Rehabilitating the Black Mac

The Black Mac is one of the largest single sewer projects undertaken in South Africa and a showcase for the innovative use of cured-in-place pipe (CIPP) lining technology .

Constructed in 1983, the original 14.4 km long Black Mac bulk sewer consisted of epoxy tar-coated asbestos cement pipes, ranging in diameter from 400 mm to 1 000 mm. This system drained an area of 24 km^2, which included Blackheath Industria, Dennemere, Eerste River, Kleinvlei and Macassar, culminating at the Macassar pump station and wastewater treatment works (WWTW).

The sewer crosses under several roads, including the N2 national highway (via a DN 1 117 jacked concrete pipe, with false invert and low-flow channel) and under the Eerste River by means of two parallel DN 300 siphons.

With the construction of the new Delft bulk sewer in 2008, the flows from the upper drainage areas were diverted to the Zandvliet WWTW to alleviate the hydraulic overloading at the Macassar WWTW. Flows from the lower catchment (Kleinvlei and Macassar) continued draining into the Macassar WWTW. With subsequent increasing flows into Zandvliet WWTW, the City of Cape Town then decided to reconnect the upper and lower Black Mac catchments. However, the hydraulic performance and condition of the sewer first had to be assessed, with Aurecon South Africa appointed as the consultant for the project.

As-built information, including as-built drawings to confirm the original pipeline properties, such as age, pipe material, wall thickness and internal diameter, formed the basis for the condition assessment. A topographical survey confirmed the pipeline gradient, cover and physical constraints. This information was combined to determine the extent of corrosion and the system's remaining useful life, considering the loss of wall thickness in conjunction with the actual external loads. Based on this, the most appropriate rehabilitation technique was chosen and the impact of this on the hydraulic capacity determined.

Black Mac UV light for the DN 1 200 pipe

PROJECT STATISTICS

Client: City of Cape Town
Consulting engineer: Aurecon South Africa
Trenchless contractor: Tuboseal
Contract value: R34 148 440
Completion date: 16 November 2017

- 3.4 km of DN 800 thermally cured unreinforced CIPP liners with thicknesses from 12.5 mm to 17.5mm
- 60 m of DN 1 000 thermally cured unreinforced CIPP liner with thickness of 19.5 mm
- 70 m of DN 1 117 non-circular UV-cured reinforced CIPP liner with thickness of 14 mm
- Inversion lengths ranging from 70 m to 171 m
- 132 894 kg resin used

The new sewer was constructed parallel to the existing Black Mac sewer. Once the new line was completed, the existing sewer was then decommissioned, cleaned and filled with a bentonite mixture

Condition assessment findings

The assessment concluded that the sewer reaches upstream of the Black Mac screening station were not severely corroded and had an estimated remaining life of 30-plus years, which was adequate. However, the severity of the corrosion increased as it proceeded downstream.

Along some reaches downstream of the siphon, as much as 20% of the pipe walls had been lost, reducing pipe strength by up to 63%. The original pipe's internal bitumen coating had offered some corrosion protection. However, in the lower portion, this protective coating had dissipated.

CIPP approach

The most suitable rehabilitation method was deemed to be CIPP. It was decided that the reaches upstream of Old Faure Road had an adequate remaining life and did not require rehabilitation immediately. Between Old Faure Road and the Eerste River siphon, the sewer would be rehabilitated using CIPP. Meanwhile, the section downstream of the Eerste River siphon up to the Macassar pump station was replaced with a new sewer to ensure sufficient capacity.

The new sewer, ranging in diameters from DN 900 to DN 1 200, was constructed parallel to the existing Black Mac sewer. Once the new line was completed, the existing sewer was then decommissioned, cleaned and filled with a bentonite mixture. This will ensure that the integrity of the decommissioned sewer is maintained and can be reactivated in the future, if required.

The final reach of the sewer (DN 1 000) immediately upstream of the Macassar pump station was also rehabilitated using CIPP technology. It would have been excessively expensive to replace it due to the restricted area available at the pump station.

Rehabilitation contract

Construction commenced on 1 November 2016 with all works completed just over a year later. Tuboseal Services was appointed as the contractor. Following bulk cleaning, physical measurements were taken to confirm the host pipe ovality so the CIPP liner could be designed to the thickness required.

Once the structural design was confirmed, the CIPP liners were ordered from a leading manufacturer in Europe. The 26 liners were all unique in terms of their length, diameter and wall thickness, which underscored the

importance of working accurately and to the highest installation standards.

Installations

Each installation involved a carefully coordinated sequence of events taking around 48 hours. The working window before the resin-impregnated liners start to cure meant that once the process started, it could not be interrupted.

Teamwork was critical: the consequence of liners curing prematurely would have severe financial implications, as would the time delays required to ship in a replacement liner.

The installation team completed the final cleaning and inspection on each reach, while the impregnation team prepared the felt liner tube by impregnating it under factory conditions with up to 7 tonnes of catalysed resin.

Each liner was transported to site submersed in ice and installed by an inversion process, during which the liner is folded inside out using water pressure.

A 1 450 kW hot water boiler was used to initiate curing of the resin over a period of about 15 hours, during which the temperature and other parameters were carefully monitored and controlled to ensure liner consistency and integrity. Each cured liner was carefully cooled down, trimmed and inspected by CCTV. A test sample from each section was submitted to an independent lab for verification of its mechanical properties.

All manhole chambers were rehabilitated using specialist materials designed to withstand chemical and sewer gas attack, ensuring that the lifespan of the manhole structures could be extended to match that of the CIPP liners. The manhole rehabilitation also included replacement of step-irons, cover slabs and improving the hydraulics by amending the benching. Where it was found that the existing manhole design negatively influenced the system's hydraulic performance, complete new manhole structures were constructed.

N2 crossing

The contract included the rehabilitation of the jacked crossing under the N2, which posed quite a technical challenge. Through collaboration, an effective solution was found. Originally, the intention was to remove the false invert, rehabilitate the badly corroded sections of the DN 1 117 pipe by replacing the lost reinforcing steel and apply a structural repair grout before installing a circular CIPP liner to prevent any further corrosion. The removal of the 70 m long false invert proved too time consuming and dangerous within the confined working space inside the pipe.

Tuboseal proposed to leave the false invert and design the CIPP liner as a non-circular section. After evaluating both unreinforced and reinforced liners for this crossing, a 14 mm UV-cured reinforced liner was considered the most appropriate solution. The UV-cured liner was procured from Saertex in Germany and installed under the guidance of Saertex technicians.

The Black Mac project demonstrated that the use of world-class pipeline rehabilitation techniques is highly feasible and effective and underscores the engineering and design prowess of South Africa's trenchless rehabilitation industry.

As in Cape Town's case, municipal clients can reap significant benefits from the reduced costs, timelines and environmental impacts that CIPP technology has to offer. 3S