ACI 548.7-04

Test Load Capacity of Polymer Concrete Underground Utility Structures

Reported by ACI Committee 548

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Test Method for Load Capacity of Polymer Concrete Underground Utility Structures

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American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
U.S.A.
Phone: 248-848-3700
Fax: 248-848-3701

www.concrete.org

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Polymer concrete underground utility structures are used to house outside plant equipment such as electrical distribution line splices, natural gas distribution vaults, water meters, and communication line splices. This test method provides procedures for full-scale testing of three loading conditions similar to vehicle loading that may be experienced in field installations. Results obtained may be used to determine the load-carrying capacity of the structure being tested and provide data for direct comparison between structures of various designs. While this method may be used for any underground structure, it is primarily for use on polymer concrete and polymer concrete/composite structures up to 10 x 10 x 10 ft (3 x 3 x 3 m) in size.

Keywords: handholes; polymer concrete; testing; underground structure; utility structure.

CONTENTS

SECTION 1—INTRODUCTION

1.1

Testing polymer concrete (PC) underground utility structures as described herein began during the 1970s and the method was included in the *Western Underground Guide 3.6, Nonconcrete Enclosures*, last printed in 1988.* Guide 3.6 was developed by a group of utilities in the western United States to specify underground utility structures made from materials other than portland-cement concrete for their use. The guide includes complete product specifications and addresses four specific enclosure sizes. Its use has spread across the country and the Guide has become a de facto standard. Preparation of this ACI 548.7 document as a stan-

**Western Underground Committee Guide*, Nonconcrete Enclosures, WUC 3.6/02/0588, Western Underground Committee.

ACI 548.7-04 became effective October 27, 2004.

dardized, separate test method permits users to specify performance criteria and incorporate testing procedures by reference. It can be used for all underground utility structure sizes currently in use. This document is to be provided to ASTM for consideration as an ASTM test method.

SECTION 2—SCOPE

2.1

This test method provides data to be used in evaluating the load-carrying capacity of polymer concrete (PC) underground utility structures, frequently called handholes, by full-scale testing of the structure. A PC underground structure includes a box, typically without a bottom, and a matching cover (Fig. 1). It may include an extension and, if so, testing shall be of the box and extension together. These test methods are primarily for PC and PC/fiber-reinforced polymer composite enclosures. They may also be used to test underground enclosures of portland-cement concrete or other materials.

2.2

Four procedures are provided:

2.2.1 *Vertical load capacity evaluation for the enclosure cover*—A concentrated load is applied to the cover to approximate a vehicle wheel load.

2.2.2 *Vertical load capacity evaluation for enclosure walls*—A concentrated load is applied to the box along its edge to approximate a vehicle wheel as it passes onto or off of the assembly.

2.2.3 *Lateral load capacity evaluation for enclosure walls*—A uniformly distributed load is applied to the largest box wall to approximate the pressures resulting from earth backfill and the surcharge of a nearby vehicle.

2.2.4 Determination of failure loads for the three defined load conditions as detailed in Section 10.4.

2.3

Each of three specimens shall be tested to the design load and cycled for each procedure. Test the three specimens to failure using Procedure 4 as given in 10.4 for each.

2.4

The design load shall be determined for testing purposes, and all safety factors related to the design load shall be reported.

2.5

Ambient service temperatures affect the performance of the enclosures. These tests shall be conducted at 75 ± 10 °F (24 ± 5 °C) unless another temperature is specified in the request for testing.

2.6

The paired values stated in inch-pound and SI units are usually not exact equivalents. Therefore, each system is to be used independently of the other. Combining values from the two systems may result in nonconformance with this test method.

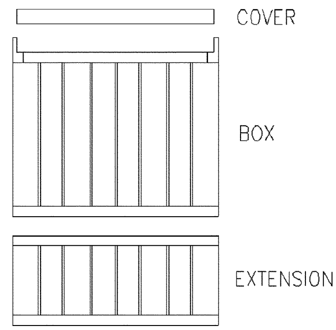

Fig. 1—Typical cover, box, and extension assembly.

SECTION 3—REFERENCED DOCUMENTS

3.1—ASTM standards

C 857 Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures

SECTION 4—TERMINOLOGY

4.1—Definitions

4.1.1 *box*—main section of handhole containing a recess to receive the cover.

4.1.2 *cover*—top surface section of the handhole for closing the top access opening of the box section.

4.1.3 *design load*—The actual, expected load or loads that an underground utility structure supports in service calculated using ASTM C 857 or other rational design method.

4.1.4 *extension*—An add-on section that fits to the bottom or to the top of a box and extends its height.

4.1.5 *handhole*—A complete assembly that is not large enough for a person to enter and providing an access to an underground utility or fixture. The assembly includes a box, a cover, and, if needed, an extension.

4.1.6 *underground utility structure*—An enclosure for use underground that may be either a handhole or manhole.

SECTION 5—SIGNIFICANCE AND USE

5.1

The results from these test methods provide users with information about the maximum load capacity and deflection characteristics of the enclosure under three static loading conditions. The loading conditions approximate the three most severe conditions of loading encountered in actual installations and allow users to compare alternative materials and constructions to determine relative structural performance in service.

5.2

Actual loads and load footprints vary in service.

5.3

This test method provides information under repetitive static load conditions and does not provide any determination of resistance to impact, creep, or fatigue.

SECTION 6—APPARATUS

6.1

A hydraulically powered testing machine capable of applying at least 50,000 lb (220 kN) force to a full-size enclosure in the various positions described. Figure 2 shows an example of a suitable machine with a 30 x 48 x 36 in. (750 x 1200 x 900 mm) specimen installed for edge load testing. Gauges on the hydraulic system shall be capable of displaying the hydraulic pressure to the nearest 25 psi (0.2 MPa) or displaying the actual load applied to the nearest 250 lb (1000 N).

6.2

Dial or digital indicators capable of accurately displaying deflections of 0.01 in. ± 0.001 in. (0.25 mm ± 0.025 mm).

6.3

A loading pad consisting of a 10 x 10 x 1 in. (254 x 254 x 25 mm) steel plate with a 10 x 10 x 0.5 in. (254 x 254 x 13 mm) piece of 60 durometer neoprene placed between the steel plate and the enclosure to be loaded.

6.4

A pneumatic device, such as a pressurized air bag, capable of uniformly distributing forces over the entire sidewall of the enclosure (such as inflatable dunnage bags for freight that have a minimum rated capacity of 10 psi [0.069 MPa]).

6.5

Gauges capable of displaying the air pressure applied to the nearest 0.05 psi (3.4×10^{-4} MPa) or water-filled manometer capable of displaying up to 120 in. (3000 mm) of water column.

6.6

A strong-back reaction frame assembly capable of containing the pressure exerted by the air bag between the specimen wall and the strong back with less than 0.1 in. (2.5 mm) deflection in the reaction assembly.

SECTION 7—SAMPLING, TEST SPECIMENS, AND TEST UNITS

7.1

At least three nominally identical enclosure assemblies are required to complete the tests specified. The enclosure assemblies are to be complete, full size, and equipped according to project specifications or manufacturer's proposed configuration. Test each of the three assemblies using Procedures 1, 2, and 3. Determine failure load using one assembly for each condition using Procedure 4.

7.2

Mount the cover in the box during the tests. Secure attachment hardware if so equipped. Test assemblies shall be supported by the base of the reaction frame for each of the tests.

SECTION 8—MEASUREMENTS

8.1

Measure the cover length and width; the box length, width, and depth; and all other pertinent dimensions shown on the enclosure drawing from the manufacturer. Report any dimensional discrepancies.

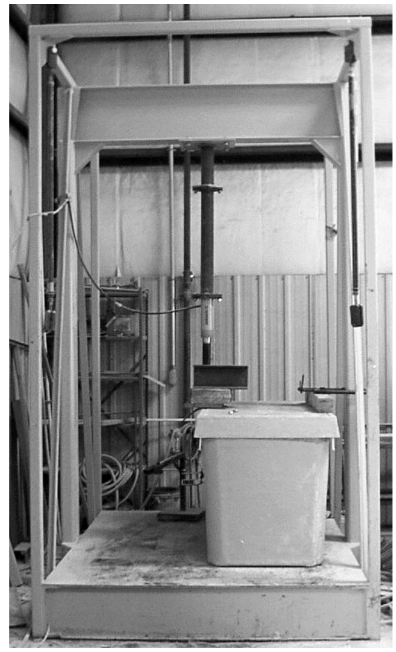

Fig. 2—Typical loading apparatus with hydraulic ram and self-reacting frame.

8.2

Measure the actual contact area of the air bag on the tested wall for the lateral load capacity evaluation.

8.3

Weigh the box and the cover.

SECTION 9—CONDITIONING

9.1

Condition enclosures at the planned test temperature for at least 24 h preceding the test.

SECTION 10—PROCEDURES

10.1—Procedure 1: Vertical load evaluation for the enclosure cover

10.1.1 Position the enclosure being tested in the testing machine so that the test load is applied perpendicular within 5 degrees to the plane of the cover at the location that produces maximum cover deflection. Center the 10 x 10 in. (250 x 250 mm) loading pad on that position. Measure deflections perpendicular within 5 degrees to the cover at the point of maximum deflection. Support the gauges on a tripod fixture mounted on the cover supports to measure only the deflection of the cover. Use two gauges to measure cover movement on opposite sides of the load plate and average the readings. Alternatively, a remote-reading gauge mounted on a frame supported by the box walls inside of the box, directly under the load, shall be used. Refer to Fig. 3.

10.1.2 Preload the specimen cover in the test apparatus to 20% of the design load before test-loading to seat all components. Set deflection measuring gauges to zero after removing the preload.

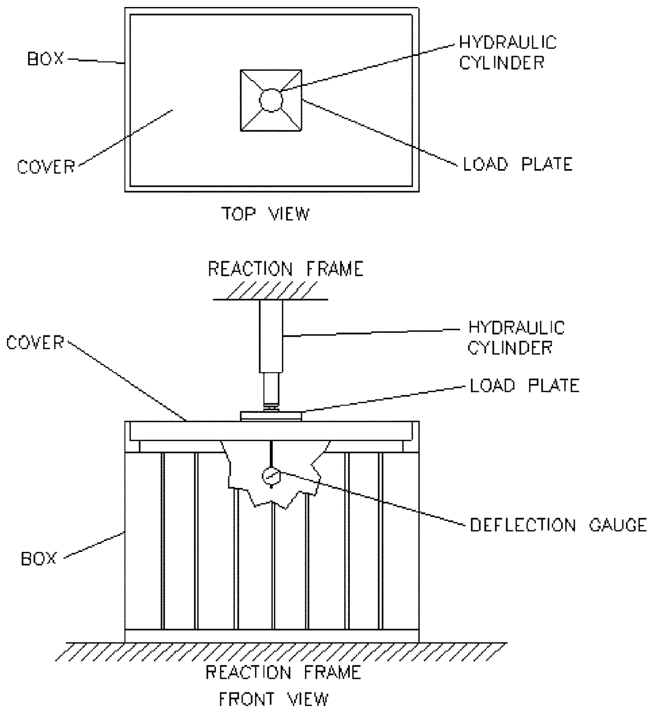

Fig. 3—Typical cover load test setup.

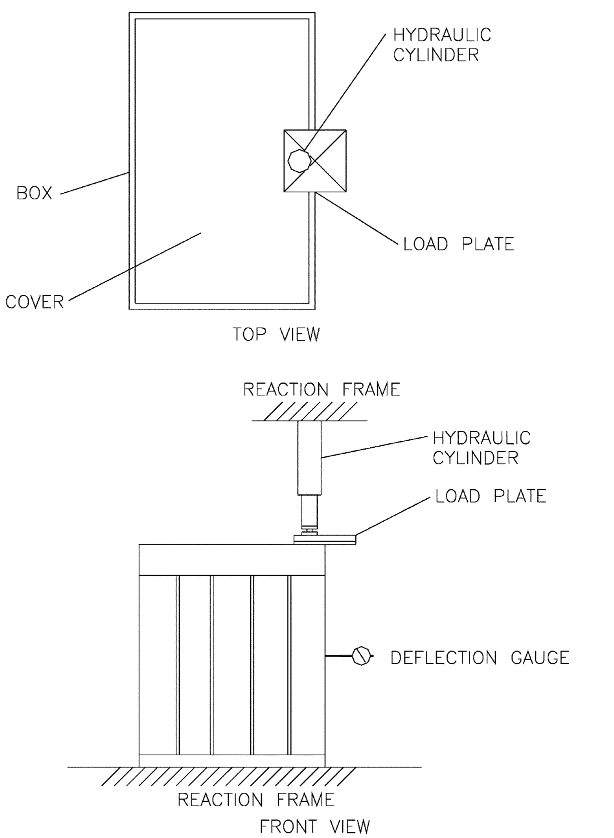

Fig. 4—Typical edge load test setup.

10.1.3 The specimen shall be tested through ten loading cycles. For the first cycle, apply the load in ten increments, each equal to 1/10 of the design load. Record load and deflection at each load increment until the design load is reached. Hold the design load for 1 min and then reduce the load to zero in equal increments of 10% of the cover's design load. Allow the enclosure assembly to rest at zero load for 1 min before resuming loading.

10.1.4 After the first cycle, and for the next nine cycles, reload the cover without increments to reach the design load within 1 min; hold at the design load for 1 min; unload without increments within 1 min; and rest at zero load for 1 min.

10.1.5 Within 1 min of completely removing the load following the tenth cycle, permanent deflections shall be measured and recorded.

10.1.6 Repeat the loading process given in Sections 10.1.1 through 10.1.5 on the other two specimens.

10.2—Procedure 2: Vertical load evaluations for walls

10.2.1 Position the enclosure in the testing machine so that the test load is applied to the center of the longest wall. Place the loading pad so that 1/2 of it overhangs the edge of the box wall, leaving a 5 x 10 in. (125 x 254 mm) portion over the box and cover edge. Measure deflections perpendicular to the center of the box wall below point of load. Figure 4 illustrates an enclosure setup for edge load testing. Preload the specimen enclosure in the test apparatus to 20% of the design load before test loading to fully seat all components. Set deflection measuring gauges to zero after removing the preload.

10.2.2 Apply the test load in 10 incremental steps equal to 10% of the vertical design load. Record load and deflection at each load increment until the design load is reached. Hold the design load for 1 min and then reduce the load to zero in equal increments of 10% of the design load. Allow the enclosure assembly to rest at zero load for 1 min before resuming loading.

10.2.3 After reaching the design load, unload and reload the enclosure nine more times at a uniform speed. Each cycle includes loading to the design load within 1 min, holding the design load for 1 min, unloading within 1 min, and resting the specimen with no load for 1 min.

10.2.4 Permanent deflections shall be measured within 1 min of load removal after the last repetition.

10.2.5 Repeat the loading process given in Sections 10.2.1 through 10.2.4 on the other two specimens.

10.3—Procedure 3: Lateral load capacity evaluation for the walls

10.3.1 Position the enclosure in the testing machine so that a pneumatic bag installed between the enclosure specimen and a strong-back reaction frame loads the largest box wall from the outside (Fig. 5). The opposite sidewall shall be supported to achieve a uniform reaction, or it shall be supported on ribs or stiffeners so long as no local failure occurs. Ensure the pneumatic bag surface has a constant pressure and is in full contact with the test specimen before any load is applied. A deflection-measuring device shall be positioned to measure the deflection of the wall being tested relative to the two box end walls. If a compressible medium is used for a reaction base, its deflection shall be measured and subtracted from the total to yield to the deflection of the test wall.

10.3.2 Apply the load in increments equal to 1/10 of the design load, reaching the design load within 5 min. Record load and deflection readings at each incremental load. Maintain the design load on the enclosure wall for 60 min. Record deflection at the beginning and end of this interval.

10.3.3 Remove the load within 1 min and record permanent deflection within 1 min of complete removal of the load.

10.3.4 Repeat the loading process given in Sections 10.3.1 through 10.3.3 on the other two specimens.

10.4—Procedure 4: Failure loading

10.4.1 Use one of the three specimens, after completion of Procedures 2 and 3, and reload the cover to failure within 5 min using the test setup from Procedure 1. Record resulting deflections at 1000 lb ± 100 lb (4500 N ± 450 N) intervals with the deflection-measuring device used. Remove the deflection-measuring devices after reaching the design load and continue increasing the load until failure. Record the failure load and mode of failure.

10.4.2 Use one of the three specimens, after completion of Procedures 1 and 3, and reload the box to failure within 5 min using the test setup from Procedure 2. Record resulting deflections at 1000 lb ± 100 lb (4500 N ± 450 N) intervals with the deflection-measuring device used. Remove the deflection-measuring devices after reaching the design load and continue increasing the load until failure. Record the failure load and mode of failure.

10.4.3 Use one of the three specimens, after completing Procedures 1 and 2, and reload the box sidewall to failure within 5 min using the setup from Procedure 3. Record the resulting deflection at 50 lb/ft^2 ± 5 lb/ft^2 (0.0025 MPa ± 0.00025 MPa) intervals. Remove the deflection-measuring devices after reaching the design load and continue increasing the load until failure. Record the failure load and mode of failure.

SECTION 11—CALCULATION OR INTERPRETATION OF RESULTS

11.1

Determine the design load designation to be used from ASTM C 857. The design load for Procedures 1 and 2 shall be the maximum wheel load shown in Table 1 of ASTM C 857 for the selected designation. Calculate design side loads for Procedure 3 using the procedures provided in ASTM C 857. The design loads used in this procedure shall include the increase for impact given in ASTM C 857.

11.2

Using the failure load L_F determined in each of the above tests, calculate and report an overall safety factor SF based on

$$SF = L_F / L_D$$

where L_D = the design load for the case being tested.

11.3

Calculate the average cover deflection at the design load for all of the specimens tested using Procedure 1.

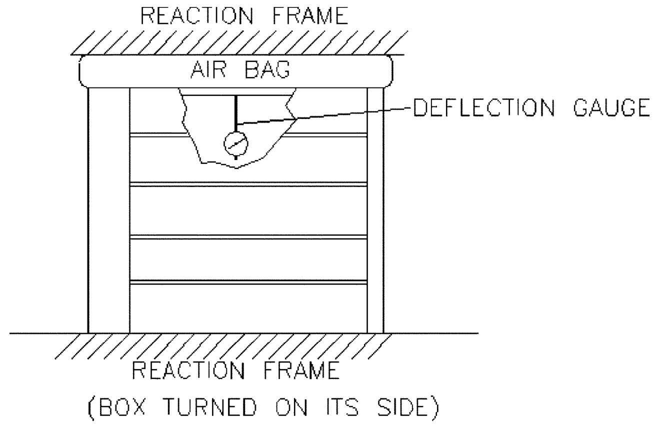

Fig. 5—Typical side load test setup.

11.4

Calculate the average box wall deflection at the design load for all of the specimens tested using Procedure 2.

11.5

Calculate the average box wall deflection at the design load for all of the specimens tested using Procedure 3.

SECTION 12—REPORT

12.1

Show the results of each test graphically by plotting the load as the ordinate and the deformation as the abscissa. Plot the total load applied for Procedures 1 and 2. Plot the pressure per unit area for Procedure 3.

12.2

In addition, the report shall include:

12.2.1 The design load, the failure load, and the calculated safety factor for each load case. If any of the specimens are not tested to failure in any of the procedures, report the highest load applied and calculate a safety factor based on this load.

12.2.2 Average cover deflection at the design load.

12.2.3 Average wall deflection at the vertical design load.

12.2.4 Average wall deflection at the horizontal design load.

12.2.5 Any dimensional discrepancies from the manufacturer's drawings.

12.2.6 The box weight and the extension weight, if applicable.

12.2.7 The cover weight.

12.2.8 The actual contact area between the air bag and the tested wall.

APPENDIX

This appendix contains an example set of test data for Section 10, Procedure 1, and a graph of the data (Fig. 6) to show the results that might be expected from the test described. This appendix is not a mandatory or required part of the procedure described in the preceding test method.

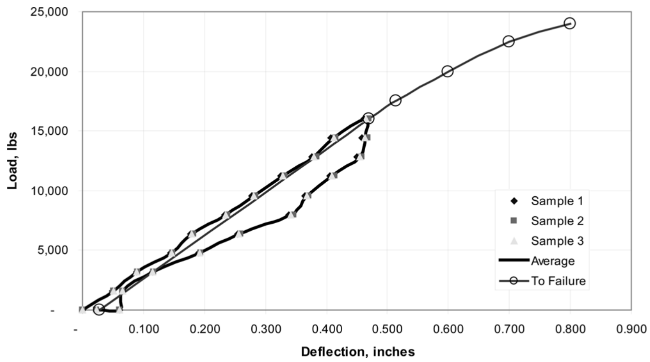

Fig. 6—Load-deflection plot example.

Example set of test data for Section 10, Procedure 1

Design load	16,000 lb				
Failure load	32,950 lb				
Safety factor	2.06				
Test temperature	75 °F				
		Deflection, in.			
Cycle	Load, lb	Sample 1	Sample 2	Sample 3	Average
1	1600	0.050	0.051	0.050	0.050
	3200	0.088	0.090	0.089	0.089
	4800	0.145	0.148	0.146	0.146
	6400	0.178	0.182	0.180	0.180
	8000	0.233	0.238	0.235	0.235
	9600	0.278	0.284	0.281	0.281
	11,200	0.326	0.333	0.329	0.329
	12,800	0.376	0.384	0.380	0.380
	14,400	0.408	0.416	0.412	0.412
	16,000	0.461	0.470	0.466	0.466
	14,400	0.459	0.468	0.463	0.464
	12,800	0.450	0.459	0.454	0.454
	11,200	0.405	0.413	0.409	0.409
	9600	0.365	0.372	0.368	0.368
	8000	0.339	0.346	0.342	0.342
	6400	0.254	0.259	0.257	0.257
	4800	0.191	0.194	0.193	0.193
	3200	0.114	0.117	0.116	0.116
	1600	0.065	0.066	0.066	0.066
	—	0.060	0.061	0.061	0.061
1 min	—	0.023	0.024	0.023	0.023
2 min	16,000				
	—				
3 min	16,000				
	—				
4 min	16,000				
	—				
5 min	16,000				
	—				
6 min	16,000				
	—				
7 min	16,000				
	—				
8 min	16,000				
	—				
9 min	16,000				
	—				
10 min	16,000				
1 min	—	0.028	0.029	0.028	0.028
	16,000	0.470	0.479	0.475	0.470
	17,500	0.514	0.524	0.519	0.514
	20,000	0.600	0.612	0.606	0.600
	22,500	0.700	0.714	0.707	0.700
	24,000	0.800	0.816	0.808	0.800
	32,950	failure			

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American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
U.S.A.
Phone: 248-848-3700
Fax: 248-848-3701

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