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Industry Guidelines

Design Guidance for Polypropylene Structured Wall Pipes

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Pipelines Integrity For a Cleaner Environment

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Design Guidance for Polypropylene Structured Wall Pipes

This publication was prepared by the PIPA Polyolefins Technical Committee .

The purpose of this guidance document is to:-

- confirm that the design codes normally used for buried flexible pipes are equally applicable to structured wall, smooth bore, polypropylene pipes
- to provide the necessary pipe material data to allow AS/NZS2566.1 to be applied to these products and
- to provide general information to assist in the application of AS/NZS2566.1.

This guidance document tabulates the typical material characteristics of PP-B as used in the manufacture of the following products produced by Iplex Pipelines Pty Limited. and Vinidex Pty. Ltd. i.e. Iplex BlackMAX ™ and SewerMAX™, and Vinidex SewerPRO® and StormPro®**,** all of which are twin-wall, smooth bore, corrugated pipes for non-pressure applications.

For other polypropylene pressure and non-pressure products reference should be made to the manufacturer.

Introduction:-

Polypropylene (PP-B) pipes have been used for over 30 years for sewerage and drainage applications, predominantly in Europe. Several years ago, structured wall, smooth bore, polypropylene sewerage and drainage pipes were also introduced in Australia. These are manufactured in accordance with AS/NZS 5065:2005.

Polypropylene was chosen for structured wall pipe applications because of its excellent material properties resulting in:

- Material efficiency - combines light weight with structural strength due to high tensile modulus (stiffness), low density and wall profile design.
- Safety in handling and installation
- Minimised transport costs
- Rapid installation

AS/NZS 2566.1 Buried Flexible Pipelines part 1: Structural Design

The structural design of buried flexible pipe systems is addressed by AS/NZS 2566.1. This Standard tabulates typical pipe material characteristics for a range of plastics and metals. Whilst AS/NZS 2566 does not provide tabulated material properties for PP-B, it clearly states the Standard may be used for materials not listed, provided suitable data can be obtained. The reason PP-B data is not tabulated in AS/NZS2566 is simply that when the standard was originally published in 1982 (as AS2566) and subsequently revised in 1998, polypropylene was not a commonly used pipe material in Australia or New Zealand. In other words, in the preparation of AS/NZS 2566.1 the Standards Committee recognised that new materials might be introduced and AS/NZS 2566.1 was prepared for this eventuality by allowing materials other than those explicitly listed. Specifically, Clause 1.2 “Application” in AS/NZS 2566.1 details this.[i] The foresight in making this provision is confirmed in AS/NZS2566.2 *Installation*, published some 4 years after Part 1, which lists polypropylene as a typical flexible pipe material.

Although allowance is made for reference to the manufacturer for material properties, it is preferable for standardisation purposes that specific values be published and generally applied.

Application of Structural Design of Buried Flexible Pipelines:-

AS/NZS 2566.1 and PIPA Technical Paper TP005 are used to predict a flexible pipe’s response to external loads, including soil loads and superimposed loads such as traffic and groundwater. AS/NZS 2566, TP005 and other design techniques, such as those used in Europe, are applicable to all flexible pipes, they are not material specific. Note that ISO 21138-1:2007 treats PVC, PP and PE equally and provides material characteristics for buried pipeline design purposes for all three plastics. <u>There is no basis for excluding PP from the structural design methods used for other plastics materials</u>.

Pipe Material Characteristics:-

In order to utilise AS/NZS 2566, certain material properties are necessary, and Table 2.1 of the Standard lists typical properties of a number of materials, both metallic and non-metallic, plus allowing for reference to the manufacturer for confirmation or provision of more specific data. The same material characteristics listed for other materials in Table 2.1 of AS/NZS2566.1 are equally relevant to PP materials. Whilst, there are several PP material “types” available, in order to optimise processing characteristics and pipe properties such as stiffness, only PP-B is used in the manufacture of structured wall non pressure pipes. The required material properties of PP-B have been tabulated below. (more detailed information relating to the types of PP can be found in the Bibliography).

Following are the appropriate additions to Table 2.1 of AS/NZS 2566:-

TABLE 2.1

TYPICAL PIPE MATERIAL CHARACTERISTICS

Pipe material	Allowable long-term vertical pipe deflection for non-pressure %	Allowable long-term ring bending strain $\varepsilon_{b\ all}$ %	Maximum allowable Long-term hoop stress $\sigma_{h\ all}$ MPa	Poisson's Ratio ν	Ring-bending modulus MPa			Long-term factor of safety		
					E_b	E_{bL} 2y	E_{bL} 50 y	Pressure η_p	Bending η_b	Combined η
Vinidex and Iplex PP non-pressure (polypropylene)	7.5	4.0	N/A	0.45	1300	640	470	N/A	2.0	1.25

Background to AS/NZS 2566 and PIPA TP005:-

AS 2566 was published in 1982 to replace AS CA68 – Plastics Pipelaying Design.

For soil loads, the prism loading is assumed to be applicable, whilst allowance is made for other techniques, such as Marston-Spangler, to be used (allowing for friction between backfill and native surround that results in reduced soil loads on the pipe).

During development of the Standard consideration was given to the numerous design techniques used throughout the world.

The Australian Standard was further refined as a joint Australian / New Zealand document in 1998 which incorporated AS/NZS 2566.1 Structural Design – Commentary. The Commentary is an important adjunct to Part 1, as it elaborates on the design procedures involved, and discusses some alternative acceptable design techniques. The 1998 version also expanded the scope to include all flexible pipes, metals as well as plastics.

In 2002, Part 2: Installation was introduced to quantify installation conditions that relate to Part 1. In that context, the techniques nominated are not intended to be mandatory for all installations, but are of benefit in using Part 1 for prediction of pipe response.

Since 2002, TEPPFA (The European Plastics Pipe and Fittings Association) in conjunction with independent experts in the field of plastics pipes design, produced an innovative approach to prediction of pipe response to soil and traffic loadings –

see PIPA TP005. PIPA TP005 presents the TEPPFA approach to prediction of pipe response under common installation conditions, not requiring specific calculations.

Further, innovative products such as profile wall, smooth bore, polypropylene sewer and stormwater pipes have been subsequently introduced, but polypropylene (PP) is not included within Table 2.2 of AS/NZS 2566.1, Typical Pipe Material Characteristics.

Design Notes:-

These notes supplement detailed information to be found in the aforementioned publications and elsewhere.

There are two common misconceptions with regard to the performance of plastics (creep-affected) pipes:

Pipe strength decreases with time, and

Soil loads apply indefinitely

*The first misconception arises from the oft-published short and long term values of properties such as material modulus. Whilst a pipe is under constant load, it will be subject to creep and therefore changing effective modulus due to changing gradient of the stress-strain curve. However, immediate response to an increase in the constant load will be in accordance with **short term properties**. This has been demonstrated by test on many occasions for both non-pressure and pressure loadings i.e. the pipes do not lose strength with time. Further, creep is recoverable over a period following load removal.*

It has been demonstrated by TEPPFA and others that there is an initial pipe deflection arising from installation conditions, soil load, and traffic loads, with stabilisation occurring within two years. This initial deflection is directly related to pipe stiffness and the effective loading time is less than two years, hence the references to two-year modulus values for long term use in AS/NZS 2566 and PIPA TP005.Further, it has been postulated, by Prof. Lars-Eric Janson for example, that soil loads may be considered as a series of short term increases, allowing the use of the short term modulus for calculation purposes. However, it should be noted that situations with constant loading, such as high water table, may demand the use of longer term modulus values, hence the inclusion of 50 year values in the Standard.

Bibliography

PIPA TP005 **Flexible Pipe Design** by Mark Heathcote, PIPA Executive General Manager, January 2009. http://www.pipa.com.au/documents/flexible-pipe-design

AS2566:1982 Australian Standard **Plastics Pipelaying Design**

AS/NZS 2566.1:1998 **Buried flexible pipelines Part 1: Structural design**

AS/NZS 2566.1 Supp1:1998 **Buried flexible pipelines Part 1: Structural design—Commentary**
(Supplement to AS/NZS 2566.1:1998)

AS/NZS 2566.2:2002 **Buried flexible pipelines Part 2: Installation**

AS/NZS 5065:2005 (Incorporating amendment No.1) **Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications**

CEN TR 1295-2 **Structural design of buried pipelines under various conditions of loading – Part 2: Summary of nationally established methods of design.**

ISO21138-1: 2007, **Plastics piping systems for non-pressure underground drainage and sewerage - Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), Polypropylene (PP) and polyethylene (PE)**

Plastics Pipes for Water Supply and Sewage Disposal by Prof. Lars-Eric Janson, 4th Ed.

Durability testing for 100 year lifetime for buried non-pressure plastic pipes - Kristian Thornblom, SP Swedish National Testing & Research Institute, Int. Conf. Plastics Pipes XIII, Session 3b, Washington DC, 2006

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[i] AS/NZS2566.1 Clause 1.2 paragraph 3 states "*Provided suitable data can be obtained, this Standard may be used for materials not listed in the above table*."