DIRECTIONAL BORING RELIABLY BEING UTILIZED FOR SEWER INSTALLATIONS

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ABSTRACT
Over the last ten years, directional boring has become a standard construction method for many types of utilities. Lack of consistently accurate methods that could ensure success for sewer main installations has been the most significant obstacle preventing the construction technique from being used more in the sewer industry. There is no way to estimate the number of construction workers that will never be injured or killed due to the use of directional boring in deep installation projects. A patent pending process called ArrowBore is now being used to install mains at all depths with grades at or even below 0.5% utilizing commercially available equipment. This paper provides a discussion of the barriers to using directional boring in critical grade situations, a detailed description of the process that was used on projects in St. Louis, Missouri, Chicago, Illinois and Baton Rouge, Louisiana all are in the USA and how the process can be utilized in other areas of the world to provide utility owners with an effective and cost competitive construction option.

Local contractors with only a slight upgrade in technical training will be able to install lines for cities across the US and abroad utilizing this method. Many engineers and utility owners have only considered utilizing directional boring when potential capital cost savings were extremely high and there was no question that the savings would offset likely future maintenance costs. It is a long term higher maintenance costs for a short section of pipe offset by the potential capital costs of other construction methods. For these situations often the utility owner and the engineer's economic evaluation suggested most past installations have varied from 2% to 3%, which severely limits the practical use of this construction method to a very narrow sector of the market. Several challenges still face public works utility owners and engineers, this paper address some of the key challenges.

Keywords: trenchless, sewers, accountability, consistent, sighting, relieving, inspection.

INTRODUCTION

The directional boring construction method offers a potentially dynamic and useful tool for public works utility owners and engineers. It is becoming more popular in the water works industry, and will likely progress towards being a standard construction practice within the next few years as more general contractors start utilizing the technology. However, the lack of guiding devices that are accurate to the tight tolerances and a tight fit hole installation, that are required for sewer main installations has limited or often precluded the use of directional boring for all but a very limited sector of the sewer industry. Many engineers and utility owners have only considered utilizing directional boring when potential capital cost savings were extremely high and there was no question that the savings would be double or triple the likely future maintenance costs. Therefore, most sewer mains installed by directional boring in the recent past have been located in areas where significant variations in the design grade were available and noticeable sags and dips (sometimes on the order of inches) were reluctantly accepted. This approach will never be widely accepted by the public works industry, nor should it be.

Directional boring is a good construction technique and over time it will be used more in every field as people that use it become more efficient and effective. However, as simple as it sounds, in order for directional boring to be accepted for sewer main installations, procedures must be developed to assure the utility owners that the technique is consistently reliable. This paper discusses one procedure that provides a way to help utility owners achieve that assurance.

WHAT SEWER UTILITY OWNERS FACE

Most new or replacement sewer installations are in areas where there is "one-shot" at getting the main in the right place and an attitude of "well, that is close enough" cannot be tolerated. What is sometimes not understood is that this mandate of having an installation be done correctly the first time does not stem from any sort of vindictive malice by the utility owners. It instead comes from years of experiences that have taught, by financial woes, which a main with a design life of forty years may end up being used for sixty years or even longer.

What the sewer industry has been lacking with respect to using directional boring as a construction method is a way to be reasonably assured that the main will be installed in its proper place prior to the full length of the pipe actually being put in place. In open trench applications, an inspector can physically see sections of the pipe as the main is installed and to verify the location of each joint (if necessary) by survey techniques. In micro tunneling, a laser sight is used to determine the relative real world location of each section of the tunnel as it moves through the ground, within hundredths of a foot (or even more accurately). Most other sewer construction techniques can use the same approach of using reasonable means to verify the location of the installation of the main line pipe prior to actual completion. Directional boring on the other hand typically utilizes locating devices that relay information that indicates where the stem location should be within some range of a foot based on the depth of the locating device. With traditional directional boring methods the true accuracy of this stem information can only be determined after the pipe is installed and some kind of inspection device is used to see how the pipe looks. This wait and see approach is stressful to everyone involved and can result in significant problems for the contractor, the utility owner and the general public later if the main line pipe is not correctly installed. In pressurized or non-critical grade situations, the survey coordinates of any particular point in the pipe are only an issue when the pipe must miss an obstruction. In sewer mains, the pipe flowline ideally should be smooth and needs to be at a slope that meets the hydraulic characteristics of its intended use. Therefore, every point is critical throughout the main, with respect to both grade and line. Does this mean that every sewer main ever installed has to be absolutely straight, with zero deviation from either line or grade? In a perfect world, maybe. In a practical world that involves real, physical difficulties that human beings must overcome, probably not. However, because sewer systems are designed based on flow characteristics and projections that are sometimes several years in the planning it does mean that it will continue to be important for sewer utility owners to do their up-most to limit the extent of line and grade problems for any installation.

CAN DIRECTIONAL BORING OFFER THE REASONABLE ASSURANCES NEEDED?

Given enough time and money, engineers, manufacturers, contractors and utility owners could do just about anything. Advances in directional boring machines and related equipment have progressed rapidly over the last ten years, but the public works sector has remained fairly reluctant to utilize it for several reasons. Most of these reasons stem from either lack of adequate knowledge about directional boring in general or previous bad experiences with poor workmanship by other utility installations that used directional boring. This leads to the real question: Can a method be incorporated with commercially available directional boring machines and equipment so that qualified contractors can utilize them now rather than at some point in the distant future?

THE ARROWBORE METHOD

The ArrowBore Method complements existing electronics and incorporates physical verification of the location of the directional boring machine's stem as it is advanced through the ground. Excavations, termed "sight-relief holes" (picture shown below) are used at certain points throughout the bore path to provide both the contractor and the utility owner's inspector with a way to visually inspect that the drill stem is installed in the correct place prior to final installation of the main. Two important things happen, the boring crew is held accountable based on the documentation at each sight-relief hole and projects are consistently completed.

Once the pilot bore is completed, a back reamer sized just slightly larger than the main, typically 1/4" to 1/2" larger than the O.D. of the pipe is connected and a hole is reamed ahead of the pipe to be installed. The distance between the back reamer and the pipe is determined by the greatest distance between the sight relief holes. The sight-relief holes allow for the relief of fluid pressure (picture shown above), while a portable vacuum machine removes the excess spoils created during the placement of the main. The "tight-fit" hole eliminates the possible deflection and flotation from line and grade that can occur when a hole is reamed to a size 1.25 to 1.5 times the O.D. of the pipe as is general practice with conventional directional boring methods. The process also allows projects to be installed at depths that vary from 15 to 25 feet with little change in cost. Much deeper depths are achievable and can possibly omit the need for lift stations in some areas. This process works well in sewer and water projects.

The process uses commercially available equipment that has relatively minimal mobilization expense. This low mobilization cost coupled with the fact that low cost tooling can be used, makes the relative risk factor for an individual bore much less than other trenchless techniques. Although this process is not completely excavation free, it is obviously much less intrusive than an open trench method. ArrowBore greatly reduces deep ditch exposure to employees and the public. Cost competitive pricing provides an attractive combination for both the private and public sector.

DIRECTIONAL BORING AS A CONSTRUCTION METHOD

The advent of directional boring has provided another potential construction method for sewer construction. However, some aspects of traditional directional boring must be further developed and refined in order to successfully use directional boring for sewer installations. Due to limitations in locating equipment, it has been difficult to consistently maintain the correct line and grade requirements of sanitary sewers. In the past, directional boring has been considered an option for grades of approximately 2% or more with the caveat that the main lamping upon completion was likely to be sacrificed. If used extensively this approach could result in increased long-term maintenance costs for some installations unless serious consideration is made beforehand. Additionally, it is likely that gravity sewer installations with slopes of 1% or less will continue to be common. With better techniques to ensure line and grade requirements are met, directional boring is another option in addition to auger boring, microtunneling and open trenching.

HORIZONTAL DIRECTIONAL BORING
Horizontal directional boring in its simplest form consists of using a machine (shown below), typically placed above ground, to advance a series of rods through soil or rock from one point to another and to install a product pipe. The methods used to achieve the result vary extensively. This type of installation is typically less satisfactory in rock conditions and often unsatisfactory in cobble or gravel conditions. Although considerable advancements have been made in both of these areas, it is however, well suited for clays and sands.

A partially hollow tube of steel, referred to as beacon housing, is typically attached to the first drill rod. A calibrated beacon that produces a magnetic field is placed in the housing. The beacon signal is read by locating equipment above ground, although a direct connection to a wire line system may be utilized. Usually, an angled plate on the front of the beacon housing (shown below) is used to adjust the direction of the sections of drill pipe, or drill string, as it is pushed forward during the pilot bore. Once the pilot bore is complete the hole is reamed to the proper size and a product pipe is installed. The equipment used for both the beacon and reaming process, referred to as downhole tools are usually relatively inexpensive.

TRADITIONAL DIRECTIONAL BORING INSTALLATIONS

Traditional directional boring requires that the flow of boring fluids be maintained around the product pipe and out the back of the bore hole as it is installed. Utilizing this technique can provide consistently good results in ensuring that the product can be successfully installed if the fluid flow is maintained (picture below show what happens when the fluid flow is not maintained). Often it is necessary to use a reamer that creates a hole approximately 1.5 times the diameter of the pipe being installed in order to maintain the large volume of fluid flow and prevent either pressure build-up in the hole or collapse.

Fluid pressure causes damage to surface areas

However, due to pipe buoyancy, variable fluid and soil composition, and other factors, it is unlikely that consistently successful results for grades of 1% or less will be achieved using this directional boring technique for sewer applications since the pipe can fairly easily deflect off line and grade in a hole this size.

POTENTIAL MARKET FOR SEWER INSTALLATIONS UTILIZING DIRECTIONAL BORING

The largest potential market for directionally bored sewer installations is in areas that are currently constructed utilizing open trench methods. Although directional boring machines are more sophisticated to operate than most open trench equipment, with some training and personal initiative most open trench operators can learn the techniques. One key future benefit this may represent for utility owners is that more contractors may utilize this type of construction on a value engineering basis. Directional boring utilizing midi-size rigs has some distinct advantages with respect to auger boring and microtunneling in this respect.

For a microtunneling installation each drive runs the risk of loosing many thousands of dollars worth of equipment if the tunneling equipment gets stuck or experiences unexpected malfunctions. This leads to higher risk assessment costs and therefore it is often not practical to attempt to use microtunneling unless the project was initially designed and bid for its use. For auger boring installations, length of the installation provides significant challenges to maintaining line and grade. Many areas of the U.S. use a distance of 400 linear feet (LF) between manholes as a standard distance. Consistently achieving correct grade at lengths of 400 LF is difficult utilizing auger boring methods. Additionally, both auger boring and microtunneling installations require fairly large and well-prepared excavation areas in which to begin the installation. Therefore, it is often economically prohibitive to specify these methods, even in areas that would have fairly high social cost if specified open trench. The cost of casing as well as actual product pipe for auger boring installations and the risk of potential damaged equipment for microtunneling as well as the excavation costs associated with preparing beginning point pits for both options are significant factors that deter their use unless specified and bid accordingly.

Directional boring requires smaller beginning pits, typically the size of excavations required for placing manholes so excavation costs are less. Typical sewer length installations have relatively little adverse impact when using directional boring and often a longer installation is less expensive per foot than a shorter one since mobilization and preparation costs can be allocated over the longer distance. As mentioned previously, downhole tooling is relatively inexpensive. Since more of the costs associated with directional boring are tied to the actual machine itself and the labor involved and less with respect to the downhole tools, there is a reduction in risk-related costs. Another significant advantage for contractors includes the fact that the machines can be used for installing other types of utilities during periods of low volume sewer work.

SEWER INSTALLATION METHODS UTILIZING DIRECTIONAL BORING

Two key elements must be addressed in order to successfully install gravity flow sanitary sewers on a consistent basis at slopes of less than 1% utilizing directional boring:

1. The locating equipment will need to be improved to allow more reliable indications of the actual location of the beacon housing for both line and grade or a process will need to be used that provides accurate verification of the beacon housing at certain points throughout the installation.

2. The pipe should be installed in a hole that is not much larger than the maximum outside diameter of the pipe while still preventing pressure build-up in the hole. Displacement of the volume of soil of the pipe being installed is the key factor to preventing this pressure build-up. By having a bore hole that is close to the same size as the maximum outer diameter of the pipe, the potential deflection and flotation of the pipe in the hole during installation is limited, both with respect to line and grade.

In order to address these issues, a process must have a way of displacing the physical volume of soil or fluid that it will take to install the pipe. The process should also have a way of verifying the actual location of the drill string at certain points along the path of the installation, primarily due to limitations in current locating equipment reliability at any significant depth.

A proprietary, patent pending ArrowBore process has been developed by Trenchless Flowline, Inc. a Columbia, Missouri based technology company that currently specializes in developing trenchless technology for the sewer and water industry. Other potential methods and processes may be forthcoming from Trenchless Flowline, Inc. and others in the industry as well.

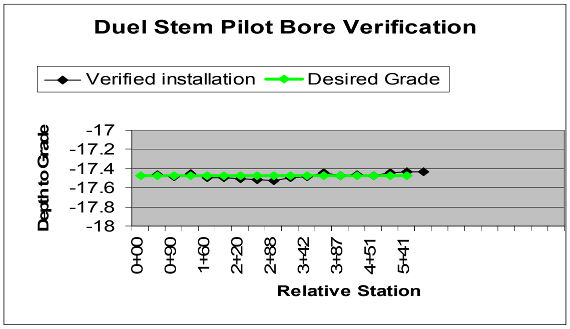
SEWER INSTALLATIONS UTILIZING DIRECTIONAL BORING

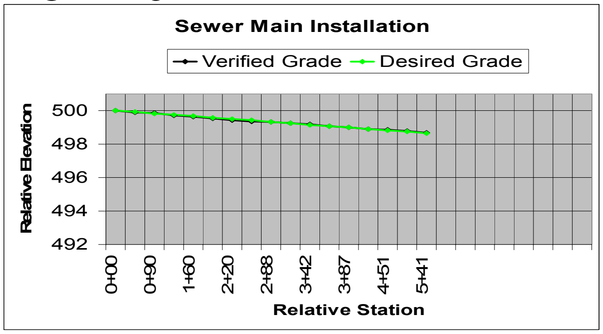
Marshalltown, Iowa utilized directional boring extensively for sewer installations in 1999, and although design changes were made with respect to line and grade, city personnel considered the method a general success. Most of the installations utilized traditional directional boring techniques.

The St. Louis, Missouri Metropolitan Sewer District (MSD) has allowed some pilot installations in areas originally slated to be open trenched in order to evaluate the use of a process with directional boring as a potential construction method. Concern with respect to future maintenance costs as well as initial construction costs necessitates that the base line requirement be that grade be maintained within a small percentage of the design grade and that the line lamp upon completion, just as would an open trench installation. For one MSD project, a 520 LF 16" pipe installed at a 0.50% slope, a manhole was set near the middle as planned in the design phase and the pipe lamped upon completion. Another 1,440 LF of 16" pipe with a grade of 0.86% was completed with the same results. Other pipe sizes have been completed including an 8" 230 LF installation also for MSD. Other projects in Chicago, Illinois at 0.70% and Baton Rouge, Louisiana at 0.27% all indicated that this process used with directional boring, can be reliably used as a construction method for sanitary sewer lines with relatively shallow slopes. All of these projects utilizing directional boring have been on projects that were bid as open trench and the contractors and owners have agreed to lump sum calculations of anticipated unit prices. This approach can provide the contractor with an option to directional bore a section, while providing the owner with a trenchless installation. Thereby limiting the impact of the installations on the local citizens and the possibility of project change orders resulting from the unknowns that seem to show up when open trench methods are used.

Open trench methods cause damage to surface areas

Baton Rouge 10" PVC @ .26% grade





Green line represents the planned bore path; the black is the actual bore. As shown in the charts the project was within hundreds. Each square box is a sight-relief hole.

CONCLUSIONS

Techniques involving processes and improved locating equipment are rapidly improving the viability of using directional boring for sewer applications, even at shallow slopes (less than 1%). Within the next two years, it is very likely that directional boring installation of sanitary sewer lines will become more and more prevalent. By accepting it as a potential method, the public works sector can help to refine, promote and improve the use of this incredibly diverse tool and help to achieve the goal of constructing new, safe and reliable sewer and water lines while minimizing the impact to the general public. Case study information is available; just send your request to www.info@trenchlessflowline.com or www.info@Advantica.biz

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