LATEST DEVELOPMENTS INCREASE THE CAPABILITIES OF SPIRAL WOUND LINERS

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ABSTRACT

For many years spiral wound liners have been the most used type of liner for the rehabilitation of deteriorated sewers and stormwater conduits throughout Australia and New Zealand.

Interflow Pty Limited has been installing the world’s most advanced spiral wound lining systems under a licensing agreement with Rib Loc Australia Pty Ltd, later Sekisui Rib Loc Australia. This agreement has allowed Interflow to exclusively install these liners across New Zealand and Australia.

Continuous development that has occurred with these liners over the past 20 years has been made possible by the co-operation that exists between the developers and the Water Authorities who are the end users. Now a 20 year strategic alliance recently signed between Interflow and Sekisui Rib Loc Australia, has increased the resources available for future developments.

This paper will highlight the most recent, as well as upcoming, developments in spiral wound liners that have furthered their capabilities for the renewal of deteriorated underground conduits. They have enabled many of the limitations of spiral wound lining technology to be overcome.

All of these advances have increased the possibilities for more effective pipeline rehabilitation, in many cases where there was no practical alternative. As with previous spiral wound lining advances, they will be first demonstrated in this region before being made available to others around the world.

KEYWORDS

Sewer rehabilitation, relining, spiral wound liners, grouting, structural liner design

1 INTRODUCTION

Spiral wound liners have been developed for the structural rehabilitation of deteriorated sewers, stormwater lines and culverts with diameters from 150mm to over 3,000mm.

These liners are made by taking a continuous strip of ribbed plastic and locking or welding the edges together to form a liner inside a deteriorated host pipe. Structural liners which restore the load carrying capacity of the deteriorated pipeline are installed by a specialist winding machine which depending on the type of spiral wound liner, can either remain at the entrance to the deteriorated host pipe, or travel up the pipeline winding the liner as it goes.

In smaller diameters, liners are made from PVC and compete in the market with cured-in-place liners or fold-and-form liners. They are expanded after installation to contact the inside of the host pipe, or, if installed by a traversing machine, wound in a single stage to provide tight contact with the host pipe.

In larger sizes spiral wound liners may be made from PVC or steel-reinforced polyethylene and are alternatives to sliplining or re-construction that needs extensive man-entry into the deteriorated pipeline.

Since their first widespread acceptance began in the 1990s numerous developments have taken place with the support and cooperation of Water Authorities to expand the possibilities for structural rehabilitation of deteriorated pipelines.

First a wider range of profile strips for Expanda Pipe was developed along with more powerful machinery to make their installation possible in larger diameter.

Rotaloc was developed as a one-stage spiral winding process that allowed even larger PVC strips to form a circular liner tight up against the host pipe. The Rotaloc winding machine that traverses along inside the pipeline winding the liner as it goes, allowing long continuous lengths of larger diameter pipelines to be lined.

Uniquely for full-bore liners, fluid, cementitious grout can be pumped behind the liner after it is installed, filling voids in the deteriorated host pipe and providing enhanced support for the liner. While not needed for small diameter pipes, grouting allowed the liner to renew larger sized deteriorated pipelines, providing a lining system capable of design to withstand heavy loading as if the deteriorated host pipe had no remaining strength. Grout developed specifically for this application can flow long distances through small spaces and cure without shrinkage or separation.

The need to provide structural liners in even larger diameter conduits that could be installed by minimising the need for bypass pumping of large volumes of flow saw the development of Ribline. This was a ribbed polyethylene liner with a continuous band of steel encased in each rib. Being polyethylene, the edges of the liner had to be welded together by an extrusion welder in the winding machine. Being welded, meant that the liner could not be expanded after installation, so had to be installed at a fixed diameter. Ribline liners therefore always require grouting.

But spiral wound liners have traditionally had limitations.

- While they can cope with deviations such as a pipeline that is not perfectly straight, they cannot be installed continuously around bends.
- Commonly available spiral wound installation techniques only can only install circular liners. This limits their application in ovoid and box section conduits.

Development to overcome these limitations has continued and further innovations have been rolled out and proven over the last couple of years. New innovations are at advanced stages of development.

2 DEVELOPMENTS TO OVERCOME LIMITATIONS

2.1 LINING AROUND BENDS

PVC as a material has some strain capacity so Expanda Pipe and Rotaloc liners can be wound continuously in pipelines with deviations in their alignment.

But these liners are limited in their capacity to cope with bends intentionally constructed on a pipeline. While relatively rare, such bends are more likely to be encountered in pipelines over 900mm in diameter, so are particularly applicable to Rotaloc spiral wound liners. Previous solutions included installing Rotaloc on straight sections, then applying a thick coating of epoxy mortar at the bends.

To overcome this limitation a modification was made to the configuration of the UPVC profile strip.

The strip was extruded with a U-shaped “loop” in the cross section. When the liner was wound around a bend, the “loop” opened slightly on the outside of the bend and closed slightly on the inside. This concertina effect allowed the walls of the liner to stretch or compress as it continuously went around the bend.

The properties of the liner are otherwise unchanged. It has the same stiffness and other material properties as the standard liner, the same jointing mechanism and is installed using the same equipment and processes. It can be directly joined to standard Rotaloc profile strip.

For Rotaloc installation, standard profile strip can be used for straight sections of a line, then bend profile strip used as required. The two types of liners can seamlessly join to each other to provide a continuous spiral wound liner between manholes. This results in a liner capable of handling the dimensions and radii of bends commonly found in sewers

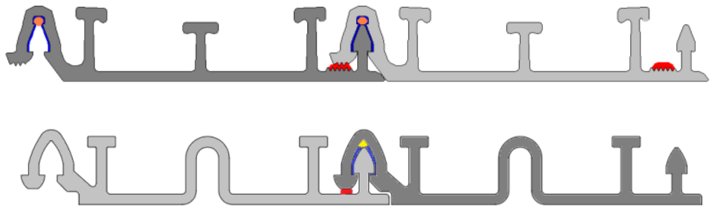

Figure 1: Rotaloc Profile strip. Top is standard strip. Bottom is bend strip with the "loop" which opens on the outside of the bend and closes on the inside of the bend

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Bend profile is available for both Rotaloc and Expanda Pipe liners, so can be installed in sewers and stormwater conduits with diameters from 150mm to 1,800mm.

One of the first applications of Rotaloc bend profile strip was on a 1,550mm nominal diameter conduit in Auckland. The bend extended over 90° with a radius of about 15 metres.

Figure 2: Rotaloc liner installed continuously around a bend in a 1.550mm nominal diameter conduit

Standard Rotaloc would not have satisfactorily negotiated the bend, and, and assuming CIPP lining was possible at that diameter it is likely at such a liner would have had significant wrinkles on the inside of the bend. Having the Rotaloc bend profile meant that a continuous liner could be wound for over 100 metres, including around this tight bend.

2.2 HIGH STRENGTH FULL - BORE LINERS IN LARGE DIAMETERS

Liner stiffness is one of of the features that must be considered in accepted design methods. The stiffer the liner, the more load it can withstand. In simple terms, stiffness is a measurement of the deflection of a liner when a given load is applied for a particular time.

Stiffness is proportional to the cube of the diameter of a liner. So for example, if the liner diameter doubles, then the moment of inertia of the liner wall is required to increase by a factor of eight if the liner is to have the same stiffness.

This becomes an issue for plastic pipes in general as the diameter increases, and is a particular problem for spiral wound liners, where light weight is required for practical installation. While a ribbed configuration provides a high stiffness to weight ratio, it is not practical to provide entirely plastic liners in heavily loaded applications at large diameters. The plastic liners become too thick and unwieldy.

This problem has been partly solved with the development of Ribline, a steel reinforced polyethylene liner. This is a ribbed liner with a continuous strip of steel encased within each rib. The steel reinforcement provides the liner with the stiffness to meet design requirements.

Unlike Expanda Pipe and Rotaloc, Ribline is a fixed diameter liner. The edges of the strip must be welded together as the liner is installed. The liner cannot be expanded after installation, so there is always an annulus.

Now further research with the Rotaloc lining system has seen the development of steel reinforced Rotaloc profile strip. A continuous strip of steel is encased in each rib, substantially increasing the liner stiffness.

Steel Rotaloc has the same type of lock configuration and is installed by the same equipment and process used for standard Rotaloc.

Steel Rotaloc expands the capacity of this system to structurally line larger diameter pipelines. Installation by the Rotaloc process, tight against the bore of the deteriorated pipeline, maximises the lined diameter and removes one of the limitations of Ribline.

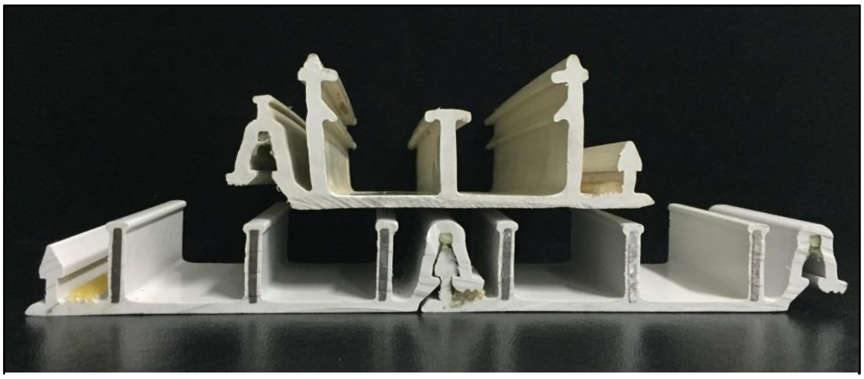

Figure 3: 22mm high steel reinforced Rotaloc has almost 3 times the stiffness of 37mm high standard Rotaloc

The difference is dramatic. A 22mm height steel reinforced Rotaloc liner has almost 3 times the stiffness of a 37mm height unreinforced liner. This means structural liners designed to carry heavy road or rail loading can be installed in larger diameter deteriorated pipelines with less loss of internal diameter.

Installation of steel reinforced Rotaloc is quicker than with Ribline as there is no continuous welding required. It is faster to set up and can handle long continuous lengths.

Steel reinforced Rotaloc has been successfully used on several recent projects and has proved to be an extension of the capacity of spiral wound liners to meet design requirements.

2.3 SPIRAL WOUND LINERS FOR LARGE NON-CIRCULAR CONDUITS

One of the limitations of machine installed spiral wound liners used to date in Australia and New Zealand is that, because of the installation method, they are only suitable for circular conduits. A machine installed spiral wound liner intimate with a non-circular conduit was not available anywhere in the world.

A large project from a major Australian Water Authority to restore a large more-or-less rectangular sewer was the inspiration for further research to attempt to overcome this limitation.

The sewer in question has an approximately rectangular cross section, nominally 3.6 metres horizontally and 2.4 metres vertically, but variable due to construction tolerances and concrete deterioration. It runs for several kilometres and is up to 90 metres deep.

The sewer is tunnelled through sandstone and has a cementitious liner. Much of this liner is deteriorated through corrosion leaving exposed sandstone and allowing significant infiltration.

As on previous projects to restore such large sewers, it was considered that the only practical option was to clean the exposed surfaces and spray a thick corrosion resistant coating such as calcium aluminate cement.

While this has been an acceptable renewal method for many years, it is susceptible to some inherent difficulties. It is labour intensive and depends on the quality of workmanship in demanding and difficult conditions. Ultimately the cementitious coating is sacrificial. While calcium aluminate cement has been used extensively and has proven to be effective, it is considered that its lifespan is likely to be less than 50 years in aggressive sewer environments.

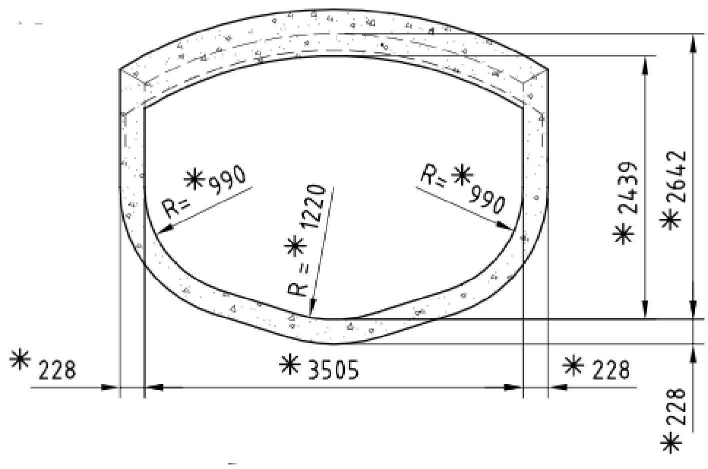

Figure 4: Nominal internal dimensions of the sewer. These vary along the sewer length due to construction tolerances and concrete deterioration

Interflow, in collaboration with its technology partner Sekisui Rib Loc Australia, has worked on the development of a radically innovative spiral wound lining system for large, non-circular sections in response to the requirements of this upcoming project. It provides a liner intimate with the shape of the host conduit and is now at an advanced stage with final testing of the structural capabilities of the liner being carried out.

The liner was developed using the capabilities of steel reinforced Rotaloc profile strip. It was considered that the steel reinforced strip with edges that could be joined by a conventional locking mechanism offered the possibility of winding a liner with sufficient stiffness to be practical for straight sections.

The installation process developed by Interflow and Sekisui Rib Loc Australia uses a winding head that travels along the steel reinforced PVC profile in close contact with the surface of the conduit. It closely follows the shape of the conduit. The profile strip is supplied from an above ground spool and has the same configuration as for other spiral wound liners.

Development and proving of the liner has been carried out in stages

The first stage involved demonstrating that the winding head developed was capable of moving along the steel reinforced profile strip joining successive wraps as it went.

Once this feasibility` was established, a structure with the approximately same shape and dimensions as the sewer was constructed from steel plate. The liner was installed in this structure demonstrating that it could be wound closely to the required shape. It was shown that the liner had sufficient stiffness to support its own weight as it was wound across the 3.5 metre soffit of the structure.

The next step was to demonstrate that the liner could be installed in the flow conditions likely to be encountered in the sewer so the structure was flooded to a depth of approximately 1200mm. Further development of the lining process resulted in the liner being successfully installed under these conditions, with the winding machine functioning effectively in joining the edges of the profile strip under water. It was also demonstrated that the liner could be wound continuously over displacements of 25mm.

The next stage was to grout the liner after installation. Grout fills gaps between the liner and the conduit and provides the liner with enhanced support. Currently testing is being undertaken to determine what bracing is required, if any, to allow grouting to be carried out without deforming the liner.

With the liner having to be grouted in stages, it is possible that grouting the invert and sections of the vertical liner walls will provide the structure with enough stiffness so that no further support is needed to allow successful grouting of the critical soffit section.

Figure 5: Machine Spiral winding of the liner in a simulated conduit with the required dimensions, demonstrating that installation is possible in partially submerged conditions.

Once grouting of the trial section is completed, testing will then be carried out to determine the hydrostatic load carrying capacity of the grouted liner. This will involve a full scale load test, considered more reliable than theoretical methods such as finite element analysis, for this unique structure.

The solution, currently at an advanced stage of development, has the potential to provide a whole new class of renewal for large and and critical deteriorated sewers. Machine installation removes the variations and uncertainties that are inevitably possible when relying on manual workmanship in difficult conditions, while a PVC lining provides a solution that can be expected to provide effective renewal for 50 years or more.

3 CONCLUSIONS

Spiral wound liners have developed over the past 25 years to become the most installed type of sewer liner in New Zealand and Australia. Over that time advances have extended their capabilities to larger sizes and to greater load carrying capacities. They have been repeatedly proven capable of providing effective renewal of deteriorated sewers, storm drains and culverts in applications where rehabilitation by lining would otherwise have been impossible.

Latest advances have seen many of the limitations of these liners overcome and they continue to extend the possibilities for structural rehabilitation of an ever-widening range of deteriorated conduit configurations under the widest range of conditions.

Major investment is being made in further research and development. The results of this should see the possibilities for trenchless structural pipeline rehabilitation extended.

As with past advances, development are taking place with the support of Australian and New Zealand Water Authorities who have always encouraged such development, demonstrating a willingness to incorporate innovative solutions where these can reasonably be seen to offer important mutual benefits.

As with all of these advances, these will first be proven in this region before being offered around the world.