TRENCHLESS NEWS

Microtunnelling through Cape Town

Cape Flats 3 Bulk Sewer

The project team responsible for the construction of the Cape Flats 3 Bulk Sewer Phase 2, comprising the City of Cape Town, AECOM and CSV Construction, has won the 2016 Joop van Wamelen SASTT Award of Excellence in recognition of exceptional contributions to the active promotion and implementation of trenchless technology in Southern Africa. **By Danielle Petterson**

THE CITY OF CAPE TOWN'S existing twin Cape Flats Bulk Sewers, constructed in the 1960s, serve an 8 000 ha area of the Cape Flats, and also provide a link for transfer of flow between two bulk wastewater catchment areas.

However, they have become severely dilapidated and silted up and can no longer adequately perform their strategic function.

The completion of Phase 2 of the Cape Flats 3 Bulk Sewer (CF3-2) will provide the final link in the system, greatly increasing the system capacity to allow rehabilitation work to be undertaken on the old sewers, as well as providing sufficient capacity in the system for at least the next 50 years.

AECOM's design for the CF3-2 was undertaken between 2012 and 2015, which included comprehensive assessments of various alignment options, as well as an evaluation of long-term operational requirements regarding the strategic nature of the sewer.

CSV Construction was appointed in July 2015, and physical construction work commenced at the beginning of 2016.

The CF3-2 was ultimately designed as a 1 000 mm diameter ductile iron rising main, starting at the Bridgetown Pump Station and discharging into the existing CF3 gravity sewer (Phase 1). The 5 km route traverses a densely populated area of Cape Town, where significant sections of the pipeline would need to be installed beneath busy roadways.

Microtunnelling

According to AECOM engineer Timothy Hotchkiss, the route was broadly debated, seeing as construction could have significant social and environmental impacts on the built-up and densely populated areas the sewer line would run beneath. Moreover, the detailed survey showed that the preferred alignment would cross numerous existing services, resulting in further complexity to an already technically challenging project.

Microtunnelling – a remote controlled mechanised pipe-jacking operation preceded by a tunnel boring machine (TBM), which

Project Team

Client: City of Cape Town
Consulting engineer: AECOM
Contractor: CSV Construction

mechanically removes soil from the jacking face using a slurry process, was suggested as a means to accommodate these challenges, but was originally not considered economically feasible, explains Hotchkiss. Therefore, the tender originally called for three conventional pipe jacks to be undertaken for the crossing of three major roads only. The balance of the pipeline was tendered as conventional open excavation with allowance for trench shoring.

However, the microtunnelling method was reconsidered when Hannes Coetzee, director of CSV, advocated the use of microtunnelling due to the number of pipe jacks under busy roads and the close proximity to other service mains. The number of traffic diversions, temporary works and the dewatering that would have been required with conventional pipe jacking remained an obstacle due to the high cost and technical challenges it presents.

Following extensive technical and financial evaluations, it was found that microtunnelling sections of the CF3-2 would indeed be feasible. One of the biggest contributing factors to making this possible was the recent introduction of a ductile iron jacking pipe to the market – a final product pressure pipe that can be jacked directly into the ground behind a TBM. This, therefore, offered a more cost-effective and operationally sustainable system than the conventional option of installing the pressure pipe through a microtunnelled concrete 'sleeve'.

Anic Smit, project lead for the City of Cape Town, commented that, ultimately, this project has proven that microtunnelling not only mitigates social and environmental impacts, but that it could also offer the City of Cape Town a financially feasible alternative at reduced risk and higher end-product quality.

The right machine for the job

CSV acquired a Herrenknecht AVN 800 XC TBM with an 1190 mm diameter extension kit for the job.

AVN machines belong to the category of closed, full-face excavation machines with a hydraulic slurry circuit. The soil to be excavated is removed using a cutter head adapted to the respective geology, be it soft soils or hard rock, making it possible to use the machines in almost all geological conditions. A cone-shaped crusher inside the excavation chamber crumbles stones and other obstructions to a conveyable grain size while tunnelling and advancing; this debris is removed through the slurry line.

CSV opted for a soft-ground cutter head on its AVN 800 XC because it has larger openings, allowing for faster advancement as the machines can accommodate larger volumes of material in the chamber. The cutter head, equipped with chisels, can also comfortably handle more solid materials. At one point, the team tunnelled through a dump site that they had not been aware of, and encountered concrete and rebar, which the machine handled without issue.

The machine also comes equipped with a high-pressure jet-water system to prevent the clogging of the crusher cone in

BENEFITS OF PIPE JACKING

Throughout the world, pipe jacking and microtunnelling are becoming increasingly important for the installation of service pipes and sewer pipes. The combination of pipe jacking and microtunnelling offers numerous advantages, especially in urban city areas:

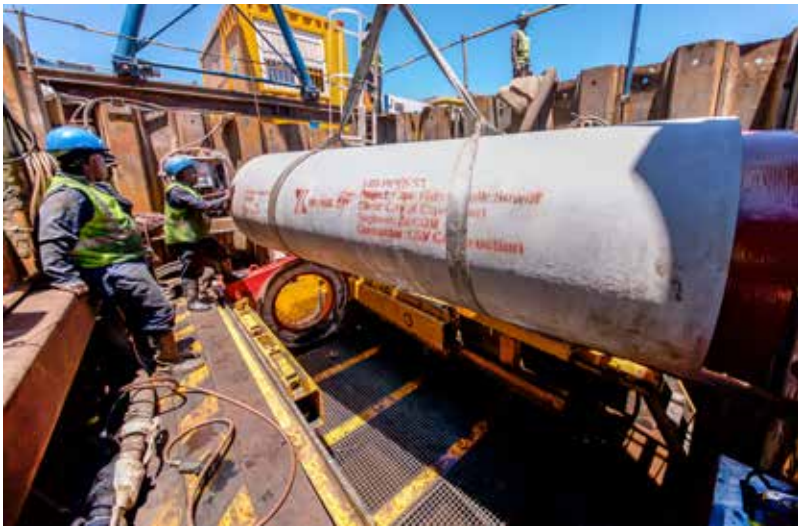
- It is suitable in nearly all geologies
- The method is safe with un-crewed underground operations
- Inclined pipe jacking and three dimensional curves are possible
- It causes minimal traffic disruption along the construction route
- In contrast to conventional methods, it is an environmentally friendly method that helps to conserve protected landscape areas (due to minimum excavation and dewatering)
- Fewer stoppage periods due to weather conditions
- Minimum soil quantities to be disposed of
- Sub-leasing of microtunnelled pipeline sleeves makes it a popular trenchless solution, especially in congested city areas.

BELOW FROM LEFT TO RIGHT
The Herrenknecht AVN 800 XC TBM with an 1 190 mm diameter extension kit being prepared for launch from the jacking shaft

Jacking the first ductile iron pipe behind the TBM

Lowering a ductile iron jacking pipe into the jacking frame

Dr Gisela Kaiser, executive director: Utilities, City of Cape Town, at the ceremonial launch of the TBM christened "Busy Lilly"



Efficient

State-of-the-art tunnelling technology from Herrenknecht is currently being applied to upgrade the sewage system in Cape Town. 1.2 km of new, sustainable tunnel infrastructure is under construction with minimum disruption to the local community.

Credit: Terry February

Construction of the Cape Flats 3 Bulk Sewer – Phase 2
Client: City of Cape Town
Engineer: AECOM
Contractor: CSV Construction

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HERRENKNECHT
Tunnelling Systems

> "One of the most critical areas of an operation is where the tunnelling machine exits the shaft, making it important to have the right type of exit seal."

cohesive soils. Although Cape Town has clayey sands, the disturbance of the cutter head was sufficient and this functionality was not needed.

RIGHT Jacking frame within the jacking shaft

BELOW RIGHT CSV operators in the microtunnelling control room

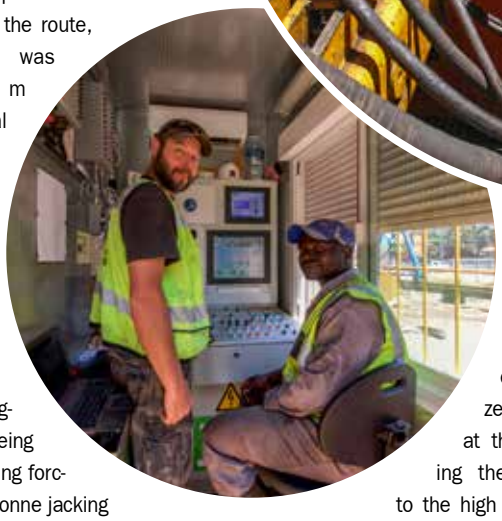
Technical details

The 4 m long ductile iron jacking pipes were supplied by Chinese company Xinxing, with a 1 170 mm OD and a 1 000 mm ID, with an outside reinforced concrete sheath and a polyurethane internal lining. According to Coetzee, these pipes offer a jacking capacity of 5 080 kN, making them significantly stronger than conventional concrete jacking pipes, significantly decreasing the likelihood of a pipe failure during the jacking operations, even for long jacking distances in excess of 200 m.

To the team's knowledge, these pipes had never been jacked in the Western Cape region before. "We teamed up with Herrenknecht because it is the best supplier of this type of slurry method small-diameter tunnelling equipment. It has the knowledge we needed to complete this project successfully," said Coetzee.

The team typically jacked between three and five pipes per eight hour work day. On their best day the team was able to jack roughly 25 m. Coetzee explains that the time-consuming part of the operation was to disconnect and reconnect the cables and slurry pipes in order to insert the next jacking pipe, since all of this equipment connected to the TBM is located within the main pipeline. Working an extended day with the four-man crew will enable 32 m to be installed comfortably.

CSV decided on a maximum drive length of 150 m to circumvent the need for inter-jack stations and the lubrication of the outside of the pipe normally required to reduce the friction on the pipe surface. Coetzee explained that the team opted not to lubricate the pipes through ports in the pipes themselves, but only to lubricate from the tunnelling machine as the tunnel advanced. The machine overcut the pipe OD by 10 mm, forming a 10 mm annulus around the pipe, which was filled using a computer-controlled pressurised bentonite injection system. "This allowed very comfortable progress and comfortable jacking pressures," he explains.



At one point along the route, the jacking length was increased to 210 m because technical challenges prevented the sinking of an additional shaft. This required additional slurry and hydraulic and communication support pipes and cables to be acquired. The longest drive ended up being 218 m long with jacking forces close to the 350 tonne jacking capacity offered by the shaft jacking frame.

An interlocking sheet pile method was used to construct 6 m x 4 m jacking shafts. In some areas, the sheet piles were driven using an excavator fitted with high-frequency vibration hammers, while in other sections, silent piling technology was used to prevent disturbance when sinking shafts close to houses.

According to Coetzee, one of the most critical areas of an operation is where the tunnelling machine exits the shaft, making it important to have the right type of exit seal. In this case, the machine was forced through a 30 mm thick neoprene exit seal to prevent sand and water from washing into the exit shaft. This is not often seen in pipe-jacking operations using open-face excavation or augers in South Africa. However, because the slurry system pushes large quantities of water through the face of the machine, it is vital to protect the exit so that the slurry does not wash back into the pit, causing possible sinkholes at the surface.

The machine was able to achieve an extremely high vertical accuracy of 13 mm and a horizontal accuracy of 47 mm, with zero disturbances at the surface during the project. Due to the high level of control possible in controlling the under-surface ground water pressures created and counteracted by pressures exerted by the slurry system and the rate of advancing of the TBM, depressions (sinkholes) and heaving at ground level can be totally avoided. Although working in an area where high groundwater levels are present, no dewatering was required for the TBM operation.

Successful completion

From February to November 2016, a total of 1 200 m of pipeline was installed successfully across eight sections with a high degree of precision, ahead of schedule and within budget, using the microtunnelling method. CSV Construction's Herrenknecht AVN 800 XC TBM is the first of its kind to be owned and operated by a Southern African company. The project team is confident that the microtunnelling technology will form a crucial role in the successful implementation of future pipeline projects located in congested urban areas of Southern Africa. 3S

Photos: Terry February (AECOM)