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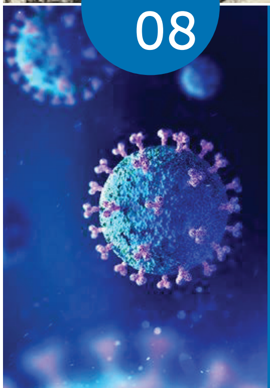
Mighty breakthrough for Europe's biggest boring machine

Page 08



Predicting our post Covid future

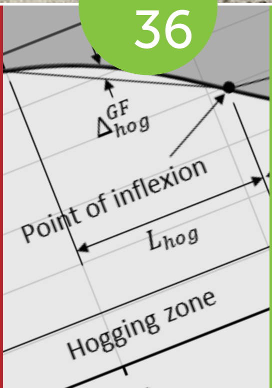
The third of three papers in which our experts address the impacts of the Covid-19 Pandemic on our industry.

Page 14

Happy new ideas!

We look forward to a better year and a host of new ideas and advances in 2021.

Page 36



Building damage assessment...

See part 1 of a fascinating report by Dr Benoît Jones and Dr Giorgia Giardina.

The Record Breakers!

The last few years have seen a flurry of new records being claimed on microtunnelling projects. Kristina Smith asks some industry experts what has caused this purple patch.

Microtunnelling has been around for over half a century, but in the last decade there's been an exponential rise in the number of projects. And a flurry of announcements about the tunnels getting longer, bigger, deeper and curvier – and records being broken (see table, p34).

"Previously, people were doing 100-metre or 200-metre straight drives," says John Grennan, a director at contractor Ward & Burke in Canada. "In the last few years, the equipment and technology has progressed to a point where we can do a microtunnelling drive 1000 metres long in any shape or configuration."

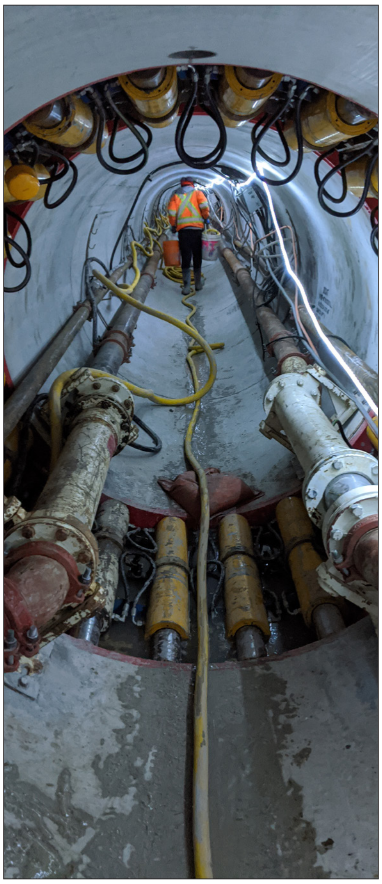
With cities already congested below ground, the ability to go deeper, through a wider variety of ground, and to curve where necessary, means that microtunnelling often makes economic and environmental sense. Many wastewater and water supply projects are turning to microtunnelling alongside power and utilities in congested areas or where a tricky crossing beneath existing infrastructure is needed.

More complex projects, however, require more expertise. Some warn that a lack of competence is introducing unnecessary risk into some microtunnelling contracts as designers and contractors bite off more than they can chew.

Not-so-micro tunnelling

Unlike a conventional TBM, a microtunnel boring machine (MTBM) does not install the tunnel lining as it progresses. Microtunnelling is a form of pipe jacking where the lining is pushed behind the machine in sections, using hydraulic jacks, with the MTBM travelling between launch and reception shafts.

The MTBM uses slurry to balance the earth and groundwater



pressure at the cutter head. Bentonite or polymer is also used to lubricate the outside of the jacking pipes so that the increasing frictional forces as the pipe gets longer doesn't become greater than the jacking capacity.

'Micro' used to mean too small to get a person inside, say 0.6m to 1.5m diameter. The American Society of Civil Engineers (ASCE) defines microtunnelling not by size but by method: the MTBM is remotely controlled, with a guidance system, pipes are installed by pipe jacking and there is continuous support at the excavation face. Larger diameter tunnels – 3m and beyond – are now being installed using this method.

Justin Shepherd, group technical director for tunnelling and underground for McConnell Dowell which is based in Australia, defines microtunnelling a little differently: "Any tunnel excavated by hand or machine - drilling, boring, augering - with the lining installed by jacking or thrusting in of the pipe casing, although some stable microtunnelled bores can remain unlined."

"The envelope is different in different parts of the world," says Anil Dean, global practice leader for tunnelling and trenchless at Stantec, who is based in California. "Diameters of 3m are done by microtunnel in Europe but not here in North America until recently." We are getting the capability here and getting people to manufacture pipe that can be installed at that diameter. It's changing the market."

First deployed in Japan and Germany in the 1960s, microtunnelling's first US project was in the 1980s. Canada had a brief, unsuccessful foray into the method in the 1990s, when the MTBMs of the day struggled to cope with its ground conditions – glacial deposits - leading to machines getting stuck and having to be dug out.

Marc Gelinas, principal engineer at Hatch and a trenchless expert, who moved back to Canada from the US in 2010 recalls that there were no microtunnelling projects in his home country at that time. "Nobody was doing it," he says. "Then, as the technology matured elsewhere, in Europe and the States, it came back in a more mature and reinforced form."

In 2011, Irish contractor Ward & Burke was alerted to an opportunity to bid for a microtunnelling project in Brampton, Ontario, Canada. Grennan travelled to Canada with his company to do the job – and has remained there ever since. That project, and subsequent ones, were delivered successfully with Ward & Burke credited with kick-starting the microtunnelling market in Canada.

"Since then, our microtunnelling volume has substantially increased to over 10km a year in Canada,"

Ward & Burke set the Canadian record for microtunnelling on the York Durham Sewage System (YDSS) Forcemain Twinning Project in Newmarket, Ontario with a drive length of 1.132km.

says Grennan. "North America is probably doing more now and pushing the boundaries more than the European counterparts. Whereas nine years ago, they were an infant."

One of Canada's biggest current microtunnelling projects is in Mississauga, Ontario. The C$160M Burnhamthorpe Water Project will see the construction of 12km of storm and sanitary water tunnels, as Canada's seventh largest city prepares to expand thanks to the addition of a light rail extension.

"Hatch's brief was to remodel the municipal infrastructure in advance of the LRT," says Gelinas. With small construction sites and a plethora of existing utilities to thread around, this is a complex programme, he adds.

Grennan doesn't expect to see much more growth in the Canadian microtunnelling market. The US, which Ward & Burke entered for the first time in 2017, has better potential for growth he says; a much larger population with demand for new or extended utilities and a present underutilisation of the technology.

McConnell Dowell Group, which delivers projects across Australia, New Zealand, Pacific, and South East Asia, has successfully undertaken many microtunnelling projects in these regions over the last 45 years. In New Zealand, though projects there tend to have a long gestation period due to the slow nature of the Resource Management consenting process and funding availability, they have completed four such microtunnelling projects this year.

"In Australia, the company delivered its first microtunnnel project in Western Australia in the late seventies and has set many local length-size class records over the years," says Shepherd. "However, with decades of microtunnelling development already undertaken, combined with current procurement models, improved rehabilitation and relining techniques and broad competition, the current market is not a rich hunting ground."

Asia Pacific is a fruitful market for the company, says Shepherd. McConnell Dowell is working in Singapore, constructing a 3.5m O.D. pipe jacked sewer on the Tuas Water Reclamation Plant, part of the Deep Tunnel Sewerage System (DTSS) Phase 2 programme for the Public Utility Board (PUB). Thailand, where the company constructed a 24km pipe jacked wastewater sewer scheme in the nineties and its first ever project using Herrenkencht's Direct Pipe method, is another growing market.

Above and opposite: McConnell Dowell set a new World Record on Watercare's Snells Algies Ocean Outfall project in New Zealand for Herrenknecht's Direct Pipe technology with a drive of 2.021km.

Curves cut costs

According to our experts, the biggest change in microtunnelling projects over the last decade can be summarised in one word: curves. "In Canada we have seen an explosion in curved microtunnelling," says Gelinas. "Ten years ago, you could count the number of curved drives there had been on one hand. Now we can do five to 10 curves in a single project."

There can be multiple benefits to the ability to include curves in a drive, explains Gelinas. Routes can be optimised to reduce the number of manholes, bypass obstacles or avoid land which is owned by others. There can be environmental and community benefits too in having more flexibility as to the route.

"It's important to be able to curve because you don't need as many drives," says Dean, "which means you can be more efficient and use the technology on more projects to deliver value to the owner."

Advances in guidance systems have been the enabler for curvier drives. Traditional guidance techniques, still used for short, straight drives, involve shining a laser in a straight line and following that. Newer systems deploy gyros or laser total stations. "These gave us the ability to tunnel curved alignments and go further distances without being restricted by the length the laser could transmit," explains Grennan.

VMT, which dominates this market, has recently upgraded its guidance technology with a universal software platform that uses the same interface for a variety of guidance methods. Launched in February 2020, TUnIS Navigation MT software can be paired with a laser system for drives up to 250m; a laser system with hydrostatic water level for straight drives up to 400m; a gyro-based system for curved and long-distance drives; and a laser total station for curved and longer drives with diameters above 1600mm I.D.

Advances in instrumentation and monitoring have also helped microtunnelling's cause. "Sensitive crossings, such as beneath railroads or highways, have always been cause for concern for the owners. Now we have the ability to connect instrumentation to the web so that it can be accessed anywhere, and the ability to automatically send an alert if a threshold settlement or vibration is reached," says Dean. "That's a big benefit."

Shepherd, who piloted TBMs at the beginning of his career, sees the benefit of linked instrumentation to the real-time control of the drive. "The big improvement is the interface between the information from the TBM and information from external sources being available in real time," says Shepherd. "Settlement monitoring, ground water level monitoring, soil pore pressure; now all this information can go instantaneously to the operator."

Availability of a whole host of project information – in real time, or at reporting intervals – is also leading to better transparency, for instance flagging up installation problems which could impact on service life.

"Digital technology is giving us better visibility into the production process, not only documenting the product being built but also the process," says Gelinas. "It allows us to ask questions a lot quicker and have conversations a lot sooner; things aren't always cut and dried.

"With Covid, it allowed my inspection staff to keep ahead of the game and be able to report to the owner, even when they couldn't travel to site."

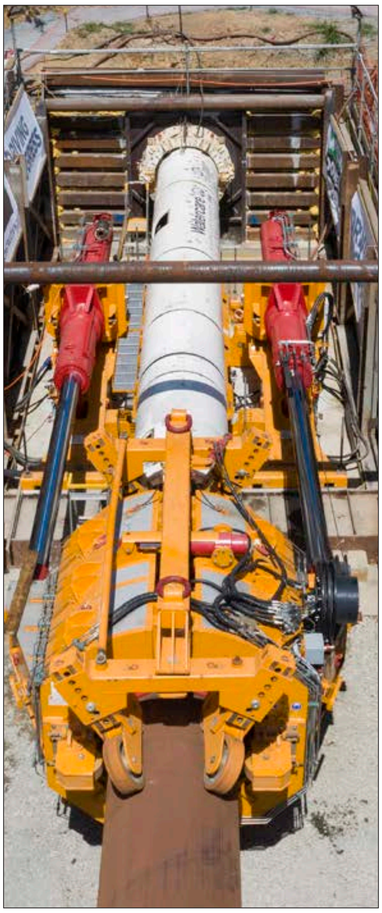
The ability for suppliers to remotely access equipment to diagnose issues or upgrade programmes has come into its own during the pandemic period, says Grennan: "Our surveyors can even log onto the TBM guidance system remotely and see how it's performing, check the parameters," he adds. "We have certainly used that a lot more than we did previously. Covid has helped push that along."

Direct Pipe

Herrenknecht's Direct Pipe variant of microtunnelling was first used in Germany in 2007, and in the US in 2010, and is now being deployed in other parts of the world. McConnell Dowell believes it is the only contractor in the Southern Hemisphere using the technology, with four projects completed since 2015, three of them in New Zealand.

Direct Pipe – a proprietary name – is often described as a combination of microtunnelling and horizontal directional drilling (HDD). With Direct Pipe, rather than the MTBM being jacked from a shaft, it is launched from a shallow trench or anchored starter tube. A pipe thruster rather than a hydraulic jacking station pushes a steel pipe into the ground behind the machine in one continuous welded section length.

"What's neat about Direct Pipe is that you can get through challenging crossings that you maybe could not complete any other way," says Dean. Stantec has been involved in Direct



Pipe crossings on a number of projects, including a dozen recent crossings in Canada and a challenging shore approach in the Middle East.

One of its big advantages is speed. There's no need to continually stop to join pipe lengths. Direct Pipe works with pipestrings which can be up to 100m or more, depending on how much space there is on site. There's no need to dig a reception shaft; the MTBM can arrive in a shallow trench or at sea can be stopped just below the seabed and unearthed. There's no need for the back-reaming process that HDD requires to widen the bore.

"Shore approaches, such as an outfall over a long distance, that's where Direct Pipe really comes into its own," says Shepherd. "Typically, there's a difference in elevation between the start of the drive on land and the end of the drive which means there is already a high-pressure differential which can be an issue with HDD.

"The other challenge with HDD is that you need a set-up out at sea which can be a problem where seas are rough." It is possible to use a HDD method conducted from one end only in such cases, adds Shepherd, but it's difficult, costly and time-consuming.

McConnell Dowell broke Direct Pipe world records starting with the Army Bay Ocean Outfall and then the Snells Algies Ocean Outfall. The Snells Algies project posed several challenges from the record distance involved, through challenging geological conditions and a curved alignment.

The Direct Pipe MTBM has since been used to drive the Westland Milk Ocean Outfall pipeline on the West Coast of New Zealand's South Island which is known for its rough seas and significant wet weather conditions. The 845m drive was completed in just over a month through sandy, gravely ground with large boulders which HDD could not have coped with.

Lowest price loses

Though they may be dubbed 'micro', these projects require competence across a variety of technologies, says Grennan. Ward & Burke, which directly employs its crews and aims to self-deliver as much of its project as possible, has at least one engineering graduate and often more on every microtunnelling site.

"One of our greatest issues is inexperienced contractors who end up winning difficult jobs, then the job has problems and the contractor gets in trouble. And the industry gets a bad name," says Grennan.

One of the frustrations for Gelinas is procurement law which prevents the best value solution being used. "Purchasing laws prevent prescriptive specifications. We have to describe things in a broader manner, so I can't always ask for exactly what I want," he says. "I'm also constrained by having to accept the lowest bid."

Mark Knight, executive director at the Centre for Advancement of Trenchless Technologies in Waterloo, Ontario highlights a lack of competence amongst some designers: "Many of the contract specifications and designs are not constructable as is," he says. "I asked one contractor why they would bid the work if it is not constructable. They replied that if they were only to bid for constructable work, they would not be bidding."

Grennan estimates that around one in five tenders are not up to scratch. "There has been improvement over the past three or four years, but you see some very strange things going out there," he adds.

Procurement solutions that make the most of contractor expertise can work well for complex projects. Dean highlights the South Surrey Interceptor (SSI) project in Greater Vancouver, British Colombia for Metro Vancouver. Stantec had designed around 400m of 3m I.D. trenchless construction in two drives with an open cut section in between them. Ward & Burke proposed microtunnelling the whole project in four drives, two with curves, hugely reducing disruption to the local community.

"Although we hadn't worked with such a diameter before on a microtunnelling project in North America, we knew these diameters had been successfully microtunnelled in Europe," says Dean. "The contractor brought through a proposal that was well thought out and the whole thing worked really well. The method delivered the best value solution to the Owner in consideration of cost, risk, and schedule while minimizing both disruption to the community and environmental impacts."

With a diameter of 3.68m, that was another record for Ward & Burke. "It's not about breaking records but it's nice to do challenging work," says Grennan. "A lot of our guys are motivated by doing technically challenging work and doing it well."

It's only worth breaking records when the objectives, benefits, planning and risk mitigations all align, warns Shepherd. Snells Algies Ocean Outfall illustrates this perfectly: the route was mostly through private land with high rock cover, in an environmentally sensitive area; the contractor had already used the MTBM in similar ground so could predict cutter head wear; an experienced team was available; and finally constructing a shaft two-thirds of the way through, where there was an option to do so would have introduced more risk than it mitigated.

However, Snells Algies Ocean Outfall may be as far as McConnell Dowell goes in terms of distance records at this diameter: "Having driven over 33% further than others, we are approaching the current limits of the equipment," says Shepherd. "If you have to do anything to the machine, it's a long way for the men to go in. We have the systems, processes and emergency drills in place but it's definitely not for the faint hearted..."

Setting records

Tunnelling Journal can't act as an adjudicator, but here are some of the microtunnelling records that have been claimed in the past few years:

Date	Technology	Project	Diameter (m)	Length (m)	Contractor	Comments
2020	Direct Pipe	Snells Algies Ocean Outfall, New Zealand	1.22	2,021	McConnell Dowell	World record for length
2020	Microtunnelling	Hunua 4 Section 11 Watermain project, Auckland	3	1,296 (Longest of three drives totalling 2,901m)	McConnell Dowell	Southern Hemisphere record for length in size class
2020	Microtunnelling	York Durham Sewage System (YDSS) Forcemain Twinning Project in Newmarket, Ontario	1.8	1,132	Ward & Burke	Canadian record for length
2019	Microtunnelling	Painesville (OH) Raw Water Intake	1.52	1,203	Ric-Man Construction	US record for length
2019	Microtunnelling	Sea outfall, Sur de Texas-Tuxpan gas pipeline, Altamira, Mexico	3.2	2,246	Terratest	World record length
2019	Microtunnelling	South Surrey Interceptor Phase 2, British Colombia, Canada	3.68	4no drives totalling 800	Ward & Burke	Largest diameter in North America
2018	Direct Pipe	Army Bay Ocean Outfall, Whangaparoa, New Zealand	1.22	1,929	McConnell Dowell	World Record for length
2018	Microtunnelling	West Cumbria Water Supplies Project for United Utilities, UK	2.28	1241	Ward & Burke	Longest microtunnel and pipejack in the UK
2017	Microtunnelling	Kingsbury Run Culvert Repair project in Cleveland for the Northeast Ohio Regional Sewer District (NEORSD).	1.52	830	Ward & Burke	Longest curved microtunnel in North America