Rules of Thumb

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In the first of this two-part series, columnist **Keivan Rafie** covers microtunnelling

THE FIRST MINIATURE TBM was developed by the Japanese, and a few years later, one was developed by the Germans. This development led to the term microtunnelling, which in its simplest form, is the use of a remote-controlled, computer-assisted, miniature, earth pressure or slurry pressure balance tunnelling machine. The latest machine nomenclature is micro tunnel boring machine (MTBM). MTBMs can be used to mine soil, mixed face, glacial deposits, alluvial deposits, gravels, cobbles, boulders, weak rock, and hard rock.

In microtunnels, ***machine steering jacks*** are controlled remotely from the surface. The equipment and ***control house*** for the remote-control equipment are usually on ground level either directly over or adjacent to the jacking shaft.

Microtunnelling can be carried out from ***small shafts*** to meet ***specific and highly-restrictive site requirements,*** such as using only one-lane of a roadway. For practical purposes, a jacking shaft of a minimum 20ft to 24ft (6.1m to 7.3m) diameter and a reception shaft of 16ft to 18ft (4.8m to 5.4m) diameter are needed. Though microtunnelling has been completed using much smaller shafts.

American Augers, Herrenknecht, Iseki, Robbins, RASA and Akkerman are a few of the ***manufacturers*** making or furnishing MTBMs.

Excavation system: MTBMs are designed with a cutterhead that is rotated by a drive motor, and it can be configured as a peripheral drive or central drive machine. Each configuration has its pros and cons. The cutterhead is configured with face tools suitable for excavating the anticipated ground ahead.

Once excavated, the material enters a chamber behind the cutterhead and is mixed with water or some mixture of water, bentonite, and polymer to achieve a toothpaste like consistency. The soil slurry mixture is then pumped through slurry discharge lines where the mixture is processed, and the "cleaned" slurry pumped back to the cutterhead through "charge" slurry lines. In theory, the face of the cutterhead counterbalances ground load, and the slurry counterbalances groundwater pressure.

Alignment control system: The alignment is controlled by placing several jacks around the articulated joint near the cutterhead. Controlling these jacks allows the head of the machine to be directed and make course corrections so the microtunnels can be driven at a precise line and grade. On most MTBMs the cutterhead is also bidirectional, helping to maintain alignment. Line and grade are often monitored by a laser system using a target located at the back of the machine. For long drives or curves gyro based surveying systems are used.

Propulsion system: The objective of the propulsion system is to push the MTBM and pipe/lining (pipe string) behind it through the ground. This is accomplished using a jacking system in the jacking shaft (i.e., launch shaft). Jacking systems typically consist of number of jacks that react against the back wall of the shaft. The wall of the pit must be designed to withstand the forces generated by the face-pressure resistance of the machine and skin friction along the pipe. When a drive length exceeds approximately 400ft (122m), interjacking stations are often installed to overcome increasing pipe weight and frictional forces.

Pipe lubrication system: MTBMs are designed to produce a hole with a diameter slightly larger than the trailing pipe, which is known as overcut. Overcut size is one of the more critical decisions to make on a project. Overcut helps reduce the jacking forces along the pipe. A lubricant can be injected into the annular space around the pipe to reduce the jacking forces and allow for longer jacking lengths. Use of a slurry-type MTBM will automatically lubricate the pipe to some extent.

Applications include a wide variety of ground conditions, and MTBMs are very versatile. Some common applications include crossings under active taxiways, runways, and interstate highways; driving intake structures in lakes; or establishing initial support for larger-scale tunnels. More inventive applications include underpinning buildings, placing pipes for ground freezing, installing monitoring instrumentation under landfills, crossing under wetlands, and installing an impermeable layer under a containment structure. Applications that require the most critical thinking in terms of MTBM include deposits of gravels, cobbles and boulders, and wood debris

Suggested reading

An Engineer's Lessons Learned from DSC Claims, 24th Annual Microtunneling Short Course, University of Colorado at Boulder, February 7-9, 2017

An introduction to pipe jacking and microtunnel design, The Pipe Jacking Association

Means and Methods – In the Engineer's Domain?, Del Nero, D. Trenchless World Magazine (2013)

Pipe jacking and Microtunneling, Thomson, J. (1993)

Standard Design and Construction Guidelines for Microtunneling, ASCE (2015)

Trenchless Technology for Installation of Cables and Pipelines, Stein, D. (2005)

Agree or disagree?

Let us know what your experience has taught you. Or let us know what topic should be included in future *Rules of Thumb* columns. *editor@tunnelsandtunnelling.com*