

GUIDE SPECIFICATION FOR PLANT-PRECAST CONCRETE PRODUCTS

PART 1: GENERAL

- 1.1 REFERENCES
- 1.2 GENERAL REQUIREMENTS
- 1.3 SUBMITTALS
 - 1.3.1 Preconstruction Submittals
 - 1.3.2 Shop Drawings
 - 1.3.2.1. Drawings for Standard Precast Concrete Units
 - 1.3.2.2. Drawings for Custom-Made Precast Concrete Units
 - 1.3.2.3. Drawings Submitted by the Customer
 - 1.3.3 Precast Concrete Unit Data Standard
 - 1.3.3.1. Precast Concrete Units
 - 1.3.3.2. Proprietary Precast Concrete Units
 - 1.3.3.3. Anchorages, Lifting Inserts and Devices
 - 1.3.3.4. Accessory Items
 - 1.3.4 Design Data
 - 1.3.5 Test Reports
 - 1.3.6 Certificates
- 1.4 DESIGN
 - 1.4.1 Standard Precast Concrete Unit Design
 - 1.4.2 Non-Standard Precast Concrete Unit Design
 - 1.4.3 Franchise Precast Concrete Units
 - 1.4.4 Joints and Sealants
 - 1.4.5 Concrete Mix Design
 - 1.4.5.1 Concrete Proportions
 - 1.4.5.2 Durability and Performance Requirements
 - 1.4.5.2.1. Concrete Compressive Strength
 - 1.4.5.2.2. Water to Cementitious Materials Ratio
 - 1.4.5.2.3. Air Content
- 1.5 QUALITY ASSURANCE
 - 1.5.1 NPCA Plant Certification
 - 1.5.2 Qualifications, Quality Control and Inspection
 - 1.5.2.1 Qualifications
 - 1.5.2.2 Quality Control
 - 1.5.2.3 Inspection
- 1.6 HANDLING, STORAGE AND DELIVERY
 - 1.6.1 Handling
 - 1.6.2 Storage
 - 1.6.3 Delivery
 - 1.6.4 Final Acceptance

PART 2: PRECAST CONCRETE UNITS

2.1 MANUFACTURERS

2.2 MATERIALS

2.2.1 Cement

2.2.2 Silica Fume

2.2.3 Fly Ash and Pozzolans

2.2.4 Ground Granulated Blast-Furnace Slag

2.2.5 Water

2.2.6 Aggregates

2.2.6.1 Aggregate Selection

2.2.6.2 Aggregates for Lightweight Concrete

2.2.7 Admixtures

2.2.7.1 Air-Entraining

2.2.7.2 Accelerating, Retarding, Water Reducing [Moderate to High]

2.2.7.3 Pigments

2.2.7.4 Corrosion Inhibitors

2.2.8 Reinforcement

2.2.8.1 Reinforcing Bars

2.2.8.1.1 Deformed Billet-steel

2.2.8.1.2 Deformed Low-alloy steel

2.2.8.2 Reinforcing Wire

2.2.8.2.1 Plain Wire

2.2.8.2.2 Deformed Wire

2.2.8.3 Welded Wire Reinforcement

2.2.8.3.1 Plain Wire

2.2.8.3.2 Deformed Wire

2.2.8.4 Epoxy-Coated Reinforcement

2.2.8.4.1 Reinforcing Bars

2.2.8.4.2 Wire and Welded Wire Reinforcement

2.2.8.5 Galvanized Reinforcement

2.2.8.6 Fiber Reinforcement

2.2.9 Inserts and Embedded Metal

2.2.9.1 Structural Steel Plates, Angles, etc.

2.2.9.2 Hot-dipped Galvanized

2.2.9.3 Proprietary Items

2.2.10 Grout

2.2.10.1. Non-shrink Grout

2.2.10.2. Cementitious Grout

- 2.3 MANUFACTURE
 - 2.3.1 Forms
 - 2.3.2 Reinforcement
 - 2.3.3 Embedded Items
 - 2.3.4 Concrete
 - 2.3.4.1 Concrete Mixing
 - 2.3.4.2 Concrete Placing
 - 2.3.4.2.1 Cold Weather Concreting
 - 2.3.4.2.2 Hot Weather Concreting
 - 2.3.4.3 Concrete Curing
 - 2.3.4.3.1 Curing by Moisture Retention
 - 2.3.4.3.2 Curing with Heat and Moisture
 - 2.3.4.4 Surface Finish
 - 2.3.4.4.1 Formed Non-Architectural Surfaces
 - 2.3.4.4.2 Unformed Surfaces
 - 2.3.4.4.3 Special Finishes
 - 2.3.4.4.4 Architectural Finishes
 - 2.3.4.5 Stripping Precast Concrete Units From Forms
 - 2.3.4.6 Patching and Repair
 - 2.3.4.6.1 Repairing Minor Defects
 - 2.3.4.6.2 Repairing Honeycombed Areas
 - 2.3.4.6.3 Repairing Major Defects
 - 2.3.4.7 Shipping Precast Concrete Units

PART 3: EXECUTION

- 3.1 INSTALLATION
 - 3.1.1 Site Access
 - 3.1.2 Installation

NOTE: This guide specification covers the general requirements for plant manufactured precast concrete products.

Comments and suggestions regarding this specification are welcome and should be directed to the NPCA Technical Services Department.

Please visit the NPCA Web site at www.precast.org.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

PART 1: GENERAL

1.1 REFERENCES

Where applicable, the latest editions of the following standards shall form a part of this specification to the extent referenced. The publications are referenced in the text of this guide specification by their basic designations only.

ACI INTERNATIONAL (ACI)

ACI PRC-211.1	Selecting Proportions for Normal-Density and High Density-Concrete - Guide
ACI PRC-213	Guide for Structural Lightweight-Aggregate Concrete
ACI PRC-237	Self-Consolidating Concrete
ACI PRC-305	Guide to Hot Weather Concreting
ACI PRC-306	Guide to Cold Weather Concreting
ACI PRC-308	Guide to External Curing of Concrete
ACI 318	Building Code Requirements for Structural Concrete

ASTM INTERNATIONAL (ASTM)

ASTM A 36	Specification for Carbon Structural Steel
ASTM A 184	Specification for Fabricated Deformed Steel Mats for Concrete Reinforcement
ASTM A 615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 706	Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 767	Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A 775	Specification for Epoxy-Coated Reinforcing Steel Bars
ASTM A 884	Specification for Epoxy-Coated Steel and Welded Wire Fabric for Reinforcement
ASTM A 1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A 1094	Standard Specifications for Continuous Hot-Dipped Galvanized Steel Bars for Concrete Reinforcement
ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Specification for Concrete Aggregates

ASTM C 39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 94	Specification for Ready-Mixed Concrete
ASTM C 138	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C 143	Test Method for Slump of Hydraulic Cement Concrete
ASTM C 150	Specification for Portland Cement
ASTM C 171	Standard Specification for Sheet Materials for Curing Concrete
ASTM C 173	Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	Specification for Air-Entraining Admixtures for Concrete
ASTM C 309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 330	Specification for Lightweight Aggregates for Structural Concrete
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete
ASTM C 497	Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile
ASTM C 595	Specification for Blended Hydraulic Cements
ASTM C 618	Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 979	Specification for Pigments for Integrally Colored Concrete
ASTM C 989	Standard Specification for Slag Cement Use in Concrete and Mortars
ASTM C 1064	Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete
ASTM C 1107	Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C 1116	Standard Specification for Fiber-Reinforced Concrete and Shotcrete
ASTM C 1240	Standard Specification for Use of Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout
ASTM C 1582	Standard Specification for Admixtures to Inhibit Chloride-Induced Corrosion of Reinforcing Steel in Concrete
ASTM C 1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

ASTM C 1603	Standard Test Method for Measurement of Solids in Water
ASTM C 1610	Standard Test Method for Static Segregation of Self-Consolidating Concrete Using Column Technique
ASTM C 1611	Standard Test Method for Slump Flow of Self-Consolidating Concrete
ASTM C 1621	Standard Test Method for Passing Ability of Self-Consolidating Concrete by J-Ring
ASTM C 1712	Standard Test Method for Rapid Assessment of Static Segregation Resistance of Self-Consolidating Concrete Using Penetration Test
ASTM C 1758	Standard Practice for Fabricating Test Specimens with Self-Consolidating Concrete
ASTM C 1778	Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete

AMERICAN WELDING SOCIETY (AWS)

AWS D 1.1	Structural Welding Code – Steel
AWS D 1.4	Structural Welding Code - Reinforcing Steel

NATIONAL PRECAST CONCRETE ASSOCIATION (NPCA)

	Quality Control Manual for Precast Concrete Plants
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1.2 GENERAL REQUIREMENTS

Precast concrete units shall be designed and fabricated by an experienced and acceptable precast concrete manufacturer. The manufacturer shall have been regularly and continuously engaged in the manufacture of precast concrete units similar to that indicated in the project specifications or drawings for at least [] years.

1.3 SUBMITTALS

The following items may be submitted upon request by the customer.

1.3.1 Preconstruction Submittals

Submit quality control procedures established by the precast manufacturer in accordance with the NPCA Quality Control Manual for Precast Concrete Plants.

1.3.2 Shop Drawings

1.3.2.1. Drawings for Standard Precast Concrete Units

The drawings for standard precast concrete units shall be shop drawings furnished by the precast concrete producer for approval by the customer. These drawings shall demonstrate that the applicable industry design standards are met.

Installation and construction information shall be included on shop drawings upon request. Details of steel reinforcement size and placement as well as supporting design calculations, if appropriate, shall be included. The precast concrete units shall be produced in accordance with the approved drawings. Drawings shall indicate assumptions used in the design of standard units. It is the responsibility of the project's engineer-of-record to verify that the design assumptions are suitable for the proposed application.

1.3.2.2. Drawings for Custom-Made Precast Concrete Units

The drawings for custom-made precast concrete units shall be shop drawings furnished by the precast concrete producer for approval by the customer. These drawings shall show complete design in such detail as to enable the customer to determine the adequacy of the proposed units for the intended purpose. Installation and construction information shall be included on shop drawings upon request. Details of steel reinforcement size and placement as well as supporting design calculations, if appropriate, shall be included. The precast concrete units shall be produced in accordance with the approved drawings.

1.3.2.3. Drawings Submitted by the Customer

The customer or customer's agent (specifier) may provide the precast concrete manufacturer with drawings for custom-made precast concrete units. Drawings shall be prepared and stamped by a licensed professional engineer. The customer or customer's agent may consult the precast concrete manufacturer during the design process on relevant production practices that may affect the design, production, handling and installation of the custom-made precast concrete unit. The customer or customer's agent accepts all liability associated with the use of the provided drawings.

1.3.3 Precast Concrete Unit Data Standard

1.3.3.1. Precast Concrete Units

For standard precast concrete units, the precast concrete producer shall supply cut sheets showing conformance to project drawings and requirements and to applicable industry design standards listed in this specification.

1.3.3.2. Proprietary Precast Concrete Units

For proprietary precast concrete units, the precast concrete producer shall supply standard plans or informative literature. Supporting calculations and design details shall be available upon request. The precast concrete producer shall provide sufficient information as to demonstrate that such products will perform the intended task.

1.3.3.3. Anchorages, Lifting Inserts and Devices

For anchors, lifting inserts and other devices, the precast concrete producer shall provide product data sheets and proper installation instructions upon request. The precast concrete unit dimensions and safe working load shall be clearly indicated.

1.3.3.4. Accessory Items

For items including, but not limited to sealants, gaskets, pipe entry connectors, steps, racks and other items installed before or after delivery, the precast concrete producer shall include proper installation instructions and relevant product data upon request.

1.3.4 Design Data

Upon request, the precast concrete producer shall supply precast concrete unit design calculations and concrete mix design proportions and appropriate mix design test data. Structural design calculations shall be signed by a licensed professional engineer.

1.3.5 Test Reports

Upon request, the precast concrete producer shall supply copies of material certifications and/or laboratory test reports, including mill tests and all other test data, for portland cement, blended cement, pozzolans, ground granulated blast-furnace slag, silica fume, aggregate, admixtures, and curing compound proposed for use on this project.

Upon request, the precast concrete producer shall submit copies of test reports showing that the mix has been successfully tested to produce concrete with the properties specified and will be suitable for the project conditions. Such tests may include compressive strength, flexural strength, plastic or hardened air content, freeze-thaw durability, abrasion and absorption. Special tests for precast concrete items shall be clearly detailed in the specifications.

Upon request, the precast concrete producer will supply copies of in-plant QA/QC inspection reports.

1.3.6 Certificates

Submit quality control procedures established in accordance with NPCA Quality Control Manual for Precast Concrete Plants or verification of current NPCA Plant Certification.

1.4 DESIGN

1.4.1. Standard Precast Concrete Unit Design

Design standard precast concrete units to withstand indicated design load conditions in accordance with applicable industry design standards []. Design must also consider stresses induced during handling, shipping and installation in order to avoid product cracking or other handling damage. Design loads for precast concrete units shall be indicated on the shop drawings.

1.4.2. Non-Standard Precast Concrete Unit Design

Design calculations and drawings of non-standard precast units shall be prepared and signed by a licensed professional engineer, and submitted for customer approval prior to fabrication. Calculations shall include the analysis of units for lifting stresses and the sizing of lifting devices.

1.4.3. Franchise Precast Concrete Units

Products manufactured under franchise arrangements shall conform to all the requirements specified by the franchiser. Items not included in the franchise specification but included in this specification shall conform to the requirements in this specification.

1.4.4. Joints and Sealants

Joints and sealants between adjacent units shall be of the type and configuration indicated on shop drawings meeting specified design and performance requirements.

1.4.5. Concrete Mix Design

1.4.5.1. Concrete Proportions

Selection of proportions for concrete shall be based on the methodology presented in ACI PRC-211.1 for normal weight concrete and ACI PRC-231 for lightweight concrete. The concrete proportions shall be developed using the same type and brand of cement, the same type and brand of pozzolan, the same type and gradation of aggregates, and the same type and brand of admixture that will be used in the manufacture of precast concrete units for the project. Accelerators containing calcium chloride shall not be used in precast concrete containing reinforcing steel or other embedded metal items.

Upon request, the precast concrete producer shall submit a mix design for each strength and type of concrete that will be used. Submitted mix designs shall include the quantity, type, brand and applicable data sheets for all mix design constituents as well as documentation indicating conformance with applicable reference specifications.

The use of self-consolidating concrete is permitted provided that its use complies with ACI PRC-237 [all applicable sections of the NPCA Quality Control Manual for Precast Concrete Plants].

1.4.5.2. Durability and performance requirements

1.4.5.2.1. Concrete Compressive Strength

Precast concrete units shall have a minimum 28-day compressive strength (f'_c) of [] psi ([] MPa), tested in compliance with ASTM C 39. Prior to shipping, tests shall show that precast concrete units have met a minimum shipping strength of 2500 psi (17 MPa), [or [] psi ([] MPa)].

1.4.5.2.2. Water-to Cementitious Materials Ratio

Concrete that will be exposed to freezing and thawing shall contain entrained air (see 1.4.5.2.3) and shall have water-cementitious ratios of 0.45 or less. Concrete which will not be exposed to freezing, but which is required to be watertight, shall have a water-cementitious ratio of 0.48 or less if the concrete is exposed to fresh water, or 0.45 or less if exposed to brackish water or sea water. For corrosion protection, reinforced concrete exposed to deicer salts, brackish water or seawater shall have a water-cementitious ratio of 0.40 or less.

1.4.5.2.3. Air Content

The air content of concrete that will be exposed to freezing conditions shall be within the limits given below.

Nominal Maximum Aggregate Size (in)	Air Content%	
	Severe Exposure	Moderate Exposure
3/8	6.0 to 9.0	4.5 to 7.5
1/2	5.5 to 8.5	4.0 to 7.0
3/4	4.5 to 7.5	3.5 to 6.5
1	4.5 to 7.5	3.0 to 6.0
1-1/2	4.5 to 7.0	3.0 to 6.0
* For specified compressive strengths greater than 5000 psi (34 MPa), air content may be reduced 1%		

Table 1 - Excerpted from ACI 201.2R Table 4.1

1.5. QUALITY ASSURANCE

Precast concrete producer shall demonstrate adherence to the standards set forth in the NPCA Quality Control Manual for Precast Concrete Plants. The precast concrete producer shall meet all applicable requirements written in subparagraph [1.5.1 or 1.5.2.] of the manual.

1.5.1. NPCA Plant Certification

The precast concrete producer shall be certified by the NPCA Plant Certification Program with proof of valid certificate at the time of product shop drawing submittal and during all product production for this project prior to and during production of the products for this project.

1.5.2. Qualifications, Quality Control, and Inspection

1.5.2.1. Qualifications

The precast concrete producer shall maintain a permanent quality control department or retain an independent testing agency on a continuing basis.

1.5.2.2. Quality Control

The precast concrete producer shall show that the following quality control tests are performed as required and in accordance with the ASTM International standards indicated:

- a. Slump/Slump Flow: A slump test shall be performed for each 150 cu. yd. (115 m³) of concrete produced per mix design, or once a day, whichever comes first. Slump tests shall be performed in accordance with ASTM C 143. Slump flow and Visual Stability Index (VSI) tests on self-consolidating concrete mixes shall be performed in accordance with ASTM C 1611.

- b. Temperature: The temperature of fresh concrete shall be measured in accordance with ASTM C 1064 when slump or air content tests are made and when compressive test specimens are made in accordance with ASTM C 31.
- c. Compressive Strength: At least four compressive strength specimens shall be made for each 150 cu. yd. (115 m³) of concrete of each mix design, two tested at or before 7 days and, if the specified design strength has not been met at that time, the other two tested at or before 28 days or at the age specified by design, in accordance with the following applicable ASTM standards: C 31, C 39, C 192, C 497 [no-slump concrete], C 1758.
- d. Air Content: Tests for air content shall be made on air-entrained, wet-cast concrete for each 150 cu. yd. (115 m³) of concrete, per mix design, but not less often than once each day when air-entrained concrete is used. The air content shall be determined in accordance with either ASTM C 231 or ASTM C 173 for normal weight aggregates and ASTM C 173 for lightweight aggregates.
- e. Density (Unit Weight): Tests for density shall be performed a minimum of once per week to verify the yield of batch mixes. Density tests shall be performed for each 150 cu. yd. (115 m³) of lightweight concrete in accordance with ASTM C 138. Density tests shall be performed for each 150 cu. yd. (115 m³) of concrete per mix design, but not less often than once per day when volumetric batch equipment is used.
- f. Plants which produce products using SCC shall conduct tests to determine the quality parameters described above. However, procedures specific to SCC shall be followed (as applicable) per ASTM C 1621, C 1610, C 1611, C 1712, and C 1758.

The precast concrete producer shall submit documentation demonstrating compliance with the above subparagraphs upon request.

1.5.2.3. Inspection

The customer or customer's agent (specifier) may place an inspector in the plant when the units covered by this specification are being manufactured. The precast concrete producer shall give notice of [] days prior to the time the precast concrete units will be available for plant inspection.

1.6. HANDLING, STORAGE AND DELIVERY

1.6.1. Handling

Precast concrete units shall be handled and transported in a manner to minimize damage. Lifting devices or holes shall be consistent with industry standards. Lifting shall be accomplished with methods or devices intended for this purpose as indicated on shop drawings. Upon request, the precast concrete producer shall provide documentation on acceptable handling methods for the product.

1.6.2. Storage

Precast concrete units shall be stored in a manner that will minimize potential damage.

1.6.3. Delivery

Precast concrete units shall be delivered to the site in accordance with the delivery schedule to avoid excessive build-up of units in storage at the site. Upon delivery to the jobsite all precast concrete units shall be inspected by the customer or customer's agent for quality and final acceptance.

1.6.4. Final Acceptance

Upon final acceptance, the customer or customer's agent acknowledges and understands the appropriate methods for handling the accepted precast concrete unit(s). Upon acceptance by the customer or customer's agent, the precast concrete manufacturer is not responsible for replacing damaged product resulting from improper handling practices on the job site.

PART 2: PRECAST CONCRETE UNITS

2.1 MANUFACTURERS

The precast concrete manufacturer must meet the requirements established in section 1.5 Quality Assurance.

2.2 MATERIALS

Except as otherwise specified, material shall conform to the following specifications.

2.2.1 Cement

ASTM C 150

ASTM C 595 (for Blended Cements)

2.2.2 Silica Fume

ASTM C 1240

2.2.3 Fly Ash and Pozzolans

ASTM C 618

2.2.4. Ground Granulated Blast-Furnace Slag

ASTM C 989

2.2.5. Water

ASTM C 1602, ASTM C 1603

[The use of reclaimed/recycled process water shall be permitted.]

2.2.6. Aggregates

2.2.6.1. Aggregate Selection

NOTE: Select gradation(s) based on job requirements and constraints. The nominal maximum aggregate size should not exceed one-fifth the narrowest dimension between sides of forms, nor three-quarters the minimum clear spacing between individual reinforcing bars or wires. Larger maximum sizes of aggregate may be used if evidence shows that satisfactory concrete products can be produced in accordance with aggregate gradation requirements in the NPCA Quality Control Manual for Precast Concrete Plants.

Fine and Coarse aggregates shall conform to the requirements of ASTM C 33, "Standard Specification for Concrete Aggregates." Evidence of compliance shall be a certification from the supplier that the aggregate meets the ASTM C 33 standard. In addition, aggregates shall be evaluated per ASTM C 1778, "Standard Guide for Reducing Risk of Deleterious Alkali-aggregate reaction on Concrete" and documentation maintained on file at the plant for potential deleterious expansion due to alkali reactivity, unless the aggregates are received from a state department of transportation approved source and are known not to be reactive.

2.2.6.2. Aggregates for Lightweight Concrete

ASTM C 330

2.2.7. Admixtures

2.2.7.1. Air Entraining

ASTM C 260

NOTE: Air-entraining requirements may be deleted when the project is located in a nonfreezing climate or will not be exposed to freezing and thawing. However, certain product-specific ASTM Standards require the use of air-entrainment regardless of the climate.

2.2.7.2. Accelerating, Retarding, Water Reducing [Moderate to High]

ASTM C 494

2.2.7.3. Pigments

ASTM C 979

2.2.7.4. Corrosion Inhibitors

ASTM C 1582

2.2.8. Reinforcement

2.2.8.1. Reinforcing Bars

2.2.8.1.1 Deformed Billet-Steel

ASTM A 615

2.2.8.1.2 Deformed Low-Alloy Steel

ASTM A 706

2.2.8.2. Reinforcing Wire

2.2.8.2.1 Plain Wire

ASTM A 1064

2.2.8.2.2 Deformed Wire

ASTM A 1064

2.2.8.3 Welded Wire Reinforcement

2.2.8.3.1 Plain Wire

ASTM A 1064

2.2.8.3.2 Deformed Wire

ASTM A 1064, ASTM A 184

2.2.8.4 Epoxy Coated Reinforcement

2.2.8.4.1 Reinforcing Bars

ASTM A 775

2.2.8.4.2 Wires and Welded Wire Reinforcement

ASTM A 884; ASTM A 1064

2.2.8.5 Galvanized Reinforcement

ASTM A 767

2.2.8.6 Fiber Reinforcement

ASTM C 1116

2.2.9 Inserts and Embedded Metal

All items embedded in concrete shall be of the type required for the intended use and meet the following standards.

2.2.9.1 Structural Steel Plates, Angles, etc.

ASTM A 36

2.2.9.2 Hot-Dipped Galvanized

ASTM A 1094

2.2.9.3 Proprietary Items

In accordance with manufacturers published literature

2.2.10 Grout

2.2.10.1 Non-shrink Grout

ASTM C 1107

2.2.10.2 Cementitious Grout

Shall be of suitable mix design for the intended use, consisting of Portland cement, sand, and water. [Provide air entrainment for grout exposed to corrosive conditions or severe weather.]

NOTE: Air-entraining requirements may be deleted when the project is located in a nonfreezing climate or when freeze-thaw durability is not required.

2.3 MANUFACTURE

Manufacture shall conform to the NPCA Quality Control Manual for Precast Concrete Plants unless specified otherwise.

2.3.1 Forms

Forms for manufacturing precast concrete units shall be of the type and design consistent with industry standards and practices. They should be capable of consistently providing uniform products and dimensions. Forms shall be constructed so that the forces and vibrations to which the forms will be subjected cause no damage to the precast concrete unit.

Forms shall be cleaned of concrete build-up after each use. Form release agents shall be applied according to the manufacturer’s recommendations and shall not be allowed to build up on the form casting surfaces.

2.3.2 Reinforcement

Applicable ASTM International and/or ACI 318 standards for placement and splicing cages of reinforcement shall be fabricated either by tying the bars, wires or welded wire reinforcement into rigid assemblies or by welding, where permissible, in accordance with AWS D1.4 weldment procedures. Reinforcing shall be positioned as specified by the design and so that the concrete cover conforms to requirements. The tolerance on concrete cover shall be one-third of that specified but not more than 1/2 in. (13 mm). Concrete cover shall not be less than 1/2 in. (13 mm), unless otherwise specified. Positive means shall be taken to assure that the reinforcement does not move significantly during the casting operations. Structural fiber reinforcement can be used along with or in place of steel reinforcement, if allowed by project specifications. When fibers are used along with steel reinforcement, data shall be provided to show conclusively that the type, brand, quality and quantity of fibers to be included in the concrete mix are not detrimental to the concrete or to the performance of the precast concrete product. Additionally, if fibers are used to replace primary steel reinforcement, data shall be provided to show conclusively that the quantity of fibers was determined and approved by a licensed engineer.

2.3.3 Embedded Items

Embedded items shall be positioned at locations specified in the design documents. Welding shall be performed in accordance with AWS D1.1 and AWS D1.4 when necessary. Inserts, plates, weldments, lifting devices and other items to be embedded in precast concrete units shall be held rigidly in place so that they do not move significantly during casting operations.

2.3.4 Concrete

2.3.4.1 Concrete Mixing

Mixing operations shall produce batch-to-batch uniformity of strength, consistency, and appearance in accordance with ASTM C 94.

2.3.4.2 Concrete Placing

Conventional concrete shall be deposited into forms as near to its final location as practical. Self-consolidating concrete shall be placed in a manner in which it flows and consolidates without segregation or air entrapment. The free fall of the concrete shall be kept to a minimum. Concrete shall be consolidated using precast industry best practices to reduce or eliminate in such a manner that segregation of the fresh concrete is minimized and honeycombing of the hardened concrete areas are kept to a minimum. Consolidation efforts are often not required when using self-consolidating concrete. Vibrators used to consolidate concrete shall have frequencies and amplitudes sufficient to produce well-consolidated concrete for the product being produced.

2.3.4.2.1 Cold Weather Concreting

Recommendations for cold weather concreting are given in detail ACI PRC-306. Adequate equipment shall be provided for heating concrete materials and protecting concrete during freezing or near-freezing weather. All concrete materials and all reinforcement, forms, fillers, and ground with which concrete is to come in contact shall be free from frost. Frozen materials or materials containing ice shall not be used. In cold weather the temperature of concrete at the time of placing shall not be below 45° F (5° C). Concrete that freezes before its compressive strength reaches 500 psi (3.4 MPa) shall be discarded.

2.3.4.2.2 Hot Weather Concreting

Recommendations for hot weather concreting are given in ACI PRC-305.

During hot weather, proper attention shall be given to constituents, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation that could impair required strength or serviceability of the member or structure. The temperature of concrete at the time of placing shall not exceed 90° F.

2.3.4.3 Concrete Curing

Commence curing operations immediately following the initial set of the concrete and completion of surface finishing.

NOTE: Due to the immediacy of form removal, with dry-cast products, have a tendency to undergo undesirable accelerated drying. Consequently, early curing periods are most critical to ensure protection from extreme temperatures and dryness. Dry-cast products must be protected from drafts and wind to prevent plastic shrinkage cracking.

2.3.4.3.1 Curing by Moisture Retention

Moisture shall be prevented from evaporating from exposed surfaces until adequate strength for stripping the precast concrete unit from the forms is reached by one of the following methods:

- Cover with polyethylene sheets a minimum of 6 mils thick (ASTM C 171)
- Cover with burlap or other absorptive material and keep continually moist
- Use of a membrane-curing compound applied per manufacturers' recommendations (ASTM C 309)

Surfaces that will be exposed to weather during service shall be cured as above a minimum of [] days. Forms shall be considered effective in preventing evaporation from the contact surfaces. If air temperature is below 50°F the curing period shall be extended.

2.3.4.3.2 Curing with Heat and Moisture

Concrete shall not be subjected to steam or hot air until after the concrete has attained its initial set. Steam, if used, shall be applied within a suitable enclosure, which permits free circulation of the steam in accordance with ACI PRC-306. If hot air is used for curing, precautions shall be taken to prevent moisture loss from the concrete. The temperature of the concrete shall not be permitted to exceed 158° F. These requirements do not apply to products cured with steam under pressure in an autoclave.

2.3.4.4 Surface Finish

Unformed surfaces of wet-cast precast concrete products shall be finished as specified. If no finishing procedure is specified, such surfaces shall be finished using a strike-off to level the concrete with the top of the form.

2.3.4.4.1 Formed Non-Architectural Surfaces

Surfaces shall be cast against approved forms in accordance with standard industry practices in cleaning forms, designing concrete mixes, placing and curing concrete. Normal color variations, form joint marks, small surface holes caused by air bubbles, and minor chips and spalls will be accepted. Major imperfections, excessive honeycombing or other major defects shall not be permitted.

2.3.4.4.2 Unformed Surfaces

Surfaces shall be finished with a vibrating screed, or by hand with a float. Normal color variations, minor indentations, minor chips and spalls will be accepted.

Major imperfections, excessive honeycombing or other major defects shall not be permitted.

2.3.4.4.3 Special Finishes

Troweled, broom or other finishes shall be according to the requirements of project documents and performed per industry standards or supplier specifications.

Precast concrete producers shall submit sample finishes for approval when required by the project documents. The sample finishes shall be approved prior to the start of production.

2.3.4.4.4 Architectural Finishes

Architectural finishes shall be according to the requirements of project documents and performed per industry standards or supplier specifications.

Precast concrete producers shall submit sample finishes for approval when required by the project documents. Full-size mockups are recommended for the approval of architectural finishes, because color variations and surface imperfections are not always apparent on small scale samples. The sample finishes shall be approved prior to the start of production.

2.3.4.5 Stripping Precast Concrete Units From Forms

Precast concrete units shall not be removed from the forms until the concrete reaches the compressive strength for stripping required by the design. If no such requirement exists, the plant shall define product-specific minimum stripping strengths that must be obtained prior to stripping. Products may be removed from the forms after the final set of concrete provided that stripping damage is minimal. Stripping strengths shall be routinely measured to ensure product has attained sufficient strength for safe handling.

2.3.4.6 Patching and Repair

No repair is required to formed surfaces that are relatively free of air voids and honeycombed areas unless the surfaces are required by the design to be finished.

2.3.4.6.1 Repairing Minor Defects

Defects that will not impair the functional use or expected life of a precast concrete unit may be repaired by any method that does not impair the product.

2.3.4.6.2 Repairing Honeycombed Areas

When honeycombed areas are to be repaired, all loose material shall be removed and the areas cut back into essentially horizontal or vertical planes to a depth at which coarse aggregate particles break under chipping rather than being dislodged. Proprietary repair materials shall be used in accordance with the manufacturer's instructions. If a proprietary repair material is not used, the area shall be saturated with water. Immediately prior to repair, the area should be damp, but free of excess water. A cement-sand grout or an approved bonding agent shall be applied to the chipped surfaces, followed immediately by consolidating an appropriate repair material into the cavity.

2.3.4.6.3 Repairing Major Defects

Defects in precast concrete products which impair the functional use or the expected life of products shall be evaluated by qualified personnel to determine if repairs are feasible and, if so, to establish the repair procedure. Final acceptance of a major defect repair shall be by the owner or the owner's representative.

2.3.4.7 Shipping Precast Concrete Units

Precast concrete units shall not be shipped until they are at least [] days old, unless it can be shown that the concrete strength has reached at least [] percent of the specified 28-day strength, sufficient for handling and adequate to prevent damage, but not less than 2,500 psi (17 MPa).

PART 3: EXECUTION

3.1 INSTALLATION

3.1.1 Site Access

The general contractor shall be responsible for providing adequate access to the site to facilitate hauling, storage and proper handling of the precast concrete units.

3.1.2 Installation

Precast concrete units shall be installed to the lines and grades shown in the contract documents or otherwise specified.

Precast concrete units shall be lifted by suitable lifting devices at points provided by the precast concrete producer.

Precast concrete units shall be installed in accordance with applicable industry standards. Upon request, the precast concrete producer shall provide installation instructions.

Field modifications to the product shall relieve the precast producer of liability regardless of whether such modifications result in the failure of the precast concrete unit.

This specification is intended solely for use by professional personnel who are competent to evaluate the significance and limitations of the information provided herein, and who will accept total responsibility for the application of this information. NPCA disclaims any and all responsibility and liability for the accuracy of and the application of the information contained in this publication to the full extent permitted by law.
