



*Innovative trenchless technologies, such as Swagelining, are facilitating the extensive rehabilitation and replacement of water mains beneath the busy streets of Hong Kong. (Photo source: Black & Veatch)*

# Rehabilitating Hong Kong's Water Mains

## – Putting Trenchless Swagelining Technology to Work

BY IAN VICKRIDGE AND STEPHANUS SHOU

***Beneath Hong Kong's busy streets lie an equally congested, spaghetti-like complex of utility services making even trenchless technologies difficult to apply. Innovative techniques employed by Black & Veatch are saving time and costs in the replacement and rehabilitation of water mains in Hong Kong.***

A major programme of water mains rehabilitation is underway in Hong Kong, where consultants and contractors are diligently working to rehabilitate or replace almost half the Region's extensive water distribution system over a 15-year period.

The Water Supplies Department (WSD) of the Government of the Hong Kong Special Administrative Region (HKSAR) provides fresh water and salt water to its customers through a network of approximately 7,400 km of water mains. An increasing number of mains failures prompted the WSD to carry out an Underground Asset Management (UAM) study on the condition and performance of these mains in the late 1990s. The study concluded that a significant proportion of the pipe system would soon be approaching the end of its service life, necessitating a major programme of replacement and rehabilitation.

The four-stage programme, which encompasses rehabilitation or replacement of approximately 3,000 km of water mains, has an estimated total cost of approximately HK\$11 billion (US\$1.4 billion). The work commenced in 2000, and the pace of work has accelerated over the past six years. More than 300km of water mains are currently being rehabilitated or replaced at a cost of around HK\$2.4 billion (US\$300 million). Construction contracts for another 250 km are due to be awarded this year. Design of an additional 750 km of pipeline rehabilitation or replacement in Stage 2 of the programme is being carried out under four major investigation, design and construction supervision consultancy packages and another one package by WSD in-house resources, with current design work scheduled for completion later this year. Stage 2 construction is due to commence in early 2007 for completion in 2011 at a total budget cost of HK\$2.6 billion.

The entire programme will be completed by 2015. Stage 3 investigation and design are scheduled to commence in the second half of 2006, and construction is scheduled to begin in 2008 for completion in late 2013. Investigation, design and construction for Stage 4 will follow with completion in late 2015. Black & Veatch is responsible for one of the Stage 1 design and construction supervision packages and three of the Stage 2 packages.

### THE CHALLENGE OF GOING UNDERGROUND

Installing and maintaining underground utilities is always a challenge, no matter

where it occurs. Every location and environment imposes specific constraints and difficulties, but Hong Kong is a particularly difficult environment in which to work underground.

The combination of the hilly natural terrain and the high-rise built environment make Hong Kong unique. The total area is 1100 square kilometres, but only less than 20% of the land area is developed, and much of this is actually reclaimed from the sea. With nearly seven million people living in such a small area, there is severe congestion both above and below ground. The rapid economic growth of the last two decades has compounded the problem as old districts have been torn down and dramatically redeveloped with huge high-rise office and apartment blocks. Because land is at a premium and already congested, it is extremely difficult to expand the road and pavement capacity to cope with either the above or below ground needs.

Beneath the city's busy streets, road openings invariably reveal an equally congested, spaghetti-like complex of utility services. It is common to find utility lines running alongside each other with little or no clearance between them. Utilities

vie for what little space remains and face intense competition to upgrade and expand underground services. Good communication and continuing liaison with other utilities and their contractors and consultants is essential to avoid project interface problems and prevent public nuisance. Lack of sufficient underground space also means there is a significant risk of damaging nearby utilities when installing or rehabilitating services.

The WSD, which is committed to minimising disruption to the public, encourages use of trenchless techniques where feasible. But although trenchless methods can reduce disruption, there are several constraints to their use in Hong Kong. The previously mentioned underground utility congestion is one such constraint. It is often difficult to find suitable locations for excavating the launch and reception pits necessary for trenchless operations.

Naturally occurring constraints also make it difficult to use trenchless techniques in Hong Kong, where ground conditions are notoriously unpredictable. High water tables, rapidly varying ground conditions, and natural obstructions such as large boulders can cause major prob-

lems for the application of pipe ramming, pipe jacking, and directional drilling. In addition, much of the urban area of Hong Kong is built on reclaimed or made up land, which can present a wide range of potential difficulties for trenchless construction. Underground obstacles such as old sheet piles and buried sea walls have caused more than one machine to become stuck or damaged underground.

Because street work has such a significant impact on traffic flow, Hong Kong requires all contractors to obtain excavation permits prior to any street excavation. For heavily trafficked roads and major strategic highways, it may take as long as six months or more to obtain necessary excavation permits. Many of these permits impose restrictions on daytime working, so all work has to be carried out at night or, in some cases, during weekends. In addition, contractors must develop temporary traffic management schemes and then participate in what can be a lengthy approval process. Although trenchless techniques can substantially reduce the need for traffic lane closure, encroachment on traffic lanes for construction of launching and receiving pits is often inevitable. So although



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*Hong Kong is the site of the largest Swagelining operation ever undertaken in Asia. (Photo source: Black & Veatch)*

trenchless methods can reduce the overall impact on traffic, obtaining all the permits and approvals imposes a major constraint on planning and programming trenchless works in Hong Kong.

Although not as severe as for open-trench work, environmental impacts associated with trenchless work nonetheless can make it difficult to implement a rehabilitation programme. In particular, it is very difficult to obtain approval to cut down roadside trees or shrubs in Hong Kong, and this is often a major consideration in identification of suitable locations for access pits for trenchless work. Similarly, excavation permits that impose requirements for work to be carried out at night present special challenges as a result of noise restrictions imposed by the Hong Kong authorities for night work in residential areas. Such restrictions can make excavation of access pits very difficult and preclude use of techniques such as pipe ramming if noise levels are unacceptably high.

### TRENCHLESS TECHNOLOGIES AT WORK

Although the WSD rehabilitation work has been challenging, contractors are gaining experience in a variety of trenchless

methods including swagelining, cured-in-place pipe (CIPP), directional drilling, impact moling, and pipe ramming in Hong Kong. For example, it would have been impossible to complete work along one of Hong Kong's busiest highways using a standard open-cut system unless the entire pipeline were rerouted along a longer alignment. To avoid the time and expense associated with that course of action, the Black & Veatch project team identified Swagelining as a better option.

Swagelining is a trenchless technique in which a flexible polyethylene pipe line is pulled through a die to temporarily reduce the diameter and then towed into an existing underground pipe, eliminating the need for extensive digging and related traffic disruption. Construction crews dig launching and receiving pits where the liner enters the existing pipe and then re-emerges further down the line. Application of this innovative alternative approach saved 30 percent in construction time and costs, and the project is recognised as the largest Swagelining operation ever undertaken in Asia.

### FUTURE PROSPECTS

Hong Kong faces even more formidable future challenges. One example is the

rehabilitation of approximately 1.4 m-diameter mains that lie below a long, heavily trafficked road tunnel. As one might imagine, access is severely limited and identifying a suitable construction technique for such a large-diameter, high-pressure pipe in such a difficult location is a challenge in itself.

Despite the difficulties, there continues to be a strong commitment to using trenchless methods and completing this major water mains rehabilitation programme by 2015. Engineers throughout Hong Kong are rising to the challenge, and technology will undoubtedly gain ground in the process. **AW**

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