

AS/NZS 2566.1
Supplement 1:1998

Buried flexible pipelines

**Part 1: Structural design—
Commentary**

**(Supplement to
AS/NZS 2566.1:1998)**

AS/NZS 2566.1 Supp1:1998

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RECONFIRMATION
OF
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Buried flexible pipelines
Part 1: Structural design—Commentary (Supplement to AS/NZS 2566.1:1998)

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NOTES

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PREFACE

This Supplement was prepared by the Joint Standards Australia/Standards New Zealand Committee WS/28, Design and Installation of Buried Flexible Pipes, as a commentary to provide background information on and explanations of particular technical aspects of AS/NZS 2566.1.

AS/NZS 2566.1 should not be interpreted as preventing the use of methods of load assessment other than those specified; as such, alternative methods will possibly be required for circumstances not covered by that Standard. However, it is considered that in the more usually encountered situations, the methods outlined in AS/NZS 2566.1 are those most acceptable to all concerned, due to their relative simplicity and the length of satisfactory experience so far obtained in their application.

The clause numbers and titles used in this Commentary are the same as in AS/NZS 2566.1, except that they are prefixed by the letter C. To avoid possible confusion between Commentary and Standard clauses referenced within the text, Commentary clauses are referred to as 'Paragraph C...' in accordance with Standards Australia policy. Gaps in the numerical sequence of Commentary clauses indicates that no commentary to those clauses are needed. Figures and tables are designated C1.1, C1.2, and so on, while the appendices are designated CA and CB.

Each Section of the Commentary concludes with a list of references which are cross-referenced numerically in the text.

Appendix CA, contains data for description, identification and classification of soils other than gravel (see Clause 3.3.1(c)(ii) of AS/NZS 2566.1).

Appendix CB, contains examples showing the application of the provisions of AS/NZS 2566.1.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

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SECTION C1 SCOPE AND GENERAL

INTRODUCTION This Commentary gives helpful background information to AS/NZS 2566.1 and emphasizes the need for compaction of the embedment material to be consistent with assumptions on which the equations are based. Appendix CB gives worked examples that illustrate the application of AS/NZS 2566.1 for the selection of an appropriate pipe material and class of pipe.

C1.1 SCOPE For pipelines subject to a very light load, it may not be necessary for the structural design to comply with AS/NZS 2566.1. This condition may be especially relevant to pipes with outside diameters of less than 250 mm.

The minimum long-term ring-bending stiffness specified in AS/NZS 2566.1 (see Paragraph C2.2) can be compared with the value of 375 N/m/m given in Ref. 1.

C1.2 APPLICATION While AS/NZS 2566.1 is applicable for the majority of water, sewerage and stormwater applications, it may, with appropriate modification as determined by the designer, be used for cable ducting, air ducting, high temperature effluents, high density effluent and slurries, unstable native soil and certain submarine and trenchless installations.

C1.4 DEFINITIONS

C1.4.1 Embedment—the terminology of zones in Figure 1.1 is consistent with other Australian Standards.

C1.4.6 Pipe

C1.4.6.2 Flexible pipe The response of flexible pipes with a very high long-term ring-bending stiffness is likely to be in either the flexible or rigid mode depending on whether the value of S_{DL} is less than or greater than $7500E'$, respectively. To ensure an adequate design for such pipes, it may be necessary to reduce the allowable strain and deflection or treat them as rigid pipes.

REFERENCE

Guidelines for static calculation of drainage conduits and pipelines, Work sheet A127, Wastewater Engineering Society of Germany (ATV), Germany:1988.

SECTION C2 PIPE MATERIALS — CHARACTERISTICS

C2.1 SCOPE OF SECTION The typical pipe material characteristic values specified in Section 2 are only intended as a general guide to designers. The designer using this Standard should verify all values with the manufacturer of the pipeline product before finalizing any design, and is cautioned on the use of typical values because these may vary according to the manufacturing process and the particular grade of material used.

Typical allowable values for deflection, strain and stress are given in Table 2.1 and represent ultimate values divided by an appropriate safety factor.

C2.2 RING-BENDING STIFFNESS Ring-bending stiffness is an indication of the ability of a pipe to resist deflection. It is determined by deflecting the pipe using line loading and no side support.

Ring-bending stiffness has an influence on the deflection, strain and buckling performance of the pipe when buried in the ground, although this is normally of less significance than the stiffness of the embedment. However, where weak or soft soils exist or where there is a high water table, pipe ring-bending stiffness becomes significant.

The method given in AS/NZS 2566.1 is only applicable to pipe products that have an initial ring-bending stiffness equal to or greater than 1250 N/m/m and long-term ring-bending stiffness equal to greater than 625 N/m/m. AS/NZS 2566.1 does not exclude the use of pipes with lesser initial and long-term ring-bending stiffness. However, special requirements for design and installation need to be considered (see Paragraph C1.1).

C2.2.1 Determination by calculation

The ring-bending stiffness for pipes made with homogeneous materials can be determined by calculation. Plastics materials exhibit creep when subjected to sustained long-term loading, hence the long-term moduli of elasticity for products made with these materials are lower. Calculations of long-term ring-bending stiffness for plastics pipes are therefore made using the apparent long-term bending modulus of the material determined from the regression characteristics of the material established from long-term type testing. It should be noted that the material's modulus, when responding to instantaneous loading, is still retained at or near to its initial value.

NOTE: 'Long-term' refers to the duration of the applied loading. It is independent of the age of the material.

The 3-minute and 50-year values for the ring-bending moduli of elasticity are published for most plastics products and may be used as the basis for design. Where available, these have been listed. Where this data is not available, regression information should be obtained to determine the long-term stiffness value.

Where pipes of homogeneous material subject to creep have a structured or profiled wall, or where pipes are of composite structure, there may be some differences between the ring-bending stiffness values determined by calculation and experimentation. It is, therefore, generally more accurate to use the latter method. For ductile iron or steel pipes with cement mortar lining, i.e. composite solid metallic pipe (see AS/NZS 2566.1) ring-bending stiffness is determined by calculation, by substituting ' $t + 0.1t_c$ ' for ' t ' in Equation 2.2.1.2.

C2.2.2 Determination by experimentation Where appropriate, the supplier should determine the initial and long-term ring-bending stiffnesses using an established test procedure.

Initial or short-term ring-bending stiffness can be determined by one of the following methods:

- (a) AS 3572.10 (Ref. 1) gives two alternative loading systems, one having a constant load and the other having a constant deflection ring-bending stiffness; in both cases, ring-bending stiffness is determined at 3% deflection after 3 min.
- (b) ISO 9969 (Ref. 2) defines various constant deflection rates according to the pipe diameter and determines ring-bending stiffness according to the applied load at 3% deflection without specific consideration of deflection time. This method will, in general, give a higher ring-bending stiffness than the other methods for pipes of diameter greater than 400 mm because the loading rates used are faster.
- (c) ASTM D 2412 (Ref. 3) determines ring-bending stiffness using an apparatus which applies a constant rate of deflection without consideration of diametral differences. The ring-bending stiffness may be calculated at any given deflection, but it should be noted that most ASTM fibreglass pipe specifications require that it should be determined at 5% deflection.

Long-term ring-bending stiffness determinations can be made using either a creep test, where pipe deflection change with time under constant load is measured, or by a relaxation test where the pipe specimen is maintained at a constant deflection and the change in the deflection load is measured. Results from these tests are used to determine projected 50-year values respectively for either deflection or load, which are then used to calculate long-term ring-bending stiffness values. There are some differences between the values obtained from these alternative tests, particularly for products that are made with high creep materials. It is argued that the creep test method tends to give higher deflection and strain than normally encountered in underground installations.

Where large deflections are encountered, it is suggested that the second order deflection factor used in ASTM D 2412 (Ref. 3) should be used rather than the simplified version used in AS 3572.10 and ISO 9967 (Refs. 1 and 5).

Accumulated field data indicates that most buried flexible plastics pipeline installations reach a stable condition within two years (Refs. 5, 6, 7 and 8). There is a contention that the values for long-term ring-bending stiffness determined from testing are apparent values only, and do not reflect the instantaneous characteristics of the material when subjected to momentary increases in load from the overburden. As the effect of ring-bending stiffness on pipe deflections is not of great significance in firm soil installations, there are some experts who contend that the concept of long-term ring-bending stiffness should be disregarded. Generally, the long-term design calculations for ring-bending stiffness should use the 2-year moduli values, except that in either weak native soils or poor embedment conditions with a high watertable, the 50-year values should be used.

C2.3 TYPICAL PROPERTIES Materials exhibit varying properties for specific performance criteria such as stress and strain. There are other performance criteria requiring limiting values unique to the application to which the material is used, i.e. deflection and buckling for buried pipelines. Combined loading calculations are a special problem owing to inconsistencies between the various pipe product Standards (see Paragraph C5.3.3).

Performance of buried pipelines is dependent on many factors, including—

- (a) resistance to ring-bending crushing loads;
- (b) jointing systems, e.g. infiltration and exfiltration;
- (c) resistance to corrosion and abrasion of pipe material, coatings and linings;
- (d) resistance to shear and longitudinal loads; and
- (e) internal pressure.

Each of the abovementioned factors may influence the performance of the others. Items (a), (b) and (d) are usually addressed in the respective product standard performance requirements. They also were considered when setting limiting values for the performance criteria used in AS/NZS 2566.1, because many individual combined circumstances may be encountered in design.

Deflection limiting values have generally been selected based on Items (a) and (b) but, in some circumstances, consideration of the damage that may be caused to applied linings and coatings has been the ruling limitation.

When specifying deflection limitations it has been assumed that the pipe deflects elliptically. Non-elliptical deformation may occur as the result of poor installation practices, such as over compaction of the embedment material. In these circumstances there will be some margin of error for the deflection limitation values that have been given.

Table 2.1 is based upon data obtained at 20°C. This may change substantially at higher or lower temperatures. Product characteristics should be obtained from the product manufacturer rather than the supplier of resins used in non-metallic pipes.

REFERENCES

- 1 AS 3572.10, *Plastics—Glass filament reinforced plastics (GRP)—Methods of test, Part 10: Determination of the initial ring stiffness of glass filament reinforced plastics pipes*, Sydney: Standards Australia, 1989.
- 2 ISO 9969, *Thermoplastic pipes—Determination of stiffness*. International Organization for Standardization, 1994.
- 3 ASTM D 2412, *Standard test methods for determination of external loading characteristics of plastic pipe by parallel plate loading*, American Society for Testing and Materials, Easton, USA: 1993.
- 4 ISO 9967, *Thermoplastic pipes—Determination of creep ratio*, International Organization for Standardization, 1994.
- 5 ZEMAN P., *Critical evaluation of the AWWA (1981) and ATV (1984) methods*, Pipetech, Conference on recent developments in the design, construction and operation of pipelines. Sydney: 1988.
- 6 JANSON L. AND MOLIN J., *Design and installation of buried plastic pipes*, Stockholm: 1991.
- 7 ELZINK W.J. AND MOLIN J., *The actual performance of buried pipes in Europe over 25 years*, Plastic pipes VIII conference, The Netherlands, September 1992.

SECTION C3 EMBEDMENT CHARACTERISTICS

C3.1 SCOPE OF SECTION The dimensions shown in Figure 3.1 are based on ISO/TR 10465-1 (Ref. 1). The values for l_c have been chosen to make it possible to achieve and verify the required degree of compaction of the haunch and the side supports (see Clause 1.4.1(b) and Clause 1.4.1(c)).

C3.2 EMBEDMENT GEOMETRY

C3.2.1 Trench width Specific installation techniques may decrease the embedment dimensions.

It should also be noted that the specified minimum dimensions may need to be increased to—

- (a) provide access for compaction equipment and jointing;
- (b) ensure a safe environment in poorer ground conditions; and
- (c) accommodate trench support systems.

C3.3 MATERIALS AND COMPACTION

C3.3.1 Materials The selection of the embedment material and its degree of compaction should involve an assessment of the cost variation, including supply and compaction for granular materials, i.e. gravel or sand, compared with non-granular soils.

Appendix CA contains a guide for the identification and classification of soil of each group symbol given in Table 3.2.

The foundation requires sufficient strength to support the imposed loads without excessive or uneven settlement. Very soft or expansive clays, irregular or fragmented rock and saturated soils are unsuitable in this regard. Where such materials are encountered, a satisfactory foundation may be achieved by first draining the groundwater, then replacing the materials with graded gravel compacted to a density index (I_D) not less than that proposed for the embedment.

Specifications should detail measures to be taken for the treatment of localized lengths of unsuitable foundation.

Particularly for an on-grade trench in pervious native soil, e.g. running sand, the selected embedment material needs to prevent the migration of fines. Embedment material consisting mainly of poorly graded coarse gravels would be unsuitable in these circumstances. In soft non-cohesive fine-grained native soils, where the potential migration of fines into the embedment is greatest, the selected material should be surrounded with an appropriate geotextile. Migration of fines may occur if the native soil and embedment material satisfy the following equation:

$$D_{85} \text{ fine} \leq 0.2 D_{15} \text{ coarse} \quad \dots \text{C3.3.1}$$

where

$$\begin{aligned} D_{85} \text{ fine} &= \text{sieve opening passing} \\ &\quad 85\% \text{ of the finer material} \\ D_{15} \text{ coarse} &= \text{sieve opening passing} \\ &\quad 15\% \text{ of the coarser material} \end{aligned}$$

In very sandy, silt or soft clay soils, particularly where groundwater is present, the geotextile should be laid in the excavated trench to fully encase the embedment, including any over-excavation and extension above the top of the pipe, to allow a minimum lapping of 250 mm over the embedment. The geotextile should be continuous around the sides and bottom of the trench without longitudinal joints.

Precautions may have to be taken when the embedment is constructed below the water table or if the gradient is steep. In these cases, it may be necessary to construct bulkheads at intervals along the pipeline, or geotextile foundations.

C3.3.2 Compaction Most disturbed native soils exhibit variability of consolidation under load. Thorough and uniform compaction of the foundation (where necessary), embedment, trench fill or embankment fill is essential for maintaining—

- (a) the required grade and alignment of the pipes;
- (b) the circumferential and longitudinal support for the pipes to prevent excessive pipe deflections and distortions; and
- (c) the required finished surface.

The structural performance of the pipe depends primarily on the extent and degree of compaction of the embedment actually achieved in the field.

It is important that all embedment is compacted to the minimum density specified in Table 3.2, as the compaction influences the long-term performance of the pipeline.

NOTES:

- 1 Gravels consisting of rounded particles are less stable than crushed aggregates.
- 2 When using suitable single-sized gravel, the degree of compaction will be more readily achieved and may only require hand tamping. It is therefore less dependent on workmanship than other materials.
- 3 The appropriate degree of compaction for trench fill or embankment fill is related to the use of the finished surface, e.g. sub-base of road pavement, and is not specified in AS/NZS 2566.1.

To achieve compaction, the embedment has to be contained laterally. In a trench, this containment is provided by the native soils of the trench walls; in an embankment, however, sufficient lateral support may not be available. In such cases, where possible, a shallow trench can be cut in the foundation material to contain the required depth of embedment. Where the relative levels of the pipe invert and the adjacent existing surface precludes trenching of the foundation, the embankment may have to be constructed to a height about equal to the pipe diameter and the containment trench, then cut through the compacted embankment fill.

C3.3.2.1 Placement The embedment material is usually placed and compacted in stages. The first stage consists of the bedding, the second is the haunch support, and so on.

To achieve uniform compaction, embedment should be compacted in layers. The thickness chosen depends on the type of embedment material and the compaction equipment. The moisture content of fine-grained soils should be kept within a specified range, usually taken to be 85% of the optimum moisture content of the material.

C3.3.2.2 Measurement Where physically possible, field tests, as outlined in AS 1289 series (Ref. 2) should be used to measure the actual degree of compaction—

- (i) initially, frequently to verify materials and procedure; and
- (ii) subsequently, generally less frequently to ensure compliance.