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17 STRUCTURAL PRECAST CONCRETE

17.1 GENERAL

17.1.1 Scope

- 1 The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Structural Precast Concrete Work.
- 2 Related Sections and Parts are as follows:

This Section

- Part 2..... Aggregates
- Part 3..... Cementitious materials
- Part 5..... Admixtures
- Part 6..... Property requirements
- Part 7..... Concrete Plants
- Part 8..... Transportation and placing of concrete
- Part 9..... Formwork
- Part 10..... Curing
- Part 11..... Reinforcement
- Part 15..... Hot weather concreting

17.1.2 References

- 1 The following standards and other documents are referred to in this Part:

AASHTOStandard Specification for Highway Bridges, Section 25

- ACI 523.2R.....Guide for Precast Cellular Concrete Floor, Roof, and Wall Units
- ACI 533R.....Guide for Precast Concrete Wall Panels
- ACI 533.1R.....Design Responsibility for Architectural Precast-Concrete Projects
- ACI 543R.....Design, Manufacture, and Installation of Concrete Piles
- ACI 550.1R.....Guide to Emulating Cast-in-Place Detailing for Seismic Design of Precast Concrete Structures
- ASCE/SEI 7.....Minimum Design Loads for Buildings and other Structures
- ACI 318-11Building Code Requirements for Structural Concrete

BS 8110The structural use of concrete.

EN 1991-1-4Eurocode 1. Actions on structures. General actions. Wind actions

EN 1992-1-1Eurocode 2. Design of concrete structures. General rules and rules for buildings

ISO 9000,Quality management systems. Fundamentals and vocabulary

ISO 9001Quality management systems — Requirements

Prestressed Concrete Institute (PCI) , Manual 116

17.1.3 Submittals

- 1 Manufacturer's Literature:
 - (a) the Contractor shall provide copies of manufacturer's specifications and installation instructions for each item of proprietary material to be used, showing compliance with this specification. Information on equipment, embedded items and other accessories shall also be provided.
- 2 Design Mixes:
 - (a) copies of mix designs with support material
 - (b) the requirements of the mix design shall be in accordance with Parts 6 and 7 of this Section.
- 3 Product Design Criteria:
 - (a) loadings for design:
 - (i) initial handling and erection stresses
 - (ii) all dead and live loads as specified on the contract drawings or as required
 - (iii) all other loads specified for the member where they are applicable.
- 4 Product Design Calculations:
 - (a) the design calculations shall be performed by a Structural Engineer experienced in precast concrete design. They shall cover all stages of handling, transportation and erection. The design shall be carried out in accordance with the requirements of EN 1992-1-1 or relevant ACI codes, and shall be accepted by the Engineer.
 - (b) calculations for the design of precast members shall be supported by a statement explaining the principle of design and type of analysis adopted
 - (c) the influence of individual members in achieving the overall stability of the structure should be considered
 - (d) computer programmes used in the designs shall be fully described and details of input and printout shall be presented in a manner which can be readily understood and the following requirements shall be met:
 - (i) programme manuals and instructions to programme users shall be made available to the Engineer upon request
 - (ii) where such programme cannot be demonstrated by the Contractor to have been fully checked or where the Engineer considers it necessary, the Contractor shall run such test examples as the Engineer may choose, in order to verify the completeness and accuracy of the programme
 - (e) members that are exposed to the weather shall be designed to provide for the movement of components without damage, failure of joint seals, undue stress on fasteners or other detrimental effects when subject to seasonal or cyclic day/night temperature ranges
 - (f) precast systems shall be designed to accommodate construction tolerances, deflection of other building structural members and the clearance of intended openings
 - (g) calculate structural properties of framing members in accordance with BS 8110 or EN 1992-1-1, or relevant ACI codes.
- 5 Shop Drawings. The Contractor shall provide the following information for the approval of the Engineer:
 - (a) layout plans and detailed fabrication and placement drawings for each structural precast element
 - (b) shop drawings are to include the following information:
 - (i) size, grade, profile and dimensions of all materials used
 - (ii) connection and anchorage details
 - (iii) lifting devices, locations and handling limitations

- (iv) steel reinforcement details
- (v) all openings, sleeves, inserts and other provisions in full co-ordination with all trades in the Contract
- (vi) identification marks.

6 Erection Procedures:

- (a) detailed outline of sequence and methods of erection including but not limited to types, capacities and numbers of craneage, methods of support and transportation.

7 Fabrication Records:

- (a) A record shall be kept for every piece of precast element produced showing the following:
 - (i) type and number
 - (ii) date of pour
 - (iii) concrete test results
 - (iv) shop drawing reference number
 - (v) type and duration of curing
 - (vi) date of delivery to Site
 - (vii) date of fixing in position.

8 Test Reports:

- (a) copies of all testing and inspection reports.

9 Trial Panels:

- (a) the Contractor shall produce trial panels in accordance with the requirements of Part 10 of this Section.
- (b) trial panels shall be retained for reference purposes for the acceptance of the production work.

17.1.4 Qualifications

- 1 Structural precast work shall be executed by an approved specialist Subcontractor for casting and also for transportation, handling and erection.
- 2 The Contractor may execute this work himself if he can satisfy the Engineer that he has sufficient experience and expertise in this field. As a minimum the Contractor shall:
 - (a) provide satisfactory evidence that his tradesmen and their supervisory personnel engaged in such work have successful experience with work comparable to that shown and specified
 - (b) provide details of organised quality control and testing procedures.

17.1.5 Quality Assurance

- 1 The precast concrete supplier shall have a quality assurance scheme that meets ISO 9001 or equivalent.
- 2 All work shall be performed to secure for the project homogeneous concrete having the required strength, surface finish, materials, durability, and weathering resistance, without planes of weakness or other structural defects, and free of honeycombs, air pockets, voids, projections, offset of plane and other defacements of concrete.
- 3 No alterations or substitutions of the structural systems shown on the Drawings are permitted unless otherwise specified.
- 4 The Contractor shall supervise and co-ordinate all phases of the structural precast concrete construction process and be responsible for the complete manufacturing process.
- 5 All methods of manufacture and practices of handling raw materials and manufactured concrete shall be reviewed by the Engineer before execution of the structural precast concrete work, at least 14 days before the beginning of precasting work.

- 6 Only materials of known quality shall be incorporated in the work.
- 7 All materials shall be properly selected, reviewed and approved by the Engineer before use, and maintained during shipment, storage and use.
- 8 Construction systems and techniques shall be properly selected, reviewed and approved by the Engineer before use, and maintained throughout the complete structural precast concrete construction phase.
- 9 Adequate spare equipment, parts, additional components and repair facilities shall be available for all tools and equipment.
- 10 Regardless of approvals by the Engineer, the Contractor shall be responsible for all materials and methods of structural precast concrete work.
- 11 If work does not meet the specified requirements, the Contractor shall at no additional cost to the Employer:
 - (a) implement removal, replacement or remedial work
 - (b) revise procedures or materials to prevent recurrence of unacceptable work.

17.1.6 Quality Control

- 1 The Contractor shall prepare and provide his quality control programme for structural precast concrete work with particular attention to details, pre-checking processes, procedures and close supervision, and in particular the Contractor shall:
 - (a) in order to assure that proper work is performed to prevent later corrective actions, assign at least one experienced supervisor full time to provide quality control for structural precast concrete work
 - (b) the assignment will not relieve the Contractor's other quality control personnel of their duties relative to the quality control of the structural requirements and surface finish of the structural precast concrete work.
- 2 The Contractor shall arrange for the training of his quality control personnel who will perform quality control of structural precast concrete work and whose training shall include but not be limited to:
 - (a) materials evaluation
 - (b) special mix design techniques
 - (c) mix placement
 - (d) vibrator selection and use
 - (e) formwork details formwork protection
 - (f) release agent use
 - (g) reinforcing steel
 - (h) detailing and installation
 - (i) finishing equipment and techniques
 - (j) corrective procedures and protection of completed work.
- 3 The Contractor's quality control personnel shall be responsible for verifying all details necessary to produce the final structural design objectives.
- 4 The Contractor's quality control personnel shall also verify the quality of the structural precast concrete work and guide the production of results which will be within acceptable physical tolerances

17.1.7 Testing

- 1 Concrete shall be tested as specified in Part 6 of this Section.

- 2 The Contractor shall:
- (a) furnish labour required to facilitate testing
 - (b) inform the Engineer with at least one day's advance notice when concrete is to be placed
 - (c) provide storage facilities for concrete test cubes
 - (d) provide material samples and access to materials as required for testing.
- 3 Should the batching plant be located more than 500 meters away from the site offices, the Contractor shall provide suitable transport acceptable to the Engineer, for the sole use of the Engineer's staff.
- 4 The Contractor shall station a qualified technician at the casting site to continuously test, inspect and report on the following:
- (a) that concrete testing is being carried out in accordance with the requirements of Part 6 of this Section
 - (b) check the following and verify conformance with specified requirements and approved shop drawings:
 - (i) all reinforcing bars
 - (ii) all embedded items
 - (iii) all formwork
 - (c) check all openings and provisions for co-ordination with all trades in the Contract as shown on approved shop drawings.
- 5 The Contractor shall provide facilities and equipment for the conducting of all tests specified herein except for the strength test which should be carried out by an approved independent testing agency.

17.1.8 Delivery, Storage and Handling

- 1 The structural precast elements shall be removed from the form without damaging or over stressing and stored or placed for transportation on a stable bed that will not allow distortion of the member.
- 2 Separate stacked members with suitable battens and bracing.
- 3 Mark each member with an identifying reference or piece mark, and the date of casting.
- 4 All piece marks are to be correlated with test reports and plan layouts or erection drawings.
- 5 The structural precast element shall be transported with sufficient battens, bracing, and supports so as to prevent over-stress by vibration or impact loadings. The Contractor shall submit his proposed method of transportation to the Engineer for approval.
- 6 Structural precast units shall be stored, handled and transported in a manner that will avoid undue strains, hair cracks, staining, or other damage.
- 7 The Contractor shall deliver the units from the casting site to the project Site in accordance with schedule and proper setting sequence.
- 8 Structural precast units shall be stored free of the ground and protected from wind or rain splashes.
- 9 The units shall be covered and protected from dust, dirt or other staining materials.
- 10 During fabrication, construction and after erection, the Contractor shall protect the castings to avoid the possibility of damage.

17.1.9 Design Loadings, Actions and Structural Members Selection

- 1 The provisions of this Clause shall apply if the Contractor is responsible for the design of the structural precast units.
- 2 The precast elements shall be designed to withstand all loading conditions against which strength and serviceability must be measured.
- 3 Vertical loads shall include the self-weight of precast elements, floor coverings and live loads as indicated on the contract drawings.
- 4 The wind loads shall be calculated based on the wind speed provided in Section 1 part 1 clause 1.5.2.
- 5 Account shall be taken of the loads and deformation caused by temperature and time dependent deformations. For such purpose 55 °C temperature variation and 90 % relative humidity should be considered for all members, except exterior elements and facade elements shall consider 85 °C.
- 6 Precast elements shall be designed in accordance with EN 1992-1-1 or relevant ACI code. Design tensile stresses should not exceed the design flexure tensile stress of concrete, at the particular age of the concrete.
- 7 Nominal cover to steel including links must meet the durability requirement of severe condition of exposure and to meet requirement for 2 h period of fire resistance, as provided for in EN 1992-1-1 or relevant ACI code.
- 8 Total deflection of precast elements should be limited to 1/350 of the span of this element.
- 9 Plan and design for openings for building services, where required or necessary.

17.2 MATERIALS

17.2.1 General

- 1 The Contractor shall obtain cement, aggregates and water from a single source, sufficient to complete the entire structural precast concrete work to assure regularity of appearance and uniformity of colour.
- 2 The Contractor shall provide all materials in accordance with and meet all applicable requirements of this section.

17.2.2 Reinforcing Bars

- 1 Reinforcing bars shall conform to the requirements of Part 11 of this Section

17.2.3 Bearing Pads

- 1 These shall be Elastomeric neoprene, conforming to AASHTO Standard Specifications for Highway Bridges (Section 25) with the following stipulations:
 - (a) use unfactored loads for design
 - (b) maximum compressive stress, 0.70 MPa
 - (c) maximum shear stress, 0.07 MPa
 - (d) maximum shear deformation, 1/2 thickness
 - (e) maximum compressive strain, 15 %

17.2.4 Embedded Steel

- 1 All embedded items shall be of stainless steel Grade 316L.

17.3 FORMING

17.3.1 General

- 1 Forms and casting beds are to be firmly seated so as not to deflect or be displaced under concreting or tensioning loads.
- 2 Correct for thermally induced strains or forces.
- 3 For member penetrations larger than 150 mm, coring or field cutting is not permitted unless approved by the Engineer.
- 4 Clean and coat forms with release agent before installation or reinforcing or embedments.

17.3.2 Tolerances

- 1 Permissible deviations of formed surfaces are not to exceed tolerances outlined in PCI Manual 116, with items as summarised or modified in Table 17.1

Table 17.1
Tolerances for Structural Precast Concrete

Description	Tolerance
Dimensions	
Length:	±5 mm
Width:	±3 mm
Thickness:	Stem ±3 mm; Flange ±2.0 mm.
Embedment or penetration location:	±0.2 %
Straightness:	±3 mm. for 300 cm
End squareness:	±3 mm

17.4 INSTALLATION

17.4.1 General

- 1 The Contractor's erection responsibilities include the safe and proper placing, aligning, and levelling of the structural precast elements on the accepted bearing surfaces and affecting their proper fastening.

17.4.2 Survey

- 1 Before placement of the structural precast elements the Contractor shall survey and maintain all temporary supports shown or required to control alignment, and deflection.
- 2 Temporary supports shall be retained until framing elements braced thereby have attained integral stability in accordance with the design.

17.4.3 Guying, Bracing and Shoring

- 1 The Contractor shall install in proper sequence and maintain all temporary supports shown or required to control alignment, deflection and stress levels.
- 2 Temporary supports shall be retained until framing elements braced thereby have attained integral stability in accordance with the design.

17.4.4 Adjustment and Correction

- 1 The Contractor shall compensate and correct for the misaligning affect of temperature, draw from welding, bolting or erection sequence or grouting.

17.4.5 Erection Tolerances

- 1 The following erection tolerances shall apply unless otherwise specified in the Contract:

(a) Variations from plumb	6 mm in 6 m run; 12 mm total in a 12 m or longer run
(b) Variation from level or elevation	6 mm in runs; 12 mm in 12 m run; maximum 12 mm at single locations
(c) Variation from position in plan	±12 mm maximum.
(d) Offsets in alignment of adjacent members at joints	1.5 mm in 3 m run, 6 mm maximum.

17.4.6 Welding

- 1 Where permission for welding is given by the Engineer, the following shall apply:
- (a) welding shall not take place until all adjacent elements to be connected have been aligned, firmly seated and braced
 - (b) control of heat build-up by limiting voltage, electrode size, and rate
 - (c) spalled or heat damaged concrete around weldments shall not be acceptable.

17.4.7 Grouting

- 1 Joints, gaps and connections shall be filled with grout as shown on the Drawings and as approved by the Engineer.

17.4.8 Field Cutting

- 1 Field cutting of holes may be done only with the Engineer's concurrence, and only with power saws or core drills. Steel reinforcement or prestressing strand shall be avoided, where the reinforcement or strand is damaged the unit shall be repaired to the satisfaction of the Engineer, or rejected.
- 2 The maximum hole size shall be 150 mm diameter or as limited by member size or strand location
- 3 Any cracks, spalls and sharp corners created by field cutting are to be ground, eased, and patched with epoxy type bonding and patching compounds.

END OF PART