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Guide to the structural design of buried pipes

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Summary of pages

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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 its secretary.

Supersession

This British Standard supersedes BS 9295:2010, which is withdrawn.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

This is a full revision of the standard, and introduces 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.

This publication can be withdrawn, revised, partially superseded or superseded.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 bsigroup.com/standards, 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.

Use of this document

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

Presentational conventions

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

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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

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0 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 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, in whole or in part, are normatively referenced in this document and are indispensable for its application[1)]. 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 in an informative manner are listed in the Bibliography.

Other publications

[N1] YOUNG, O.C. and M.P. O'REILLY. *A guide to design loadings for buried rigid pipes*. Transport and Road Research Laboratory, Department of Transport. London: HMSO, 1983, Second Impression 1987.

[N2] HIGHWAY AUTHORITIES AND UTILITIES COMMITTEE (HAUC). *New Roads and Street Works Act 1991. Specification for the reinstatement of openings in highways.* HAUC (UK), 2002.

[N3] WASTE AND RESOURCES ACTION PROGRAMME (WRAP). Quality Protocol: *Aggregates from inert waste. End of waste criteria for the production of aggregates from inert waste.* Banbury: WRAP. 2013.

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS EN 1295-1:2019 and the following apply.

3.1.1 buried pipe system

composite structure comprising the pipe, its joints and the surrounding soil embedment

3.1.2 pipe-soil system

conceptual two-dimensional structural unit comprising the buried pipe and an annulus of the surrounding soil, including pipe embedment and native ground, which interact to resist applied external and internal loads and/or imposed deformations

NOTE The size of soil annulus varies according to the relative stiffness of the pipe and the soil.

3.2 Symbols

For the purposes of this British Standard, the following symbols apply.

NOTE The following table gives the units for the symbols, unless these are given as otherwise in the text.

Symbols	Description	Units [A)]
A	cross-sectional area of wall per unit length	mm^2
B_c	outside diameter of pipe	m
B'_c	combined width of multiple pipes laid in parallel	m
B_d	effective width of trench	m
C_c	soil load coefficient in embankment conditions	–
C_d	soil load coefficient in narrow trench conditions	–
C_L	soil modulus adjustment factor (Leonhardt's coefficient)	–
C_w	water load coefficient	–
c_u	undrained compressive strength of cohesive soil	kPa
D	mean diameter of pipe (measured to neutral axis of wall)	m
D_f	strain factor	–
D_i	internal diameter of the pipe	m
D_L	deflection lag factor	–
D_{Lsr}	deflection lag factor for semi-rigid pipes	–
D_R	reduction factor on long-term deflection due to internal pressure	–
E	flexural (Young's) modulus of elasticity of pipe material	–

Symbols	Description	Units [A)]
E_h	hoop tensile modulus of elasticity of pipe material	–
E_p	modulus of elasticity of pipe material	MPa
E_p^*	plane strain modulus of pipe material	MPa
E_x	creep modulus of elasticity of pipe at time x	MPa
E'	overall modulus of soil reaction	MPa
E'_2	embedment soil (Spangler) modulus	MN/m^2
E'_3	native soil (Spangler) modulus	MN/m^2
F_b	buoyant force (destabilizing force)	kN/m
F_d	downward force (stabilizing force)	kN/m
F_m	bedding factor	–
F_s	factor of safety against buckling	–
F_{se}	factor of safety for rigid pipe material (external load design)	–
F_{si}	factor of safety for rigid pipe (internal pressure design)	–
f_{ctm}	factored tensile stress due to bending	MPa
$f_{ctm:fl}$	factored flexural tensile stress due to bending	MPa
GWL	level of groundwater	–
H	depth of cover to top of pipe	m
H_e	height of plane of equal settlement above top of pipe	m
HN	internal height	m
H_w	height of water table above invert of the pipe	m
I	second moment of area of the pipe wall per unit length	mm^4/mm
I_σ	influence value for determination of soil stresses produced by surface loads	–
K	coefficient of lateral earth pressure	–
K_a	fully active value of K	–
K_o	at-rest value of K	–
k_{sc}	shallow cover reduction factor on soil modulus	–
K_x	deflection coefficient	–
M_H	bending moment, vertical load (soil and external water)	–
M_p	compacted density (modified Proctor density)	%
M_s	constrained soil modulus	MPa
M_{sb}	constrained soil modulus of the pipe zone embedment	MPa
M_{sn}	constrained modulus of native soil of the trench wall	MPa
M_{Ult}	total factored bending moment	kNm/m
M_V	bending moment, horizontal load (soil and external water)	–
m_{qh}	bending moment coefficient for egg-shaped pipe, horitzontal	–
m_{qv}	bending moment coefficient for egg-shaped pipe, vertical	–
N	ring thrust in pipe wall	kN/m
N_{SPT}	penetration resistance in blows per 300 mm from a standard penetration test (SPT)	–
N_y	distortional component of ring thrust	kN/m
N_z	uniform component of ring thrust	kN/m
n	pipe-soil stiffness factor	–
n_w	number of waves around circumference of pipe	–
P	vertical pressure due to soil and surcharge	kN/m^2

