Upsizing pipelines using trenchless techniques

For the past two decades, South Africa's urban population has grown at a rate of at least 50% higher than the national average. This has created an enormous demand for water services. **By Alaster Goyns***

355 OD HDPE pipe bursting casing containing a TR 210 hammer

THE POPULATION DENSITIES in both established and newly developed areas are significantly higher than was envisaged during their original planning. Hence water services could be undersized by a factor of between five and 10 times for the current demand.

Urban densification leaves little space for digging trenches to install, replace and repair pipelines. Trenches seriously disrupt communities and businesses and are not practical or cost-effective; however, the trenches themselves only occupy a portion of the space. Excavated material and access next to trenches for placing materials and installing pipes is needed, resulting in a footprint several times the trench width.

The primary requirement for a water pipeline is hydraulic capacity. This has to be prescribed by the pipeline owner based on the demands of the end users. In order to meet this requirement, and continue doing so, the pipeline must meet several secondary ones, namely: strength, water-tightness and durability. The problems that occur with pipelines and their subsequent failures are, in general, due to their inability to meet one of these secondary requirements.

The techniques used in the developed world effectively rectify the problems associated with the secondary requirements:

- fixing leaking joints, as they provide a continuous water-tight pipeline from manhole to manhole
- reinstating the structural integrity, as they can be designed to carry the loads imposed, extending service life
- maintaining the durability, as the materials used are corrosion resistant under almost any conditions.

However, these techniques do not address the issue of providing the additional capacity demanded by the current densification of SA's urban areas that is likely to continue for several decades.

Trenchless options

Going trenchless minimises surface disruption and space utilisation and, in particular, with service rehabilitation:

- the route to be followed is predetermined
- the route can be inspected using multisensor systems, so unforeseen problems can be identified and corrected
- the in-service structural requirements to carry external loads are reduced
- there is no need to import bedding materials
- working conditions are safer
- there is virtually no chance of any damage to nearby services
- air pollution is reduced as the use of heavy excavation equipment is minimal.

However, there are other factors that need to be considered:

- the condition of the original system must be assessed before selecting the rehabilitation technique to use
- the loading conditions need to be evaluated to determine which are critical
- the impact of any potential damage that could occur to the liner during installation
- the contractor doing the work must have the necessary expertise and equipment.

Although rehabilitation cannot rectify problems designed or built into a system, a thorough condition assessment and the use of appropriate techniques will minimise the impact of such problems and the associated risks.

Pipe bursting

This can be done in several ways, the simplest being a static pull using rods or similar mechanisms attached to a fixed dimension bursting head that is larger than the existing old pipe.

This breaks it into fragments, pushes these fragments into the surrounding soil and simultaneously pulls in a new pipe of the same or larger diameter to replace the old one. More sophisticated systems

800 OD HDPE pipe reaming in Themba

use a pneumatically driven hammer or a hydraulically expanding head to break the existing pipes.

There are other techniques for the on-line replacement of pipelines, such as pipe splitting and pipe implosion, which are based on the same principles. The combination of HDD with pipe bursting is used for pipe eating and reaming where the fragments of the old pipe are removed rather than displaced. This is especially useful where the original pipe material is considered to be hazardous (asbestos cement).

All these techniques involve the insertion of a bursting head into the old pipe. The leading end of this is smaller than the pipe to be replaced and is attached to pulling rods or a cable. The trailing end is attached to the new pipe and has an outside diameter slightly larger than that of the new pipe, so that the friction on the new pipe is reduced. The pulling cable or rod is fed from the reception pit through the pipeline to the insertion pit where it is connected to the leading end of the bursting head. A typical pipe bursting schematic is shown in Figure 1.

Normal pipe bursting methods are not used for asbestos pipe lines. They are usually water supply lines and the contractor needs to be registered as an asbestos handler. The asbestos will stay in the ground but must be removed from excavated areas and dumped at an asbestos handling facility.

Apart from meeting the primary requirement of capacity, there are several factors to be taken into consideration when using any of these techniques:

- required pulling forces and stresses on new pipe
- distances below the surface, from other services and surrounding facilities
- controlling line and level
- location and spacing of pits and other access holes
- repair history and potential obstructions
- external damage during installation.

The benefits of upsizing old pipelines in SA's densified urban areas are seldom

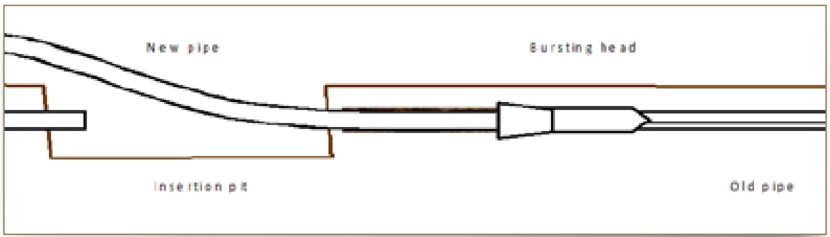

FIGURE 1 Typical schematic of pipe bursting operation

realised. The velocity and capacity of a partly full pipe at a given gradient is dependent on the diameter to the power of 2/3 and 8/3, respectively. The amount that the old pipe can be upsized is dependent on the soil conditions, the material used and the condition of the old pipe.

As pipe bursting follows the route of the existing pipeline, there is not much that can be done to eliminate any line and level problems built into the pipeline. However, owing to the pulling/pushing of a continuous pipe from access point to access point, with a cable or rods under tension, there will be a tendency to smooth out any sharp changes in alignment. With water supply lines, this should not pose a serious problem as they will be operating under pressure.

However, with gravity lines such as sewers, changes in vertical alignment – in particular changes from steeper to flatter gradients and back falls or sagging can seriously influence the hydraulic performance, leading to deposition and reduced capacity. A pre-rehabilitation inspection using a multisensor system can identify unforeseen problems. Where these are serious, it may be justified to excavate down to the pipeline and do an appropriate point repair.

The rapid urbanisation in SA has placed enormous strain on those tasked with providing services, in particular water services

As shown in Figure 1, pipe bursting requires at least insertion and reception pits. Additional access pits will probably be needed between these where connections to the pipeline are required. The insertion and reception pits should be located so that their numbers are minimised and the length of bursting between them is maximised to make the optimum use of the equipment available.

ABOVE RIGHT Pipe splitting of a steel pipe in Barberton
ABOVE 450 OD HDPE pipe bursting casing containing a TR 360 hammer

On sewer rehabilitation projects, the burst length will usually be between manholes spaced an appropriate distance apart, with the bursting operation passing through the intermediate manholes where measures have been taken to accommodate the replacement pipe. When a sewer is significantly upsized, the modifying of manholes may prove uneconomical and it is necessary to rebuild them. It may also be necessary to use larger bursting tools and to lubricate with bentonite to reduce friction.

As intermediate access pits for connections entry and reception are small excavations, they are usually done by hand as the amount of excavation can more effectively controlled than using an excavator. However, the proper shoring of the pits is essential for the safety of the workers and the safety of the surrounding area.

Soil and subsurface investigations, including collecting the necessary information to design the project, assist the contractor in submitting a realistic bid and selecting the appropriate bursting system: shoring of the shafts, dewatering system, compacting backfill material, etc. Such competent decisions and bidding increases the chances of success during the construction phase of the project.

Concluding comments

The rapid urbanisation in SA has placed enormous strain on those tasked with providing services, in particular water services. The existing backlog and the densification of established urban areas exacerbate the burden on limited capacity. On-line replacement techniques are an effective way of rehabilitating and simultaneously upsizing ageing pipelines. They minimise the amount of excavation required, and as the excavations needed are for connections, they are small and require care to avoid damaging other services, they are done by hand. In addition, there are other activities associated with these techniques, which create employment, making these techniques really appropriate for SA where unemployment is a serious concern.

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