ASCE STANDARD

ASCE/CI

15-17

Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

CONSTRUCTION INSTITUTE

ASCE STANDARD

ASCE/CI

15-17

Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)

ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

CI CONSTRUCTION INSTITUTE ASCE

PUBLISHED BY THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Library of Congress Cataloging-in-Publication Data

Names: American Society of Civil Engineers, author.
Title: Standard practice for direct design of buried precast concrete pipe using standard installations (SIDD).
Description: Reston, Virginia : American Society of Civil Engineers, 2017. | "ASCE/CI 15-17." | Includes bibliographical references.
Identifiers: LCCN 2016057194 | ISBN 9780784413074 (soft cover : alk. paper) | ISBN 9780784480335 (PDF)
Subjects: LCSH: Pipe, Concrete–Design and construction. | Underground pipelines–Design and construction. | Precast concrete. | Soil-structure interaction.
Classification: LCC TA447 .A53 2017 | DDC 625.7/34–dc23 LC record available at https://lccn.loc.gov/2016057194

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4382
www.asce.org/bookstore | ascelibrary.org

This standard was developed by a consensus standards development process that has been accredited by the American National Standards Institute (ANSI). Accreditation by ANSI, a voluntary accreditation body representing public and private sector standards development organizations in the United States and abroad, signifies that the standards development process used by ASCE has met the ANSI requirements for openness, balance, consensus, and due process.

While ASCE's process is designed to promote standards that reflect a fair and reasoned consensus among all interested participants, while preserving the public health, safety, and welfare that is paramount to its mission, it has not made an independent assessment of and does not warrant the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed herein. ASCE does not intend, nor should anyone interpret, ASCE's standards to replace the sound judgment of a competent professional, having knowledge and experience in the appropriate field(s) of practice, nor to substitute for the standard of care required of such professionals in interpreting and applying the contents of this standard.

ASCE has no authority to enforce compliance with its standards and does not undertake to certify products for compliance or to render any professional services to any person or entity.

ASCE disclaims any and all liability for any personal injury, property damage, financial loss, or other damages of any nature whatsoever, including without limitation any direct, indirect, special, exemplary, or consequential damages, resulting from any person's use of, or reliance on, this standard. Any individual who relies on this standard assumes full responsibility for such use.

ASCE and American Society of Civil Engineers—Registered in U.S. Patent and Trademark Office.

Photocopies and permissions. Permission to photocopy or reproduce material from ASCE publications can be requested by sending an e-mail to permissions@asce.org or by locating a title in ASCE's Civil Engineering Database (http://cedb.asce.org) or ASCE Library (http://ascelibrary.org) and using the "Permissions" link.

Errata: Errata, if any, can be found at https://doi.org/10.1061/9780784413074.

Copyright © 2017 by the American Society of Civil Engineers.
All Rights Reserved.
ISBN 978-0-7844-1307-4 (soft cover)
ISBN 978-0-7844-8033-5 (PDF)
Manufactured in the United States of America.

24 23 22 21 20 19 18 17 1 2 3 4 5

ASCE STANDARDS

In 2014, the Board of Direction approved revisions to the ASCE Rules for Standards Committees to govern the writing and maintenance of standards developed by ASCE. All such standards are developed by a consensus standards process managed by the ASCE Codes and Standards Committee (CSC). The consensus process includes balloting by a balanced standards committee, and reviewing during a public comment period. All standards are updated or reaffirmed by the same process every five to 10 years. Requests for formal interpretations shall be processed in accordance with Section 7 of ASCE Rules for Standards Committees, which are available at www.asce.org. Errata, addenda, supplements, and interpretations, if any, for this standard can also be found at www.asce.org.

Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD), Standard ASCE/CI 15-17, was approved for publication by the Codes and Standards Committee with a waiver from the rules for Codes and Standards Committees. The waiver is to allow reference to another standard without referring to an edition date. The committee's intent is that the standard being referenced is the latest edition available.

This standard has been prepared in accordance with recognized engineering principles and should not be used without the user's competent knowledge for a given application. The publication of this standard by ASCE is not intended to warrant that the information contained therein is suitable for any general or specific use, and ASCE takes no position respecting the validity of patent rights. The user is advised that the determination of patent rights or risk of infringement is entirely their own responsibility.

A complete list of currently available standards is available in the ASCE Library (http://ascelibrary.org/page/books/s-standards).

This page intentionally left blank

CONTENTS

ACKNOWLEDGMENTS . . . vii

PART I. GENERAL . . . 1
1.0 Scope . . . 1
2.0 Applicable Documents . . . 1
2.1 ASTM (American Society for Testing and Materials) . . . 1
2.2 AASHTO (American Association of State Highway and Transportation Officials) . . . 1
2.3 AREMA (American Railway Engineering and Maintenance-of-Way Association) . . . 1
3.0 Definitions . . . 2
3.4 Orientation Angle . . . 2
3.5 Prism Load . . . 2
4.0 Notations . . . 2
5.0 Summary of Practice . . . 3

PART II. DIRECT DESIGN METHOD USING STANDARD INSTALLATIONS (SIDD) . . . 7
6.0 General . . . 7
6.1 Design Procedures and Criteria . . . 7
6.2 Design Submittals . . . 7
7.0 Design Requirements . . . 7
7.2.1 Load Factors . . . 7
7.2.2 Strength Reduction (phi) Factors . . . 7
7.2.3 Crack Control Factor . . . 7
7.2.4 Orientation Angle, θ . . . 7
7.2.5 Process and Material Factors . . . 7
7.3.1 Pipe Wall Thickness . . . 7
7.3.2 Concrete Strength . . . 7
7.3.3 Reinforcement . . . 7
8.0 Materials . . . 8
8.1 Concrete . . . 8
8.2 Reinforcement . . . 8
9.0 Loads . . . 8
9.1 Dead Loads . . . 8
9.2 Live Loads . . . 8
9.3 Intermittent Internal Hydrostatic Pressure . . . 8
10.0 Standard Installations . . . 8
10.3 Compaction Specifications . . . 8
11.0 Pressure Distribution and Stress Analysis . . . 8
12.0 Reinforcement . . . 8
12.2 Minimum Reinforcement . . . 9
12.3 Maximum Flexural Reinforcement . . . 9
12.3.1 Limited by Radial Tension . . . 9
12.3.2 Limited by Concrete Compression . . . 9
12.4 Crack Control . . . 10
12.5 Shear Strength . . . 10
12.6 Stirrups . . . 10
12.6.2 Radial Tension Stirrups . . . 10
12.6.3 Shear Stirrups . . . 10
12.6.4 Extent of Stirrups . . . 11
12.6.5 Stirrup Anchorage . . . 11
12.7 Welds, Splices, and Development of Reinforcement . . . 11
13.0 Nonreinforced Concrete Pipe . . . 11
14.0 Pipe Designation . . . 11

PART III. CONSTRUCTION OF SOIL/PRECAST CONCRETE PIPE SYSTEMS . . . 13
15.0 General . . . 13
16.0 Safety . . . 13
17.0 Excavation . . . 13
18.0 Foundation . . . 13
19.0 Bedding . . . 13

20.0 Pipe Placement and Joining . . . 13
21.0 Haunch . . . 14
22.0 Lower Side . . . 14
23.0 Overfill . . . 14
24.0 Sheathing Removal and Trench Shield Advancement . . . 14
25.0 Precast Concrete Appurtenances . . . 14
26.0 Minimum Cover for Construction Loads . . . 14

APPENDIX A: SI UNITS FOR NOTATION AND EQUATIONS . . . 15
A1.0 Scope . . . 15
A4.0 Notations . . . 15
A12.0 Reinforcement . . . 16
A12.2 Minimum Reinforcement . . . 16
A12.3 Maximum Flexural Reinforcement . . . 16
A12.3.1 Limited by Radial Tension . . . 16
A12.3.2 Limited by Concrete Compression . . . 16
A12.4 Crack Control . . . 16
A12.5 Shear Strength . . . 17
A12.6 Stirrups . . . 17
A12.6.2 Radial Tension Stirrups . . . 17
A12.6.3 Shear Stirrups . . . 17
A12.6.4 Extent of Stirrups . . . 17
A12.6.5 Stirrup Anchorage . . . 17
A12.7 Welds, Splices, and Development of Reinforcement . . . 17
A13.0 Nonreinforced Concrete Pipe . . . 18

COMMENTARY . . . 19
C1.0 Scope . . . 19
C2.0 Applicable Documents . . . 19
C2.1 ASTM (American Society for Testing and Materials) . . . 19
C3.0 Definitions . . . 19
C4.0 Notations . . . 19
C5.0 Summary of Practice . . . 19
C6.0 General . . . 20
C6.1 Design Procedures and Criteria . . . 20
C6.2 Design Submittals . . . 20
C7.0 Design Requirements . . . 20
C7.2.3 Crack Control Factor . . . 20
C7.2.4 Orientation Angle, θ . . . 21
C7.2.5 Process and Material Factors . . . 21
C9.0 Loads . . . 21
C9.3 Intermittent Internal Hydrostatic Pressure . . . 22
C10.0 Standard Installations . . . 24
C11.0 Pressure Distribution and Stress Analysis . . . 24
C12.0 Reinforcement . . . 25
C12.2 Minimum Reinforcement . . . 26
C12.3 Maximum Flexural Reinforcement . . . 26
C12.3.1 Limited by Radial Tension . . . 26
C12.3.2 Limited by Concrete Compression . . . 26
C12.4 Crack Control . . . 26
C12.5 Shear Strength . . . 27
C12.6 Stirrups . . . 27
C12.6.2 Radial Tension Stirrups . . . 27
C12.6.3 Shear Stirrups . . . 27
C12.6.4 Extent of Stirrups . . . 27
C12.6.5 Stirrup Anchorage . . . 28
C12.7 Welds, Splices, and Development of Reinforcement . . . 28
C14.0 Pipe Designation . . . 28
C19.0 Bedding . . . 28
C23.0 Overfill . . . 28
C26.0 Minimum Cover for Construction Loads . . . 28

INDEX . . . 29

ACKNOWLEDGMENTS

The American Society of Civil Engineers (ASCE) acknowledges the work of the Direct Design of Buried Concrete Pipe Box Sections Standards Committee of the Construction Institute of ASCE. This group comprises individuals from many backgrounds, including consulting engineering, research, construction, education, government, design, and private practice.

Direct Design of Buried Concrete Pipe Box Sections Standards Committee

Kim Spahn, P.E., M.ASCE, *Chair*
Josh Beakley, P.E.
Eric A. Carleton, P.E., M.ASCE
Oliver S. Delery Jr., P.E., F.ASCE
Steve DelloRusso, P.E.
Jeffrey I. Enyart, P.E., M.ASCE
R. Hartley Field
Curtiss W. Gilley, P.E., F.ASCE
Corey Lee Haeder, P.E., M.ASCE
Paul M. Heffern, P.E., M.ASCE
George W. Hodge II, P.E., M.ASCE
John M. Kurdziel, P.E., M.ASCE
Joe M. Lundy Jr., Aff.M.ASCE
Hugh Martin, P.E., M.ASCE
Timothy J. McGrath, P.E., F.ASCE
Wallace J. Munden, P.E., M.ASCE
Michael P. Murphy, P.E., M.ASCE
Charles R. Nelson, Ph.D., P.E., M.ASCE
David K. Nishimura, P.E.
James A. Nystrom
Edward C. Page, P.E., M.ASCE
Gerald R. Price, P.E., M.ASCE
Roman J. Selig III, A.M.ASCE
Enrico Stradiotto
Joseph P. Zicaro, P.E.
Jonathan C. Esslinger, P.E., F.ASCE, *ASCE Staff Contact*
Katerina Lachinova, *ASCE Staff Contact*

This page intentionally left blank

PART I
GENERAL

1.0 SCOPE

1.1 This standard practice covers the direct design of buried precast concrete pipe using Standard Installations Direct Design (SIDD) manufactured in accordance with ASTM C 1417 and the design and construction of the soil–pipe interaction system, intended for the conveyance of sewage, industrial wastes, storm water, and drainage.

1.2 When buried, concrete pipe is part of a composite system made up of the pipe and the surrounding soil envelope, which interact and contribute to the strength and structural behavior of the system.

1.3 Part II of this standard practice presents the SIDD method for buried precast concrete pipe. SIDD is a design and analysis method that accounts for the interaction between the pipe and soil envelope in determining loads, pressure distributions, moment, thrust, and shear in the pipe and includes a procedure for calculating the required reinforcement.

1.4 Part III of this standard practice presents construction requirements for precast concrete pipe designed by the SIDD method.

1.5 This standard practice may be used as a reference by the owner and the owner's engineer in preparing project specifications based on the SIDD method.

1.6 The design procedures given in this standard practice are intended for use by engineers who are familiar with the installation and pipe characteristics that affect the structural behavior of buried concrete pipe installations and the significance of the installation requirements associated with each SIDD type. Before applying the design procedures given in Part II, the engineer should review the guidance and requirements given in other sections of this standard practice and its accompanying commentary.

1.7 The values of dimensions and quantities are expressed in inch–pound (English) units, which are to be regarded as standard. English unit values are converted to SI unit values, which are presented in parentheses or a section following the English units. For clarity, Appendix A repeats the notation and contains the full translation of equations to SI units. The use of SI units is in accordance with ASTM Practice E 380. SI units expressed in parentheses and in Appendix A are supplied for information only and are not a part of this standard practice.

Note: Some of the applicable standards referenced may have a double designation (Axxx/AxxxM) or separate inch–pound (English) and SI (metric) unit editions. Only the inch–pound unit edition of a standard is listed in this practice. If the practice is used in an SI unit design, the user should investigate whether separate SI unit editions of the referenced standards are available.

2.0 APPLICABLE DOCUMENTS

2.1 ASTM (American Society for Testing and Materials)

2.1.1 A 1064/A 1064M Standard Specification for Carbon–Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

2.1.2 C 822 Definitions of Concrete Pipe and Related Products

2.1.3 C 985 Standard Specification for Nonreinforced Concrete Specified Strength Culvert, Storm Drain, and Sewer Pipe

2.1.4 C 1417 Standard Specification for Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design

2.1.5 C 1479 Standard Specification for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations

2.1.6 C 1628 Standard Specification for Joints for Concrete Gravity Flow Sewer Pipe, Using Rubber Gaskets

2.1.7 D 698 Moisture–Density Relations of Soils and Soil–Aggregate Mixtures Using 5.5-lb Rammer and 12-in. Drop

2.1.8 D 1557 Moisture–Density Relations of Soils and Soil–Aggregate Mixtures Using 10-lb Rammer and 18-in. Drop

2.1.9 D 2487 Classification of Soils for Engineering Purposes

2.1.10 D 2488 Recommended Practice for Description of Soils (Visual Manual and Procedure)

2.1.11 E 380 Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.2 AASHTO (American Association of State Highway and Transportation Officials)

2.2.1 Standard Specifications for Highway Bridges, 17th Edition

2.2.2 T 99 The Moisture–Density Relations of Soils Using a 5.5-lb (2.5 kg) Rammer and a 12-in. (305 mm) Drop

2.2.3 T 180 The Moisture–Density Relations of Soils Using a 10-lb (4.54 kg) Rammer and an 18-in. (457 mm) Drop

2.3 AREMA (American Railway Engineering and Maintenance-of-Way Association)

2.3.1 Manual for Railway Engineering

3.0 DEFINITIONS

3.1 For definitions of terms relating to concrete pipe, see ASTM Definitions C 822.

3.2 For terminology related to soil classifications, see ASTM Classification D 2487 and ASTM Practice D 2488.

3.3 For terminology and definition of terms relating to structural design, see AASHTO Standard Specifications for Highway Bridges.

3.4 Orientation Angle. An angular tolerance assumed for the position of the top of the pipe during the design of a pipe requiring a specific installation orientation because of the reinforcement cage configuration or the positioning of stirrups.

3.5 Prism Load. Weight of column of earth over the outside diameter of pipe.

3.6 Fig. 3-1 illustrates the definitions and limits of the terms foundation, bedding, haunch, lower side, backfill or overfill, invert, crown, springline, top of pipe, and bottom of pipe as used in this standard practice.

4.0 NOTATIONS

The following symbols are used in this standard:

A_s = area of tension reinforcement required in length b, in.^{2}/ft (cm^2/m);
A_{si} = area of total inner cage reinforcement required in length b, in.^{2}/ft (cm^2/m);
A_{so} = area of total outer cage reinforcement required in length b, in.^{2}/ft (cm^2/m);
A_{vr} = area of stirrup reinforcement required to resist radial tension forces, in.^{2}/ft (cm^2/m) in each line of stirrups at circumferential spacing s_v;
A_{vs} = area of stirrup reinforcement required to resist shear, in.^{2}/ft (cm^2/m) in each line of stirrups at circumferential spacing s_v;
b = width of section that resists stress, in. (mm); taken as 12 in. (English units); taken as 1,000 mm (SI units);
b = unit length of pipe, ft (m); taken as 1 ft (English units); taken as 1 m (SI units);
B_1 = crack control coefficient for effect of spacing and number of layers of reinforcement;
C_1 = crack control coefficient for type of reinforcement;
d = distance from compression face to centroid of tension reinforcement, in. (mm);
D_i = inside diameter of pipe, in. (mm);
D_m = mean diameter of pipe, taken as 1;
D_o = outside diameter of pipe, in. (mm);
f'_c = design compressive strength of concrete, lb/in.^{2} (MPa);
f_{mr} = the design modulus of rupture of the pipe wall, lb/in.^{2} (MPa);
f_s = maximum service load stress of reinforcing steel for crack control, lb/in.^{2} (MPa);
f_v = maximum developable strength of stirrup material, lb/in.^{2} (MPa);
f_y = design yield strength of reinforcement, lb/in.^{2} (MPa);
F_c = factor for effect of curvature on diagonal tension (shear) strength in curved components;

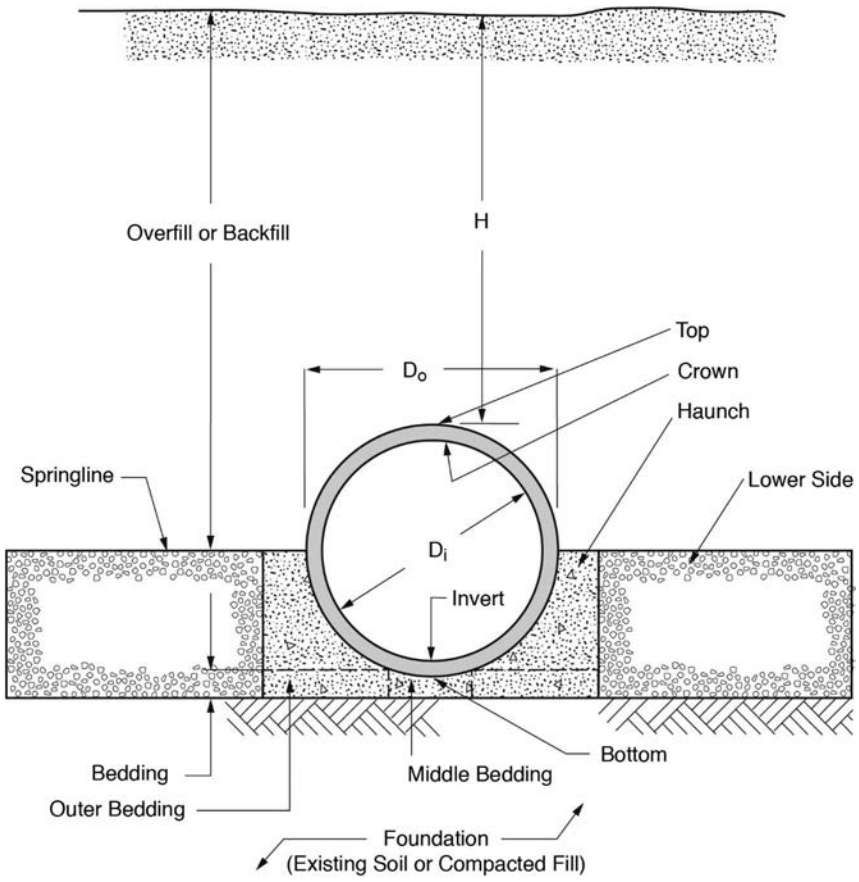


FIGURE 3-1. Pipe/Installation Terminology