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Structural

PIP STS03001
Plain and Reinforced Concrete Specification

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

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PIP STS03001

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1. Scope

This Practice provides requirements for cast-in-place concrete construction.

This Practice describes technical requirements for furnishing and installing materials and for proportioning, mixing, placing, testing, and curing of plain and reinforced concrete.

This Practice supplements ACI 301-16, *Specifications for Structural Concrete*, and ACI 301M-16, *Specifications for Structural Concrete (Metric)*.

2. References

Applicable parts of the following Practices, industry codes and standards, and references shall be considered an integral part of this Practice. The edition of references shall be as shown in *ACI 301-16 / ACI 301M-16* Section 1.4 or, if not listed in *ACI 301-16 / ACI 301M-16*, shall be the edition in effect on the date of contract award, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP STF05121 - *Anchor Fabrication and Installation into Concrete*

2.2 Industry Codes and Standards

- American Concrete Institute (ACI)
 - ACI 117 - *Specification for Tolerances for Concrete Construction and Materials and Commentary*
 - ACI 117M - *Specification for Tolerances for Concrete Construction and Materials and Commentary (Metric)*
 - ACI 237R - *Self-Consolidating Concrete*
 - ACI 301-16 - *Specifications for Structural Concrete*
 - ACI 301M-16 - *Specifications for Structural Concrete (Metric)*
 - ACI 304R - *Guide for Measuring, Mixing, Transporting, and Placing Concrete*
 - ACI 305.1 - *Specification for Hot Weather Concreting*
 - ACI 306.1 - *Standard Specification for Cold Weather Concreting*
 - ACI 350.1 - *Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures*
 - ACI 350.1M - *Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures (Metric)*
 - ACI 350.5 - *Specifications for Environmental Concrete Structures*
 - ACI 350.5M - *Specifications for Environmental Concrete Structures (Metric)*
 - ACI SP-66 - *ACI Detailing Manual*
- ASTM International (ASTM)
 - ASTM A615/A615M - *Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement*
 - ASTM A1064/A1064M - *Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete*

- ASTM C33/C33M - *Standard Specification for Concrete Aggregates*
- ASTM C150/C150M - *Standard Specification for Portland Cement*
- ASTM C618 - *Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete*
- ASTM C920 - *Standard Specification for Elastomeric Joint Sealants*
- ASTM C989/C989M - *Standard Specification for Slag Cement for Use in Concrete and Mortars*
- ASTM C1602/C1602M - *Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete*
- ASTM C1610/C1610M - *Standard Test Method for Static Segregation of Self-Consolidating Concrete Using Column Technique*
- ASTM C1611/C1611M - *Standard Test Method for Slump Flow of Self-Consolidating Concrete*
- ASTM C1621/C1621M - *Standard Test Method for Passing Ability of Self-Consolidating Concrete by J-Ring*
- ASTM C1712 - *Standard Test Method for Rapid Assessment of Static Segregation Resistance of Self-Consolidating Concrete Using Penetration Test*
- ASTM D1751 - *Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)*
- ASTM D5249 - *Standard Specification for Backer Material for Use with Cold- and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints*
- ASTM E1745 - *Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs*
- Concrete Reinforcing Steel Institute (CRSI)
 - *Manual of Standard Practice*
- National Ready Mixed Concrete Association (NRMCA)
 - *Quality Control Manual - Section 3, Certification of Ready Mixed Concrete Production Facilities – Plant Certification Check List*

3. Definitions

constructor: Party responsible for supplying materials, equipment, tools, supervision, and labor for installation of concrete materials in accordance with contract documents. The term constructor shall apply also to constructor's subcontractor(s) and vendor(s).

contract documents: Any and all documents, including codes, studies, design drawings, specifications, sketches, practices, and data sheets, that purchaser or engineer of record has transmitted or otherwise communicated, either by incorporation or reference, and made part of the legal contract agreement or purchase order between purchaser and constructor.

engineer of record: Purchaser's authorized representative with overall authority and responsibility for engineering design, quality, and performance of civil works, structure, foundations, materials, and appurtenances described in contract documents. Engineer of record shall be licensed as defined by laws of the locality in which the work is to be constructed, and be

qualified to practice in the specialty discipline required for the work described in contract documents.

environmental engineering concrete structures: Concrete structures intended for conveying, storing, or treating water, wastewater, or other nonhazardous liquids, and for secondary containment of hazardous materials.

manufacturer: Party who produces and warrants performance of products, materials, and/or items provided in accordance with contract documents. Products, materials, and/or items are manufactured in a controlled process using standard codes, specifications, tests and possibly include shop drawings to assist in proper application, installation and/or use. The term manufacturer shall apply also to manufacturer's subcontractor(s) and/or vendor(s).

mass concrete: Any volume of structural concrete in which a combination of dimensions of the member being cast, the boundary conditions, the characteristics of the concrete mixture, and the ambient conditions can lead to undesirable thermal stresses, cracking, deleterious chemical reactions, or reduction in the long-term strength as a result of elevated concrete temperature due to heat from hydration.

owner: Party who has authority through ownership, lease, or other legal agreement over site, facility, structure or project wherein concrete materials will be used.

purchaser: Party who awards contract to constructor. Purchaser may be owner or owner's authorized agent.

self-consolidating concrete: Fresh concrete that can flow around reinforcement and consolidate within formwork under its own weight without vibration.

supplier: Party responsible for supplying concrete materials in accordance with contract documents.

4. Requirements

4.1 General

- 4.1.1 Concrete supply and construction shall be in accordance with all requirements of *ACI 301-16 / ACI 301M-16*, except as modified or supplemented in this Practice or by contract documents.
- 4.1.2 Requirements of federal, state or local agencies that have jurisdiction where concrete is to be placed shall apply.
- 4.1.3 Any conflicts or inconsistencies between this Practice, design drawings, or other contract documents shall be brought to the attention of purchaser for resolution.
- 4.1.4 For applications designated as environmental engineering concrete structures in contract documents, concrete supply and construction shall also be in accordance with *ACI 350.5 / ACI 350.5M*.
- 4.1.5 Any placement of concrete designated in contract documents as mass concrete or any placement of structural concrete with a minimum dimension equal to or greater than 4 ft (1200 mm) shall be considered mass concrete unless otherwise specified in contract documents and shall be in accordance with Section 8 of *ACI 301 / ACI 301M*. For applications designated as environmental engineering

concrete structures in concrete documents, any placement of concrete designated in contract documents as mass concrete shall also be in accordance with Section 8 of *ACI 350.5 / ACI 350.5M*.

4.2 Quality Control

- 4.2.1 A written quality control program and inspection procedures document shall be submitted to purchaser for approval. These documents shall provide details of how compliance with requirements of this Practice and contract documents shall be achieved.
- 4.2.2 Samples for testing shall be obtained in accordance with *ACI 301 / ACI 301M*. Rate of sampling shall be in accordance with *ACI 301 / ACI 301M* and the following:
 - a. For structures and foundations, samples shall be obtained in accordance with the following requirements:
 - (1) One sample minimum per 100 cubic yards (76 cubic meters) of concrete
 - (2) One sample minimum for each structure or foundation, except if placing a number of items each smaller than 25 cubic yards (19 cubic meters)
 - (3) One sample minimum per 25 cubic yards (19 cubic meters) if placing a number of items each smaller than 25 cubic yards (19 cubic meters)
 - b. For paving and slabs on grade, obtain one sample per 50 cubic yards (38 cubic meters) of concrete.
 - c. For underground pipe or electrical encasements and fireproofing, obtain one sample at beginning of each day of concreting work.
 - d. For all other concrete, obtain samples in accordance with Section 4.2.2.a.
 - e. Additional samples shall be obtained if observations of tests for slump (except for self-consolidating concrete), temperature, or air content indicate nonconformance with contract documents.
 - f. For self-consolidating concrete only, additional samples shall be obtained if observations of tests for slump flow, T_{50} , Visual Stability Index (VSI), column segregation or passing ability indicate nonconformance with contract documents.
- 4.2.3 For each concrete sample obtained, the following tests shall be conducted in accordance with *ACI 301 / ACI 301M*:
 - a. Compressive strength
 - b. Slump (except for self-consolidating concrete)
 - c. Temperature
 - d. Air content

- 4.2.4 For each concrete sample obtained for self-consolidating concrete, the following tests shall also be conducted:
- a. Slump flow in accordance with *ASTM C1611/C1611M*
 - b. T_{50} and Visual Stability Index (VSI) in accordance with Appendix of *ASTM C1611/C1611M*
 - c. Column segregation in accordance with *ASTM C1610/C1610M* or *ASTM C1712*
 - d. Passing ability in accordance with *ASTM C1621/C1621M*
- 4.2.5 Test cylinder sets shall be dated and numbered consecutively.
- 4.2.6 Concrete quality control test reports shall be provided to purchaser weekly unless otherwise specified in contract documents. Data in test report shall include, but not be limited to, the following:
- a. Location of concrete on the job and associated design drawing numbers and structure/foundation identification
 - b. Specified compressive strength (f'_c)
 - c. Date placed
 - d. Proportions of concrete mix or mix identification
 - e. 7- and 28-day compressive strength and compressive strength for any other duration as specified in contract documents
 - f. Slump (except for self-consolidating concrete), air and concrete temperatures at time of placement, time of day concrete was batched, and time of day concrete was placed
 - g. For self-consolidating concrete only, slump flow, T_{50} , Visual Stability Index (VSI), column segregation and passing ability
 - h. Air content
 - i. Name of inspector making cylinders and cylinder number
- 4.2.7 Constructor shall notify testing agency when concrete is to be placed.
- 4.2.8 Ready mixed concrete suppliers shall be certified in accordance with one of the following:
- a. Certification by holding a current NRMCA Certificate of Conformance for Concrete Production Facilities
 - b. Certification from an independent testing agency stating conformance with NRMCA Certification of Ready Mixed Concrete Production Facilities
 - c. Certification from Department of Transportation or governing authority for the project site location
- The certification shall be current for duration of concrete supply.

4.3 Quality Assurance

- 4.3.1 Unless otherwise specified in contract documents, the purchaser shall be responsible for furnishing a testing agency to act as the “owner’s testing agency” as defined by *ACI 301 / ACI 301M*.
- 4.3.2 The purchaser shall have the right to make inspections at any time at the source of supply of materials, at the place of preparation of materials, at the mixing plant if ready mixed concrete is used, and during execution of all concrete work.

4.4 Submittals

- 4.4.1 The items listed in Table 2 shall be submitted for engineer of record review and approval of items in the Approval Column. Work shall not proceed without approval.
- 4.4.2 Additional documentation which is not listed in Table 2 shall be submitted to purchaser if required by contract documents.

4.5 Materials

4.5.1 General

- 4.5.1.1 Materials shall be in accordance with this Practice and contract documents unless otherwise approved in writing by purchaser.
- 4.5.1.2 Materials and application thereof shall be in accordance with applicable federal, state and local volatile organic compound regulations.

4.5.2 Cementitious Materials

- 4.5.2.1 Portland cement shall be in accordance with *ASTM C150/C150M*, Type I or Type II unless otherwise specified in contract documents.
- 4.5.2.2 Only one brand of cement shall be used.
- 4.5.2.3 Fly ash may be used in accordance with *ACI 301 / ACI 301M* and shall be in accordance with *ASTM C618*, Class F unless otherwise specified in contract documents. Class C fly ash may be used if Class F is not available.
- 4.5.2.4 Ground Granular Blast Furnace Slag (GGBFS) in accordance with *ASTM C989/C989M* may be used if available.
- 4.5.2.5 Cementitious materials used for mass concrete applications shall be in accordance with *ACI 301 / ACI 301M* Section 8.2.1.1. For applications designated as environmental engineering concrete structures in contract documents, cementitious materials used for mass concrete applications shall also be in accordance with *ACI 350.5 / ACI 350.5M* Section 8.2.1.1.

4.5.3 Admixtures

- 4.5.3.1 All admixtures shall require engineer of record’s authorization for use.
- 4.5.3.2 Only one manufacturer for each admixture shall be used. Admixtures used together shall be from same manufacturer or documentation of compatibility from manufacturers shall be submitted for approval prior to use.

- 4.5.3.3 Calcium chloride and admixtures containing soluble chlorides shall not be permitted.
- 4.5.3.4 For applications designated as environmental engineering concrete structures in contract documents, admixtures used for mass concrete applications shall be in accordance with *ACI 350.5 / ACI 350.5M* Section 8.2.1.2.

4.5.4 Aggregate

- 4.5.4.1 Aggregate shall be in accordance with *ASTM C33/C33M*.
- 4.5.4.2 Aggregate shall be obtained from a single source.
- 4.5.4.3 Aggregates proposed for use shall be tested in accordance with Appendix of *ASTM C33/C33M*, or a record of satisfactory performance shall be submitted to engineer of record for approval.
- 4.5.4.4 Fine and coarse aggregate shall meet the restrictions on reactive materials in accordance *ASTM C33/C33M*.

4.5.5 Reinforcement

- 4.5.5.1 Reinforcing bars shall be deformed billet steel in accordance with *ASTM A615/A615M*, Grade 60 (420) unless otherwise specified in contract documents.
- 4.5.5.2 Reinforcing shall be uncoated unless otherwise specified in contract documents.
- 4.5.5.3 Welded wire reinforcement shall be plain wire in accordance with *ASTM A1064/A1064M*. Wire shall be of sufficient size to fabricate in sheets. Rolls of welded wire reinforcement shall not be used.
- 4.5.5.4 Tie wire shall be black annealed wire, 16 gage (1.29 mm) minimum.

4.5.6 Water

Water used for mixing water, ice, curing, or any other function relating to placement of concrete shall be potable or meet the requirements of *ASTM C1602/C1602M*.

4.5.7 Accessories

Accessories shall meet the requirements of *ACI 301 / ACI 301M*.

4.5.8 Joints

- 4.5.8.1 Joint filler shall be in accordance with *ASTM D1751* unless otherwise specified in contract documents.
- 4.5.8.2 Backer rod for joint sealant shall be in accordance with *ASTM D5249*. Diameter shall be 1.5 times the width of the joint unless otherwise specified in contract documents.
- 4.5.8.3 Joint sealant shall be in accordance with *ASTM C920*, unless otherwise specified in contract documents.

4.5.9 Anchorage

Anchorage shall be in accordance with *PIP STF05121*, unless otherwise specified in contract documents.

4.5.10 Vapor Barrier

Below floor vapor barrier shall be in accordance with *ASTM E1745*, Class A, and minimum 10 mil (250 μ m) thickness unless otherwise specified in contract documents.

4.6 Execution

4.6.1 General

4.6.1.1 Storage, handling, measuring, mixing, transporting, and placing of concrete materials shall follow the methods and means outlined in *ACI 304R* and comply with manufacturer's written recommendations for handling, storage, and protection.

4.6.1.2 Execution for self-consolidating concrete shall follow the methods and means outlined in *ACI 237R*.

4.6.2 Formwork

4.6.2.1 Unless otherwise specified in contract documents, 3/4-inch (20-mm) chamfer strips shall be provided at all corners on permanently exposed surfaces.

4.6.2.2 Form-release agents shall not be applied if concrete surfaces shall receive special finishes or where the agent may affect applied coverings. Alternately, inside surfaces of untreated formwork shall be soaked with clean water and kept moist before placing concrete.

4.6.2.3 Form removal shall be in accordance with *ACI 301 / ACI 301M* and the following:

- a. For structures for which forms do not provide vertical support or lateral stability (e.g., footings, piers, columns, walls, or sides of beams), the forms may be removed 48 hours after completion of placement if concrete is sufficiently hard to prevent damage by form removal, and if curing starts immediately.
- b. Unless otherwise specified in contract documents, forms for self-supporting members may be removed if concrete compressive strength is at least 80 percent of the specified 28-day compressive strength. Refer to *ACI 301 / ACI 301M*, Section 2.3.4, for determining compressive strength of concrete for removal of formwork.
- c. Unless otherwise approved by the purchaser, forms shall not be left permanently in place.

4.6.2.4 Form accessories that remain embedded in the concrete (e.g., ties and hangers) shall be a commercially manufactured type.

4.6.2.5 Formed concrete surfaces shall be constructed in accordance with the tolerances shown in *ACI 117 / ACI 117M*.

- 4.6.2.6 Formwork for columns and walls shall be provided with adequate cleanout openings to permit inspection and easy cleaning after reinforcement has been placed.
- 4.6.2.7 All side and bottom surfaces of concrete for structures that will be exposed shall be formed. Unless otherwise approved by engineer of record, vertical surfaces of concrete for subgrade structures and pavements shall be formed at least to a depth of 12 inches (300 mm) below grade. Concrete below this level may be placed against earth.
- 4.6.2.8 Formwork design calculations and drawings shall be sealed by engineer of record for the formwork.

4.6.3 Joints

- 4.6.3.1 All joints shall be located and constructed in accordance with contract documents. Any variation from the location specified shall be approved by engineer of record.
- 4.6.3.2 Control joints to be cut with a saw shall be cut as soon as concrete is hard enough to prevent surface raveling and aggregate dislodging, and within 8 hours after concrete placement.
 - a. Control joints shall be cut in accordance with saw manufacturer's written recommendations.
 - b. Sawing sequence shall be based on concrete placement time and size of slab.
- 4.6.3.3 Control joints in slab toppings shall be located directly above and in line with the control joints in underlying concrete slab.
- 4.6.3.4 Isolation joints shall be placed where pavement adjoins vertical surfaces (e.g., walls, columns, catch basins, manholes, and equipment foundations). Isolation joints shall be located in accordance with contract documents.
- 4.6.3.5 Dowels at expansion joints shall be properly aligned to prevent any restraint on expansion movement at the joint.
- 4.6.3.6 The surface of joints shall be cleaned of scale and laitance and thoroughly wetted, but free of standing water, before placing adjoining concrete.

4.6.4 Waterstops

Waterstops shall be installed in accordance with contract documents and manufacturer's written recommendations.

4.6.5 Reinforcing and Embedments

4.6.5.1 Detailing and Fabrication

1. Reinforcement placing drawings and bending schedules shall be prepared in accordance with *ACI SP-66* and *CRSI Manual of Standard Practice* and submitted to engineer of record for review and approval.

2. Reinforcement placing drawings and bending schedules shall show number, grade, size, length, mark, location, and bending diagrams for reinforcing bars.
3. Splices in reinforcement shall be detailed, fabricated, and located only as shown on the design drawings.
4. Fabrication drawings shall indicate the related PO number, release number, and design drawing number.
5. Reinforcement shall be tagged with weather-resistant metal tags.
6. Each bundle of fabricated bars shall be tagged. The tags shall indicate reinforcement placing drawing number, release number, mark number, grade, bar quantity, and bar size.
7. Each bundle of stock-length straight bars shall be tagged to indicate bar quantity, grade, bar size, and bar length.
8. Fabrication tolerances shall comply with the requirements of *ACI 117 / ACI 117M*.

4.6.5.2 Installation

1. Embedded aluminum items shall not be permitted.
2. Anchors, inserts, sleeves, drains, curb and seat angles, nosing, and other embedded items shall be installed before placing concrete. Welding of these items to the reinforcing bars shall not be permitted.
3. Embedded portion of anchor rods shall be wrapped with non-bonding tape for the required length and location specified in contract documents if applicable.
4. Anchor threads above the top of concrete elevation specified on the design drawings shall be covered with duct tape or other suitable means to keep the threads clean and to prevent any damage during placement of concrete.
5. Anchor sleeves shall be filled with a nonbonding moldable material or an elastomeric moldable non-hardening material unless otherwise specified in concrete documents. Anchor sleeves shall be capped or plugged to keep out water, concrete, and debris until sleeves are filled with a nonbonding moldable material or an elastomeric moldable non-hardening material, or for sleeves specified in contract documents to be filled with grout (by others).
6. Grout pockets for anchors and shear keys to be grouted in place (by others) shall be capped or plugged to keep out water, concrete, and debris until pockets are filled with grout.
7. Reinforcing bars shall be spliced in accordance with design drawings only. Unless otherwise approved by engineer of record, welded or mechanical splices shall not be permitted.

4.6.5.3 Tolerances

Embedments shall be installed in accordance with tolerances shown in Table 1, unless otherwise specified in contract documents. The term “anchor group” used in Table 1 is defined as the set of anchors for a single fabricated steel shipping piece, or a single piece of equipment or skid.

Table 1 – Tolerances for Embedments

Measurement	Tolerance
Anchor projection	+ or – 1/4 inch (6 mm)
Center of anchor group	+ or – 1/4 inch (6 mm)
Center to center of any two anchors within a group	+ or – 1/8 inch (3 mm)
Center to center between anchor groups	+ or – 1/4 inch (6 mm)
Anchor plumbness	1/8 inch in 3 feet (4 mm in 1 meter)
Plate inserts in columns, walls, and beams horizontal and vertical location	+ or – 1/4 inch (6 mm)
Shapes and plate inserts in floor slabs	+ or – 1/4 inch (6 mm) horizontal + or – 1/16 inch (2 mm) elevation

4.6.6 Proportioning and Mixing

- 4.6.6.1 Concrete minimum 28-day compressive strength, f'_c , shall be 4,000 psi (28 MPa) unless otherwise specified for Exposure Class in accordance with *ACI 301 / ACI 301M* or other requirements in this Practice or other contract documents.
- 4.6.6.2 Maximum water-cementitious materials ratio shall be 0.4 for environmental engineering concrete structures or concrete designated to be Exposure Class C2 or Exposure Class F3, 0.45 for concrete designated to be Exposure Class F2 or Exposure Class S2 or S3, and 0.5 for all other concrete, unless otherwise specified in contract documents.
- 4.6.6.3 High early strength concrete or other types of high performance concrete shall meet the requirements specified in contract documents.
- 4.6.6.4 Fly ash content shall not exceed 25% by weight of cementitious material, unless approved by engineer of record.
- 4.6.6.5 Unless otherwise specified in contract documents, nominal maximum size of coarse aggregate in concrete shall be in accordance with *ACI 301 / ACI 301M*.
- 4.6.6.6 Concrete mixtures shall comply with the most restrictive requirements of *ACI 301 / ACI 301M* Section 4.2.2.7 for the exposure category and class specified by engineer of record in contract documents.
- 4.6.6.7 Unless otherwise specified in the contract documents, concrete shall be air entrained in accordance with *ACI 301 / ACI 301M* Section 4.2.2.7.b based on the freezing and thawing exposure class specified in contract

documents with the exception of trowel-finished concrete which shall not be air entrained.

- 4.6.6.8 Self-consolidating concrete shall be proportioned to meet slump flow in accordance with *ASTM C1611/C1611M*, T_{50} in accordance with Appendix of *ASTM C1611/C1611M*, and passing ability in accordance with *ASTM C1621/C1621M*, as specified in contract documents for each specific application. Visual stability index (VSI) shall have a rating of 0 (highly stable) or 1 (stable) in accordance with Appendix of *ASTM C1611/C1611M*. Column segregation shall be less than 10% in accordance with *ASTM C1610/C1610M* or *ASTM C1712*.
- 4.6.6.9 Admixtures shall be added at batch plant unless otherwise directed or approved by engineer of record.
- 4.6.6.10 Concrete envelopes for underground electrical ducts and cover slabs for direct-buried cables shall have a minimum 28-day compressive strength, f'_c , of 3,000 psi (21 MPa) and be colored red by adding 10 pounds of red oxide powder per cubic yard (6 kilograms per cubic meter) of concrete unless otherwise specified in contract documents.
- 4.6.6.11 Concrete envelopes for underground instrument air-line ducts shall have a minimum 28-day compressive strength, f'_c , of 3,000 psi (21 MPa) and be colored yellow by adding 10 pounds of yellow oxide powder per cubic yard (6 kilograms per cubic meter) of concrete unless otherwise specified in contract documents.
- 4.6.6.12 On-site mixed concrete shall not be permitted unless otherwise approved by purchaser.

4.6.7 Placing Concrete

- 4.6.7.1 Inspection and authorization shall be obtained from purchaser before placing concrete.
- 4.6.7.2 Concrete that has achieved initial set or has been contaminated by foreign matter shall not be deposited in the structure.
- 4.6.7.3 Re-tempering or addition of water after concrete is first mixed shall not be permitted.
- 4.6.7.4 The addition of ice at construction site shall be permitted only if it has been considered in the mix design. The concrete manufacturer shall provide written instructions on required amount of ice and mixing procedure.
- 4.6.7.5 Materials and equipment for protection, finishing and curing shall be operational at placement site before placement begins.
- 4.6.7.6 Slabs shall be placed in alternating panels.
- 4.6.7.7 The interval between concrete deliveries shall be such that no more than 20 minutes interruption elapse during placement of a single foundation or slab, unless approved by engineer of record.
- 4.6.7.8 Discharge of concrete shall be completed within 45 minutes after introduction of mixing water to cement and aggregates or introduction of

the cement to the aggregates. This time may be extended up to 90 minutes with approval of engineer of record.

4.6.8 Curing and Protection

- 4.6.8.1 Concrete shall be cured and protected in accordance with *ACI 301 / ACI 301M* unless otherwise specified in this Practice or in contract documents.
- 4.6.8.2 Concrete not in contact with forms may utilize any of the methods indicated in *ACI 301 / ACI 301M* for the preservation of moisture.
- 4.6.8.3 Liquid membrane curing compounds shall not be used on surfaces that shall receive bonded treatments, tiles, paint or other adhered finishes, epoxy toppings, or additional concrete unless otherwise specified in contract documents.
- 4.6.8.4 Curing and protection of concrete for environmental engineering concrete structures shall comply with the following:
 - a. The provisions of *ACI 350.5 / ACI 350.5M*.
 - b. Temperature differential between freshly placed and previously placed concrete elements shall be maintained at 18°F (10°C) or less until a minimum compressive strength of 3,500 psi (24 MPa) is achieved.
- 4.6.8.5 Curing and protection of mass concrete shall be in accordance with *ACI 301 / ACI 301M* Section 8.3.1. For applications designated as environmental engineering concrete structures in contract documents, curing and protection of mass concrete shall also be in accordance with *ACI 350.5 / ACI 350.5M* Section 8.3.2.

4.6.9 Loading of Self-Supporting Members

No superimposed load shall be applied to self-supporting members before 28-day verification of specified compressive strength, unless specified 28-day compressive strength has been verified by field-cured cylinders and approved by engineer of record.

4.6.10 Surface Finishing and Tolerances

- 4.6.10.1 Surface finish and correlating tolerance requirements shall be in accordance with *ACI 301 / ACI 301M* and *ACI 117 / ACI 117M* and as specified in contract documents.
- 4.6.10.2 Equipment bases shall be finished with a floated finish. Stairs, steps, ramps, and walks shall be finished with a broom finish.

4.6.11 Repair of Surface Defects

- 4.6.11.1 Tie holes, honeycombs, and other concrete surface defects shall be repaired promptly after form removal at a time and in a manner that shall not delay, interfere with, or impair the proper curing of the fresh concrete unless otherwise specified or approved by engineer of record.

- 4.6.11.2 Engineer of record shall be notified before proceeding with repair if the defect is any of the following:
- a. Depth is greater than 3 inches (75 mm) at the maximum point and surface area is greater than 150 square inches (100,000 square mm).
 - b. Depth is greater than 1/4 the thickness of the member and greater than 6 inches (150 mm) in any other direction.
 - c. Reinforcing steel is exposed.
- 4.6.11.3 Prepackaged grouts and patching compounds or a patching mortar similar to the concrete mix without coarse aggregate may be used with approval of engineer of record.
- 4.6.11.4 Out-of-tolerance slabs shall be repaired by grinding down high points and/or raising low points by using a self-leveling compound or repair topping approved by engineer of record and installed in accordance with manufacturer's recommendation.
- 4.6.11.5 Critical slab areas, identified in contract documents shall be replaced if out-of-tolerance. A demolition and replacement plan for the slab areas shall be submitted to engineer of record for review and approval before proceeding.

4.6.12 Hot and Cold Weather Concreting

- 4.6.12.1 If the combination of temperature, humidity, and wind velocity is expected to cause a rate of evaporation equal to or greater than 0.2 pounds per square foot per hour (1 kilogram per square meter per hour), the provisions of *ACI 305.1* shall be followed.
- 4.6.12.2 Cold weather concreting shall meet the requirements of *ACI 306.1* for minimum temperatures specified therein.

4.6.13 Architectural and Prestressed Concrete

Architectural and prestressed concrete requirements that are in addition to *ACI 301 / ACI 301M* and this Practice shall be in accordance with contract documents.

4.6.14 Tightness Testing of Environmental Engineering Concrete Structures

If specifically required in the contract documents, tightness testing of environmental engineering concrete structures shall be performed in accordance with *ACI 350.1 / ACI 350.1M*.

Table 2 – Supplier Data Requirements

	Type of Submittal		When Required					Remarks
	For Approval	For Record	Weekly	14 Days Before Placement	14 Days Before Fabrication	With RFQ Submittal	Other	
Supplier's QA Program	X					X		
Batch Plant and Truck Mixer Certification		X		X				
Mix Designs	X			X				
Trial Batch Qualification Test Results	X			X				
Cement Certifications		X		X				
Mineral Additive Certifications		X		X				If applicable
Fine and Coarse Aggregate Certifications		X		X				
Admixture Data Sheets and Certifications		X		X				
Material Suppliers, Sources, and Certifications		X		X				
Manufacturer Spec's, Certifications and Installation Instructions		X		X				
Proposed Curing Methods	X					X		
Reinforcing Bending Schedule and Placing Drawings	X				X			
Certified Mill Test Reports for each bar size and heat number		X		X				If requested
Coating Inspection Reports		X	X					If applicable
Concrete Delivery Ticket		X					With delivery	
Compression Test Reports		X	X					
Compression Breaks 500 psi (3.5 MPa) or more below required		X					Same day	Engineer of record needs to review and provide disposition of low strength concrete results
Water Testing Reports		X		X				If applicable
Mass Concrete Thermal Control Plan	X			X				Required for each mass concrete placement