

This is a preview of BS 9295:2020+A1:2025. [Click here to purchase the full version from the ANSI store.](#)

BSI Standards Publication

Guide to the structural design of buried pipes



This is a preview of BS 9295:2020+A1:2025. [Click here to purchase the full version from the ANSI store.](#)

Publishing and copyright information

The BSI copyright notice displayed in this document indicates when the document was last issued.

© The British Standards Institution 2026

Published by BSI Standards Limited 2026

ISBN 978 0 539 41531 5

ICS 23.040.01; 93.030

No copying without BSI permission except as permitted by copyright law.

The following BSI references relate to the work on this document:

Committee reference B/505

Drafts for comment 19/30359667 DC; 23/30453511 DC

Amendments/corrigenda issued since publication

Date	Text affected
July 2026	C.1 See Foreword for details. Missing equation added in 7.3.8.4.2, Table 10, Table 13 and Table 17 corrected and Figure 11 corrected

This is a preview of BS 9295:2020+A1:2025. [Click here to purchase the full version from the ANSI store.](#)

Contents	Page
Foreword	V
Introduction	1
1 Scope	1
2 Normative references	1
3 Terms, definitions and symbols	2
4 Concepts used in the structural design of buried pipes	7
4.1 The buried pipe system	7
4.2 Longitudinal and sectional behaviour	7
4.3 Classification of buried pipes	7
<i>Figure 1 — Design criteria for pipes laid in open trench</i>	8
<i>Table 1 — Pipe classification</i>	8
<i>Figure 2 — Rigid and flexible pipe behaviour</i>	9
4.4 Design models	9
<i>Figure 3 — Soil pressure changes immediately after pipe burial</i>	10
4.5 Short-term and long-term stiffness characteristics of polymeric pipe materials	12
4.6 Classification of native/embedment soils and trench width	14
<i>Figure 4 — Effective trench width, B_d</i>	14
4.7 Key parameters to be specified by the designer	15
4.8 Pipe and design method selection	15
<i>Figure 5 — Clauses applicable to the selection and design of pipe</i>	15
5 Classification and calculation of loads	16
5.1 Introduction	16
5.2 Vehicle surcharge loads	16
<i>Figure 6 — Illustration of eccentric surcharge load on pipe</i>	16
5.3 Road and field surcharge loads	17
<i>Figure 7 — Loading configurations</i>	17
<i>Figure 8 — Example of calculated backfill, road traffic surcharge and combined loadings expressed as a line load on a rigid DN 300 pipe</i>	18
<i>Table 2 — Surcharge pressures (kN/m^2), $P_{s(\text{kPa})}$ as a function of depth to cover to crown, H</i>	18
<i>Figure 9 — Surcharge pressure (kN/m^2), P_s due to vehicle wheels</i>	19
5.4 Surcharge pressure due to construction vehicles	19
<i>Figure 10 — Surcharge pressure, P_s due to construction vehicles</i>	20
5.5 Railway loadings	20
<i>Figure 11 — Loading configurations for LM 71 and RL railway loading models</i>	21
<i>Figure 12 — BS EN 1991-2:2003, load model 71 ($\alpha = 1.0$) (RU to BS 5400-2²¹) surcharge pressure at depth</i>	22
<i>Figure 13 — Rail London (RL to BS 5400-2³¹) surcharge pressures at depth</i>	23
<i>Figure 14 — Factor for calculating multi-track railway loadings</i>	24
6 Rigid pipe design	24
<i>Figure 15 — Flowchart for pipe design with rigid pipes</i>	25
6.1 General	25
6.2 Wide and narrow trenches	26
<i>Figure 16 — Effect of trench width, B_d on calculated vertical backfill load on pipe</i>	26
<i>Figure 17 — The silo effect</i>	27
6.3 Complete and incomplete projection	27
<i>Figure 18 — Complete projection</i>	28
<i>Figure 19 — Incomplete projection</i>	28

This is a preview of BS 9295:2020+A1:2025. Click here to purchase the full version from the ANSI store.

	<i>Figure 20 — Settlement deflection ratio</i>	29
	<i>Table 3 — Recommended values for r_{sd} and E'_3</i>	29
	<i>Table 4 — Guide values of Spangler modulus for native soils, E'_3</i>	30
6.5	Projection ratio, ρ	30
6.6	Soil properties	30
	<i>Table 5 — Values of $K\mu$ and $K\mu'$ for specific soil types</i>	30
6.7	Bedding factors	31
6.8	Crushing strength adjustments for pressure pipes	31
6.9	Minimum bedding factor and factor of safety	31
	<i>Table 6 — Rigid pipe embedment</i>	32
6.10	Design loads for rigid pipes	33
	<i>Table 7 — Design bedding factors for pipes laid in wide trench and embankment conditions with bedding classes B and S and outside diameter greater than or equal to 900 mm</i>	33
	<i>Table 8 — Load coefficients for incomplete projection condition</i>	34
6.11	Supporting strength of rigid pipes	35
6.12	Factors of safety	36
	<i>Table 9 — Minimum values of F_{se} and F_{si}</i>	36
6.13	Limit state design	36
	<i>Table 10 — Design factors of actions</i>	37
6.14	Design of egg-shaped pipes	37
	<i>Figure 21 — Dimensions and bedding distribution cases for egg-shaped pipes</i>	38
	<i>Table 11 — Bending moment coefficients for egg-shaped pipes</i>	39
6.15	Simplified bedding table for vitrified clay pipes	40
	<i>Table 12 — Simplified table for the embedment of vitrified clay pipes in wide trench conditions</i>	41
6.16	Simplified bedding table for concrete pipes	43
	<i>Table 13 — Simplified bedding table for concrete pipes – Strength class 120</i>	43
7	Flexible pipe design	45
7.1	General	45
7.2	Marston-Spangler method	45
	<i>Figure 22A — Flowchart for pipe design: GRP pipes</i>	46
	<i>Figure 22B — Flowchart for pipe design: Steel pipes</i>	47
	<i>Figure 22C — Flowchart for pipe design: Thermoplastics pipes</i>	48
	<i>Table 14 — Guide values of Spangler modulus for native soils, E'_3</i>	49
	<i>Table 15 — Flexible pipe embedment properties</i>	50
	<i>Table 16 — Flexible pipe embedments</i>	51
	<i>Figure 23 — Deflection lag factor</i>	52
	<i>Table 17 — Component of ovalization built in during pipe installation, Δ_o/D</i>	55
7.3	Gumbel method	58
	<i>Figure 24 — Principal deformation modes of the buried pipe ring</i>	59
	<i>Figure 25 — External loads on the pipe-soil system</i>	60
	<i>Figure 26 — Components of load on the pipe-soil system</i>	60
	<i>Table 18 — M_{sb} values</i>	62
	<i>Table 19 — M_{sn} values</i>	63
	<i>Table 20 — Values of soil support combination factor, S_c</i>	63
	<i>Table 21 — K values for design</i>	65
	<i>Table 22 — Design values of initial deflection, δy_o</i>	68
	<i>Table 23 — Values of δy_2 for design</i>	68
	<i>Figure 27 — Linear buckling modes</i>	69
	<i>Table 24 — Values of k_{sc} for design</i>	69

This is a preview of BS 9295:2020+A1:2025. [Click here to purchase the full version from the ANSI store.](#)

8.1	General	72
	<i>Figure 28 — Flowchart for design of semi-rigid pipes of ductile iron</i>	72
8.2	Installation conditions	73
	<i>Table 25 — Semi-rigid pipe embedments</i>	73
	<i>Table 26 — Semi-rigid pipe embedment properties</i>	74
8.3	Design pressures for semi-rigid pipes	74
	<i>Table 27 — Load coefficients for incomplete projection condition</i>	75
	<i>Figure 29 — Deflection lag factor</i>	77
	<i>Table 28 — Guide values of Spangler modulus for native soils, E'_3</i>	77
8.4	Semi-rigid pipe embedment properties	78
8.5	Design data for semi-rigid pipes	80
8.6	Bedding for ductile iron pipes	80
	<i>Table 29 — Embedment classes</i>	80
8.7	Simplified bedding table for ductile iron pipes	80
	<i>Table 30 — Safe depths of cover (m) for ductile iron water pipe with field surcharge</i>	82
	<i>Table 31 — Safe depths of cover (m) for ductile iron water pipe with main road surcharge</i>	84
	<i>Table 32 — Safe depths of cover (m) for ductile iron sewer pipe with field surcharge</i>	86
	<i>Table 33 — Safe depths of cover (m) for ductile iron sewer pipe with main road surcharge</i>	88
Annex A	(informative) Other design considerations	90
A.1	Removal of trench support systems	90
A.2	Uniformly distributed surcharge loads of large extent	91
A.3	Uniformly distributed surcharge loads of limited extent	91
	<i>Figure A.1 — Soil loads and stresses produced by surface loads (after Fadum [13])</i>	92
	<i>Figure A.2 — Uniform surcharge U_s/unit area of limited extent in fixed position</i>	93
A.4	Pipes installed by trenchless installation techniques	93
	<i>Figure A.3 — Pipe in tunnel, heading or jacked into place</i>	94
A.5	Pipes installed in tunnels and headings	94
A.6	Bedding factor for rigid pipes under an embankment	94
A.7	Longitudinal flexibility	94
A.8	Multiple pipes in trench	95
	<i>Figure A.4 — Multiple pipe trenches</i>	96
	<i>Figure A.5 — Uneven loading of multiple pipes laid in parallel</i>	97
	<i>Figure A.6 — Circumstances which can result in large lateral loads: Embankment</i>	98
A.9	Buoyancy effects	99
	<i>Figure A.7 — Schematic of groundwater flotation forces</i>	100
A.10	Pipelines in poor ground	101
	<i>Figure A.8 — Pipelines in poor ground</i>	102
	<i>Figure A.9 — Use of geotextile around pipe embedment</i>	103
	<i>Figure A.10 — Pipeline on piles</i>	104
	<i>Table A.1 — Recommended maximum length of rocker pipes</i>	105
A.11	Trench backfilled with concrete	105
A.12	Thrust blocks	107
A.13	Pipes at shallow depths	107
	<i>Figure A.11 — Protection of a shallow pipeline using concrete surround</i>	108
	<i>Figure A.12 — Protection of shallow pipeline with a slab</i>	109
A.14	Laying rigid pipes with concrete beds or surrounds	109
	<i>Figure A.13 — Plain and reinforced beddings and surrounds</i>	110

This is a preview of BS 9295:2020+A1:2025. [Click here to purchase the full version from the ANSI store.](#)

A.16	Pipework under floor slabs	111
	<i>Figure A.14 — Pipework under a floor slab</i>	111
A.17	Pipework laid in a void under a suspended floor	111
A.18	Laying pipework through substructure walls	112
	<i>Figure A.15 — Pipework built in to the wall</i>	112
	<i>Figure A.16 — Pipework passing through the wall</i>	112
A.19	Laying pipework in trenches adjacent to foundations	112
A.20	Laying foundations adjacent to an existing drain or sewer	113
A.21	Longitudinal effects	113
	<i>Table A.2 — Overview of limit state conditions to be checked for longitudinal effects</i>	114
A.22	Bedding materials for pipes	118
	<i>Table A.3 — Compaction fractions for bedding materials</i>	118
	<i>Table A.4 — Maximum recommended level of impurity (by mass)</i>	119
A.23	Compaction fraction test	120
A.24	Load coefficients for the incomplete projection condition	120
	<i>Table A.5 — Equation errors (per cent)</i>	121
A.25	Calculation of surcharge pressures in Table 2	121
Annex B	(informative) Worked examples	122
B.1	Design of a concrete pipeline in accordance with Clause 6	122
B.2	Design of a vitrified clay pipeline in accordance with Clause 6	127
B.3	Design of a polyethylene pipeline in accordance with Clause 7	128
B.4	Worked example for polyethylene pressure pipeline (PE100)	136
	Bibliography	142

Summary of pages

This document comprises a front cover, an inside front cover, pages I to VI, pages 1 to 144, and a back cover.

This is a preview of BS 9295:2020+A1:2025. [Click here to purchase the full version from the ANSI store.](#)

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 29 February 2020. It was prepared by Technical Committee B/505, *Wastewater engineering*. A list of organizations represented on this committee can be obtained on request to the committee manager.

Supersession

BS 9295:2020 superseded [BS 9295:2010](#), which has been withdrawn.

BS 9295:2020+A1:2025 supersedes BS 9295:2020, which is withdrawn.

Relationship with other publications

This British Standard is complementary to [BS EN 1295-1:2019](#) and [PD CEN/TR 1295-2:2005](#).

[BS EN 1295-1:2019](#) specifies general requirements for the structural design of buried pipes under various conditions of loading. Guidance is also given on the application of the nationally established methods of design declared by, and used in, CEN member countries at the time it was prepared. The established United Kingdom method is described as BS 9295.

[PD CEN/TR 1295-2:2005](#) summarizes the nationally established methods of design made available to CEN. The United Kingdom method is described in [A.9](#), which is consistent with BS EN 1295-1:1997.

This British Standard gives further information to facilitate in full the structural design of buried pipes under various conditions of loading using the established United Kingdom method; it does not alter any of the provisions of [BS EN 1295-1:2019](#).

Information about this document

BS 9295:2020 was a full revision of the document, and introduced the following principal changes:

- incorporation of the content of National Annex A to BS EN 1295:1997; and
- inclusion of the Gumbel method for the design of buried pipes.

Text introduced or altered by Amendment No. 1 is indicated in the text by tags [A1](#) [A1](#). Minor editorial changes are not tagged.

Amendment No. 1 introduces changes to provide consistency of units between those commonly used and those necessary for direct numerical input to formulae. Where values are derived from graphs, this distinction of units is particularly important. For historic reasons, various figures and tables have contained source information in particular units. Different pipe standards also use different units for the same named variable.

Text introduced or altered by Corrigendum No. 1 is indicated in the text by tags [C1](#) [C1](#).

Minor editorial corrections are not tagged.

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at knowledge.bsigroup.com or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

This is a preview of BS 9295:2020+A1:2025. [Click here to purchase the full version from the ANSI store.](#)

As a guide, this British Standard takes the form of guidance and advisory recommendations. It is not to be quoted as if it were a specification or a code of practice.

Presentational conventions

The guidance in this document is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Additional commentary, explanation and general informative material is presented in smaller italic type.

Where words have alternative spellings, the preferred spelling of the *Shorter Oxford English Dictionary* is used (e.g. “organization” rather than “organisation”).

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient’s own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This is a preview of BS 9295:2020+A1:2025. [Click here to purchase the full version from the ANSI store.](#)

Introduction

This revision of BS 9295 has been prepared to maintain alignment with [BS EN 1295-1:2019](#), which now cites BS 9295 as the primary source of the methods accepted for the structural design of buried pipes in the UK. The opportunity has been taken to review various shortcomings in the earlier UK design methods, many of which have arisen due to changes in the nature of pipes over the period since those methods were originally published.

Changes from the methods previously published as [BS EN 1295-1:2019](#) and BS 9295 include the introduction of a new conceptual model for the design of buried flexible pipes focused on large-diameter structured-wall thermoplastics pipes, explicit consideration of the quality of workmanship envisaged during installation, non-circular shaped concrete pipes, and a wider range of bedding materials. Non-circular shaped pipes in materials other than concrete are not in common use in the UK so their design is not covered by this edition.

1 Scope

This British Standard gives the UK established method for the structural design of buried pipes under various conditions of loading. The procedures are explained, with tables listing the recommended design values for the appropriate variables in the design formulae, figures providing graphical information on vehicle surcharge loadings, and tables of rigid pipe bedding factors.

NOTE The scope of [BS EN 1295-1:2019](#) is restricted to the structural design of water supply pipelines, drains and sewers, and other water industry pipelines, whether operating at atmospheric, greater or lesser pressure.

Some aspects of longitudinal effects are discussed (see [Annex A](#)), but this topic is not fully covered.

The initial selection of options for the pipe material involves consideration of matters beyond structural design and is outside the scope of this standard.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions, or limits the application, of this document¹⁾. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

[BS EN 545](#), *Ductile iron pipes, fittings, accessories and their joints for water pipelines – Requirements and test methods*

[BS EN 598](#), *Ductile iron pipes, fittings, accessories and their joints for sewerage applications – Requirements and test methods*

[BS EN 622-4](#), *Fibreboards – Specifications – Part 4: Requirements for softboards*

[BS EN 1295-1:2019](#), *Structural design of buried pipelines under various conditions of loading – Part 1: General requirements*

[BS EN 1610:2015](#), *Construction and testing of drains and sewers*

[BS EN 1992-1-1:2004+A1:2014](#), *Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings*

[BS EN 13242:2002+A1:2007](#), *Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction*

¹⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.