Specification for Cast-in-Place Concrete Pipe

Reported by ACI Committee 346

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The engineer or architect may make these specifications applicable to any project by citing them in the project specifications. Supplements can be made by designating or specifying individual project requirements as needed. This document must be used in conjunction with ACI 301. Inclusion of this document in a project specification, with mandatory checklist items, will provide necessary default values for mandatory checklist items in ACI 301.

Keywords: cast-in-place concrete pipe (CIPCP); circumferential cracking; concrete pipe; longitudinal cracking; no-joint pipe

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FOREWORD

F.1 This foreword is included for explanatory purposes only; it does not form a part of Specification ACI 346.

F.2 Specification ACI 346 may be referenced by the architect/engineer in the project specifications for any building project, together with supplementary requirements for the specific project. Responsibilities for project participants must be defined in the project specifications. The specification cannot and does not address responsibilities for any project participant other than the contractor.

F.3 Each technical section of Specification ACI 346 is written in the three-part section format of the Construction Specifications Institute, as adapted for ACI requirements. The language is imperative and terse.

F.4 Checklists do not form a part of Specification ACI 346. Checklists assist the architect/engineer in selecting and specifying project requirements in the project specifications.

PREFACE

P.1 Specification ACI 346 is intended to be used by reference or incorporation in its entirety in the project specifications. Individual sections, articles, or paragraphs shall not be copied into the project specifications because taking them out of context may change their meaning.

P.2 A statement such as the following will serve to make Specification ACI 346 a part of the project specifications:

P.3 If sections or parts of Specification ACI 346 are copied into project specifications or any other document, they shall not be

ACI 346-01 supersedes ACI 346-90 (Reapproved 1997) and became effective September 17, 2001.

Mandatory requirements checklist (ACI 301)

ACI 301 Section/ Part/Article	ACI 346 Section/ Part/Article	Notes to architect/engineer
3.2.1	N/A	—
3.3.2.7	N/A	—
4.2.2.6	N/A	Cast-in-place concrete pipe (CIPCP) does not require reinforcing steel, and therefore, Table 4.2.2.6 is not applicable.
4.2.2.8	1.5.2	The default compressive strength of 3000 psi (20.7 MPa) is used.
5.3.1.4	N/A	—
6.3.7	—	Finish for the interior of the pipe shall be metal finish.
9.2.1.1	N/A	Prestressing not used in CIPCP.

Optional requirements checklist

ACI 301 Section/ Part/Article	ACI 346 Section/ Part/Article	Notes to architect/engineer
—	2.1.2.2	When sulfate resistance is required, specify degree of protection required in 318, Table 4.3.1.
—	3.1.1.3, 3.2.3.4	May use 90% ASTM D 1557.
—	3.4.1	When a load test is desired, specify the requirement in the contract documents.
—	3.4.2	Where a hydrostatic test is desired, specify the requirement in the contract documents. Default head is 6.0 ft (1860 mm) measured from the pipe soffit.
—	3.3.2	Where pipe function does not require repair of circumferential cracks, specify "circumferential crack repair not required in contract documents." Default requires circumferential crack repair.

Submittals checklist

1.5.3	Mixture proportions
1.5.1	Soils report
1.5.2	Pipe geometry report

referred to as ACI standards because the specification has been altered.

Work on __(Project Title)__ shall conform to all requirements of ACI 346-XX published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by the requirements of these contract documents.

PART 1—GENERAL

1.1—Summary

1.1.1 These specifications cover construction of cast-in-place concrete pipe (CIPCP). This specification is not valid for pipe with a diameter over 120 in. (3050 mm). The values stated in inch-pound units are to be regarded as the standard. Values in parentheses are for information only.

1.1.2 CIPCP shall conform to ACI 301-96 Sections 1, 4, and 5.

1.2—Referenced standards

1.2.1 *ACI Standards*

301-99 Standard Specifications for Structural Concrete

318-99 Building Code Requirements for Reinforced Concrete

1.2.2 *ASTM Standards*

C 76-88 Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

C 171-97a Specifications for Sheet Material for Curing Concrete

C 309-97 Specification for Liquid Membrane-Forming Compounds

C 361-89 Specification for Reinforced Concrete Low Head Pressure Pipe

C 497-97 Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile

C 497-98 Standard Test Methods for Concrete Pipe

D 698-91(1998) Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft)

D 1557-91 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort

D 2419-95 Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate

1.3—Definitions

This list supplements ACI 301-96, Section 1.2. The following terms are defined for general use in these specifications.

Backfill—fill starting at top of pipe and continuing to surface or finished grade or subgrade.

Boulders—rocks having any dimension larger than 12 in. (300 mm).

CIPCP—cast-in-place concrete pipe.

CLSM—controlled low-strength material.

Differential displacement—linear offset distance between two pieces of pipe measured along the plane of crack.

Earth—soil or rock other than flowable granular materials.

Grade—pipe design invert elevation minus pipe design thickness of pipe.

Haunch—either side of the pipe, extending to a point vertically 25 degrees above springline.

Metal finish—the finish imparted to the interior of the pipe by casting machine and hand-trowelling devices manufactured from metal.

Offset tolerances—the difference in pipe thickness, transverse and longitudinal, resulting from the metal form used in the casting process.

Repair—process by which cracks and defects in concrete surfaces are corrected to bring pipe into conformance with these specifications.

Sensitive clays—clays with an undisturbed strength that is at least 10 times greater than remodeled or reworked strength.

Soffit—uppermost portion of the inside cross section of pipe.

Trench—an excavation in the ground engineered for the placement of pipe.

Trench form—semicircular bed of trench shaped to provide full, firm, and continuous support for bottom 230 degrees of pipe.

1.4—System description

CIPCP is an underground, continuous concrete conduit having no reinforcing steel, joints, or seams except as necessitated by construction requirements. CIPCP is used to

Table 2.1—Slump requirements

Pipe diameter	Slump
Less than 42 in. (1050 mm)	2 - ½ ± 1 - ½ in. (64 ± 38 mm)
42 to 72 in. (1050 to 1800 mm)	2 - ½ ± 1 in. (64 ± 25 mm)
Greater than 72 in. (1800 mm)	2 ± ½ in. (51 ± 13 mm)

Table 3.1—Wall thickness*

Internal diameter		Minimum wall thickness	
Inches	Millimeters	Inches	Millimeters
24, 27, and 30	600 and 750	3	76
36	900	3.5	89
42	1050	4	102
48	1200	5	127
54	1350	5.5	140
60	1500	6	153
66	1650	6.5	165
72	1800	7	178
78	1950	7.5	191
84	2100	8	203
90	2250	8.5	216
96	2400	9	229
108	2700	10.5	254
114	2900	11	280
120	3050	12	305

*For any internal diameter not indicated above, the minimum wall thickness shall be equal to the next size larger pipe.

Table 3.2—Offset tolerances

Pipe diameter	Allowable offsets
Less than 42 in. (1050 mm)	1/2 in. (13 mm)
42 to 72 in. (1050 to 1800 mm)	3/4 in. (19 mm)
Greater than 72 in. (1800 mm)	1 in. (25 mm)

convey irrigation water, storm water, or industrial waste under a maximum internal operating head of 15 ft (4.5 m) and external loads as subsequently discussed.

1.5—Submittals

1.5.1 *Pipe geometry reports*—Pipe dimensions shall be as reported in Table 3.1. If a design is required that differs from Table 3.1, a pipe geometry report shall be furnished. The report shall specify the inside and outside dimensions and include minimum wall thickness and additional sacrificial thickness needed for abrasive and high flows, or both.

1.5.2 *Concrete mixture*—Concrete mixture proportions report shall be submitted. The report shall specify gradation, compressive strength, and slump range.

1.5.3 *Test reports*—If load (3.4.1) or hydrostatic (3.4.2) tests are required, a test report of results and recommendations shall be furnished.

PART 2 — PRODUCTS

2.1—Concrete

2.1.1 *Slump*—Slump shall be within limits shown in Table 2.1.

2.1.2 *Compressive strength*

2.1.2.1 Compressive strength (f'_c) shall be 3000 psi (20.7 MPa).

2.1.2.2 When sulfate resistance is specified, the mixture shall be proportioned in accordance with ACI 318-99.

PART 3 — EXECUTION

3.1—Preparation

3.1.1 *Trench*

3.1.1.1 *Excavation*

a) The trench shall be excavated using electronically guided equipment to established grade and alignment. The trench shall be shaped to the outside diameter of the pipe to provide the trench form. The trench shall provide a full, firm, and continuous support by undisturbed earth, rock, or compacted fill in the trench form. Trench form shall be stable and free of protrusions, mud, debris, and running water.

b) Trench shoring shall comply with OSHA and local government trench regulations. Boulders projecting into trench form shall be removed to at least 6 in. (150 mm) below grade. The resulting void shall be filled in accordance 3.1.1.3 or with concrete.

3.1.1.2 *Unstable soils*

a) Noncohesive, unstable strata, or lenses of loose sand, silt, or other noncohesive soils within trench form shall be stabilized or overexcavated and refilled in accordance with 3.1.1.3.

b) Sensitive clays encountered in trench form shall be stabilized or overexcavated and filled in accordance with Section 3.1.1.3.

3.1.1.3 *Overexcavation*—After overexcavation, the grade shall be reconstituted by filling voids with sand, pea gravel, crushed rock, or cohesive soil. Material used to reconstitute grade shall be compacted to a minimum of 95% maximum dry density in accordance with ASTM D 698. CLSM may used as an alternative.

3.1.1.4 *Backfill material*—In-place backfill material shall meet the specified compaction requirement.

3.2—Construction

3.2.1 *Tolerances and geometry*

3.2.1.1 *Grade and alignment*

a) *Grade*—Departure from and return to established a grade shall not exceed 1 in. per 10 linear ft (25 mm per 3 m). Maximum departure shall be limited to 1-1/2 in. (40 mm).

b) *Alignment*—Departure from and return to established alignment shall not exceed 2 in. per 10 linear ft (50 mm per 3 m). Maximum departure shall be limited to 4 in. (100 mm).

3.2.1.2 *Wall thickness*—Wall thickness shall be as shown in Table 3.1. Grade and alignment shall be controlled so that thicknesses of the pipe wall are symmetrical.

3.2.1.3 *Pipe diameter tolerances*—Internal diameter of pipe at any point shall not be less than 98% of the design diameter.

3.2.1.4 *Offset tolerances*—Offset tolerances shall be as shown in Table 3.2.

3.2.2 *Concrete placement*

3.2.2.1 *Placement method*—Pipe shall be constructed monolithically. Concrete shall be vibrated, rammed, tamped,

or worked with until thoroughly consolidated. Soil adjacent to the pipe shall be sufficiently wet so that it does not absorb water from concrete nor expand upon additional wetting.

3.2.2.2 *Construction joint*

a) *Cold joint*—At the end of placement or any stoppage that requires a casting machine to pull away from pipe construction, the pipe end shall be left in a rough condition at a slope of approximately 45 degrees with 24 in. (600 mm) long No. 4 reinforcing dowels embedded 12 in. (300 mm) around the pipe circumference. The dowels shall be placed at 12 in. (300 mm) intervals for pipe sizes up to 72 in. (1800 mm) diameter and at 18 in. (450 mm) intervals for pipe sizes 78 to 120 in. (2000 to 3000 mm) diameter. Within 30 min before pipe casting resumes, pipe end surface shall be thoroughly cleaned of foreign materials, coatings, and loose or defective concrete, and thoroughly wetted. A tie-in cap shall be cast over joint across the top of pipe from trench wall to trench wall. The tie-in cap shall be 24 in. (600 mm) minimum in length and centered over the joint. Thickness shall be 1.5 times minimum wall thickness, shown in Table 3.1.

b) *Collar*—Joint for connections to another pipe or structure shall be made by squaring off the end of pipe. Excavation of the trench shall be made along the sides and bottom of the pipe to permit casting of concrete collar. Collar shall be 24 in. (600 mm) minimum in length and centered on joint. Thickness shall be 1.5 times the minimum wall thickness shown in Table 3.1.

3.2.2.3 *Finish*—Interior surface of pipe shall receive a metal finish.

3.2.3 *Curing, backfilling, and clean-up*

3.2.3.1 *Curing*—Use one of the methods described in 3.2.3.2 for exterior curing and the method described in 3.2.3.3 for interior curing the pipe.

3.2.3.2 *Exterior curing*

a) Polyethylene film complying with ASTM C 171 and with minimum nominal thickness of 0.0015 in. (0.038 mm) shall be placed on the exposed top surface immediately after the pipe is cast. Film shall be anchored in place to ensure continuous, adequate curing.

b) Pigmented membrane-curing compound conforming to ASTM C 309 shall be applied to exposed top surface immediately after the pipe is cast. Compound shall be applied at not less than 1 gal. for each 150 ft^2 (1 L for each 3.7 m^2) of exposed concrete. Pipe shall then be covered with a minimum of 3 in. (75 mm) of moist loose soil when the curing compound is sufficiently hard to resist damage. Backfill shall not be placed until the concrete has attained 75% of design strength.

3.2.3.3 *Interior curing*—A humid atmosphere within pipe, as evidenced by condensation on interior surface, shall be maintained for at least 7 days following concrete placement, except for a maximum period of 48 h allowed for removing forms and making repairs. Measures shall be taken to prevent air drafts from drying pipe. Pipe end openings shall be covered.

3.2.3.4 *Backfill*

a) Backfill shall not commence until concrete attains a compressive strength of 2500 psi (17 MPa).

b) First lift over pipe shall be not less than 2 ft (0.6 m) or more than 3 ft (0.9 m) before compaction. Backfill material shall be free of all organic material, rubbish, and debris. Backfill shall be mechanically compacted. Water densifying shall not be permitted. Second and subsequent lifts shall be placed in horizontal layers of thickness compatible to the material being placed and type of equipment being used to achieve the required compaction.

c) CLSM may be used as backfill.

3.3—Repair

3.3.1 *Crack repair*—Crack repairs shall not be made until completion of backfill. Crack width shall be determined by penetration to more than 0.25 in. (6.4 mm) of a standard machinist-gage leaf defined in ASTM C 497-98.

3.3.2 *Circumferential*—Circumferential cracks 0.01 in. (0.25 mm) or less in width shall not require treatment. Cracks greater than 0.01 in. (0.25 mm) in width and less than 0.05 in. (1.3 mm) in width shall be cleaned and filled with cement mortar. Cracks 0.05 in. (1.3 mm) in width and greater shall be cleaned and filled to a minimum depth of 0.4 in. (10 mm) in width with an elastomeric sealant.

3.3.3 *Longitudinal*

3.3.3.1 Longitudinal cracks with a width of more than 0.01 in. (0.3 mm) in width and less than 0.0005 multiplied by outside diameter shall be cleaned and filled with mortar or filled to a depth of 0.4 in. (9.6 mm) with elastomeric sealant.

3.3.3.2 Longitudinal cracks having differential displacement greater than 0.08 in. (2.0 mm) or width greater than 0.0005 multiplied by outside diameter shall be repaired by full depth epoxy pressure grouting.

3.4—Field quality control

3.4.1 *Load tests*—Load tests shall be performed when required by contract documents. Test load applied to the top of pipe shall be at least 125% of the maximum earth load plus live load to which the pipe will be subjected. The pipe shall be inspected before and after load testing. Load tests shall be made without disturbing the earth supporting the lower 230 degrees of pipe. The test load shall be applied in accordance with 3.4.1.1 or 3.4.1.2.

3.4.1.1 *Sandbox test*—Load shall be applied to a 4 ft (1.2 m) length of pipe through a sandbox in such a manner that sand forms a bedding over 1/4 the circumference of the pipe, measured at the centerline of the crown. Sandbox shall be made of metal or dressed timber so heavy as to avoid appreciable bending by side pressure of sand. A strip of cloth or plastic film may be attached to the inside of the sandbox on each side, along the lower edge, to prevent the escape of sand between the sandbox and pipe. Depth of bedding above the pipe at the thinnest point shall be 1/4 the inside diameter of the pipe. Sandbox shall not contact pipe or sides of trench. Sandbox shall be filled with clean sand containing not less than 5% moisture and passing a 4.75 mm (No. 4) sieve. Upper surface of sand shall be struck off level with a straight edge and covered with a rigid top bearing plate. Lower surface of the plate shall be a true plane made of heavy timbers or other rigid material capable

of distributing the test load uniformly without appreciable bending. Test load shall be applied to the bearing plate by piling weights directly on the bearing plate or by moving heavy equipment of predetermined weight onto the bearing plate. The bearing plate shall not be allowed to touch the sandbox.

3.4.1.2 *Wheel load test*—A wheel load equivalent to the test load shall be applied to pipe. Two feet (0.6 m) of compacted fill shall be maintained between pipe and wheel load.

3.4.2 *Hydrostatic test*—When required by contract documents, a hydrostatic test shall be made on completed pipe at any time after the concrete has reached design strength. Pipeline shall be filled with water to the design head above inside pipe crown and kept filled for a minimum of 48 h before the test. Line may be filled in one length or between bulkheads or structures. Water used shall have a temperature above 50 F (10 C). Test shall be for a period of 4 h. Exfiltration rate shall not exceed 1000 gal. per in. diameter per mi per 24 h (927 L per 10 mm of diameter per km per 24 h).