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Standard Specification for Precast Concrete Duct Bank[1]

This standard is issued under the fixed designation C1903; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification includes the manufacturing requirements and installation guidelines of a precast duct bank system including polyvinyl chloride (PVC) duct enclosed in a concrete envelope. This specification also includes information relating to trenching, backfilling, plugging, and other incidentals necessary for a complete installation.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
A706/A706M Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
A1064/A1064M Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field
C33/C33M Specification for Concrete Aggregates
C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
C143/C143M Test Method for Slump of Hydraulic-Cement Concrete
C150/C150M Specification for Portland Cement
C231/C231M Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C260/C260M Specification for Air-Entraining Admixtures for Concrete
C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
C494/C494M Specification for Chemical Admixtures for Concrete
C595/C595M Specification for Blended Hydraulic Cements
C618 Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C805/C805M Test Method for Rebound Number of Hardened Concrete
C822 Terminology Relating to Concrete Pipe and Related Products

[1] This test method is under the jurisdiction of ASTM Committee C13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.01 on Non-Reinforced Concrete Sewer, Drain and Irrigation Pipe.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

C979/C979M Specification for Pigments for Integrally Colored Concrete
C989/C989M Specification for Slag Cement for Use in Concrete and Mortars
C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete (Withdrawn 2022)[3]
C1064/C1064M Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
C1116/C1116M Specification for Fiber-Reinforced Concrete
C1157/C1157M Performance Specification for Hydraulic Cement
C1602/C1602M Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
C1609/C1609M Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading)
C1611/C1611M Test Method for Slump Flow of Self-Consolidating Concrete
C1619 Specification for Elastomeric Seals for Joining Concrete Structures
C1812/C1812M Practice for Design of Journal Bearing Supports to be Used in Fiber Reinforced Concrete Beam Tests
D5334 Test Method for Determination of Thermal Conductivity of Soil and Rock by Thermal Needle Probe Procedure
D7957/D7957M Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement
F477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

2.2 *Other Standards:*
NEMA TC-2 Standard for Electrical Polyvinyl Chloride (PVC) Conduit[4]
NEMA TC-6&8 Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations[4]
NECA/NEMA 605 Standard for Installing Underground Nonmetallic Utility Duct[4]
UL 651 Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings[5]
IEEE 442 Guide for Thermal Resistivity Measurements of Soils and Backfill Materials[6]
AASHTO LRFD Bridge Design Specifications[7]

3. Terminology

3.1 *Definitions*—For definitions of terms relating to precast concrete duct bank, see Terminology C822.

4. Basis of Acceptance

4.1 *Acceptance on the Basis of Proof of Design Tests, Material Tests, and Inspection of Manufactured Precast Duct Bank Sections for Visual Defects and Imperfections*—Acceptability of precast duct bank sections shall be determined by such material tests as are required in Section 5 and Section 6; and by visual inspection of the finished sections to determine conformance with the accepted design and its freedom from defects in accordance with Section 10.

4.2 *Thermal Resistance (Rho)*—When required by project specifications, Precast Duct Bank Sections shall be verified to have a thermal resistivity (Rho) value no greater than specified as tested in accordance with Test Method D5334 or IEEE 442. Test to be completed at least annually or whenever concrete mixture proportions or materials change.

4.3 *Age for Acceptance*—Precast duct bank sections shall be considered ready for acceptance when it conforms to the requirements as indicated by the specified tests, but not before design strength has been met.

5. Materials

5.1 *Cementitious Materials:*

5.1.1 *Cement*—Cement shall conform to the requirements of Specification C150/C150M or C1157/C1157M, or shall be blended cement conforming to the requirements of Specification C595/C595M.

5.1.2 *Slag Cement*—Slag cement shall conform to the requirements of Specification C989/C989M.

5.1.3 *Fly Ash*—Fly ash shall conform to the requirements of Class F or Class C of Specification C618.

[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] Available from National Electrical Manufacturers Association (NEMA), 1300 N. 17th St., Suite 900, Arlington, VA 22209, http://www.nema.org.
[5] Available from Underwriters Laboratories (UL), UL Headquarters, 333 Pfingsten Road, Northbrook, IL, 60062, http://www.ul.com.
[6] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., Piscataway, NJ 08854-4141, http://www.ieee.org.
[7] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

5.2 *Allowable Combinations of Cementitious Materials*—Any combination of cementitious materials shall be acceptable for use in the concrete if the mix meets the testing requirements of Section 9 in this specification.

5.3 *Aggregates*—Aggregates shall conform to Specification C33/C33M except that the requirement for gradation shall not apply.

5.4 *Admixtures*—The following admixtures and blends are acceptable:

5.4.1 Air-entraining admixture conforming to Specification C260/C260M;

5.4.2 Chemical admixture conforming to Specification C494/C494M;

5.4.3 Chemical admixture for use in producing flowing concrete conforming to Specification C1017/C1017M; and

5.4.4 Chemical admixture or blend meeting requirements of this standard.

5.5 *Fibers*—The use of fiber-reinforced concrete (FRC) conforming to the requirements of Specification C1116/C1116M Type 1 (steel FRC), Type II (glass FRC), and Type III (synthetic FRC) shall be permitted in precast duct bank sections.

5.6 *Integral Color*—Concrete incorporated into precast duct bank sections to be mixed with integral red color to indicate electrical encasement shall meet the requirements of Specification C979/C979M.

5.7 *Water*—Water used in the production of concrete shall be potable, or non-potable water that meets the requirements of Specification C1602/C1602M.

5.8 *Reinforcement*—When required by manufacturer's design, reinforcement shall meet the requirements of Specification A615/A615M, A706/A706M, A1064/A1064M, or D7957/D7957M.

NOTE 1—Typical manufacturing procedures do not require reinforcement.

5.9 *Conduit*—Conduit cast into precast duct bank sections shall be sized according to project requirements and meet all material and dimensional requirements UL 651, TC-6 & 8 Schedule 40 or Type EB, except as modified below:

5.9.1 It shall be permissible to modify the bottom socket dimension to match entrance dimension to allow for field fit of precast sections.

5.9.2 Conduit with modified socket dimensions shall be marked "Precast-EB" for use in precast concrete duct bank sections built to the requirements of this specification.

5.10 *Gasket Material*—When required by project specifications, conduit gaskets shall meet the requirements of Specification C1619 Class E or Specification F477.

6. Design

6.1 Precast duct bank sections shall be designed to meet dead load and HL93 live load requirements in accordance with AASHTO LRFD Bridge Design Specifications or project specific requirements as specified by the owner at the time of order.

6.2 *Dimensions*—Overall dimensions of precast duct bank sections shall be designed to provide for the following:

6.2.1 *Conduit Spacing:*

6.2.1.1 From face of concrete to OD of conduit = 3 in. (76 mm) minimum. This requirement does not apply to bell surfaces.

6.2.1.2 From OD of conduit to OD of adjacent conduit = 3 in. (76 mm) minimum. This requirement does not apply to bell surfaces of adjacent conduit.

6.2.2 *Length of Section*—Laying length of a precast duct bank section, as measured from face to face parallel to the center axis of the section along a given edge, shall be as shown on manufacturer's product details with tolerances as defined in Section 10.

6.3 *Material Strengths*—The manufacturer shall define the following to meet the design requirements of the precast duct bank sections:

6.3.1 *Minimum Handling Compressive Strength of the Concrete*—(f'_{ci}) as required by the design, but shall not be less than 2,000 psi (13.8 MPa) or as required by the handling devices incorporated into the section. It is not prohibited to determine initial handling strength of a precast duct bank section through application of a properly correlated rebound hammer in accordance with Test Method C805/C805M.

6.3.2 *Minimum Compressive Strength of the Concrete at Time of Delivery*—(f'_c) as required by the design, but shall not be less than 4,000 psi (25.6 MPa), to be determined in accordance with Test Method C39/C39M.

6.3.3 *Minimum Reinforcement Yield Strength and Ultimate Strength*—(f_y) and (f_u), if required.

6.3.4 *Minimum Elastic Modulus of Reinforcement*—(E_s), if required.

6.3.5 *Fiber*—FRC shall provide a minimum average equivalent strength ratio, R_{e3}, of 30 % when tested in accordance with Test Method C1609/C1609M, using the roller support system described in Practice C1812/C1812M. Dosage shall be as recommended by the manufacturer.

NOTE 2—An R_{e3} value of 30 % is chosen to correspond to 0.18 % minimum reinforcement ratio used in typical concrete design.

6.4 *Product Details*—Precast duct bank section documentation when required by owner/purchaser to define the following:

6.4.1 The concrete mix design, including all materials and admixtures within the concrete matrix.

6.4.2 Area and locations of reinforcement in units of $in.^2/ft$ (mm^2/m), if required.

6.4.3 Volume of fiber reinforcement, if required, in units of lb/yd^3 (kg/m^3) or percent of volume of concrete.

6.4.4 Product dimensions and tolerances.

7. Joints

7.1 ~~*Concrete Shear Key:*~~*Conduit Shear Protection:*

7.1.1 Precast duct bank ~~section shall be manufactured with an integral concrete shear key of sufficient strength~~ system shall be designed, manufactured, and installed to develop adequate support ~~between~~at the ends of the precast sections to protect the conduit from excessive shear loads induced by differential movement of adjacent sections caused by ~~anticipated~~design dead and live loads.

7.1.2 At a minimum, the ~~integral concrete shear key~~ installed system shall be of sufficient strength to transfer a factored wheel load included in AASHTO HL93 design from section to ~~section. Determination of shear key~~ section without deflecting conduit by more than 10 % of the inside diameter. Determination of provided strength to be performed using structural analysis in accordance with AASHTO LRFD requirements, or by physical testing.

7.2 *Conduit*—Each individual conduit section cast integrally into precast concrete duct bank shall meet the following:

7.2.1 End of conduit bell to be cast flush with the end mating surface of the concrete section.

7.2.2 End of spigot that will be inserted into the bell to extend from the mating surface of the precast concrete duct bank section a sufficient length to engage the bell as detailed in the joint design provided by the manufacturer.

7.2.3 Joint to be provided with one of the following sealing options as required by the project specifications:

7.2.3.1 *Gasket Joint*—Gasket joint shall be integral with bell of conduit, installed in gasket groove on Spigot end of conduit, or another configuration that meets the requirements of Specification C1619 or F477. Gasket joint shall meet the pressure test requirements of 9.7 of this standard.

7.2.3.2 *Slip Joint*—No gasket required. Maximum centered annular space between bell and spigot to be no greater than 0.03 in. (0.8 mm).

7.2.3.3 *Regardless of Joint type*—minimum insertion length of spigot into bell to be no less than ½ of the nominal conduit inside diameter or that distance where the gasket is fully engaged.

8. Manufacture

8.1 *Mixture:*

8.1.1 The aggregates shall be sized, graded, proportioned, and mixed with such proportions of cementitious materials, water, and admixtures, if any, to produce a thoroughly mixed concrete of such quality that the precast duct bank will conform to the test and design requirements of this specification.

8.1.2 Cementitious materials shall be as specified in 5.2 and shall be added to the mix in a proportion not less than 470 lb/yd^3 (280 kg/m^3) unless mix designs with a lower cementitious materials content demonstrate that the quality and performance of the precast duct bank meet the requirements of this specification.

8.1.3 For wetcast concrete, air content shall be as specified on the manufacturer's mix design and tested in accordance with Test Method C231/C231M. If air content is not specified on the mix design, target air content shall be 6 % (±2 %).

8.1.4 For wetcast concrete, unit weight test shall be performed in accordance with Test Method C138/C138M using the calibrated vessel from the pressure meter meeting Test Method C231/C231M. If air content is not required as shown on approved mix design, manufacturer to verify unit weight of concrete by another acceptable means.

8.1.5 Integral color pigment shall be included in such quantity as to produce a sufficiently red colored concrete to clearly differentiate precast duct bank from standard concrete that is not colored. Pigment shall meet the requirements of Specification C979/C979M. The owner shall have the option to request a sample prior to fabrication of the precast duct bank sections for use as a comparison for minimum pigment content in the produced sections.

8.2 *Wetcast Concrete*—Concrete that does not meet the requirements of self-consolidating concrete in accordance with 8.3 or drycast concrete in accordance with 8.4 shall meet the requirements for slump as determined in accordance with Test Method C143/C143M. The slump at time of placement shall meet the requirements of the manufacturer's mix design and be between 1 in. (25 mm) and 8 in. (203 mm). This test shall be performed at least on the first (2) batches of a production shift or until desired slump is achieved. Retest if changes in concrete consistency are noticed.

8.3 *Self-Consolidating Concrete*—When SCC is used to produce precast duct bank sections, Test Method C1611/C1611M (slump flow of self-consolidating concrete) shall be used in place of Test Method C143/C143M (slump of hydraulic-cement concrete). This test shall be performed at least on the first (2) batches of a production shift or until desired spread and visual stability index are achieved. Retest if changes in concrete consistency are noticed. Target flow and visual stability index shall meet requirements specified on the manufacturer's mix design meeting Test Method C1611/C1611M requirements.

8.4 *Drycast Concrete*—Use of drycast concrete production techniques are not prohibited as long as all material and testing requirements listed in Section 9 are met. A visual inspection to verify that the conduit is not damaged by the vibration process must be conducted by the manufacturer.

8.5 *Curing*—Precast duct bank sections shall be subjected to any one of the methods of curing described in 8.5.1 to 8.5.4 or to any other method or combination of methods approved by the owner, that will give satisfactory results. The precast duct bank shall be cured for a sufficient length of time to meet the specified minimum handling compressive strength.

8.5.1 *Steam Curing*—Sections shall be placed in a curing chamber, free of outside drafts, and cured in a moist atmosphere maintained by the injection of live steam for such time and such temperature as needed to enable the duct bank section to meet

the strength requirements. At no time shall the ambient temperature exceed 140°F (60°C). The curing chamber shall be so constructed as to allow circulation around the duct bank section.

8.5.2 *Water Curing*—Sections shall be water-cured by covering with a water saturated material or by a system of perforated pipes, mechanical sprinklers, porous hose, or by any other approved method that will keep the section moist during the specified curing period.

8.5.3 *Sealing Compound*—A sealing compound conforming to the requirements of Specification C309 shall be applied and should be left intact until the required minimum handling strength requirements are met. The concrete at the time of application shall be within 10°F (6°C) of the ambient temperature. All surfaces shall be kept moist prior to the application of the compounds and shall be damp when the compound is applied.

8.5.4 The manufacturer is not prohibited from combining the methods described in 8.5.1 to 8.5.3 provided the required minimum concrete handling compressive strength is attained.

9. Physical Requirements

9.1 *Qualifications of Testing Personnel*—Manufacturing facility quality control personnel responsible for verification of requirements of this standard shall hold ACI Grade I "Concrete Field Testing Technician" or ACI Level 1 "Concrete Laboratory Testing Technician" certification, or be scheduled for such exams to become certified within 30 days. Designated personnel or a designated back-up holding the same certification shall be present for all quality control operations associated with precast duct bank production.

9.2 *Compressive Strength using Cylinders*—Manufacturer shall prepare and test compressive strength samples in accordance with Practice C31/C31M and Test Method C39/C39M as follows:

9.2.1 Cylinders shall be 4 by 8 or 6 by 12 size and cured in a manner that is equivalent to the products they represent.

9.2.2 A minimum of five cylinders shall be prepared from each mix design poured in a given day except as noted below. Test cylinders as follows:

9.2.2.1 One cylinder shall be tested prior to handling sections to confirm minimum handling strength is achieved. As an option to casting a handling cylinder, an adequately correlated rebound hammer shall be used as defined by Test Method C805/C805M. Before this data can be used a minimum of 10 data points of correlated compressive breaks with rebound hammer test data is required and shall to be verified at least twice a year.

9.2.2.2 Two cylinders shall be tested at seven days.

9.2.2.3 Two cylinders shall be tested at 28 days or sooner if product is being shipped prior to 28 days of age.

9.2.2.4 The compressive strength of representative cylinders tested prior to shipment must meet the strength required by the design or cores may be taken as described in 9.3.

9.3 *Compressive Strength Using Cores*—If compressive strength cylinders do not meet design strength, the manufacturer shall determine the size, quantity and location for core samples to be obtained and tested in accordance with Test Method C42/C42M. Results of core testing to be presented to the owner for approval. If both cylinder samples and core samples fail to meet design strength requirements, represented sections are to be rejected.

9.4 *Temperature of Concrete:*

9.4.1 Concrete temperature at the time of placement shall be less than 95°F (35°C) as determined in accordance with the requirements of Test Method C1064/C1064M.

9.4.2 Temperature inside conduit shall be maintained below 140°F (60°C) throughout the curing cycle.

9.4.3 Maximum temperature differential within the section shall be less than 30°F (17°C) over a distance of 1 ft (305 mm).