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WARNING! Do Not Bid On This Project

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1. ABSTRACT

This paper illustrates common deficiencies in trenchless bid packages which, whether intentionally or unintentionally, result in an unfair transfer of risk to the bidding Contractor. Deficiencies often include inadequate subsurface characterization, lack of casing or product pipe design, problematic geometry, unnecessarily restricted work space, or specification of unrealistic trenchless performance requirements. These are situations where the bidding Contractor should request immediate clarification, and in some instances avoid bidding altogether. In some instances, the Contractor may have an opportunity to educate the Owner regarding the design deficiencies and the associated risk.

This paper provides a number of brief case studies where critical details of the trenchless bid documents were insufficient or inadequate, resulting in elevated risk, and even the failure of the installation. The points made herein are intended to reinforce trenchless design standards, and to serve as a warning to bidding Contractors.

2. INTRODUCTION

For projects advertised and awarded through bidding, it's the responsibility of the Owner to prepare a design package which is readily constructible within standard industry practices. This applies to all construction trades. Unfortunately, when the evolution of the construction technology outpaces design methodology or experience, the quality and suitability of the design may suffer. Unfortunately, this is often the case in the trenchless industry. In our experience the designer may not be adequately knowledgeable of the specified trenchless method. The designer must realize the limitations of the specific trenchless method, the impact of the subsurface conditions at the site, and the pipe design requirements. In most cases, specification of a given trenchless method requires that the Contractor implement <u>that</u> method, which should be readily constructible using standard industry practices.

Trenchless projects, by their nature, involve risk, and bid packages with poorly conceived plans and specifications place inordinate risk on the general Contractor, and the trenchless Subcontractor. Ultimately this increases project cost and schedule, and reduces the potential for successful project completion. Deficient design documents force many contractors to ask *"should I bring this to the attention of the owner?"*, knowing this may impair their competitive edge during bidding or cause their bid to be declared unresponsive. Trenchless Contractors may encounter bid packages that are so poorly conceived, that they can't reasonably submit a bid due to the associated risk.

3. METHOD SELECTION

Before trenchless design can begin, the designer needs to select a technically feasible method. In order to select the appropriate method, the designer must be familiar with all common trenchless methods, and understand the advantages, and limitations of each. There must also be an understanding of the basic data requirements for determination of constructability. This helps ensure that an inadequate method isn't pushed into design, and ultimately construction.

Some typical limitations, and sources of potential risk for common trenchless methods are summarized in Table 1, below.

Table 1. Typical Trenchless Considerations by Method

Method	**Considerations**
HDD	Not suitable for gravity based installations Pipe must be designed for installation loads Pipe must be designed for burial The presence of bedrock and obstructions must be determined The depth of the bore must be sufficient to withstand drill fluid pressures
Microtunneling	Pipe must be designed to withstand jacking loads Ground conditions must be known to select appropriate machine and cutterhead Basal stability must be considered Mixed face conditions should be avoided Oversized materials (cobbles, boulders) in clast-to-clast contact can be problematic
Auger Boring	Limited steering control Sensitive to elevated groundwater levels in granular soils Pipe must be designed to withstand jacking loads Sensitive to obstructions, especially in smaller diameters (<36 inches)
Pilot Tube (displacement method)	Sensitive to soil density - requires displaceable materials Ineffective if obstructions or oversized materials present Sensitive to elevated groundwater levels in granular soils Maximum installation length limited by steering system
Pipe Jacking	Basal stability must be considered Sensitive to elevated groundwater levels in granular soils Pipe must be designed to withstand jacking loads
Pipe Ramming	Limited steering control Vibrations may impact stability of adjacent soil mass May be to elevated groundwater levels in granular soils Casing must be designed to withstand ramming loads

4. ALIGNMENT SELECTION

In the development of the trenchless alignment, in both plan and profile, the designer needs to consider the constructability of the project, in addition to the requirements and impacts of pipe placement.

Common deficiencies or errors in trenchless alignment selection include the following:

- Selection of HDD alignments which do not consider the ability of the surrounding formation to contain the drill fluid pressures required during construction, and have not considered the risk of inadvertent drill fluid loss ("frac-out"). Note that one size does not fit all with respect to appropriate HDD drill depth. This needs to be assessed on a case-by-case basis, with respect to the subsurface conditions, and installation geometry.
- Development of HDD alignments with curves exceeding the bending capabilities of the product pipe. In general, this is a problem most often encountered when dealing with metallic pipe (e.g., steel or steel-coated

pipe, ductile iron pipe). A common rule of thumb is that metallic pipe should not be installed across bends with radii that are tighter/smaller than pipe diameter in inches x 100 feet (for example, 24 inches allows a minimum radius of 2,400-ft). Installations which require tighter curves should be accompanied by a comprehensive stress analysis specific to the pipe.

- HDD profile alignments which have entry angles which are too steep for the Contractor's equipment (typically 18 to 22 degrees).
- HDD profile alignments which have exit angles which are too steep to allow efficient insertion of the pipe into the borehole.
- Trenchless alignments which are too close to existing utilities, particularly utilities with unconfirmed locations.
- Jacked alignments (microtunneling, pilot tube, auger boring, pipe jacking, etc.) which do not avoid fill soils, which could contain obstructions, or native soils known to contain large amounts of cobbles and boulders.
- Jacked alignments (specifically pilot tube, auger boring, pipe jacking) which are placed below the water table in granular soils, with no consideration given to dewatering or ground improvement.
- Jacked alignments which are located without regard to mixed face conditions, which could adversely impact efficient advance, or steering. The most common example is a jacked alignment placed at or near the top of bedrock, where the bedrock surface may be erratic, or otherwise poorly defined.
- Jacked alignments that are located with unrealistic clearance below roadway pavements. In general, a useful rule-of-thumb is that the jacked pipe crown should be located at least twice the pipe diameter below the ground surface, or roadway surface. However, the vertical offset may need to be increased if the soils present a high risk of settlement or heave.

5. WORK SPACE ALLOCATION

Once a trenchless method is selected, the design engineer needs to show the available work space on the project plans. In general, proposed installations without sufficient work and staging space can result in increased cost and schedule impacts, and in some cases can render a project unconstructible

The most common mistakes in allocation of work space generally include the following:

- Not depicting the work or laydown space available to the Contractor.
- Not allowing sufficient space for the equipment needed for the equipment required. This is a common problem with HDD bid packages, where a given installation may require a certain rig size, as well as support equipment.
- For HDD projects, not allowing sufficient pipe laydown space to complete the pullback without mid-pull pipe welding or fusing. Although mid-pull pipe assembly is it does pose increased risk to the pullback operation.
- Jacking pit locations without sufficient room for topside equipment.

The most cases, it can be useful to develop a mockup of the construction site during design, to ensure that adequate space is available.

6. GROUND CHARACTERIZATION

One of the basic requirements for all trenchless installations is a detailed understanding of the subsurface conditions in the vicinity of the trenchless alignment. This should allow the designer to select the appropriate installation method, and the Contractor to bid the project with the correct tools.

It is, or should be readily accepted that ground characterization programs for trenchless projects require subsurface investigations. However, a remarkable number of trenchless designs are bid with insufficient subsurface exploration, and in some cases, no explorations whatsoever. These projects increase the risk of installation failure, and differing site conditions claims filed by the Contractor. Requirements for investigation programs will vary by location, and geologic region. In general, some of the most common deficiencies in ground characterization programs for trenchless projects include the following:

- Explorations with insufficient spacing (too far apart).
- Explorations with insufficient depth (terminated above the proposed alignment).
- Insufficient characterization of oversized materials, which may be difficult to sample, but can be detected by drilling behavior.
- Limited information regarding the nature of the deposit (e.g., fill versus native soil, and source of native soils).
- Poor characterization of soil gradation (e.g. fine sand vs. silt).
- Misidentification of organic soils, or soils which could adversely impact long-term pipe stability.
- Inadequate characterization of groundwater level, and response to drilling (e.g., observation of running sands, or rate of inflow during drilling).
- Insufficient characterization of the depth to bedrock, and identification of shallow bedrock.
- Poor bedrock characterization, which should include bedrock type, weathering, hardness, a jointing.
- Explorations which are terminated at shallow depths upon encountering an obstruction, without determining the nature of the obstruction.
- Lack of subsurface utility information.
- Limited laboratory testing of samples.

In addition, we offer the following thoughts on the presentation of subsurface information:

- Although geotechnical baseline reports (GBR's) may be suitable for some trenchless projects (in particular microtunneling projects), , and the contractual implications of these reports are unfamiliar to large portions of the trenchless industry. We find that many small to medium-sized trenchless contractors often have not worked with these reports. If a GBR is included in the Contract Documents, the purpose and implications of the report should be explained carefully to the contractors bidding the project.
- Many specifications suggest that the Contractor is responsible for additional explorations, if the Contractor believes additional explorations are needed. In our experience, smaller trenchless contractors are unfamiliar with the process of obtaining additional subsurface explorations, and will be unwilling to do this due to loss of competitive advantage. If the designer believes additional explorations are required, these should be specifically required.
- Smaller trenchless subcontractors may not be familiar with the terminology included on exploration (test boring, test pit, etc.) logs, or with lab testing. The designer should include a sample classification scheme, and an explanation of terms.
- Subsurface conditions that may present elevated levels of risk should be brought to the attention of the bidding contractors. This can be accomplished by callouts on the drawings, discussion in the specifications, and during pre-bid meetings.
- Certain formations, by their nature, present risk to trenchless installations. For example, Glacial Till deposits should be expected to contain cobbles and boulders, even if they are not encountered by the test borings. It's the responsibility of the designer to interpret the subsurface conditions and identify areas of potential geologic risk on the Contract drawings and specifications.

7. PIPE DESIGN

Pipes installed by trenchless methods are often subjected to a greater degree of stress than pipe installed by shallow cut-and-cover methods. Accordingly, the pipe material must be selected carefully, and designed to withstand this stress.

During the pipe design process, the designer should evaluate the short-term installation loads, and long term operational loads, and select the pipe accordingly. Guidelines for evaluation of installation loads, such as jacking calculations for microtunneling, pipe jacking and pilot tube, and HDD pull force calculations are provided by numerous readily available NASTT, ASTM and ASCE publications. A short list of useful design references is included at the end of this paper.

Common deficiencies in pipe design, and trenchless alignment selection, relative to pipe limitations include the following:

- Development of HDD alignments which require pipe pull loads which exceed the safe pull strength of the product pipe.
- Installation depths that exceed the short and long-term buckling capacity of the pipe.
- Pipe grade requirements which are unrealistic for the selected method, and/or the subsurface conditions present
- Jack type installations which do not consider the jacking loads which will be required

Recently, we've seen numerous trenchless bid packages where the specifications require the Contractor to provide calculations to assess the pipe. These have included proposed HDD installations where the Contractor is required to provide pull force evaluation, and jacking installations where the Contractor is required to provided jacking force assessment. In some instances, it becomes clear that the designer has not completed these calculations during preparation of the Contract Documents, and is pushing the responsibility to the Contractor. While it is appropriate to require that the Contractor to provide these calculations for comparison, the designer needs to complete assessment the installation loads during design, to justify the pipe material selection.

8. CASE STUDIES

Case Study #1

Case Study #1 involves installation of a 10-in HDPE gravity sewer pipe by HDD. The bid plans suggested a 1,280-ft long HDD alignment, with horizontal and vertical curves having radii of 300 feet. The bore path would cross below two lanes of an interstate highway, with vertical clearance between the bore and pavement of 4 feet. The bore path would also pass beneath a drainage ditch, with a vertical of 3 feet. The bore would also pass beneath a number of utilities, with offsets ranging from 1.5 to 5 feet. The proposed entry area for the bore was 100 feet higher than the exit. The proposed bore path was located at or near the bedrock surface, as determined by test borings. The project specifications required an installation grade accuracy of +/- 6 inches, with no definable low spots.

Brierley reviewed the bid plans at the request of the Contractor considering bidding the HDD installation, and determined that the installation involved an unnecessarily high level of risk, and might have been unconstructible, for the following reasons:

- The grade requirements were not readily achievable using HDD, particularly with a bore path at or close to the bedrock surface, due to typical steering limitations;
- The curve radii were too tight for the contractor's drill rods;
- The bore path was not deep enough below the highway, and the potential for surface settlement or inadvertent drill fluid loss was considered to be high;
- The depth of the bore path below the drainage ditch was determined to be insufficient to avoid inadvertent drill fluid loss; and
- The extreme elevation difference between the entry and exit area was determined to be too great to allow for effective drill fluid management, given the site layout.

In this case, the Contractor weighed the considerations above, and elected not to submit a bid for the project.

Case Study #2

Case Study #2 involves installation of a 24-in steel wastewater casing under an active railroad easement, below five (5) active rails. To minimize disruption of rail traffic, the casing installation was designed to be completed by jack and bore (auger boring) methods. The proposed casing crown was designed with a minimum clearance of 13.5 vertical feet below the bottom of the lowest rail.

The proposed installation was to be completed in an area known to have an erratic, weathered bedrock (granite) surface. Despite this, subsurface investigations were not completed for the installation. Rather, the designer referenced test borings conducted for a building located over 600 feet away from the railroad (plan distance).

During installation of the casing by jack and bore, an obstruction was encountered at the approximate halfway point of the alignment, which caused warping of the casing. The Contractor engaged a test boring contractor to complete probes over the casing, and determined that shall bedrock was present beneath the rails. As excavation within the easement was not allowed, the Contractor elected to advance a 48-in casing over the 24-in casing to the obstruction. The 24-in casing was then retracted, and the 48-in casing advanced following removal of the bedrock using hand tools.

When posed with a differing site conditions claim, the Owner argued that the Contractor "should have anticipated" that shallow bedrock was present in the area, despite not have specific test borings. The Contractor's counsel argued that the design (24-in jack and bore) was not readily constructible as bid. The case is still in litigation.

9. CONCLUSIONS

It IS the responsibility of the Owner/Designer to bring a constructible project to the table. If a specific trenchless method is specified, then it is the responsibility of the Designer to verify that the project is constructible using common industry means and practices for the specified method.

Likewise, it is reasonable for the trenchless Contractor to assume that project can be constructed by the specified method(s) at the site, using industry standard means. The site-specific conditions represented in the Contract Documents at the time of award form the basis for Owner/Designer's assertion that the project is constructible as specified new information or unexpected conditions revealed after contract award will form the basis for change condition claims and contract renegotiation.

Owner/Designer responsibilities include using experienced staff when developing installation concepts and design documents. Interestingly, most contract specifications require the trenchless contractor have at least 5 years of experience with the intended installation method. This same experience requirement should also apply to design personnel. For complex projects, or projects with numerous trenchless installations, it may be worthwhile for the Owner to have third party complete an independent design review prior to project bidding.

During the bidding process, the Contractor needs to understand and weigh the risk of the proposed installation as represented by the Contract Documents. This includes careful study of the specifications, drawings, and available subsurface information. Don't assume that all projects are readily constructible as shown. In certain instances, the Contractor may have the opportunity to alert the Owner and/or designer to perceived design deficiencies. In other cases, it may be worthwhile for the Contractor to avoid bidding to minimize their exposure.

10. REFERENCES

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