temperature below 150° F in bottom cast concrete wythe.

2.19 FABRICATION TOLERANCES

Usually retain paragraph below unless tolerances for Project deviate from PCI recommendations. PCI MNL 135 product tolerances are standardized throughout the industry. Revise product tolerances if additional costs of more exacting tolerances are justified.

- A. Fabricate structural precast concrete members of shapes, lines and dimensions indicated, so each finished member complies with PCI MNL 135 product tolerances as well as position tolerances for cast-in items.

Note: The fabricated bowing tolerance is not to be confused with thermal/shrinkage out-of-plane deflection resulting from temperature and moisture gradients through the precast member cross section, especially insulated panels.

2.20 FINISHES

- A. Commercial (Structural) Finishes

Select finish from one of four subparagraphs below. If more than one finish is required, Create a finish schedule or describe locations in each precast concrete member article. Finishes below are in ascending order of finish quality and cost. Insert other specific finish requirements to suit Project. Specify the minimum finish grade consistent with a product's application and the intended use of the structure. Consult fabricators regarding the finishes appropriate for various products and cost effectiveness. Coordinate precast concrete finishes with required floor, ceiling, roof, and deck finishes or toppings.

Specify Commercial Grade when the product will not be visible in the completed structure, or when the function of the structure does not require an enhanced surface. This is essentially an "as cast" finish.

1. Commercial Grade: Remove large fins and protrusions and fill large holes. Rub or grind ragged edges. Faces shall be true, well-defined surfaces. Air holes, water marks, and color variations are acceptable. Allowable form joint offsets are limited to 3/16 in.

Specify Standard Grade where products are exposed to view but the function of the structure does not require a special finish. The surface is suitable for an applied textured coating but not necessarily suitable for painting. This is the typical finish grade for all structural members.

2. Standard Grade: Normal plant-run finish produced in forms that impart a smooth finish to concrete. Surface holes smaller than 1/2 inch caused by air bubbles, normal color variations, form joint marks, and minor chips and spalls are acceptable. Fill air holes greater than 1/4 inch in width that occur in high concentration (more than one per 2 in.²). Major or unsightly imperfections, honeycombs, or structural defects are not permitted. Allowable joint offset limited to 1/8 inch.

Specify Grade B Finish on visually exposed structural members such as columns or walls. Grade B Finish definition is primarily for surface finish. Color variations are acceptable.

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

Specify Grade A Finish where surface will be painted (especially with a textured or "sand" paint); however, some surface blemishes will be visible. If a surface with fewer imperfections than allowed for "Grade A" is needed, specify the requirements as a "special finish." Specify a sample panel for a Grade A Finish. Requirements for Grade A Finish are not applicable to extruded products using zero-slump concrete in their process.

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

Specify the extent to which float or trowel marks, variations of texture, or other surface blemishes will be permitted. Require samples to establish acceptance criteria for any exposed finish. Revise finish below to light-broom or as-cast finish if float finish is unnecessary, or upgrade to smooth, steel-trowel finish.

- B Screed or float finish unformed surfaces. Strike off and consolidate concrete with vibrating screeds to a uniform finish, float finish, if required. Hand screed at projections. Normal color variations, minor indentations, minor chips, and spalls are permitted. No major imperfections, honeycombing, or defects are permitted.

Retain paragraph above or below. Screed or float finish above is standard; Smooth steel-trowel finish below may also be achieved.

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

If composite topping is required, retain subparagraph below.

D. Apply broom-roughened surface finish in accordance with ACI 318 to structural precast concrete members that will receive concrete topping after installation.

E. Commercial (Structural) Architectural (CA) Finishes

1. Exposed faces shall be free of joint marks, grain, or other obvious defects. Corners, including false joints shall be uniform and straight. Finish exposed-face surfaces of structural precast concrete members 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 manufacturers, coordinate with "Fabricators" Article. Revise if multiple samples are approved.

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

Select type of architectural finish from subparagraphs below for CA units. Indicate on Drawings which members require special finish. 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 116 for more information on special finishes. Review sample of special finishes prior to bidding.

- b. As-Cast Surface Finish: Provide surfaces to match accepted sample or mockup units for acceptable surface air voids, sand streaks, and honeycombs.
- c. Textured-Surface Finish: Impart texture by form liners to match accepted sample or mockup units for acceptable surface air voids, streaks, and honeycombs, with uniform color and texture.
- d. Bushhammer Finish: Use power or hand tools to remove matrix and fracture coarse aggregates to match accepted sample or mockup units.
- e. Exposed Aggregate Finish: Use chemical retarding agents applied to forms and washing and brushing procedures, to expose aggregate and surrounding matrix surfaces after form removal to match accepted sample or mockup units.
- f. Abrasive-Blast Finish: Use abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces to match accepted sample or mockup units.
- g. Acid-Etched Finish: Use acid and hot-water solution, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces to match accepted sample or mockup units. Protect hardware, connections and insulation from acid attack.
- h. Honed Finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures to match accepted sample or mockup units.
- i. Polished Finish: Use continuous mechanical abrasion with fine grit, followed by filling and rubbing procedures to match accepted sample or mockup units.
- j. Sand-Embedment Finish: Use selected stones placed in a sand bed in bottom of form, with sand removed after curing to match accepted sample or mockup units.
- k. Thin Brick Facings: Refer to "Thin Brick Facings" Article.
- l. Stone Veneer Facings: Refer to "Stone Veneer Facings" Article.

2.21 SOURCE QUALITY CONTROL

Always retain paragraph below because it establishes the minimum standard of plant testing and inspecting. PCI MNL 116 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 116.

- A. Quality-Control Testing: Test and inspect precast concrete according to PCI MNL 116 requirements. If using self-consolidating concrete also test and inspect according to PCI TR-6 "Interim Guidelines for the Use of Self-Consolidating Concrete" and ASTM C 1611, ASTM C 1712, ASTM C 1610, and ASTM C 1621.

Delete first paragraph and subparagraph below if not required. PCI certification may 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 structural 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.
- C. Strength of structural precast concrete members will be considered deficient if units fail to comply with ACI 318 concrete strength requirements.

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

- D. Testing: If there is evidence that strength of structural precast concrete members may be deficient or may not comply with ACI 318 requirements, fabricator shall employ an independent testing agency to obtain, prepare, and test cores drilled from hardened concrete to determine compressive strength according to ASTM C 42.
1. A minimum of three representative cores shall be taken from members of suspect strength, from locations directed by Architect.
 2. Cores shall be tested in an air-dry condition or if members will be wet under service conditions, test cores, after immersion in water, in a wet 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 percent of the 28-day design compressive strength and no single core is less than 75 percent of the 28-day design compressive strength.
 4. Test results shall be reported in writing on the same day that tests are performed, with copies to Architect, Contractor, and precast concrete fabricator. Test reports shall 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 member(s) represented by core tests; design compressive strength; type of failure; actual 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 structural precast concrete members comply with requirements, clean and dampen core holes and solidly fill with concrete mixture that has no coarse aggregate, and finish to match adjacent precast concrete surfaces.
- B. Defective Work: Structural precast concrete members that do not comply with acceptability requirements in PCI MNL 116, including concrete strength, manufacturing tolerances, and color and texture range are unacceptable. Chipped, spalled or cracked members may be repaired. The Architect reserves the right to reject any member if it does not match the accepted samples. Replace unacceptable units with precast concrete members that comply with requirements.

PART 3 – EXECUTION

3.1 PREPARATION

- A. Deliver anchorage devices for structural precast concrete members 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, bearing surfaces tolerances, and other conditions affecting precast concrete performance.
- B. Proceed with structural precast concrete installation only after unsatisfactory conditions have been corrected.
- C. Do not install structural precast concrete members 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 members.

3.3 ERECTION

- A. Install loose clips, hangers, bearing pads, and other accessories required for connecting structural precast concrete members to supporting members and backup materials.
- B. Erect structural precast concrete level, plumb and square within the specified allowable erection tolerances. Provide temporary structural framing, supports and bracing as required to maintain position, stability, and alignment of members until permanent connections are completed.

1. Install temporary steel or plastic spacing shims or bearing pads as precast concrete members 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. Provide and install headers of cast-in-place concrete or structural-steel shapes for openings larger than one slab width according to hollow-core slab fabricator's written recommendations.
- C. Connect structural precast concrete members in position by bolting, welding, grouting, or as otherwise indicated on approved 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.
- D. Welding: Comply with applicable AWS D1.1 and AWS D1.4 requirements for welding, welding electrodes, appearance of welds, quality of welds, and methods used in correcting welding work.
1. Protect structural precast concrete members 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 D1.1 or D1.4.
 3. Clean-weld-affected metal surfaces with chipping hammer followed by brushing or power tool cleaning and then reprime damaged painted surfaces in accordance with manufacturer's recommendations.
- Retain last subparagraph above or first subparagraph below.**
4. For galvanized metal, clean weld affected metal surfaces with chipping hammer followed by brushing or power tool cleaning, and apply a minimum 0.004 inch (4 mil) thick coat of galvanized repair paint to galvanized surfaces in conformance with ASTM A 780.
 5. Visually inspect all welds critical to structural 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.
- E. At bolted connections, use tack welding or other approved means to prevent loosening of nuts after final adjustment.
1. Unless indicated otherwise, all bolts to be installed to a snug-tight condition in accordance with AISC at a minimum.
 2. For connections utilizing high-strength bolts and slip critical connections verify bolt position and tightness at installation. For sliding connections, properly secure bolt but allow bolt to move within connection slot. For slip critical connection, apply specified bolt torque and check 25 percent of bolts at random by calibrated torque wrench. If inadequate bolt torque is found, test all bolts.

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

- F. Grouting or Dry-Packing Connections and Joints: Indicate joints to be grouted and any critical grouting sequences on Shop (Erection) Drawings. Grout open spaces at keyways, connections and joints where required or indicated. Provide reinforcing steel where indicated. Retain fowable grout in place until strong enough to support itself. Fill joints completely without seepage to other surfaces. 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 at least 24 hours after initial set.
1. Trowel top of grout joints on roofs smooth to prevent any unevenness that might interfere with placing of, or cause damage, to insulation and roofing. Finish transitions due to different surface levels not steeper than 1 to 12.
- G. Field cutting or coring of structural precast concrete members is not permitted without approval of the Engineer.

Paragraph below refers to fastening under the control of precast concrete erector. Coordinate with and repeat warning in other Sections if additional construction will be fastened to precast, prestressed concrete members.

- H. Fasteners: Do not use drilled or power-actuated fasteners for attaching accessory items to structural precast concrete members unless approved by Engineer.

3.4 ERECTION TOLERANCES

Review tolerances in PCI MNL 135. Consult structural engineer and precast concrete fabricators and erectors and revise paragraph below if other tolerances are needed.

- A. Erect structural precast concrete members level, plumb, square, true, and in alignment without exceeding the noncumulative erection tolerances of PCI MNL 135.
- B. Level out variations between adjacent members by jacking, loading, or any other feasible method as recommended by the fabricator and acceptable to the Architect.

3.5 FIELD QUALITY CONTROL

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

- A. Special Inspections: **[Owner will engage][Contractor will engage]** a qualified special inspector to perform the following special inspections and prepare reports:
 1. Erection of loadbearing structural 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 E 165 or ASTM E 1444 and 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 fabricator's plant. Defects occurring after delivery are normally repaired before final joint sealing and cleaning as weather permits.

- A. Repairs will be permitted provided structural adequacy, serviceability and durability of members are not impaired. Appearance of repairs shall be within industry standards.

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

- 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.
- C. 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.

- D. Wire brush, clean, and paint damaged prime-painted components with same type of shop primer.
- E. Remove and replace damaged structural precast concrete members when repairs do not comply with specified requirements.

3.7 CLEANING

Specify whether erector or precaster does cleaning under the responsibility of General Contractor. Consider use of biodegradable, bio-based cleaning products.

- A. Clean mortar, plaster, fireproofing, weld slag, and any other deleterious material from concrete surfaces and adjacent materials immediately.

- B. Clean exposed surfaces of structural precast concrete members after erection and completion of joint treatment to remove weld marks, other markings, dirt, and stains.
- C. Perform cleaning procedures, if necessary, according to precast concrete fabricator's recommendations. Protect adjacent work from staining or damage due to cleaning operations.
- D. Do not use cleaning materials or processes that could change the appearance of exposed concrete finishes or damage adjacent materials.

END OF SECTION 034100