

Structural design of buried pipelines under various conditions of loading —

Part 1: General requirements

ICS 23.040.01

National foreword

This British Standard is the UK implementation of EN 1295-1:1997.

The UK participation in its preparation was entrusted by Technical Committee B/505, Wastewater engineering, to Subcommittee B/504/505/1, General requirements for pipes and fittings.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

The attached National Annex comprises the calculation procedure for the structural design of buried pipelines as practised in the UK. As the UK submission has been agreed, the BSI committee has included it to allow the UK pipe industry an early opportunity to view the calculation procedure.

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.

Amendments/corrigenda issued since publication

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English version

Structural design of buried pipelines under various conditions of loading — Part 1: General requirements

Calcul de résistance mécanique des canalisations
enterrées sous diverses conditions de charge —
Partie 1: Prescriptions générales

Statische Berechnung von erdverlegten
Rohrleitungen unter verschiedenen
Belastungsbedingungen —
Teil 1: Allgemeine Anforderungen

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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CEN

European Committee for Standardization
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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 165, Waste water engineering, the Secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement at the latest by January 1998, and conflicting national standards shall be withdrawn at the latest by January 1998.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This standard is intended for use in conjunction with the series of product standards covering pipes of various materials for the water industry.

This standard comprises two Parts:

- Part 1: *General requirements*, dealing with the requirements for structural design of pipelines and giving the basic principles of the nationally established methods of design;
- Part 2: *Summary of the nationally established methods of design*, giving an overview of these methods as prepared by the various countries where they are in use.

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Introduction

The structural design of buried pipelines constitutes a wide ranging and complex field of engineering, which has been the subject of extensive study and research in many countries over a period of many years.

Whilst many common features exist between the design methods which have been developed and established in the various member countries of CEN, there are also differences reflecting such matters as geological and climatic variations, as well as different installation and working practices.

In view of these differences, and of the time required to develop a common design method which would fully reflect the various considerations identified in particular national methods, a two stage approach has been adopted for the development of this European Standard.

In accordance with this two stage approach, the joint working group, at its initial meeting, resolved 'first to produce an EN giving guidance on the application of nationally established methods of structural design of buried pipelines under various conditions of loading, whilst working towards a common method of structural design'. This standard represents the implementation of the first part of that resolution.

1 Scope

This standard specifies the requirements for the structural design of water supply pipelines, drains and sewers, and other water industry pipelines, whether operating at atmospheric, greater or lesser pressure.

In addition, this standard gives guidance on the application of the nationally established methods of design declared by and used in CEN member countries at the time of preparation of this standard.

This guidance is an important source of design expertise, but it cannot include all possible special cases, in which extensions or restrictions to the basic design methods may apply.

Since in practice precise details of types of soil and installation conditions are not always available at the design stage, the choice of design assumptions is left to the judgement of the engineer. In this connection the guide can only provide general indications and advice.

This Part of the standard specifies the requirements for structural design and indicates the references and the basic principles of the nationally established methods of design (see annexes A and B).

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of the publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

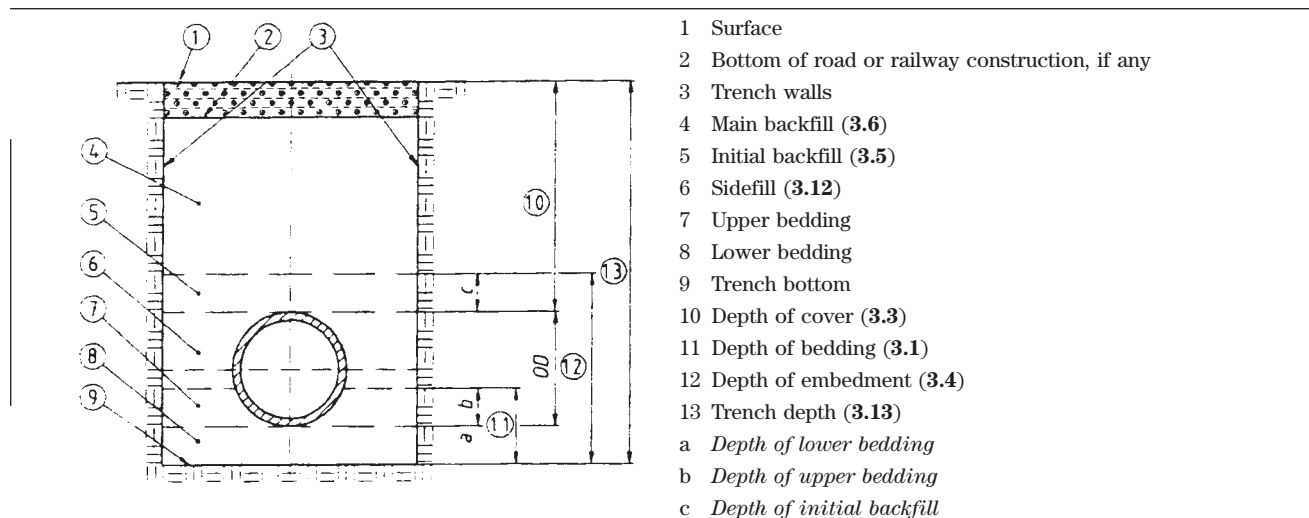
prEN 1610 *Construction of pipelines for drains and sewers*

3 Definitions

For the purposes of this standard, the following definitions apply (see also annex A).

3.1 Installation terms

Installation terms are given in figure 1. The same terms apply for embankment installations and for trenches with sloping sides.



NOTE. The terms in figure 1 are the same as in prEN 1610.

Figure 1. Trench installation

3.1.1 compaction

Deliberate densification of soil during the construction process.

3.1.2 consolidation

Time-dependent densification of soil by processes other than those deliberately applied during construction.

3.1.3 embedment

Arrangement and type(s) of material(s) around a buried pipeline which contribute to its structural performance.

3.2 Design terms

3.2.1 bedding factor

Ratio of the maximum design load for the pipe, when installed with a particular embedment, to the test load which produces the same maximum bending moment.

3.2.2 design pressure (DP)

Maximum operating internal pressure of the system or of the pressure zone fixed by the designer considering future developments but excluding surge.

3.2.3 load bearing capacity

Load per unit length that a particular combination of pipe and embedment can sustain without exceeding a limit state.

3.2.4 maximum design pressure (MDP)

Maximum operating internal pressure of the system or of the pressure zone fixed by the designer considering future developments and including surge, where:

- MDP is designated MDPa when there is a fixed allowance for surge;
- MDP is designated MDPc when the surge is calculated.

3.2.5 silo effect

Effect whereby lateral earth pressure in trench backfill causes friction at the trench wall to carry part of the weight of the backfill.

3.2.6 soil-structure interaction

Process whereby the deformations of soil and/or pipe caused by the contact and reaction pressures between a pipe and the surrounding soil distribute the pressures to achieve equilibrium.

3.2.7 system test pressure (STP)

Hydrostatic pressure applied to a newly laid pipeline in order to ensure its integrity and tightness.

4 Requirements

4.1 All pipelines shall be designed to withstand the various loadings to which they are expected to be subjected, during construction and operation, without detriment to their function and to the environment.

4.2 The future owner of the pipeline is free to specify the appropriate method of design to be adopted.

4.3 The designer shall determine whether or not the pipeline comes within the scope of the methods covered by this standard.

4.4 The design adopted shall be such that construction may be carried out safely and so as to ensure that the design assumptions regarding the influence of construction procedures and soil characteristics will be satisfied.

4.5 Subject to the other requirements of clause 4, design should be carried out preferably using in its entirety one of the methods in annex B of this standard.

4.6 Methods of design, in accordance with annex B, when presented in the form of tables, charts or computer programmes, shall be deemed equivalent to a full calculation, provided that any simplification does not reduce the level of safety to below that which would be obtained by full design. Outputs from computer programmes shall be capable of verification.

4.7 Where a design method other than one of those in annex B is employed, the designer shall satisfy himself that the method constitutes a coherent system and provides the level of safety required.

4.8 Account shall be taken of the probable consequences of pipeline failure in establishing the acceptable level of safety.

4.9 The values adopted for all variables, including factors of safety, shall be in accordance with the method used.

5 Basis of design procedures

5.1 General

Whilst there are differences between some of the established national design procedures, there are no differences in respect of the fundamental basis of design, which is the interactive system consisting of the pipe and the surrounding soil.

The external loadings to be considered shall include that due to the backfill, that due to the most severe surface surcharge or traffic loading likely to occur, and those due to any other causes, producing a loading of significant magnitude such as self weight of the pipe and water weight, as appropriate. The internal pressure in the pipeline, if different from atmospheric, shall also be treated as a loading.

The design of the pipeline, and its embedment, shall provide an adequate level of safety against the appropriate ultimate limit state being exceeded. In addition, the design loading shall not result in any appropriate serviceability limit state being exceeded.

5.2 External loads

Account shall be taken of the effect of the stiffness of the pipe and the stiffness of the surrounding soil.

Where appropriate, account shall be taken of the effects of trench construction, of groundwater and of time dependent influences. The design should take into consideration, however, the possible effect on trench conditions of any further planned works.

The effective pressure due to the backfill and any distributed surface loads shall be calculated on the basis of the principles of soil-structure interaction.

The pressure exerted on pipelines by concentrated surface surcharges, such as vehicle wheels, shall be calculated in accordance with a method based on Boussinesq, and account shall be taken of impact.

5.3 Limit states

The ultimate limit state for all types of pipe is reached when the pipe ceases to behave in the manner intended in the structural design.

Serviceability limit states may be dictated by effects either on the performance of pipelines or on their durability (for example leakage, deformation or cracking beyond allowable limits).

Additional serviceability limit states may apply to particular pipe materials, and reference shall be made to the relevant standards.

The design of the pipeline shall ensure that these above limit states are not reached. This will include consideration of one or more of the following factors:

- strain, stress, bending moment and normal force or load bearing capacity, in the ring or longitudinal direction as appropriate;
- instability (e.g. buckling);
- annular deformation;
- watertightness.

Where fluctuating loads of significant magnitude and frequency will exist, appropriate consideration should be given to their cumulative effects.

5.4 Longitudinal effects

Longitudinal effects include bending moments, shear forces and tensile forces resulting for example from non-uniform bedding and thermal movements and, in the case of pressure pipelines (see 6.5), from Poisson's contraction and thrust at change of direction or cross-section.

These effects may be accommodated by the angular deflection and/or the shear resistance of flexible joints and by the flexural strength of pipes, the serviceability limits of which should be obtained from the different product standards.

The designer shall check that these provisions, together with the embedment design, are sufficient for the project and, where needed, specify adequate additional measures.

6 Additional considerations for pressure pipelines

6.1 General

Pipelines operating at internal pressures above or below atmospheric are subjected to loadings in excess of those at atmospheric pressure.

The application of internal pressure not only introduces additional stresses and strains in the circumferential direction, but can also modify the deformation of flexible and semi-rigid pipes. In addition, pressure pipelines, containing changes of direction or other discontinuities, shall be designed for the longitudinal tensile loading, or the thrusts at the discontinuities.

Special consideration shall be given to pipelines which will be subject to transient surge pressures. Both positive and negative transient pressures shall be considered, but it may not be appropriate for these to be taken in combination with the full vehicle surcharge load.

The design shall take account of the design pressure, the maximum design pressure, and the system test pressure (see 3.2).

Pressure pipelines shall also satisfy the design criteria which would apply if they were non-pressure pipelines, in order to ensure their satisfactory structural performance for the initial period between construction and the application of the internal water pressure, and subsequently when emptied for maintenance.

6.2 Stresses and strains resulting from simultaneous loads

Internal pressures above or below atmospheric produce circumferential stresses and strains which act simultaneously with bending stresses and strains due to external loadings.

Design cases to be considered depending on pipe material and/or type and respective load intensities, can be one or more of the following:

- circumferential stresses resulting from combined loads;
- circumferential strains resulting from combined loads;
- separate analysis of circumferential stresses or strains.

Similar cases shall be considered for the longitudinal direction, when appropriate.

NOTE. If the cross-section of the pipe is truly circular, circumferential stresses and strains due to internal pressure will be purely tensile or compressive, but if the pipe cross-section is not truly circular or has been deformed there will also be bending stresses and strains due to internal pressure.

6.3 Effect of pressure on deformation

When positive internal pressure is applied to a not truly circular pipe, it tends to re-round the deformed pipe, i.e. to reduce the out-of-circle deformations.

The re-rounding process may have the beneficial effect of reducing the bending stresses and strains in the pipe wall. The extent to which the re-rounding process reduces pipe deformation depends on pipe properties and on other various factors, such as the ratio of the internal pressure to the external pressure and the amount of consolidation of the soil which has taken place around the pipe. Thus, the beneficial effects of re-rounding are likely to be greater if the pressure is applied soon after backfilling, and less if there is a longer delay until the first pressurization.

Although the application of internal positive pressure will always produce some degree of re-rounding, the magnitude is difficult to predict. Also, although pipe ovalization benefits from internal pressure, stresses and strains may not benefit to the same extent (e.g. when the deflected shape is not elliptical).

6.4 Buckling of pressure pipes

Positive internal pressure assists pipes which are not rigid to resist any tendency to buckle, but since there can never be complete certainty that the pressure may not be removed at some time during the life of the pipeline, it is normal to design pipelines to resist buckling without this assistance.

Pipelines subject to hydraulic transients may experience sub-atmospheric pressures, and, although these are usually of very short duration, they tend to increase the tendency to buckle.

Proper account shall be taken of this possibility in the design of such pipelines, and it is preferable to rely on a conservative estimate of the sub-atmospheric pressure. When calculating stability, the sub-atmospheric pressure shall be added to the external pressure caused by sustained loading.

6.5 Thrusts and longitudinal stresses

A further effect of the application of internal pressure in pipes is the generation of thrusts at bends and other discontinuities. Depending on the type of provision made for resisting these thrusts, the pipes and fittings may be subjected to additional longitudinal bending and/or tensile stresses, and to excessive movement which could cause dislocation of joints.

7 Influence of construction procedures

7.1 General

Of the various factors to be considered in the structural design process, some, such as pipe diameter and depth of cover, can be regarded as entirely under the control of the designer. Other factors, such as the methods adopted for trench excavation and for filling around and above the pipeline, are only under the control of the designer to the extent that they are specified in advance, and supervised during construction.

7.2 Trenching procedures

The width of the trench can influence the extent to which the backfill load may be reduced by the silo effect, and this effect is taken into account for certain applications.

The width of the trench can also influence the quality of the lateral soil support at the sides of the pipes. This effect is variously covered in the design procedures, via the coefficient of lateral earth pressure, the bedding factor, the soil modulus, etc.

The slope of the trench sides can affect the magnitude of the backfill load, and, if vertical trench sides are employed, consideration shall also be given to the method of support.

If the trench supports are withdrawn after embedding and/or backfilling, voids are left which can cause loosening of the soil, reducing the quality of the embedment and the friction on which the silo effect relies, and also promote long term settlement.

The presence of groundwater, and the use of measures such as groundwater lowering to remove it during construction, can have important effects. The absence of groundwater assists in the compaction of backfill, but the subsequent return of groundwater after completion of backfilling can cause movements of soil particles, possibly leading to increased loads and reduction of support to the sides of the pipe.

7.3 Pipe bedding

If the nature of the ground at the base of the trench is such that it will not itself provide adequate support, then, for all types of pipe, the thickness of lower bedding shall be designed to ensure adequate support along the length of the pipeline.

Where pipes are installed in soft ground, the thickness of the lower bedding may need to be increased in order to prevent excessive settlement of the pipeline.

The thickness of upper bedding should be such as to ensure that the bending moments in the pipe (as calculated directly or covered by the bedding factor) are acceptable.

7.4 Filling procedures

In the vicinity of the pipe, the placing and compaction of the fill material have great influence on structural performance. They affect the distribution of soil pressure around the circumference of the pipe, and hence the response of the pipe. The amount of compaction applied initially during installation also affects the amount of settlement which will take place later, as a result of natural consolidation, or consolidation accelerated by traffic. Usually, the larger such settlements, the greater the load which will be transferred to the pipe.

When the soil around the pipe is being compacted in order to improve its structural quality, some of the energy is diverted into the pipe (as strain energy of deformation) and some into the native soil. The extent to which the total compaction energy is so diverted depends upon the pipe-soil stiffness ratio and the type of native soil.

Prediction of these effects is difficult and is further complicated by the sensitivity of some soils to moisture content. The use of soils which are easy to compact, and which have low sensitivity to moisture content, can therefore greatly reduce the magnitude of strains developed in pipes as a result of installation.

8 Design philosophies and factors of safety

Field and experimental studies of pipelines show variations in observed earth pressures and pipe deformations, stresses and strains. The main cause of these variations is the inevitable inconsistency of soil characteristics and construction practices, already described in clause 7 of this standard. The magnitude of the variation can be reduced by good supervision, control measurement and by the use of fill materials which are easily placed and treated, but some degree of variation is inevitable.

Variations in pipe characteristics, such as strength or elasticity, also occur in practice.

Appropriate allowance for these variations should be made at the design stage and should be in accordance with one of the following design philosophies.

- a) The design procedure shall aim to predict the mean values of loads, and shall compare these with the load bearing capacity of the pipeline based on mean values of pipe strength or stiffness (for example as derived by calculation), and on average earth pressure distribution assumptions.
- b) The design procedure shall aim to predict the maximum possible (high fractile or upper bound) values of loads, and shall compare these with estimates of the load bearing capacity of the pipeline based on lower bound (or low fractile) values of pipe strength or stiffness (for example as established by testing), and on unfavourable earth pressure distribution assumptions.

The factors of safety to be employed with designs following philosophy b) will be lower than those used in a), to achieve the same probability of failure.

Annex A (informative)

Pipe definition according to cross-sectional behaviour

The definition according to cross-sectional behaviour of pipes as rigid, semi-rigid or flexible, is essentially based on consideration of the structural performance of the pipe cross-section under external loads.

Some nationally established methods of design distinguish between 'flexible', 'semi-rigid' and 'rigid' pipes on the basis of the relative pipe and surrounding soil stiffnesses. This distinction is particularly useful in the evaluation of the backfill load for which the pipeline should be designed.

In other nationally established methods of design, the distinction between 'flexible' and 'rigid' is based on the type of material from which the pipe is made, and the way in which the material is used. Thus pipes whose material would fracture at only small deformations of the pipe cross-section are regarded as 'rigid', whilst pipes whose cross-sections can deform substantially without fracture are regarded as 'flexible'.

Designers should take account of both considerations, and recognize that the definition of a pipe as 'rigid' or 'flexible' according to one approach may not invariably be associated with the same definition in the other approach. Having selected the design procedure to be employed, designers should use the method of definition incorporated in that procedure.

Whilst materials can be defined as flexible or rigid according to their failure strain, a pipe made from a material with a low failure strain will not necessarily be defined as rigid. Materials which fail at low elongations, if used in thin-walled pipe, may produce very flexible pipes, because the deformation of the pipe cross-section corresponding to the limiting strain in the pipe wall is large. This aspect of material and pipe performance is usually dealt with by calculating the pipe deformation corresponding to the limiting strain, and using this as a basis for establishing an absolute limit on permissible pipe deformation.

Annex B (informative)

Nationally established methods of design

This annex includes the nationally established methods of design declared, submitted by and used in member countries and collated by the joint working group. The documents listed in B.1 have been submitted to the joint working group except those in B.1.4, B.1.9 and B.1.11.

B.1 Identification of methods and addresses where they are available

B.1.1 Austria

The Austrian nationally established methods for structural design of buried pipeline are given in:

- Standards ÖNORM B 5012-1 and 2.

These standards may be obtained from:

Österreichisches Normungsinstitut

Heinestraße 38

A-1021 Wien

Phone: +43-222-21-300

Telefax: +43-222-21-300-818

Telex: 115 960

B.1.2 Belgium

The Belgian nationally established method for calculation of asbestos-cement pipes is given in:

- ISO 2785 *Directives for selection of asbestos-cement pipes subject to external loads with or without internal pressure*, second edition
1986-07-01 (Ref. No. ISO 2785 : 1986 (E))

This standard may be obtained from:

International Organization for Standardization

Case Postale 56

S-1211 Genève 20

B.1.3 Denmark

The Danish nationally established methods for design of buried pipelines are given in:

- DS 430 *Dansk Ingeniørforenings norm for lægning af fleksible ledninger af plast i jord* (Dansk Ingeniørforenings Code of practice for the laying of underground flexible pipelines of plastic)
- DS 437 *Dansk Ingeniørforenings norm for lægning af stive ledninger af beton mv i jord* (Dansk Ingeniørforenings Code of practice for the laying of underground rigid pipelines of concrete, etc.)

These standards may be obtained from:

Dansk Standard

Danish Standards Association

Baunegaardsvej 73

DK-2900 Hellerup

Phone: +45-39-77-01-01

Telefax: +45-39-77-02-02

B.1.4 Finland

The Finnish methods are given in:

- *Suomen kuntaliitto: Vesijohtojen ja viemäreiden suunnittelu*, 1979 (Design of water supply and wastewater pipelines).

– *Suomen kuntaliitto: Kunnallisteknisten töiden yleinen työselitys*, 1990 (General work specification for municipal engineering).

– *Suomen rakennusinsinöörien Liitto: Maahan ja veteen asennettavat kestopuoviputket*, 1990 (Thermoplastic pipes buried in ground and under water).

– *Suomen kunnallisteknillinen yhdistys: Betoiputkinormit*, 1990 (Concrete pipe rules).

These documents may be obtained from:

Suomen Standardisoimisliitto

PO box 116

FIN-00241 Helsinki

B.1.5 France

The French nationally established methods are given in:

- General title: *Cahier des clauses techniques générales applicables aux marchés publics de travaux* (Book of general technical requirements applicable to public procurements).
- Fascicule 70: *Ouvrages d'assainissement* (Sewerage works).
 - See chapitre III: *Règles de conception et de calcul des ouvrages* (Design and calculation rules for sewerage works).
- Fascicule 71: *Fourniture et pose de canalisations d'eau, accessoires et branchements* (Supply and installation of water pipelines, accessories and fittings).
 - See chapitre II: *Prescriptions particulières aux tuyaux, raccords et leurs accessoires* (Special requirements for pipes, fittings and accessories).
 - See chapitre IV: *Matériaux et fournitures d'un type non-courant ou nouveau* (Materials and products of a non-traditional or new type).

These regulations may be obtained from:

Direction des Journaux Officiels

26, rue Desaix

F-75727 Paris cedex 15

B.1.6 Germany

The German nationally established methods are:

- ATV A 161 *Statische Berechnung von Vortriebsrohren* (Standard code of practice of the ATV-Abwassertechnische Vereinigung, work sheet A 161 Structural design for jacking pipes) first edition 1990.
- *Richtlinie für die statische Berechnung von Entwässerung kanälen und -leitungen* Arbertsblatt A 127 (Standard code of practice of the ATV-Abwassertechnische Vereinigung, work sheet A 127. Guidelines for the statical analysis of sewage channels and pipelines) second edition 1988.

These standards may be obtained from:

Gesellschaft zur Förderung der Abwassertechnik (GFA)

Postfach 1165

D-53758 Hennef



Documents

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B.1.7 Netherlands

The Dutch nationally established method for concrete pipes is based on the following documents:

- CUR report no. 122 (a) *Pipes in the ground. Design of plain and reinforced concrete pipes.* CUR, 1985.
- NEN 7126 (b) *Circular unreinforced, reinforced and steel fibre reinforced concrete pipes and unreinforced pipes with a base. Requirements and test methods.* NNI, first print, September 1991.
- NEN 3218 (b) *Drainage and sewerage gravity systems outside buildings. Installation and Maintenance.* NNI, first print, 1984.

A summary of the procedure is given in: *Design procedure for plain and reinforced pipes to be laid into the ground*, according to CUR report no. 122 (a).

These standards may be obtained from:

- a) CUR
PO Box 420
NL-2800 AK Gouda
- b) Nederlands Normalisatie-Instituut (NNI)
Kalfjeslaan, 2
PO Box 5059
NL-2600 GB Delft

B.1.8 Norway

The Norwegian method for concrete pipes is based on the following documents:

- *Design loads on concrete pipes in road construction*
Internal report No. 1521
Norwegian Road Research Laboratory
- *Earth pressure on concrete pipes*
Internal report No. 1554
Norwegian Road Research Laboratory

These documents may be obtained from:

Norwegian Road Research Laboratory
Postbox 8142 DEP
N-0033 OSLO

The Norwegian method for plastics pipes is based on the following document:

- VAV P70 *Markavloppsrör av plast för självfallsledningar i jord* (Buried gravity sewer plastics pipes) Stockholm 1992.

This standard may be obtained from:

VAV
Regeringsgatan 86
S-111 39 Stockholm

B.1.9 Spain

The Spanish methods for reinforced concrete and prestressed concrete pressure pipes cylinder and non-cylinder type are given in:

- *Instrucción del Instituto Eduardo Torroja para tubos de hormigón armado o pretensado* (Guideline of the Instituto Eduardo Torroja for reinforced and prestressed concrete pipes).

This document may be obtained from:

I.C.C. 'Eduardo Torroja'
Apdo. Correos 19002
SP-28080 Madrid

The Spanish nationally established methods for asbestos-cement and for plastics (uPVC and HDPE) pipelines are given in:

- UNE 88211 *Asbestos-cement pipelines.* (Guide for selection of asbestos cement pipes subject to external loads with or without internal pressure).
- UNE 53331 *Plásticos. Tuberías policloruro de vinilo (PVC-U) y polietileno de alta densidad (PE-HD). Criterio para la comprobación de los tubos a utilizar en conducciones con y sin presión sometidas a cargas externas* (Plastics-uPVC and HDPE pipes — Guide for selection of gravity and pressure pipelines subjected to external load).

These standards may be obtained from:

AENOR
Fernández de la Hoz, 52
SP-28010 Madrid

B.1.10 Sweden

The Swedish nationally established methods are given in:

- VAV P70 *Markavloppsrör av plast för självfallsledningar i jord* (Buried gravity sewer plastic pipes) Stockholm 1992
- VAV P43 *Trafiklast på rörledning med jordöverfyllning*, September 1982 (Traffic load on buried pipelines)
- VAV P48 *Hållfasthetsdimensionering av rörledning av armerad betong med jordöverfyllning*, July 1986 (Strength calculation of buried pipeline of reinforced concrete pipes)
- VAV P56 *Anvisningar för provning av armerade betongrör*, April 1993 (Instructions for quality control of reinforced concrete pipes)
- VAV P9 *Anvisningar för oarmerade betongrör*, April 1991 (Instructions for non-reinforced concrete pipes)

These standards may be obtained from:

VAV
Regeringsgatan 86
S-111 39 Stockholm

B.1.11 Switzerland

The Swiss nationally established method is given in:

- SIA V 190, *Kanalisationen* (Sewage system), Edition 3/1993
- SIA Dokumentation D 01000, *Kanalisationen 4* (Sewage system 4), Edition 25/3/1993.

These documents may be obtained from:

Schweizerischer Ingenieur-und Architekten-Verein (SIA)
Selnaustrasse 16, Postfach
CH-8039 ZURICH

Telefon: + 41 1 283 15 60
(Normen-und Drucksachenverkauf)
Telefax: + 41 1 201 63 35.

B.1.12 United Kingdom

The following publications are regarded as the primary sources of information regarding the standard UK procedures:

- 1) BS 8005 : Part 1 *Guide to new sewerage construction*

Published by the British Standards Institution

Scope: Recommends that all sewerage design should normally use the 'computed load method based on the work of Marston, Spangler and others'. Bedding factors are recommended for use in rigid pipe design, and references to other documents are provided for details of design procedures for rigid and flexible pipe sewers.

- 2) BS 8301 *Building drainage*

Published by the British Standards Institution.

Scope: Limited to pipes of DN 300 and smaller sizes. Provides simplified design recommendations for rigid and flexible pipes in normal installation circumstances.

- 3) *Simplified tables of external loads on buried pipelines*

Published by The Stationery Office.

Scope: Provides simplified design procedure for rigid pipes, ranging in diameter from DN 100 to DN 3000, installed in trench conditions.

- 4) *A guide to design loadings for buried rigid pipes*

Published by The Stationery Office

Scope: Provides detailed design procedure for rigid pipes installed in trench and embankment conditions. Pressure and non-pressure pipelines are covered.

- 5) *Pipe materials selection manual — Water mains : UK Edition*

Published by the Water Authorities Association and the Water Research Centre.

Scope: Provides detailed design procedures for pressure and non-pressure GRP pipelines, and for pressure pipelines in PVC and polyethylene. Trench and embankment installations are covered. Provides general guidance on the design of pipelines using other materials, and provides references to other documents for guidance on their detailed design.

- 6) *Guide to the water industry for the structural design of underground non-pressure uPVC pipelines* (Document ER201 E).

Published by the Water Research Centre.

Scope: Provides detailed design procedure for non-pressure PVC pipelines in trench and embankment installations.

- 7) *Ductile iron pipelines: Embedment design* (Document PJF268 Section 5).

Published by Stanton and Staveley.

Scope: Provides detailed design procedures for pressure and non-pressure ductile iron pipeline in trench and embankment installations, provides simplified design procedure for pipes in the range DN 80 to DN 1600.

- 8) *The Building Regulations 1985: Drainage and Waste Disposal: Approved Document H.*

Published by The Stationery Office.

Scope: Provides simplified design procedures for non-pressure pipelines of DN 150 and smaller sizes.

- 9) *Revised bedding factors for vitrified clay drains and sewers*

(Information and Guidance Note No. 04-11-02).

Published by the Water Research Centre.

Scope: Provides guidance relating to bedding factors for all rigid pipes at an appropriate time.

- 10) *Directive for selection of asbestos-cement pipes subject to external loads with or without internal pressure* (ISO 2785)

Scope: Detailed design procedures for pressure and non-pressure asbestos-cement pipelines in trench and embankment installations.

NOTES

i) A review of bedding factors and factors of safety for rigid pipes is currently being undertaken by the water industry in the UK. Amendments may be introduced from time to time in the light of experience, research and development.

ii) The documents listed above make reference to certain further documents for detailed guidance on design, and these further documents may themselves be regarded as representative of the established methods used in the UK.

iii) Also published in the UK, by various pipe manufacturing organizations, are design guides and manuals covering the application of the established methods to specific types of pipe.

Loads on buried concrete pipelines: Tables of total design loads in trench (Concrete Pipe Association).

Design tables for determining the bedding construction of vitrified clay pipelines (Clay Pipe Development Association)