
USACE / NAVFAC / AFCEA UFGS-03412N (September 1999)

Preparing Activity: NAVFAC Replacing without revision
NFGS of same number and date

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

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SECTION 03412N

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PLANT-PRECAST PRESTRESSED STRUCTURAL CONCRETE
09/99

NOTE: This guide specification covers the requirements for building and waterfront facilities construction using precast, prestressed concrete that is plant manufactured.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

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

NOTE: This guide specification shall not be used for bridge or roadway construction. This guide does not cover post tensioned concrete, or prestressed concrete that is site manufactured.

NOTE: The following information shall be shown on the project drawings:

1. Live and dead loads, and whether the topping is included in the dead load.
2. Details of fitting, bearing, and connections.
3. Location of expansion and control joints.
4. Camber.

5. Style and area of steel fabric reinforcement in areas where required. Kind and size of reinforcing bars and spacing.
6. Strength and type of concrete.
7. Detail of placement of sealant or fillers in joints.
8. Fire rating.
9. Lightweight concrete unit weight.
10. Tendon types, physical properties, and allowable design stresses.
11. Special requirements for concrete cover over tendons and other reinforcing.
12. Areas where toppings are required, indicate areas where the full thickness of the topping is not present.

PART 1 GENERAL

1.1 REFERENCES

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACI INTERNATIONAL (ACI)

ACI 304R	(2000) Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R	(1999) Hot Weather Concreting
ACI 306.1	(1990) Standard Specification for Cold Weather Concreting
ACI 309R	(1996) Guide for Consolidation of Concrete
ACI 318M/318RM	(2002) Metric Building Code Requirements for Structural Concrete and Commentary

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO HB-17 (2002) Standard Specifications for Highway
Bridges

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A135.4 (1995) Basic Hardboard

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4 (1998) Structural Welding Code -
Reinforcing Steel

ASTM INTERNATIONAL (ASTM)

ASTM A 185 (2002) Steel Welded Wire Reinforcement,
Plain, for Concrete

ASTM A 416/A 416M (2002) Steel Strand, Uncoated Seven-Wire
for Prestressed Concrete

ASTM A 421 (1998a) Uncoated Stress-Relieved Steel
Wire for Prestressed Concrete

ASTM A 497 (2002) Steel Welded Wire Reinforcement,
Deformed, for Concrete

ASTM A 615/A 615M (2003a) Deformed and Plain Billet-Steel
Bars for Concrete Reinforcement

ASTM A 616/A 616M (1996a) Rail-Steel Deformed and Plain Bars
for Concrete Reinforcement

ASTM A 617/A 617M (1996a) Axle-Steel Deformed and Plain Bars
for Concrete Reinforcement

ASTM A 706/A 706M (2003) Low-Alloy Steel Deformed and Plain
Bars for Concrete Reinforcement

ASTM A 82 (2002) Steel Wire, Plain, for Concrete
Reinforcement

ASTM C 1107 (2002) Packaged Dry, Hydraulic-Cement
Grout (Nonshrink)

ASTM C 150 (2002ae1) Portland Cement

ASTM C 260 (2001) Air-Entraining Admixtures for
Concrete

ASTM C 33 (2003) Concrete Aggregates

ASTM C 330 (2003) Lightweight Aggregates for
Structural Concrete

ASTM C 494 (1992) Chemical Admixtures for Concrete

ASTM C 59/C 59M5	(2000; Rev A) Blended Hydraulic Cements
ASTM C 59/C 59M5M	(1997) Blended Hydraulic Cements (Metric)
ASTM C 618	(2003) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 94	(1994) Ready-Mixed Concrete
ASTM C 989	(1999) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

PRECAST/PRESTRESSED CONCRETE INSTITUTE (PCI)

PCI MNL-116	(1999) Quality Control for Plants and Production of Structural Precast Concrete Products
PCI MNL-120	(1999) Design Handbook - Precast and Prestressed Concrete
PCI MNL-124	(1989) Design for Fire Resistance of Precast Prestressed Concrete

UNDERWRITERS LABORATORIES (UL)

UL Fire Resist Dir	(2004) Fire Resistance Directory
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1.2 DESCRIPTION OF WORK

The work includes the provision of precast, prestressed concrete herein referred to as prestressed members. Prestressed members shall be the product of a manufacturer specializing in the production of precast prestressed concrete members. In the ACI publications, the advisory provisions shall be considered to be mandatory, as though the word "shall" has been substituted for "should" wherever it appears; reference to the "Building Official," the "Structural Engineer" and the "Architect/Engineer" shall be interpreted to mean the Contracting Officer.

1.3 SUBMITTALS

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army

projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings for precast prestressed concrete members[; G][; G, [_____]]

SD-04 Samples

NOTE: Sample panels should only be required when an architectural grade finish is specified.

Precast prestressed concrete surface finish

Submit two 300 by 300 by 50 mm 12 by 12 by 2 inch thick sample panels representative of the color and finish for [each type of prestressed member requiring an architectural finish.] [_____.]

SD-05 Design Data

Precast prestressed concrete design calculations

Concrete mix design

SD-06 Test Reports

Pozzolan test

Submit results of pozzolan tests performed within 6 months of submittal date.

Concrete mix test reports

SD-07 Certificates

Quality control procedures

SD-11 Closeout Submittals

Concrete batch ticket information

1.4 QUALITY CONTROL

1.4.1 PCI Quality Certifications

NOTE: Edit when prestressed members are to be fire rated. On most large jobs, not all members will have the same fire rating, so fire ratings for each specific member should be indicated for clarity.

NOTE: When concrete toppings are indicated, they are normally allowed to be used in establishing the design strength of the prestressed member. However, areas where the topping is not the full thickness, and areas without topping located inside of larger areas with topping need to be indicated so that the topping is not used in the untopped areas to establish the design strength of the prestressed members.

NOTE: For normal routine projects, use the first paragraph. For complex or large precast/prestressed projects, use the second paragraph. Note that use of the second paragraph may limit competition. Verify the availability of certified PCI precasters in the bidding area.

ACI 318M/318RM and the PCI MNL-120. Design prestressed members (including connections) for the design load conditions and spans indicated, and for additional loads imposed by openings and supports of the work of other trades. Design prestressed members for handling without cracking in accordance with the PCI MNL-120. [Prestressed members [where indicated] shall have a fire rating [of [_____] hours] [as indicated] in accordance with UL Fire Resist Dir Fire Resistance Directory, or as designed in accordance with PCI MNL-124.] [Concrete toppings shall [not] be used in establishing the design strength of the prestressed members.]

1.4.1.1 Product Quality Control

PCI MNL-116 for PCI enrolled plants. Where panels are manufactured by specialists in plants not currently enrolled in the PCI "Quality Control Program," provide a product quality control system in accordance with PCI MNL-116 and perform concrete and aggregate quality control testing using an approved, independent commercial testing laboratory. Submit test results to the Contracting Officer.

or

1.4.1.2 Product Quality Control

NOTE: Category C1: Mild steel reinforced precast concrete element. Category C2: Prestress hollow core and repetitive products. Category C3: Prestressed Straight Strand Structural Members. Category C4: Prestressed Draped Strand Structural Members.

Plants shall be certified by the PCI Plant Certification Program for category [C1] [C2] [C3] [C4] work.

1.4.2 Fabrication, Sampling, and Testing

PCI MNL-116, at the prestressor's option, in lieu of core samples, ACI 318M/318RM full scale load tests may be performed. Perform on randomly selected members, as directed by the Contracting Officer.

1.5 DELIVERY, STORAGE, AND HANDLING

Lift and support prestressed members at the lifting and supporting points indicated on the detail drawings. Store prestressed members off the ground. Separate stacked prestressed members by battens across the full width of each bearing point. Protect from weather, marring, damage, and overload.

1.6 QUALITY ASSURANCE

1.6.1 Certificates

1.6.1.1 Procedures

Submit quality control procedures established in accordance with PCI MNL-116 by the prestressing manufacturer.

1.6.2 Content of Drawings

Submit drawings indicating complete information for the fabrication, handling, and erection of the prestressed member. Drawings shall not be reproductions of contract drawings. Design calculations and drawings of prestressed members (including connections) shall be prepared and sealed by a registered professional engineer, and submitted for approval prior to fabrication. The drawings shall indicate, as a minimum, the following information:

- a. Marking of members for erection
- b. Connections for work of other trades
- c. Connections between members, and connections between members and other construction
- d. Location and size of openings which cut prestressing strands, or require the relocation of prestressing strands to be cast in the member

- e. Headers for openings
- f. Joints between members, and joints between members and other construction
- g. Reinforcing, including prestressing steel details
- h. Schedule and sequence of tensioning and detensioning prestressing strands
- i. Material properties of steel and concrete used
- j. Lifting and erection inserts
- k. Dimensions and surface finishes of each member
- l. Estimated camber
- m. Erection sequence and handling requirements
- n. All loads used in design (such as live, dead, handling, and erection)
- o. Bracing/shoring required
- p. Areas to receive toppings, topping thickness

1.6.3 Design Calculations

Submit calculations reflecting design in accordance with the paragraph entitled "Precast Prestressed Concrete Member Design." Design calculations and drawings of prestressed members (including connections) shall be prepared and sealed by a registered professional engineer, and submitted for approval prior to fabrication. Submit calculations for volume change as part of the design calculations.

1.6.4 Mix Design

Thirty days minimum prior to concrete placement, submit a mix design for each strength and type of concrete. Include a complete list of materials including type; brand; source and amount of cement, pozzolan, and admixtures; and applicable reference specifications.

1.6.5 Requirements

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 job conditions. Obtain approval before concrete placement.

1.6.6 Batch Test

ASTM C 94. Submit mandatory batch ticket information for each load of ready-mixed concrete.

PART 2 PRODUCTS

2.1 CONCRETE

NOTE: Normal prestressed design is based on concrete having a compressive strength of [35 MPa] [5000 psi] at 28 days. Some prestressors like to speed up production by using Type III (high early strength) concrete.

NOTE: Delete air entraining requirements when the project is located in a nonfreezing climate.

ACI 318M/318RM, for contractor furnished mix design. The minimum compressive strength of concrete at [28] [_____] days shall be [35 MPa] [5000 psi] [_____] , unless otherwise indicated. [Add air-entraining admixtures at the mixer to produce between 4 and 6 percent air by volume.]

2.2 MATERIALS

2.2.1 Cement

NOTE: For normal prestressing (not requiring sulfate resistance), use the first bracketed item. If sulfate resistance is required, use the second bracketed item.

[ASTM C 150, Type I, II, or III; or ASTM C 59/C 59M5M ASTM C 59/C 59M5 Type IP(MS) or IS(MS)] [ASTM C 150, Type II; or ASTM C 59/C 59M5M ASTM C 59/C 59M5 Type IP(MS) or IS(MS)] blended cement, except as modified herein. The blended cement shall consist of a mixture of ASTM C 150 cement and one of the following materials: ASTM C 618 pozzolan or fly ash, or ASTM C 989 ground iron blast furnace slag. The pozzolan/fly ash content shall not exceed 25 percent by weight of the total cementitious material. For exposed concrete, use one manufacturer for each type of cement, ground slag, fly ash, and pozzolan.

2.2.1.1 Fly Ash and Pozzolan

ASTM C 618, Type N, F, or C, except that the maximum allowable loss on ignition shall be 6 percent for Type N and F.

2.2.1.2 Ground Iron Blast-Furnace Slag

ASTM C 989, Grade 100 or 120.

2.2.2 Water

Water shall be fresh, clean, and potable.

2.2.3 Aggregates

2.2.3.1 Grading and Composition

NOTE: Select gradation(s) based on job requirements and constraints. The maximum aggregate size shall not exceed three-quarters the minimum cover over

tendons and reinforcing. Aggregate grading sizes with their general grading ranges are as follows: Size 57 (25 mm one inch to No. 4 sieve), Size 67 (20 mm 3/4 inch to No. 4 sieve), and Size 7 (12 mm 1/2 inch to No. 4 sieve).

ASTM C 33, Size [57] [67] [7] [____], except as modified herein. Obtain aggregates for exposed concrete surfaces from one source. Aggregates shall not contain any substance which may be deleteriously reactive with the alkalis in the cement.

[2.2.3.2 Aggregates for Lightweight Concrete

ASTM C 330.

]2.2.4 Nonshrink Grout

ASTM C 1107.

2.2.5 Admixtures

[2.2.5.1 Air-Entraining

NOTE: Delete air entraining requirements when the project is located in a nonfreezing climate.

ASTM C 260.

]2.2.5.2 Accelerating

ASTM C 494, Type C or E.

]2.2.5.3 Water Reducing

ASTM C 494, Types A, E, or F.

]2.2.6 Reinforcement

2.2.6.1 Reinforcing Bars

NOTE: Specify ASTM A 706/A 706M reinforcing where welding or bending of reinforcement bars is important. In addition with permission of the designer, ASTM A 775 epoxy coated reinforcing may be specified where extra reinforcement protection is required.

[ASTM A 706/A 706M, Grade 400 60;] ASTM A 615/A 615M, Grade [300] [400] [40] [60], ASTM A 617/A 617M, Grade [300] [400] [40] [60]; or ASTM A 616/A 616M, Grade 400 [50] [60].

2.2.6.2 Welded Wire Fabric

ASTM A 185 or ASTM A 497.

2.2.6.3 Spiral Wire

ASTM A 82.

2.2.6.4 Prestressing Strands

- a. Seven Wire Stressed Relieved: ASTM A 416/A 416M for low relaxation wire.
- b. Single Wire Stressed Relieved: ASTM A 421 for low relaxation wire.

2.2.7 Bearing Pads

2.2.7.1 Elastomeric

AASHTO HB-17, for plain neoprene bearings.

2.2.7.2 Hardboard (Interior Only)

ANSI A135.4, class as specified by the prestressing manufacturer.

2.2.8 Cementitious Grout

Shall be a mixture of portland cement, sand, and water. Proportion one part cement to approximately 2.5 parts sand, with the amount of water based on placement method. Provide air entrainment for grout exposed to the weather.

2.3 FABRICATION

PCI MNL-116, unless specified otherwise.

2.3.1 Forms

Brace forms to prevent deformation. Forms shall produce a smooth, dense surface. Chamfer exposed edges of columns and beams 20 mm 3/4 inch, unless otherwise indicated. Provide threaded or snap-off type form ties.

2.3.2 Reinforcement Placement

ACI 318M/318RM for placement and splicing. Reinforcement may be preassembled before placement in forms. Provide exposed connecting bars, or other approved connection methods, between prestressed and cast-in-place construction. Remove any excess mortar that adheres to the exposed connections. Provide curvature or drape of the prestressing strands using approved hold-down devices.

2.3.3 Inserts

When the ends of the prestressed member will be exposed, recess the prestressing stands using inserts. After detensioning, remove inserts and fill the recess with nonshrink grout.

2.3.4 Concrete

2.3.4.1 Concrete Mixing

ASTM C 94. Mixing operations shall produce batch-to-batch uniformity of

strength, consistency, and appearance.

2.3.4.2 Concrete Placing

ACI 304R [, ACI 305R for hot weather concreting] [, ACI 306.1 for cold weather concreting,] and ACI 309R, unless otherwise specified.

2.3.4.3 Concrete Curing

Commence curing immediately following the initial set and completion of surface finishing. Provide curing procedures to keep the temperature of the concrete between 10 and 85 degrees C 50 and 190 degrees F. When accelerated curing is used, apply heat at controlled rate and uniformly along the casting beds. Monitor temperatures at various points in a product line in different casts.

2.3.5 Prestressing

NOTE: For normal prestressing use a release strength of 23 MPa 3500 psi, unless the design requires a higher release strength. Some release strengths are indicated in the PCI Design Handbook for selected prestressed members based on different load conditions, strand patterns, and span lengths.

Do not transfer prestressing forces during detensioning until the concrete has reached a minimum compressive strength of [24 MPa] [3500 psi] [____], unless a higher strength is required by the Contractor furnished design.

2.3.6 Surface Finish

Repairs to honeycombed sections located in a bearing area shall be approved by the Contracting Officer prior to repairs. Prestressed members which contain honeycombed sections deep enough to expose prestressing strands shall be rejected. Prestressed members containing hairline cracks which are visible and are less than 0.5 mm 0.02 inches in width, may be accepted. However, prestressed members which contain cracks greater than 0.5 mm 0.02 inches in width shall be approved by the Contracting Officer. When approved, the member shall be repaired. Any prestressed member that is structurally impaired shall be rejected.

2.3.6.1 Unformed Surfaces

Provide a [floated] [steel troweled] finish.

2.3.6.2 Formed Surfaces

NOTE: PCI MNL-116 different grades of formed surface finishes:

Commercial Grade: Concrete produced in forms that produce a rough finish. Fins are removed and large surface blemishes filled. Sharp edges that will be visible in the finished structure are ground down.

Standard Grade: Same finish as commercial grade,

except the forms do not produce a texture on the concrete. Surface can be painted, but will have surface voids.

Finish Grade B: Same as standard grade, except all surface blemishes should be filled or finished to provide a smooth surface of uniform appearance if painted.

Finish Grade A: Same as Finish Grade B, except that the components of the completed structure, where exposed, shall be reasonably color matched. This finish is difficult to obtain.

PCI MNL-116 (Appendix A - Commentary), Chapter 3, for grades of surface finishes.

- a. Unexposed Surfaces: Provide a [commercial] [standard] grade surface finish.
- b. Exposed Surfaces: Provide a [standard grade] [finish Grade B] surface finish. [In addition to a Grade B surface finish, members shall have a smooth rubbed finish.]

2.3.6.3 Architectural Finish

Provide a [finish Grade A] [_____] surface finish to those members indicated.

PART 3 EXECUTION

3.1 SURFACE REPAIR

Prior to erection, and again after installation, check prestressed members for damage, such as cracking, spalling, and honeycombing. As directed by the Contracting Officer, prestressed members that do not meet the surface finish requirements specified in Part 2 in paragraph entitled "Surface Finish" shall be repaired, or removed and replaced with new prestressed members.

3.2 ERECTION

NOTE: Consult the designer of the structure. All prestressed members are subject to volume changes due to creep, shrinkage, and temperature. Heavily prestressed members and long members are particularly susceptible to large volume changes. If the prestressed member is restrained in position prior to the majority of the volume change occurring, the prestressed members will exert excessive forces on its connections and supporting structures that could cause a structural failure.

Even though connections can be designed to "accommodate" the volume changes of prestressed members, most designers are not aware of the severity of the problem. Most prestressing

manufacturers are aware of the problem and can design appropriate connections; however, the prestressing manufacturer does not check the rest of the structural system for structural integrity.

If a prestressed member is to be placed in a restrained condition, the prestressed member may be allowed to age prior to placement to allow the majority of the volume change to occur. The optimum time period is 90-120 days.

Erect prestressed members after the concrete has attained the specified compressive strength, unless otherwise approved by the prestressing manufacturer. [In addition, prestressed members shall not be rigidly fixed in position until the prestressed member has "aged" [90] [_____] days after detensioning.] Erect in accordance with the approved detail drawings. PCI MNL-116 and PCI MNL-120 (Chapter 8), for tolerances. Provide a 1:500 tolerance, if no tolerance is specified. Brace prestressed members, unless design calculations submitted with the detail drawings indicate bracing is not required. Follow the manufacturer's recommendations for maximum construction loads. Place prestressed members level, plumb, and square within tolerances. Align member ends.

3.3 BEARING SURFACES

Shall be flat, free of irregularities, and properly sized. Size bearing surfaces to provide for the indicated clearances between the prestressed member and adjacent prestressed members or adjoining field placed surfaces. Correct bearing surface irregularities with nonshrink grout. Provide bearing pads where indicated or required. Do not use hardboard bearing pads in exterior locations. Place prestressed members at right angles to the bearing surface, unless indicated otherwise, and draw-up tight without forcing or distortion, with sides plumb.

3.4 WELDING

AWS D1.4 for welding connections and reinforcing splices. Do not weld prestressing strands. Protect the concrete and prestressing strands from heat during welding.

3.5 OPENINGS

Holes or cuts requiring prestressing steel to be cut, which are not indicated on the approved detail drawing, shall only be made with the approval of the Contracting Officer and the prestressing manufacturer. Drill holes less than 300 mm 12 inches in diameter with a diamond tipped core drill.

3.6 GROUTING

Clean and fill indicated keyways between prestressed members, and other indicated areas, solidly with nonshrink grout or cementitious grout. Provide reinforcing where indicated. Remove excess grout before hardening.

3.7 SEALANTS

Provide as indicated and as specified in Section 07920 JOINT SEALANTS.

3.8 CONCRETE TOPPING

Provide as indicated and as specified in Section 03300N CAST-IN-PLACE CONCRETE.

-- End of Section --