

**M**icrotunneling is considered by many to be the most complex and costly of all the various trenchless technologies. Even though microtunneling is a proven method of construction, high mobilization costs and the small number of contractors qualified to do microtunneling work make the procedure one of the least-used trenchless technologies. However, there are projects with surface and subsurface conditions for which microtunneling is the best or sometimes only possible way that a section of pipe can be installed. Other mitigating factors can also make microtunneling a practical and economical option.

Remote-controlled equipment excavates small-diameter tunnels using a laser-guided cutting head to maintain extremely precise line and grade; tolerances within hundredths of feet are common. As the cutting head proceeds, jacking equipment pushes new pipe into place. In the United States, microtunneling is used to install pipe in diameters from 12 to 72 inches. The most common materials are pipes made of vitrified clay, fiberglass and reinforced concrete.

"Over the past 15 years, there has been steady growth in the number of microtunneling contractors, the number of machines in the marketplace, and the footage of pipe installed by microtunneling," says David Abbott, a principal with Jason Consultants Group, Washington, D.C., specializing in trenchless technology.

Because of his extensive experience in underground construction and specifically with microtunneling, *Underground Construction* asked Abbott to evaluate the state of the microtunneling industry and evolution of equipment and techniques that help contractors be more productive. Here are his comments.

#### *How would you describe the microtunneling industry today?*

I believe the microtunneling industry is reasonably mature . . . the technology is better accepted than it was 10 or 15 years ago. Participants in microtunneling projects – the owner, the engineer, equipment manufacturers, the contractor and some-

## Acceptance, Productivity Of

# Microtunneling Grows

by Jeff Griffin ■ Senior Editor

times lawyers – are increasingly familiar with the technology and its use. Most owners and engineers know the techniques that can be used and have some idea of the areas of application, though perhaps a fuller understanding of the technique, its application and how best to apply the method while minimizing risk is less well understood.

#### *How fast is demand growing?*

Demand for microtunneling fluctuates as does the volume of most public works construction. Averages of 150,000 feet of microtunneling were being recorded in the United States in the mid-to-late '90s. There are no accurate figures recorded by the industry over the past years, but I anticipate similar annual averages being constructed with perhaps a little growth.

#### *Is microtunneling being used on different types of projects than in the past?*

With increased understanding of the technique comes perhaps wider application of its capabilities. More difficult projects in terms of depth, length, soil types and groundwater cover are being successfully completed. The trend is to longer



drives with the lengths – some of them very long – increasing annually.

Jason Consultants has engineered microtunneling drives up to 4,000 feet with a jacked pipe lining. Microtunneling in rock is becoming more common, but care needs to be exhibited because of the smaller, lower capability disc cutters than can be fitted to a microtunnel machine and also the limited

thrust and torque available in machines to make the cutters excavate rock efficiently.

Microtunneling for lake taps for the abstraction of water from reservoirs and sea outfall construction also are becoming more common. It is necessary when working underwater and recovering equipment.

### *How is today's microtunneling equipment different than models sold five years ago?*

The basic concept of microtunneling has changed little since it was developed, but there have been gradual and progressive changes based on technology developments and practical experience. In the last five years, there have been increased use of sophisticated alignment control systems using advanced surveying techniques inside the tunnel or a combination of gyroscopes and electronic water level control to achieve long drives with better control or to undertake curved microtunneling.

The ability to excavate rock has increased with the greater capability of discs being employed on larger machines. This includes the use of gripper sections in the rear of the machines to facilitate adequate loads on the cutter disc to excavate the rock, and to minimize any peak loads developed by jacking forces applied from a distance behind the machine to jack the pipes.

Additionally, the use of automatic lubrication for long or challenging drives has both reduced jacking forces and the risks associated with those projects.

### *Are today's machines more productive?*

Productivity in terms of actual advance rates – with the exception of the use of high pressure water in soft clays – has not significantly changed because these are a function of soils plus type and configurations of machines. Some improvement in the operation in clay soils has been achieved with the use of a small microtunnel-size EPB (earth pressure balance) machine with a rising screw-type auger that removes soil from the face of the machine and also controls the pressure at the face by varying the rate of spoil removal.

Longer installations now are almost routine, not only for the ability to complete long crossings, but for the economic benefit of minimizing the number of shafts required and reducing the number of moves of surface equipment – particularly when using larger machines. This saves time, costs and minimizes site disturbance.

To date, the longest was an 8,300-foot microtunneled drive in Germany in the late '90s. Drives with medium diameter machines of 1,000 to 1,500 feet are relatively routine.

Diameters of pipe that can be installed relate to hydraulic requirements, and on



average these don't change. In the last five years, there has been a trend for larger pipes to be installed by microtunneling, but this appears to be a cyclic variation only. There is a potential for increased use of polymer concrete jacking pipe with the opening of the first plant for this type of pipe in the United States. The U.S. definition of microtunneling includes pipe to diameters of 144 inches. The international definition stops at 1,000 mm or 40 inches.

### *What are the keys to maximizing productivity on microtunneling projects?*

All types of underground construction, including microtunneling, are technically challenging. This is increasingly so with both the growing technical complexity of microtunneling systems and their application on more challenging projects requiring deeper and longer construction in more difficult soils.

In a broad perspective, two key factors are precursors to success: experience and planning. Good engineering at the design stage including involving the project owner and engineer; selecting the right contractor; and proper set up, operation and support of equipment with all parties monitoring construction are essential.

Projects that have these prerequisites are properly set up and staffed which both increases productivity while minimizing

stoppages and downtime which reduce productivity.

Planned use of separation plants for spoil is generally accepted as a means of efficiently cleaning slurries and increasing productivity. Similarly, the use of high-pressure water jets in the heads when working in soft clay and greater care in the use of interjacks and lubrication around the pipes being jacked are now more common.

### *What types of projects are best suited for microtunneling?*

Microtunneling is used to install sewers, stormwater pipes, water mains, gas pipes and duct and conduit for electric and communications cables. The technology provides the ability to install pipes to high degrees of accuracy – plus or minus one inch – and at considerable depths comparatively economically.

The economics of construction come into play with the non-grade requirements of water, gas and power and communications cable installations which can be made at shallow depths following general ground contours typically by open cut or in some cases installations made with small directional drilling machines.

Where pipes must be installed to line and particularly to grade for gravity flow, where smaller pipes flow into larger pipes which successively increase in depth, the accuracy

# Microtunneling

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of microtunneling leads to its principal use for sewers and storm-water system. Other projects are for highway, railroad and airport runway crossings; lake, reservoir and ocean inlets; and river and stream crossings where open cut may be unacceptable.

A simple cost comparison of microtunneling and open cut at depths of 15 or 20 feet typically tend to be the threshold for considering the use of microtunneling. Where there are restrictions such as a river, lake, highway or urban constraints from traffic or multiple utilities, then the use of open cut may be limited and become a driver for using microtunneling.

## *Compared to other trenchless methods, does microtunneling offer benefits that others do not?*

Microtunneling – and certainly with a slurry machine – offers the capability to install non-man-entry tunnels to close tolerances and in difficult ground conditions and under a water head 100 feet or deeper. It allows the direct installation of smaller-diameter pipes without construction of larger man-entry tunnels.

Microtunneling provides the capability to deal with a wide range of soils, including gravel, cobble, boulders, rock and groundwater conditions without the need for dewatering or grouting and the attendant problems and costs they may entail.

Surface settlement is minimized by the means of microtunnel systems to provide what is called earth pressure balance – the application of controlled pressure at the face of the machine to counter balance both external soils and groundwater pressures. This capability, together with the capability to control the rate of advance of the tunnel with the rate of excavation at the face, minimizes over excavation at the tunnel face and settlement at the surface.

## *Will microtunneling equipment change in the next few years?*

As previously stated, there have been many developments in equipment over the past 20 years. Most incremental changes were made to incorporate new technology or improve reliability, and to respond to operational needs. Data logging of control and operational information is a good example. There also have been improvements to increase rock excavating capability and the development of ‘pilot pipe’ systems. Changes are gradual in a conservative industry so I foresee no major changes in the next 24 months.

## *What is the future for microtunneling?*

I expect steady, if unspectacular, growth in the volume of work undertaken annually by microtunneling contractors. New techniques, enhancements of existing techniques, as well as increased experience and confidence of contractors will continue to extend the use of microtunneling in terms of volume and for work on more difficult and challenging projects.

**Editor's Note:** *The principal source for this article, David Abbott, holds a bachelor's degree in civil engineering from Liverpool University in England and is a registered professional engineer throughout Europe.*

*Before joining Jason Consultants, he was based in the United States as a senior executive with leading international tunnel equipment companies and since 1983 has been involved in the designed construction of more than 350 microtunneling, pipe jacking, tunneling and outfall/river-crossing projects.*

*Abbott is a well-known speaker at international pipeline, tunneling and trenchless technology conferences and seminars and has presented more than 30 papers at various forums and conferences in many countries. He also has written numerous articles for technical journals.*