CHALLENGES IN HDD DESIGN

By Jeff Puckett, P.E.

When considering the challenges that are involved in horizontal directional drilling (HDD), what typically comes to mind are the feasibility concerns that make HDD installations difficult to construct. Excessive crossing lengths, large pipe diameters, hard or abrasive rock, cobbles and boulders and solution cavities are good examples. My involvement in the HDD industry over the last 26 years has provided a thorough understanding of the issues that can impact the feasibility of a crossing. Having spent countless hours on HDD construction sites during that time, I've also developed a genuine appreciation for the numerous issues that HDD contractors have to manage. And while many of those issues do have an impact on HDD design, it's important to realize that engineers who design HDD crossings face a different set of challenges than the contractors who construct them.

Professional engineers are held to a code of ethics that requires prioritizing the safety, health and welfare of the public and adhering to principles that will protect the environment. In that regard, I've been fortunate to work with owners and contractors who share an unwavering commitment to safety and the environment. Engineers also have a unique obligation to design in accordance with applicable engineering standards. When applied to the HDD design process, this obligation encompasses not only the geometry of the design, but also the information that is needed to produce it and to complete any associated calculations. Having produced several of the publications that serve as guidelines in the HDD industry, the engineering standards that our company adheres to are fairly clear. Unfortunately, not everyone agrees on the standards that apply to HDD engineering services, and engineering standards don't necessarily apply to non-engineers who design HDD crossings. As a result, one of the challenges we face is educating our clients with regard to applicable standards and balancing our obligations as engineers with their project objectives.

When confronted with a particularly difficult crossing, we sometimes jokingly say that we can draw anything — implying that the challenging aspects of the crossing don't necessarily make it any harder to depict on a drawing, even if it's not actually feasible. But we obviously wouldn't be in business very long if we made a habit of producing crossing designs that couldn't be completed. It goes without saying that HDD crossing designs should be constructible, although crossings that either approach the state of the art or have significant feasibility issues may involve considerable risk and uncertainty. In such cases, we assist our clients in evaluating that risk and advise them if we believe it to be unreasonable. Such an evaluation is complicated by the fact that risk and feasibility are somewhat dependent on the skill and capabilities of the selected HDD contractor, which is rarely known in the early phases of a project.

A few of the other challenges that we frequently encounter in designing HDD crossings are described below.

Evaluating Hydrofracture Risk. During the design phase, it has become standard practice to evaluate the risk of inadvertent drilling fluid returns due to hydrofracture using quantitative methods, such as the Delft Equation. The results of this evaluation are conveyed to the client in a graphical format and are frequently used in securing permits. Ideally, the crossing can be designed in such a way that the hydrofracture calculations indicate a low risk of inadvertent drilling fluid returns. However, in certain subsurface conditions, particularly clay, it can be difficult, if not impossible to demonstrate that the crossing is in fact, low risk. One may assume these challenges could be remedied by simply going deeper, but the benefits of doing so are largely offset by increases in annular pressure due to additional hydrostatic head. In some cases, more favorable soils can be found at depth, which if targeted can improve the results of the calculations. But the decision to go deeper often increases the length of the crossing, in turn increasing the duration of construction operations. This introduces more drilling fluid downhole, which has the potential to increase the risk of inadvertent returns.

Compound Curves. HDD crossings are occasionally designed with simultaneous curvature in the horizontal and vertical planes, which is commonly referred to as a compound curve. Interestingly, compound curves may be easier for contractors to drill than they are for engineers to accurately draw in three dimensions. That said, compound curves can be problematic for contractors, as achieving the desired angular change in two planes at once is often more difficult than steering in a single plane. The greatest challenge with regard to compound curves during the design phase is the fact that simultaneous curvature in the horizontal and vertical planes results in a combined radius that is lower than the radius in either plane individually. As a result, the design radius in both planes must be increased, which often increases the overall length of the crossing. In some instances, this makes it impossible to fit a design within the desired easement.

Insufficient Subsurface Information. In some cases, either for reasons beyond the owner's control or in a deliberate attempt to reduce costs, the subsurface information obtained for design purposes falls well short of what is recommended based on HDD industry guidelines. This usually involves taking fewer exploratory borings than are needed, or extending the borings to a depth that is too shallow to be of much value. This presents challenges during the design phase as it impacts our ability to conform to applicable engineering standards and reduces the accuracy of our hydrofracture calculations. Insufficient subsurface information can also significantly increase the owner's risk as claims associated with unanticipated subsurface conditions are much more likely when there is not a clear baseline for the conditions that are expected.

Problematic Permit Requirements. Some of the requirements that we see from regulatory agencies, state departments of transportation, and railroads are challenging from the standpoint of HDD design as they either increase the risk of problems during construction or eliminate HDD as an option. One example is the requirement for a crossing to be perpendicular to a highway or railroad that is being crossed. This seems to be a reasonable requirement for crossings installed by trenching or conventional boring. However, when installing a pipeline beneath a highway or railroad by HDD, there often isn't enough space within the existing right-of-way for a perpendicular crossing to achieve an acceptable depth of cover. Modifying the alignment to cross at an angle allows for a greater setback from the obstacle, increasing the depth of cover and reducing the risk of surface impacts. Another example is the requirement for a deep HDD installation beneath a railroad to be cased. Typically, the only way this can be achieved is by installing a larger diameter casing by HDD, then pulling the pipeline into the larger casing. Installation of a larger pipe requires a larger diameter hole, which generally increases risk. This requirement occasionally results in HDD being eliminated from consideration and the crossing being installed as a shallow conventional bore, which could potentially involve a greater risk of impacting the railroad. Lastly, permit requirements sometimes limit the diameter of the reamed hole to less than what is typical in the HDD industry. This can increase the risk of getting the pipe stuck during pullback, and the reduction in annular space may not accommodate the additional drilling fluid that is displaced as the pipe is pulled into the hole, increasing the potential for inadvertent returns and surface heave.

Proximity to Existing Utilities. One of our greatest concerns in designing HDD crossings is the possibility that an existing underground utility could be damaged as a result of HDD operations. As long as all existing utilities in the vicinity of a proposed HDD crossing are known to exist and can be accurately located, we can typically design the crossing to provide a safe separation distance. Unfortunately, it is not always possible to identify and locate all of the utilities that could potentially be impacted. Avoidance of adjacent utilities that were also installed by HDD can present a considerable challenge during the design phase due to the fact that as-built documentation produced for HDD installations often doesn't accurately describe the location of the installed pipe or conduit.

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