Long Term Strength
Long term strength in the buried condition is a critical consideration in pipeline assets. Specifications often refer to a required design life of 100 years.

It may be possible to observe the real-life performance of pipes that have been installed for up to 100 years. However, significant process and material changes have occurred over the years.

While there may be some similarities between products manufactured a century ago and some products manufactured today, that is not to say that an apples for apples comparison can or should be made.

As a result, Finite Element Analysis (FEA) has become an accepted tool by which to extrapolate installed pipeline behaviour into the future. This form of analysis can be bench marked against soilbox testing and accelerated product testing.

As referred to earlier in this bulletin, VPipeTM concrete pipe is designed into the ground as a rigid pipe, assuming that there is no lateral support from the soil in which it is buried.

Typically, rigid pipe, when tested to first crack in the ring-bending test, has a diametral deflection to inside diameter ratio in the order of 0.5%. However, if a pipe is able to deflect more, then the side walls of the pipe move to contact the soil more actively, which means the pipe acquires additional support from the soil. This results in some of the vertical force (from the weight of the soil above the pipe) being offset, and the soil around the pipe now helping the pipe to carry the load. These effects are utilised in flexible pipe design, and have been proven to apply for VPipe concrete pipe by soil box testing. For VPipe concrete pipe, the diametrical deflection to inside diameter ratio is in the order of 3 to 4%, which is sufficient to bring about additional soil support. The extra strength that is gained by VPipe concrete pipe from the soil is not utilized in the design of the pipe to meet the long term design loads required for each size and class of pipe.

This extra strength therefore serves as an additional factor of safety over the entire service life of the pipe once the pipe is correctly installed.

This extra support from the soil also has significant implications with respect to creep. AS 4139 requires that in the case of VPipe concrete pipe, the analysis required by the standard takes into account the soil support of the pipe, and the creep characteristics of the pipe are accounted for by means of determining the reduction in stiffness with age of the pipe and determining the long-term installed deflection of the pipe.

The reduction in stiffness of the pipe is determined by means of stress relaxation testing where the pipe is held at a constant deflection in a saturated condition and the reduction in the reaction force of the pipe is measured with time. This reduction in force with time enables the long-term stiffness of the pipe to be determined at a future time period of 2 years after which time soil consolidation is complete.

Figure 1 - The Crush Load or Ring-Bending Test

The standard then requires a fully saturated, semi-rigid pipe to have an in-ground long-term deflection no greater than 50% of its deflection at the point of maximum load capacity in ring bending. This results in a safety factor on ultimate deflection of 2.

This methodology established in AS 4139 ensures that once designed into the ground as a rigid pipe, the pipe is at no time overstressed, and cannot possibly collapse due to creep failure under design soil loading. The extra strength that is gained by VPipe concrete pipe from the soil has been verified by soil box testing at Queens University (Vancouver Canada), the University of Texas (USA), the University of Central Florida (USA) and the University of NSW. FEA has also been conducted to predict factors of safety for all sizes and classes of VPipe concrete pipe at maximum burial depth in all installation types specified in AS 3725. In all cases the factors of safety operating on design crush loads exceed those required by AS4139. In addition, FEA has been conducted on saturated pipe in order to understand the complex soil-structure interaction between pipe and soil.

A comprehensive two-dimensional FEA analysis was undertaken on VPipe 375mm Class 2 pipes under six possible installation conditions, which are as described in Australian Standard AS 3725. The following three main types of pipe support were included in the design verification of pipes:

- Type U support corresponds to uncontrolled pipe installations.
- TypeHsupportforpipesinstalledwithhaunchsupportwith three possible subcategories H1 and H2.
- TypeHSsupportforpipesinstalledwithhaunchandside support with three possible sub categories HS1, HS2 and HS3.

Construction sequencing was included in the analyses by deactivating and activating soil elements. A live load scenario for moving loads was also included in the analyses. The live load analysis was carried out under shallower burial depth.

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RCPA
THE AUSTRALIAN PIPE COMPANY

TECHNICAL BULLETIN

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FRCPIPES 100 year design life.

Introduction

FRCPIPE has over 75 years of pipe manufacturing experience in Australia. With this background, RCPA understands the requirements of the industry, and confidently offers our durable **FRC**PIPE concrete pipe products specifically designed for below ground stormwater drainage applications. Since RCPA introduced fibre reinforced concrete pipe technology in 1984, over 10,000 kilometres of our pipe has been laid.

RCPA understands that, apart from installed cost, the critical parameters for engineers and specifiers in the selection of pipeline assets are long-term strength and durability. The in-ground strength of **FRC**PIPE concrete pipes is enhanced by its ability to deflect and utilise passive soil support in addition to conforming to all of the design requirements for rigid concrete pipe design. This unique property adds to the built in safety, making **FRC**PIPE the Smart concrete pipe. Furthermore, our manufactured quality is maintained under an independently audited ISO9001 quality assurance scheme on raw materials, the manufacturing process, and finished product.

Design & Specification

In Australia, reinforced concrete pipes (RCP) are manufactured either in accordance with AS4139 “Fibre reinforced concrete pipes and fittings” or AS/NZS 4058 “Precast concrete pipes (pressure and non pressure)”.

FRCPIPE concrete pipes are manufactured in accordance with AS 4139. Each size and class is classified according to their long term design loads (Tc) which are determined from the minimum crush load of the pipe. This crush load is the test load at failure of pipes under the action of externally applied compressive loads, using the three-edge load configuration, see Figure 1. The design loads and factors of safety on ultimate crush load for each size and class of pipe throughout the concrete pipe industry are identical irrespective of the method of manufacture or whether they are made in accordance with AS 4139 or AS/ NZS 4058. This enables engineers to specify simply the size and class of pipe necessary for a particular installation, and leave it to the customer to specify the supplier.

FRCPIPE **concrete pipe can therefore be used, in the appropriate size and class, wherever a RCP is specified.**

Figure 1 - The Crush Load or Ring-Bending Test

Concrete pipe is designed into the ground in accordance with AS/NZS 3725 “Design for the installation of buried concrete pipes”.

This design methodology and installation requirements assumes rigid pipe behaviour where there is no lateral support from the soil in which it is buried, but its load bearing capacity can be changed by altering the support under the pipe (bedding factor), according to the type of installation configuration used as defined by the standard.

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