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2011: Lessons Learned Rehabilitating Manholes & Pump Stations with Fibreglass Liners. Fibreglass Liners have a lot of advantages, but there are some pitfalls. These are some of the lessons learned.

LESSONS LEARNED REHABILITATING MANHOLES & PUMP STATIONS WITH FIBREGLASS LINERS

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ABSTRACT

Fiberglass liners are used to rehabilitate manholes and pump stations that have deteriorated due to age, corrosion, and structural cracking. The bases can be coated, or in the case of pump stations, a fiberglass Flygt TOPS base can be fitted. The fiberglass liner is used to rehabilitate the walls. It is first sealed to the base, and then the annulus between the liner and the structure is grouted with a flowable grout.

The fiberglass liner is custom designed and manufactured to the required diameter and depth, and to have the needed stiffness to handle the pressures from grouting. If the liner has insufficient stiffness, it will bulge inwards during grouting. This will lead to the fiberglass failing by cracking along the apex of the bulges due to stresses from thermal expansion.

This paper records the author's experiences with installing fiberglass liners manufactured by ARMATEC Environmental Ltd. It includes a failure with a thin liner.

KEYWORDS

Fibreglass liner, manhole, pump station, rehabilitation

1 INTRODUCTION

Many concrete manholes and pump stations in wastewater networks require rehabilitation. Many of the city networks are ageing, now approaching the end of their 50 to 100 year design life. Corrosion from hydrogen sulphide gases causes loss of structural integrity, particularly in the upper gas zone portions. Leaks outwards through cracks cause problems for the environment, and infiltration into the network increases the hydraulic load on wastewater treatment plants; these leaks are often from joints between the concrete sections.

Often manholes and pump stations are replaced with new ones, but in some cases the logistics of this brings a lot of difficulties. Replacing a manhole or pump station may mean taking it off-line and require over-pumping. Road closures and large open excavations require extensive safety procedures. All of these add to costs.

Photographs 1 & 2: 100 year old leaking manhole in location with difficult access replaced with new fiberglass manhole with sewer live throughout the installation.

An alternative is to rehabilitate the existing structures. This can minimize over-pumping, excavations, road closures, and safety issues; it can be done with the sewer live or interrupted with bungs stopping flows for short periods.

Coatings are used to rehabilitate manholes and pump stations. Coatings require good surface preparation to achieve adhesion to the substrate, application, and quality control procedures. High relative humidity and surface dampness are often problems for many coatings. Often the concrete has deteriorated to 10 or 20 mm depth; this unsound material must be removed and replaced before the coating can be applied. All of this can be very difficult in the confined spaces involved. The typical life of coatings installed is 5 to 10 years, especially if there are high concentrations of hydrogen sulphide gas. Some coatings the author has seen used have failed within the first year. Unless the coatings include layers of glass reinforcing, they are not able to structurally repair the concrete, and, if the concrete substrate moves and cracks in the future, the coating will crack.

An alternative is to install a pre-made fiberglass liner inside the existing concrete manhole or pump station. Properly engineered and manufactured fiberglass can overcome corrosion, leaks and infiltration. It can add strength back to the existing structure, and will not necessarily crack if the concrete moves and cracks. Once installed offers an indefinite life with little maintenance. Installing a pre-made fiberglass liner comes with its own difficulties, and this paper reviews the author's experiences gained in rehabilitating existing manholes and pump stations with fiberglass liners.

2 REHABILITATING THE BASE

Typically the base is 5% to 10% of the total inside surface area, so is relatively small. Being at the base, access can be easier. However complex shapes of inlets, outlets, and pumps bring additional difficulties.

2.1 MANHOLE BASE REHABILITATION

Specialist coatings are used due to the complex shapes of manhole bases, with inlet and outlet pipes and haunching done to shape the flows. Successful coatings used are moisture tolerant epoxy coatings, formulated to give ultra low permeation and excellent chemical resistance. One coating that has a successful track record in this application is ARMALINE 1730 from ARMATEC. This moisture tolerant epoxy coating can adhere to a damp substrate and cure underwater. It is applied by hand application to a thickness of 1 to 3mm.

Photograph 3: Manhole in dairy factory chemical drain coated with moisture tolerant and chemically resistant ARMALINE 1730 epoxy coating. Complex shapes require rehabilitation by coating.

Photograph 4: Base of deep manhole in municipal sewer system coated with moisture tolerant and chemically resistant ARMALINE 1730 epoxy coating. Again, complex shapes require rehabilitation by coating.

2.2 PUMP STATION BASE REHABILITATION

The base of a pump station can be rehabilitated with coatings as described above, or a specialist fiberglass ‘TOPS’ base can be fitted when FLYGT pumps are used. This base can also be installed in new installations. The fiberglass base is factory fitted with the pump seating elbows bolted to the base and has a flange around the top for stability (Photograph 5).

Photograph 5: FLYGT TOPS fiberglass base, with pump seating elbows installed, ready to install

The size of the base is selected to suit both the pumps and the internal diameter of the pump station. Once the manhole is cleared off the existing pumps and piping, the base is lowered to the bottom of the pump station, oriented correctly, and then the cavity between the fiberglass and the pump station wall is grouted with a flowable cement grout.

Photograph 6: FLYGT TOPS fiberglass base installed in bottom of new deep pump station. A protective coating has been applied to the wall of this new pump station.

3 REHABILITATING WALLS WITH FIBREGLASS LINER

Once the base has been done, rehabilitating the straight walls with a pre-made fiberglass liner is the same for both manholes and pump stations.

3.1 FIBREGLASS LINER

The fiberglass liner is custom manufactured to suit any diameter and depth. The thickness of the fiberglass liner is custom engineered, from 6mm upward, to resist buckling during grouting after installation. The fiberglass liner can be designed to provide as much additional structural strength as needed. Isophthalic polyester resins are used for municipal sewerage systems, and vinyl ester resins are used for industrial systems handling CIP chemicals.

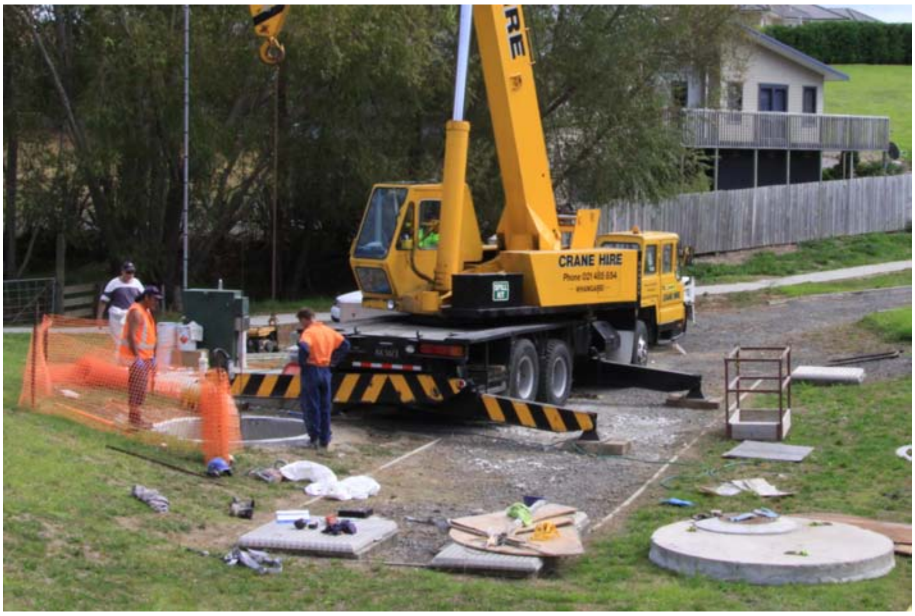
Photograph 7: Fibreglass liner ready to install. The dark rings are external stiffening rings to resist buckling during grouting after the liner is installed.

3.2 TOP REMOVAL

The top of the manhole or pump station must be removed to allow the fiberglass liner to be installed. This excavation is relatively small (Photograph 8) compared to removing and replacing the entire unit. In some instances, where the surrounding soil is unstable, very large excavations may be required.

Photograph 8: Minimal excavation to remove manhole top in preparation for installing fiberglass liner.

Photograph 9: Top off manhole, and preparing to install fiberglass liner.



A protective coating is applied to the underside of the top before it is reinstalled.

3.3 WALL SURFACE PREPARATION

Minimal surface preparation is needed. The only requirement is that all protrusions must be removed, as these may hinder the installation of the fiberglass liner. This may include inlet and outlet piping, steps, and any other installed equipment. Washing down of the walls is usually done before the base is coated, and this is usually sufficient. Removal of unsound concrete is not required, as design does not require the fiberglass liner to 'adhere' to the substrate.

3.4 INSTALLING THE FIBREGLASS LINER

The fiberglass liner is lowered in once the base has been coated. The bottom of the liner needs to be fitted to the base to minimize gaps in preparation for achieving a seal. This may mean that it needs to be contoured to suit existing haunching, irregular shapes, or inlet and outlet pipes.

With pump stations that have a FLYGT TOPS base fitted (see section 2.2), the flange around the top of the base is ideal for landing the fiberglass liner on.

Photograph 10: Lowering a fiberglass liner into position after base is completed.

Once landed, the bottom of the fiberglass liner must be sealed to the base, so that grouting of the annulus between the existing structure and the fiberglass liner can be done. The first step in this process is to fill any gaps, and this can be done with a variety of materials including foam, putty and trowelable grout. Then a fiberglass bandage is applied from the liner to the base, and allowed to cure.

All inlet pipes are made off and sealed to the fiberglass liner before grouting can be done.

3.5 GROUTING THE ANNULUS

The annulus is grouted with a flowable cement grout. It is not a structural grout, but is required to fill the annulus to keep the fiberglass liner in position and in shape. Grouting must be done in increments, so that buckling of the fiberglass liner does not occur.

To ensure the seal at the bottom of the liner holds, a small first pour is done, and this is allowed to cure. Then additional pours are done following the strict depth limits of pours.

A slow setting grout can be pre-mixed and poured into the annulus from the top. This method usually requires 6 hours or more to set, before the next pour can be made.

Alternatively, a fast setting grout can be used by pouring a pre-measured quantity of water into the annulus, then flowing the correct quantity of dry grout down the annulus. This can set in less than an hour, and the next pour can be made.

Photograph 11: Completed fiberglass liner

Photograph 12: Completed installation with top back on and road re-instated

The end result is a manhole or pump station with a lining that has an indefinite life. The smooth internal fiberglass surface is corrosion resistant and easily cleaned.

4 THIN FIBREGLASS LINERS DON'T WORK

4.1 LESS THICKNESS, LESS COST, LESS STIFFNESS

Thin fiberglass liners were tried in an attempt to reduce costs. As the cost of the fiberglass liner is almost directly proportional to the quantity of fiberglass used, lesser wall thicknesses reduce cost. The problem that arises is a dramatic reduction in the stiffness of the liner, because the stiffness is proportional to the cube of the wall thickness.

4.2 INSTALLATION DIFFICULTIES

A number of problems arose when a thin liner was installed in a two-metre diameter manhole/pump-station. This is a manhole, with no pumps, that is directly connected to a pump station so the wastewater level rises and falls as in a pump station. This manhole/pump-station was originally coated concrete, but the coating had failed due to high levels of hydrogen sulphide.

Firstly, the reduced stiffness made it difficult to transport and install the fiberglass liner. The liner had to be braced inside at all times before installing. During lowering into the manhole, it could not be kept round, and this caused the installers a lot of difficulty and time contouring and sealing it to the base.

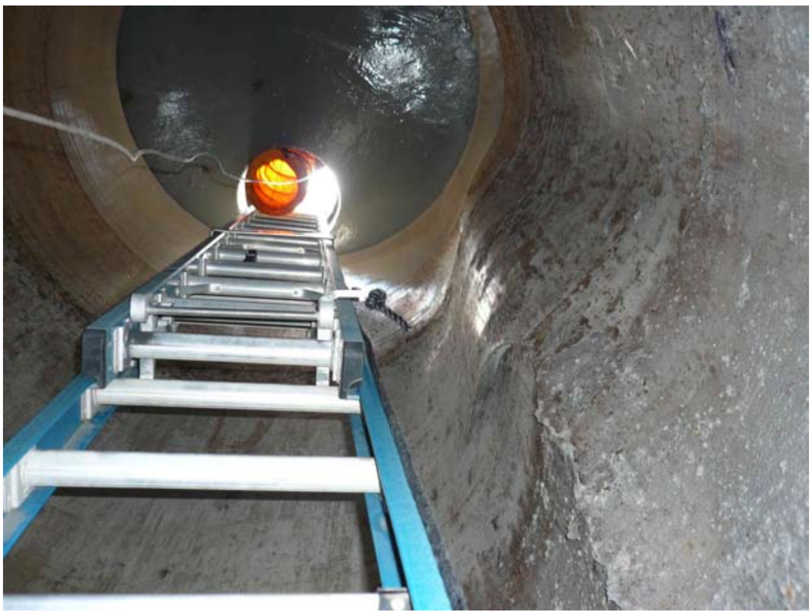
Secondly, when grouting the annulus, the pour depths had to be reduced, but were exceeded. This caused the liner to bulge inwards in a number of places each time this happened.

At the finish of installation, the bulges were clearly evident, but were mainly cosmetic. The fiberglass liner was intact and performed its function. A watch was kept on this once the manhole was closed back in.

4.3 FIBREGLASS CRACKED AT BULGES

The fiberglass liner cracked and failed within 3 months of installation. Cracks formed centred on the apex of the bulges. It was determined that the cause of the failure was repeated temperature fluctuations as the wastewater level rose and fell in the manhole/pump-station during day-to-day operation. These temperature fluctuations caused thermal expansion of the fiberglass, and this manifested itself as stress concentrations at the apex of the bulges, and finally cracks once the yield point of fiberglass was reached. If the fiberglass liner had been exactly round, the stresses from the thermal expansion would have resulted in compressive forces in the fiberglass as it tried to expand against the grout, and with no irregularities like bulges, the fiberglass would have stayed in position and been fine.

Photograph 13: Fibreglass liner bulged during installation, and cracked during operation due to repeated temperature fluctuations. This manhole/pump-station was originally coated concrete that failed within 1 year.



4.4 NEW THICKER LINER INSTALLED

A new stiffer liner was installed once the bulges were removed (Photograph 10). The extra stiffness was achieved with a thicker wall, plus external stiffening ribs. The effectiveness of this will be monitored.

5 CONCLUSIONS

FIbreglass liners can be used to rehabilitate deteriorated manholes and pump stations in wastewater systems. Installation is straight forward, and can minimize costs by reducing the need for extensive excavation, over-pumping, and road closures.

The liners are corrosion resistant, and can be designed to add strength back to a deteriorated structure.

The fiberglass liner must have sufficient stiffness for handling and installation. Bulges must not be allowed to form. If they do, they will be failure points in the future.

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