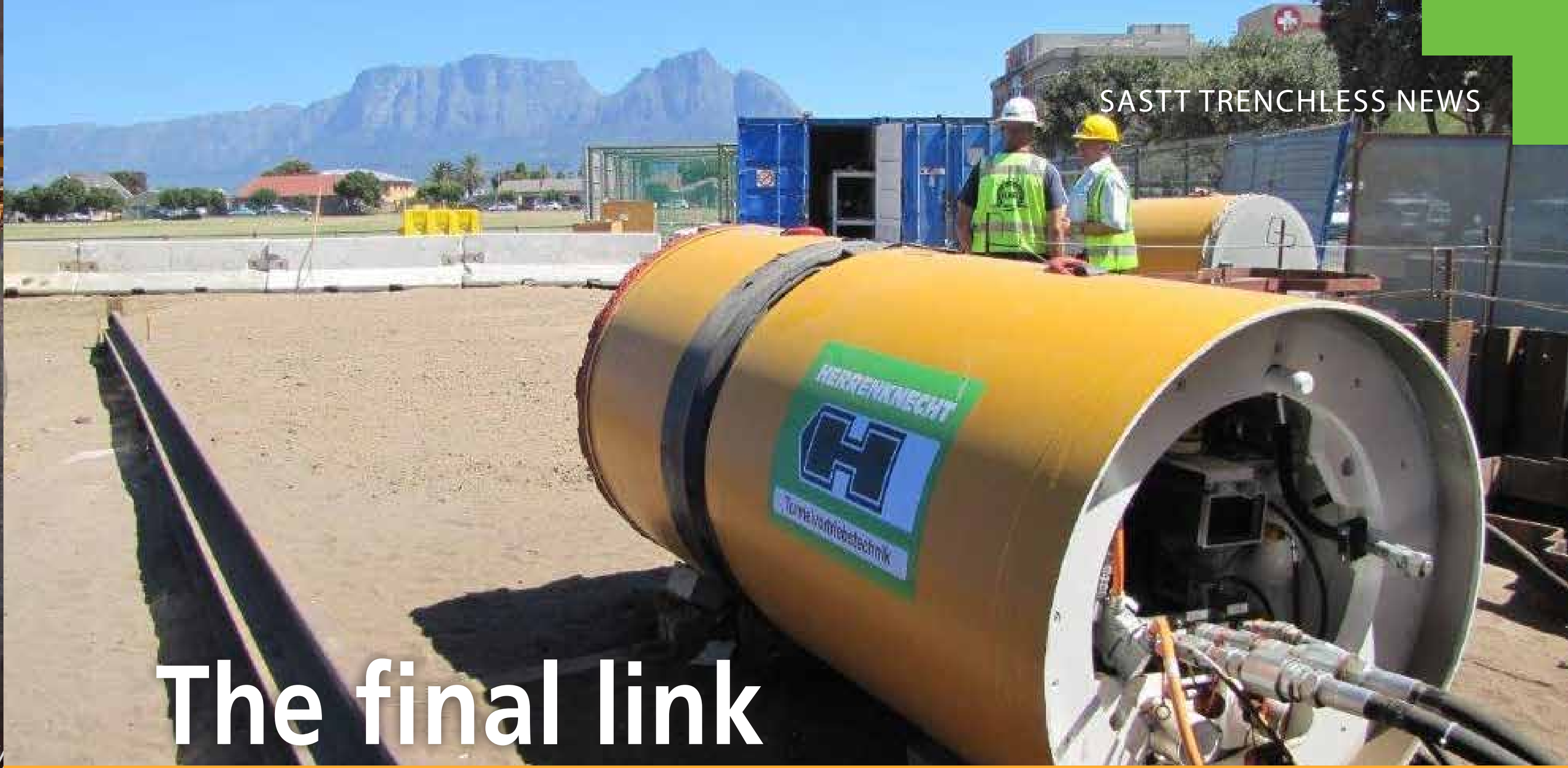

The final link

Cape Flats 3 Bulk Sewer – Microtunnelling Solution

The successful construction of the second phase of the Cape Flats 3 Bulk Sewer provides the final link in the City of Cape Town's strategic Cape Flats bulk sewerage system. Microtunnelling played a big role in achieving this target.

PROJECT TEAM

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

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, and included comprehensive assessments of various alignment options.

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 Timothy Hotchkiss, engineer, AECOM, 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 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, CSV Construction, advocated the use of microtunnelling due to the number of pipe jacks under busy roads and the close proximity to other sensitive utilities. The number of traffic diversions, temporary works and dewatering that would have been required with conventional pipe jacking remained an obstacle due to the high cost and technical challenges presented.

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 microtunnel boring machine. This, therefore, offered a more cost-effective and operationally sustainable system than the conventional option of the pressure pipe being installed through a microtunnelled concrete 'sleeve'.

Anic Smit, project lead, City of Cape Town, commented that this project has ultimately proved 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 an AVN 800 XC TBM from Herrenknecht – the leading premium provider worldwide for all-round technical solutions in mechanised tunnelling – with a 1 190 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.

Technical details

The 4 m long ductile iron jacking pipes were supplied by Chinese company Xinxing, at 1 170 mm OD and 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, and significantly decreasing the likelihood of a pipe failure during the jacking operations, even for long jacking distances in excess of 200 m.

These pipes had never been jacked in South Africa 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 workday. On its best day, the team was able to jack 25 m. Coetzee asserts that working an extended day with the four-man crew would enable 32 m to be installed comfortably.

CSV decided on drive lengths of 150 m to circumvent the need for inter-jack stations. Coetzee explains 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 218 m because technical challenges prevented the sinking of an additional shaft.

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

According to Coetzee, the machine was able to achieve an extremely high vertical accuracy of 13 mm, with zero disturbances at the surface during the project, for the 1 120 m of microtunnelling. Due to the high level of control possible in controlling the ground and groundwater pressures created and counteracted by pressures exerted by the slurry system and the rate of advancing of the MTBM, 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 MTBM operation.

Successful completion

From February to November 2016, a total of 1 200 m of pipeline was installed successfully across eight sections, 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 the congested urban areas of Southern Africa. 3S

BENEFITS OF MICROTUNNELLING

Throughout the world, microtunnelling is becoming increasingly important for the installation of pipes. 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**
- **It causes minimal traffic disruption along the construction route**
- **In contrast to conventional methods, it is an environment-friendly method that helps to conserve protected landscape areas (due to minimum excavation and dewatering)**
- **Fewer stoppage periods due to weather conditions**
- **Minimal soil quantities to be disposed of**
- **Sub-leasing of microtunnelled pipeline sleeves makes it a popular trenchless solution, especially in congested city areas**