Rules of Thumb

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In the second of a two-part series on microtunnelling, **Keivan Rafie** interviews Stantec's **Don Del Nero,** vice president and global tunneling and trenchless practice leader

WHAT ARE THE MOST DIFFICULT ISSUES FACING THE INDUSTRY?

Answer: First, engineers are over specifying how microtunnelling projects should constructed. It is one thing to mandate that an MTBM is to be used, or an MTBM is to be used with mixed face cutters. But I have seen engineers go to the point of specifying the MTBM horsepower or even how jacking loads should be calculated by the contractor. Over specification of means and methods starts to encroach on the concept of implied warranty so engineers should avoid being overly specific.

Second, cutterheads are complex and require specialized expertise to use correctly. There are several case histories of problems with MTBM cutterheads that have too many openings, too large of an opening size, or the openings are in the wrong location on the cutterhead. This is a concern in sands, silts, clays, gravels, cobbles, and boulders. The openings in the cutterhead may have to be restricted to accommodate the given ground condition.

The third most significant threat to the industry is excessive MTBM skin-up. To be competitive on most projects, it is in the contractor's best interests to mobilize an MTBM they already have in-house. This becomes an issue when the mechanical and electrical properties of the MTBM are not upgraded to accommodate the increased diameter. Here is some perspective to help clarify. If a 72-inch MTBM is upsized to 96-inch, the face area goes from 28 sq. ft. to 50 sq. ft. That is an 85 per cent increase in face area, which translates to a significant increase in muck volume that may or may not be accommodated by the machine's capabilities.

WHAT ARE THE MOST CRITICAL VARIABLES IN USING AN MTBM IN COBBLES AND BOULDERS?

Answer: There are many critical variables in this difficult ground condition. A minimum MTBM diameter of greater than 60 inches is often recommended in this ground condition. To facilitate an ever-better chance of success, a 72-inch MTBM should be considered. These larger sizes have the higher torque and thrust required to successfully mine in cobbles and boulders. As far as cutterhead tooling, disk cutters have shown the most success in this type of soil.

MTBM advance rate selection is also commensurate with selecting the right MTBM size. Advance rate must be much slower in cobbles and boulders than for sands, silts, and clays matrices. Another aspect of MTBM size selection is the maximum size cobble or boulder to be mined. In some instances, a maximum size often quoted is 30 per cent of the MTBM diameter. On some projects this has led to mining issues. My recommendation is to use us an MTBM that is at least 80 per cent larger than the largest cobble or boulder (maximum clast size of 20 per cent of the diameter).

A related factor is the cutterhead opening ratio. In some situations, it may be necessary to reduce the cutterhead opening ratio to as low as 10 per cent when mining in cobbles and boulders to avoid clogging the cutting chamber.

The geologic and engineering properties of the cobble and boulder materials are also of utmost importance. The subsurface investigation program should focus on the frequency, distribution, size, shape, composition, abrasivity, strength, and soil matrix character. The soil matrix that surrounds the cobbles and boulders is important because an understanding of whether the clasts will be plucked or held in place during mining must be theorized. Relative to the subsurface investigation, the conventional standard penetration test borings do not provide the coverage and sampling required to evaluate cobbles and boulders. Test pits, outcrop mapping, large caisson borings, and rotosonic borings should be considered.

HOW EFFECTIVE ARE MTBMS IN MINING FULL-FACE ROCK?

Answer: In short, very effective. Since the early 2000s there have been as many as 50 projects that have used an MTBM to mine in full-face rock. Rock unconfined compressive strength over 250 MPa can be mined with an MTBM if the right machine and ancillary equipment is used. The various MTBM manufacturers can provide specific machine selection for specific rock conditions. But remember, judgment and experience should always be coupled with the manufacturer recommendations.

To determine if an MTBM can be used in full-face rock, there are a number of variables to consider, including rock UCS, RMR, abrasivity, rock tensile and shear strength, overcut, horsepower and diameter, thrust and torque, cutting tools, drive length, type of pipe lubrication, and pipe characteristics.

Also, maximum overcut should be in the 1 per cent range for excavated diameter, but even that requires significant judgment.

Pipe jacking loads are also critical as the thrust increase required to mine the rock needs to be accommodated in the pipe wall. Intermediate jacking stations may be required to supplement the jacking capacity in the jacking shaft when considering a full-face rock project. The thrust required in full-face, hard rock is likely two or more times the thrust required in soft ground MTBM mining.

Another significant factor is cutterhead tooling. For most hard-rock projects the MTBM will need to be fitted with disk cutters. Cutter technology is a science unto itself, and expertise in this discipline should be engaged. Specific guidance on disk cutter size, spacing, location, and metallurgy should be obtained when attempting a microtunnel project in full-face rock

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*