Microtunneling in Spite of Inherent Risks

by Peter J. Tarkoy, Ph.D.

Why Microtunneling Risks?

Microtunneling has installed 750,000 ft of pipe in the United States to date and the vast majority of the work is carried out according to plan. However, we become involved in too many projects where problems could have been avoided from the outset.

It is our intent to address that small percentage of microtunneling projects that are not considered successful and thereby provide means to avoid similar problems in the future.

Such problems have substantially increased project costs, proved disastrous to project schedules, and have resulted in dire economic consequences to contractors unnecessarily. One might ask: Why?

Achilles' Heel of Microtunneling

Microtunneling is particularly sensitive to misapplication and unanticipated ground conditions because:

1. it deals with a small diameter excavation and for the most part is non man-entry,
2. microtunneling machines are limited to a range of conditions that any one machine can negotiate,
3. the heading is filled with machinery,
4. there is generally no access to the face,
5. the excavated material is unseen and only partially observable beyond the separation plant,
6. there are no alternatives for dealing with conditions at the excavation face (such as hand mining, grouting, breaking up boulders),
7. microtunneling requires a great deal of experience and skill, and
8. the only other possibility is to rescue the MTBM by digging it up.

Under ideal conditions microtunneling is a magnificent solution that minimizes surface disturbance and economic impact. However, ideal conditions do not coincide with typical geology of the various regions present in the United States.

In many cases, microtunneling is applied as a panacea without recognizing its sensitivities and limitations. Therefore, exploration, design, and the plans and specifications rarely deal adequately with the inevitable geological conditions that are encountered. Sensitivities or limitations of microtunneling do not disqualify its use, they just require more attention to detail with alternative methods and payment that have to be incorporated into the specifications.

Figure 1: Unanticipated Boulders Larger Than the MTBM

Problems

What are the typical problems microtunneling machines have encountered? They are:

1. Undefined, un-indicated, and unanticipated conditions that are adverse to and beyond the capabilities of the microtunneling machine such as:
   - obstacles that stop the forward progress of the MTBM (obstructions, boulders, high concentration of cobbles),
   - ground conditions which will not support required bearing capacity or reaction for MTBM operation,
   - rock layers and hard zones, in soft rock or soil,
   - plastic clay with mixed ground,
   - unusual silts,
   - interfaces between materials having radical differences in density and consistency.
2. inadequate torque,
3. choking of MTBM cutterhead in some types of ground,
4. having to rescue the MTBM
5. impossible rescue situations
6. delays,
7. cost overruns, and
8. adversarial relationships and disputes.

Some Examples

In one instance a 24 in. diameter machine encountered a boulder (Figure 1) that was 12 in. larger than the machine, which was designed for soil excavation.

In Figure 2, an MTBM was chocked with an unanticipated concentration of cobbles.

Recently, till blow counts in excess of SPT 200 on cobbles and boulders were used to argue that the contractor should have anticipated unconfined compressive strengths of nearly 4,000 psi (Figure 3). These strengths were beyond soil strengths and well within the range of rock strengths.

A microtunnel rock excavation maximum anticipated and encountered unconfined compressive strength differed by a factor of three (Figure 4). This difference exceeded the capability of the MTBM and the contract was cancelled for the convenience of the owner, without project completion.

There have also been instances of microtunneling projects failing as a result of inexperienced contractors, overly optimistic expectations, and inadequacy of equipment.

How to Minimize Risks

In order to minimize risks:

1. geotechnical exploration must be tailored to microtunneling,
2. it is necessary to provide anticipated conditions and behavior for

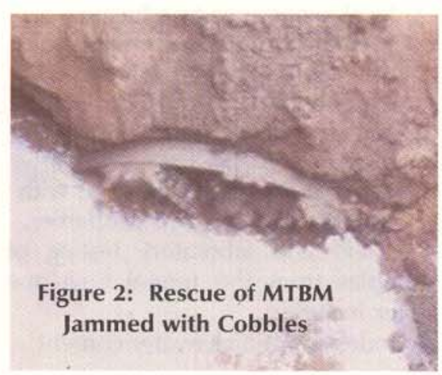

Figure 2: Rescue of MTBM Jammed with Cobbles

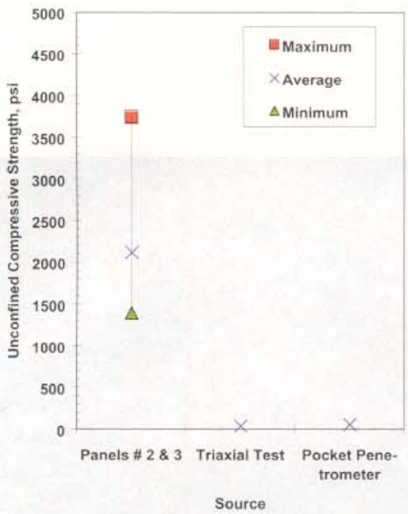

Figure 3
UCS of Rock-Like Glacial Till

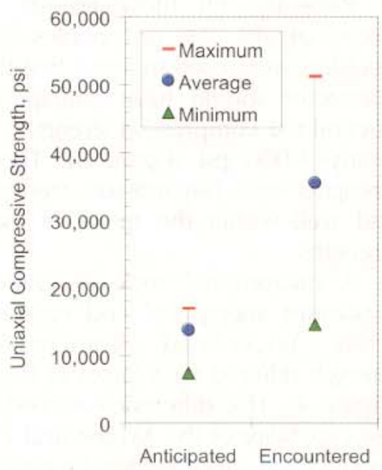

Figure 4
Difference Between Anticipated and Encountered

selecting means and methods, and
3. project design must consider microtunneling limitations.

Geotechnical Baseline

Geotechnical exploration and a baseline report (by a senior geotechnical engineer experienced in microtunneling) should incorporate:
1. geological history of area,
2. relevance of local conditions,
3. local experience to educate "out-of-towners" with references to technical articles of local experience,
4. local knowledge to modify exploration, and
5. descriptions of the materials with summaries of all their properties.

Field and laboratory testing of samples from the tunnel envelope must include:
1. index properties (water content, unit weight, Atterberg Limits, etc),
2. SPT,
3. grain size distribution,
4. density tests,
5. strength,
6. hardness,
7. obstructions, and
8. water conditions.

The engineer's responsibility includes providing data that allows the contractor to:
1. determine material quantities and behavior,
2. select the appropriate equipment, methods, and progress rates,
3. establish estimates of stabilization, materials, supplies, wear, and maintenance, and
4. prepare a construction cost estimate

Geotechnical baseline reports must include interpretations of anticipated conditions and behavior that:
1. relate general geology to the construction envelope,
2. specifies anticipated quantities of occurrences of various materials that affect excavation and stabilization, and
3. the need for hindsight "shoulds."

Anticipated conditions and behavior must be defined in terms of:
1. averages,
2. ranges, and
3. the most adverse.

This will allow a contractor to determine:
1. average performance,
2. the appropriate equipment necessary to negotiate the full range of conditions,
3. possible alternatives to deal with most adverse conditions without major delays, catastrophic stoppages, and unexpected changes in methods.

For the geotechnical data to be effective the presentation must:
1. be factual and quantitative,
2. utilize color graphics along the alignment (preferably in a profile),
3. include local experience, and
4. force a narrow interpretation for bidding.

Project Design, Plans, & Specifications

Plans and specification appropriate to microtunneling must provide:
- project specific (not boiler plate) specifications
- bill of quantities (boulders),
- minimum requirements,
- alternatives for methods, payment, and rescue, and
- disputes resolution consistent with industry standards.

In some cases, it is appropriate for the engineer to require minimum requirements for means, methods, and equipment, including microtunneling contractor qualifications. For example, in order to avoid problems with the likely occurrence of boulders, specifications called for a minimum requirement of disk cutters and an air lock and access to the face for cutter changes under a river crossing (Figure 5).

Figure 5: Contract Specified MTBM to Excavate Till with Boulders

The Facts of Life

The reality is that:
1. 90 percent of disputes are differing site conditions,
2. the differing site condition clause is part of the contract, and
3. a DSC is not "bad," it seeks bids without contingencies and in turn promises to protect the contractor against unanticipated conditions.

In the end, if you don't like the consequences, change the cause. The owner and engineer have control setting the course of a project through exploration, design, and the specifications. A contractor can only follow the specifications. The quality of the exploration, design, and specifications, therefore, will dictate the consequences or outcome of the project.

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