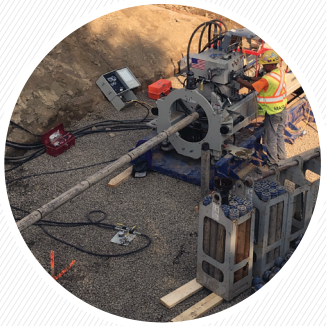
GUIDED AUGER BORING

Method of Operation



AKKERMAN

GUIDED AUGER BORING OVERVIEW

Guided Auger Boring is the method of accurately installing pipelines by using a guided boring machine (GBM) system in conjunction with an auger boring machine to:

- Ensure bore accuracy,
- maximize drive lengths,
- expedite installations,
- avert downtime associated with failed bores and
- obtain project savings.

This method has become the most common application for our guided boring systems in the US, and with ever-evolving tooling innovations, its utilization has positively impacted the auger boring market in the last decade and furthered industry expectations on what can be achieved.

Auger boring has been around since the 1940s, and the machines are widely manufactured and commonly used. Traditional auger boring is used for installing steel casing pipe under roads, railroads and other obstacles. Auger boring systems are powerful and cost effective; however, they cannot achieve an accurate installation.

Historically, options for determining auger boring alignment were limited. Often the lead casing grade was checked with a water level or laser by pulling back the augers to survey at the lead casing, if the casing was large enough to allow for personnel entry. Because of this, drive lengths were also limited to 200-lf. or less. If corrections were needed, the contractor would manually manipulate the casing's lead edge to correct and maintain alignment. These approaches are time-consuming and unsafe in certain ground conditions.

Today's contractors must contend with a variety of buried utilities and manage pipe installations in much tighter corridors than in years past. Auger boring contractors are finding fewer instances where they have the luxury to perform an unguided bore, and often project specifications require an accurate grade with narrow easements and tight tolerances. The method of guided auger boring is necessary to accurately install a pipeline where there is little or no surface access, in environmentally sensitive areas, and under active highways to name a few.

With the advent of enhanced digital camera technology, it is possible to see the guidance system's LED target at a greater distance. The Akkerman GBM guidance system can maintain line and grade within a quarter of an inch at distances of approximately 400 linear feet. Given ideal geological conditions, distances of well over 500 linear feet are regularly achieved with the same level of accuracy.

Guided auger boring also saves the contractor in project casing costs. Typically on an unguided auger bore, contractors will select oversized casing to create a larger annular space to correctly position the interior carrier pipe to achieve the required alignment. When an accurate line and grade is obtained, a smaller sized casing can be used with the added benefit of producing less soil volume for disposal.

Another advantage of guided auger boring is using pilot tubes for exploratory work. Using pilot tubes as a probing tool is a minimal investment of time in the instance where abandonment must occur due to an insurmountable obstacle.

A few hybrid guided auger boring applications have also emerged including guided pipe ramming and pipe roofing.

When a contractor adds a guided boring system to their fleet, they can also bid on stand-alone three-pass guided boring projects.

In summary, the reasons to guide your auger boring machine are:

- Improved accuracy - within a 1/4-inch (6 mm) per 400-linear feet (122 m) versus 36-inches (914 mm) per 300-linear feet (91 m) deviation with an unguided bore
- Longer drive potential in ideal ground conditions
- Smaller casing sizes equal cost savings and less soil volume produced
- Faster installation
- Exploratory work – find obstacles

EQUIPMENT FOR A GUIDED AUGER BORE

All guided auger boring operations begin with the installation of the pilot tubes across the full length of the bore. Pilot tube installation is accomplished by using several key components from the guided boring machine (GBM) system:

- Pilot tubes,
- soil appropriate steering head,
- guidance system,
- jacking frame,
- power pack and
- lubrication pump.

Pilot Tubes

Akkerman's Dual-Wall Pilot Tubes allow for fluid passage to the steering head through a 1.3-inch (33 mm) outside ring and visibility of the guidance system's LED illuminated target in the 2.8-inch (71 mm) inner tube (see Figure 1) for target visibility and steering control. When pilot tubes are connected, o-rings prevent water from entering the inner tubes. Pilot tubes are robust and designed to withstand high rotational and jacking forces.

Figure 1. Dual-Wall Pilot Tubes allow for fluid passage to the steering head through an outside ring and visibility of the guidance system's target in the inner tube chamber.

When properly maintained, a contractors' inventory of pilot tubes sees thousands of linear footage.

For convenient handling, cleaning and maintenance pilot tubes are stored and transported in racks containing twelve or forty pilot tubes.

Steering Head

The lead pilot tube adapter features an affixed steering head (see Figure 2) that is compatible with the project's ground conditions. For example, a bullet steering head has the least amount of surface area and is used in high blow count geology, and a blunt 45-degree head is used in soft geology.

Figure 2. A bullet steering head is used for high blows count ground and a blunt, 45-degree steering head is used for soft ground conditions.

Guidance System

The guidance system contains:

Theodolite with remote focus,

camera with video surveillance system,

LED illuminated target (see Figure 3), and

digital computer-controlled monitor assembly.

Figure 3. LED illuminated target.

The guidance system is used to monitor the location of the target in the steering adapter. The theodolite with a camera on the telescope and video surveillance system is positioned between the jacking frame cylinders to site-down the center of the pilot tubes, and the theodolite's cross hairs are set to the drive's line and grade. The guidance system monitor assembly is positioned on the monitor mount on the jacking frame and adjusted to view the target (see Figure 4).

Figure 4. Operator viewing target's position on monitor.

Jacking Frames

All Akkerman GBM jacking frames can be used for the guided auger boring method, but the GBM 240A jacking frame was specifically designed to mount and clamp on auger boring machine track with a universal adapter that adjusts to fit the track width and elevation of most auger boring machines on the market.

When the launch and reception shafts are excavated and shored, the pit floor is installed at the alignment's line and grade. Next, the auger bore track is installed. The jacking frame is placed at the front most position on the auger bore track, closest to the bore entrance point and set on the centerline of the bore path. The auger boring machine is secured on the track directly behind the jacking frame and serves as a backstop during pilot tube installation. The GBM 240A Jacking Frame installs each pilot tube with smooth and continuous advancement using dual 48-inch (1,200 mm) stroke cylinders. The jacking frame's jacking force is designed for up to 100 tons (91 mt), and pullback force of 50 tons (45 mt).

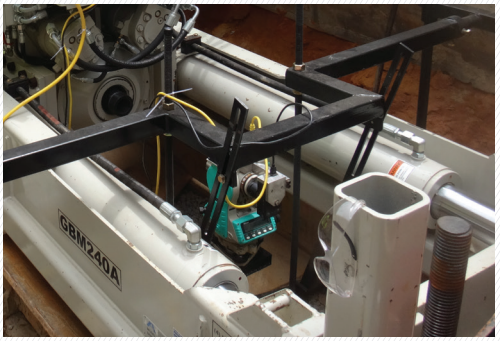


Figure 5. Guidance system mounting stand is used to position the theodolite between the jacking frames' thrust cylinders.

Power Pack

The power pack is positioned alongside the launch shaft to provide hydraulic power for the jacking frame and electric power to the guidance system. The power pack assembly is housed in a secure container which also provides storage for pilot tube tooling and accessories.

Lubrication Pump

The proper selection and application of lubrication is an essential step for successful pilot tube installation to reduce friction and decrease jacking thrusts. Lubrication also assists to flush cuttings, provide ground stability and ease thrust resistance during the installation of subsequent increase tooling. Akkerman currently offers five diesel engine and electric motor single and dual tank lubrication pump models to suit a variety of project requirements. Lubrication pumps house bentonite and/or polymers for continuous in-tank mixing and provide fluid supply and pump pressure for many bore lengths and ground conditions. The use of a lubrication pump is particularly important for rock pilot tube installations where the flushing of cuttings is essential to the bore's success. Depending on the procedure, the lubrication pump might be utilized from the jacking or reception shaft to introduce lubricant to the increase tooling. Contractors are advised to consult with a qualified mud supplier to pair the correct drilling fluid with the project's geological conditions before the project begins.

GUIDANCE SYSTEM SET-UP

After the jacking frame is correctly positioned on the auger boring machine track, the next step is to set up the guidance system in a manner that protects it from the effects of movement or vibration from the jacking frame, nearby equipment or personnel.

A guidance system mounting stand is used to position the theodolite between the jacking frames' thrust cylinders on the centerline of the bore (see Figure 5). The stand's mounting stakes are secured on both sides of GBM jacking frame, away from any moving parts in the launch shaft. The theodolite is attached to the mounting stand with an adjustable platform that is used to level and align the theodolite.

The target is inserted into the target holder and placed inside the steering head adapter. A soil appropriate steering head is connected to the steering head adapter and threaded into the swivel drive assembly on the jacking frame gear box.

PILOT TUBE INSTALLATION

After the steering head is launched, pilot tube installation commences. As the operator advances each length of pilot tube, a new pilot tube segment is threaded onto the former and pushed forward by the hydraulic cylinders on the jacking frame. The pilot tube racks are positioned next to the frame for easy operator access. Lubrication flows through the annular space in the pilot tube string to the lubrication port on the steering head bill.

While the pilot tube advancement is happening, the operator concurrently assesses the target's position on the monitor to keep the pilot tube string on line and grade. If an adjustment is necessary, the operator rotates the steering head in the appropriate direction and pushes the pilot tube string forward. As pilot tubes are advanced, the angled steering head displaces the ground in the direction that it is rotated until line and grade are corrected. While this sequence unfolds, operators log the jacking and rotational forces to make note of any ground changes to prepare them for what to expect during the casing installation.

On projects with extra long distances, dry nitrogen can be used to flush the pilot tube sight path to reduce moisture and improve visibility of the target.

Pilot tube installation is complete when the steering head reaches the reception area (see Figure 6). The pilot tubes have now established a path for subsequent tooling and pipe installation with the auger boring machine. The guidance system and GBM jacking frame are removed from the launch shaft and the auger bore machine is positioned on the track to accommodate the steel casing length. A pilot tube adapter connects to the last pilot tube to the lead casing with cutter bit, increase tooling or reaming head.

The auger boring machine finishes the installation of the steel casing as the interior augers remove the soil. As the tooling string advances, pilot tubes are simultaneously un-threaded in the receiving area.

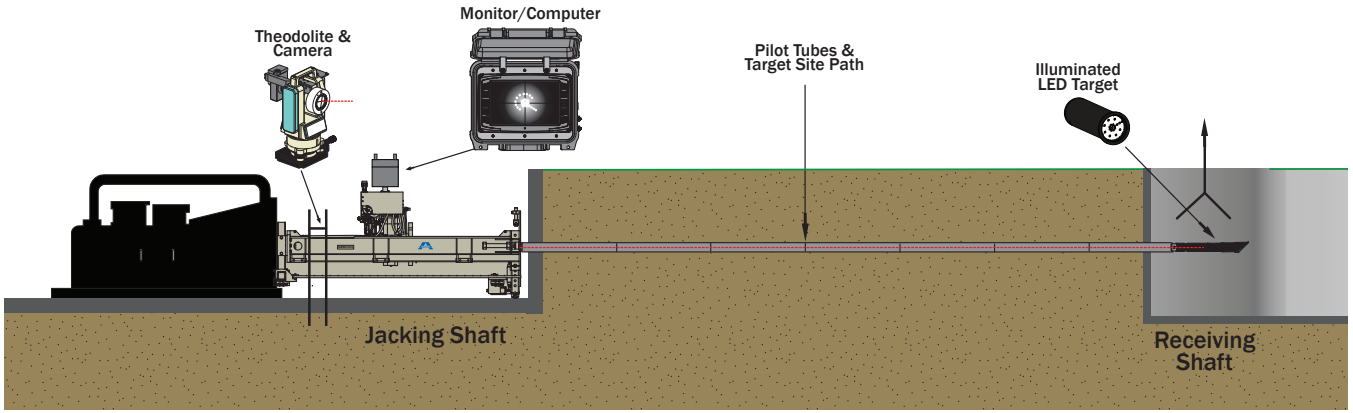


Figure 6: Installation of Pilot Tubes on Line and Grade

TO INSTALL PILOT TUBES IN UP TO 12 KSI UCS ROCK

In non-displaceable soil and rock geological profiles up to 12 ksi UCS, the Rock Drill Adapter (RDA) and a TriHawk® drill bit or other soft rock steering head tooling provide a means for accurate pilot tube rock installations. The technology works best in somewhat homogeneous geologic conditions where the drill bit can engage the entire hard ground or rock mass. The assembly is not intended to work through cobbles and boulders where the drill bit is likely to deflect from its intended path.

The RDA houses the guidance system's target and features a splined adapter that mates to a TriHawk® drill bit or commercially available drill bit to the lead pilot tube (see Figure 7). Steering control with the RDA and drill bit is managed by carefully advancing the drill bit while cutting only in the direction of the desired movement and with much lower thrust pressures than a standard pilot tube installation. Akkerman GBM Jacking Frames are equipped with an RDA jacking pressure control assembly so the operator can conveniently manage these levels when using the RDA assembly.

Instrumental to the successful operation with the RDA and drill bit is the continuous use of a bentonite and/or polymer to cool the drill bit and provide the proper viscosity to flush and carry the cuttings away from the face of the bore. Lubrication travels through the annular space in the pilot tube, then out through the drill bit port where it mixes with the cuttings to flush back to the launch shaft. Again, contractors should consult with a qualified mud supplier at the onset of the project to receive ground appropriate recommendations.

SWIVELS PREVENT ROTATION OF PILOT TUBES

Swivels can be used between the pilot tube adapter and cutter bit to reduce rotational forces on the auger string and prevent rotation of the pilot tubes while the cutter bit excavates. Akkerman offers several varieties of high thrust bearing swivels, and some are designed as a swivel and cutter head assembly combined for excavating difficult ground.

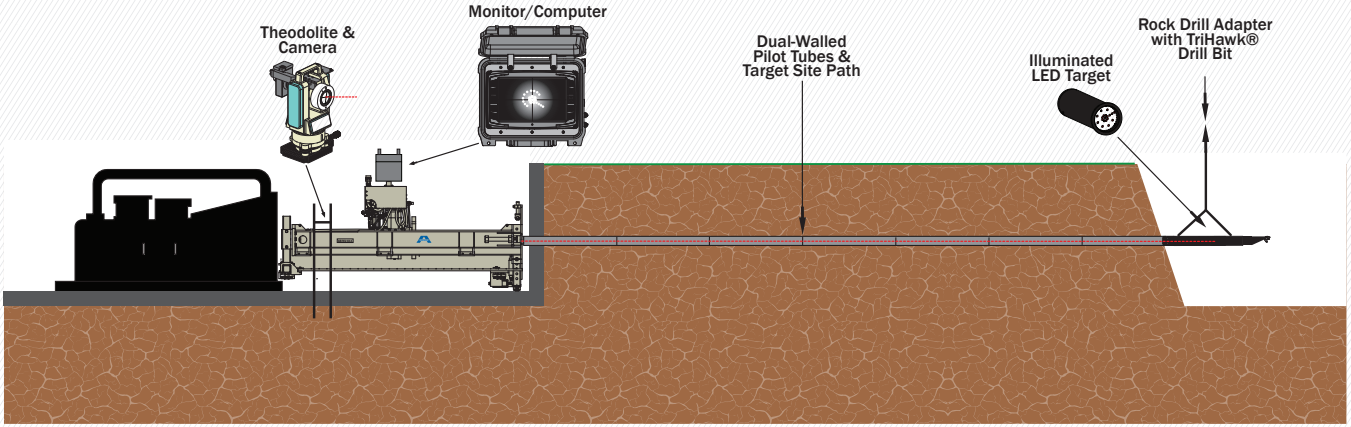


Figure 7: The Rock Drill Adapter adapts to TriHawk® drill bit and other soft rock steering head tooling to lead the installation of pilot tubes in up to 12 ksi UCS ground conditions.

INCREASE TOOLING OPTIONS

By the time the crew is ready to install the final steel casing pipe, they already have an idea of the bore's ground conditions and the locations of ground variability based on their pilot tube installation experience. This information, along with project's geotechnical data will inform the best choice of increase tooling to match the steel casing diameter.

Weld-On Reaming Heads

In soft, non-compacted ground, where the casing can be easily advanced with the thrust of the auger boring machine, a Weld-On Reaming Head (WORH) is used to increase the steel casing diameter. As the name implies, WORHs are welded to the casing and feature arms that connect to the pilot tube and casing. The arms are flush with the inside diameter of the steel casing to allow for correct positioning of the cutter bit and augers for soil removal from the pipeline. The arms on the WORH cut the soil into chunks, much like a cookie cutter, which allows it to be enveloped into the casings for removal by the augers. As this process unfolds, the casing follows the line and grade established by the pilot tubes. The WORH is connected to the pilot tube adapter with a heavy duty guide rod to provide rigidity and reduce potential damage to the pilot tubes.

Single-stage WORHs are available from 12-36-inch (304-914 mm) diameters. The typical tooling sequence for the single stage WORHs is:

- Pilot tube adapter connected to
- heavy duty guide rod(s),
- connected to single-stage WORH,
- connected to final steel casing with enclosed augers for soil removal (see Figure 8).

If the final steel casing diameter is 36 or larger (914 mm+), a single-stage WORH of a smaller diameter is attached to the pilot tube as an intermediate step followed by a two-stage WORH that marries the smaller casing to the final diameter casing. The length of the smaller diameter intermediate casing can be as short as 10-feet (3 m) or as long as the full length of the bore depending on soil conditions and contractor preference.

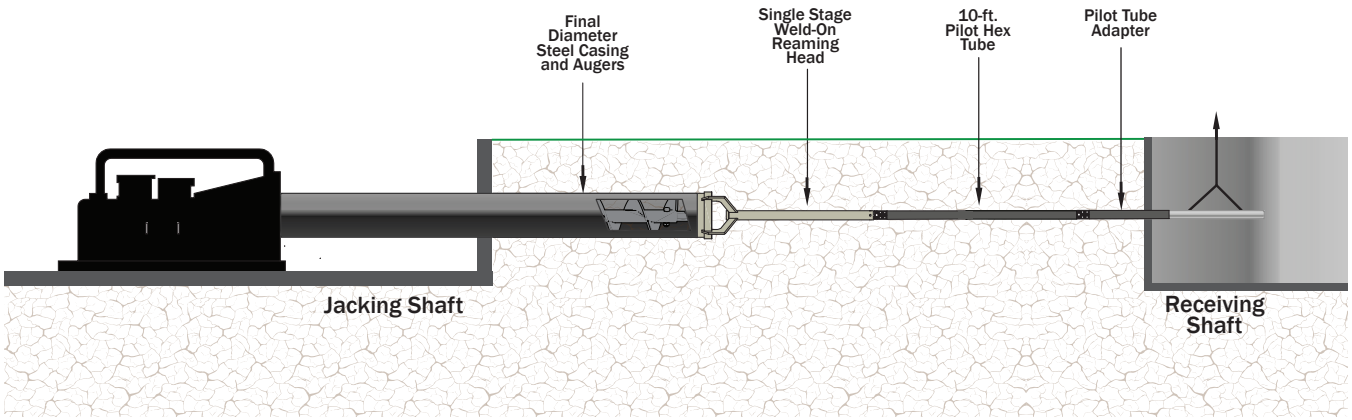


Figure 8: Upsizing to the Steel Casing with the Single-Stage Weld-On Reaming Head.

The typical tooling sequence for a two-stage WORHs installation is:

Pilot tube adapter connected to

heavy duty guide rod(s),

connected to single-stage WORH and matching diameter steel casing and auger,

connected to two-stage WORH and

connected to final steel casing with enclosed augers for soil removal (see Figure 9).

Figure 9. Upsizing to the final diameter steel casing with a two-stage WORH.

All-in-One Swivel, Guide Rod and Cutter Head

The Guide Rod Swivel (GRS) 50 (Figure 10) is a bearing swivel, interchangeable cutter head and pilot tube guide rod combined. The GRS-50 family contains six of the most common steel casing diameters with cutter heads that can be interchanged with the assembly's universal bearing swivel. The GRS-50 withstands up to 50 tons of continuous thrust to excavate stiff and difficult ground and has a reusable, weld-on steel casing housing, a cutter head with retractable wings cutters, and a bearing swivel that connects to the auger string. The GRS-50 connects to the pilot tube string with a guide rod

Figure 10. Swivel, guide rod and cutter head all-in-one.

attached to the pilot tube adapter. The GRS-50 can be pulled back from the casing in the event that an obstacle is encountered, or for inspection of the tunnel or cutter face and reconnected with the guide rod without losing line and grade. Lubrication can be run from the reception shaft through the pilot tubes and guide rod to flush the cutter head.

To Install up to 42-Inch Steel Casing in Rock

The Rock Boring Unit (RBU) is used to install steel casing as large as 42-inches (1,070 mm) in diameter in up to 25 ksi UCS rock (see Figure 11).

Figure 11. Rock Boring Unit (RBU).

The RBU housing is welded to the steel casing and the lead auger is attached with a hex connection (see Figure 12). The RBU increases the diameter of the bore by fracturing and excavating rock with disc cutters. Paddles in the cutter face move soil through the assembly to the augers for removal.

HYBRID METHODS OF GUIDED AUGER BORING

Contractor ingenuity has brought about several unique guided auger boring methods including guided pipe ramming and pipe roofing.

Guided Pipe Ramming

Guided pipe ramming was first conducted in 2006 to rescue a stuck auger bore on a project in Farmington, UT to install 24 and 36-inch (600 and 900 mm) casing under railroad tracks. The method has since become a standard service offering for several contractors to install up to 144-in. (3.7m) casing. Guided pipe ramming uses the guided auger boring method of accurately installing pilot tubes to establish line and grade which are followed by a pneumatic pipe hammer powered by an air compressor which attaches to back end of the product pipe (see Figure 13). The hammer transfers

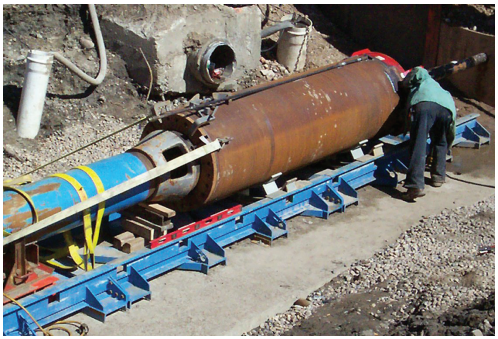


Figure 13. The first guided pipe ramming project in 2006. Photo credit Claude H. Nix Construction.

force to the open-ended pipe to advance it with repetitive blows. Contractors like this method because it can be an economical solution for short large diameter casing installations in difficult ground, and the pneumatic hammer ensures ground control at the face of the excavation so the potential for settlement is minimal.

Guided Pipe Roofing

The guided pipe roofing method is used for short tunnels, culverts or crossings for extra reinforcement in heavily traversed regions for stress distribution and to mitigate

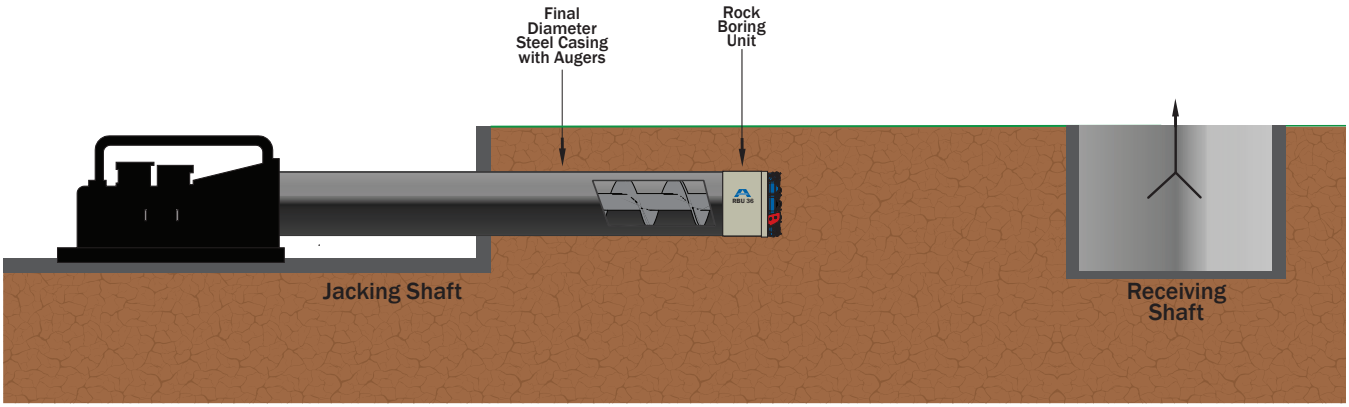


Figure 12: The Rock Boring Unit is used to excavate up to 25 ksi UCS rock.

Figure 14. Example of a pipe roofing project using a GBM system to install pilot tubes for accurate steel casing placement. Photo credit LRL Construction Co. Inc.

ground settlement (see Figure 14). Interconnected lengths of steel casing following the pilot tubes to provide an arch or roof above a support structure, culvert or tunnel.

Pilot tubes are first successively installed to form the arch on line and grade. The GBM jacking frame is positioned on an adjustable platform to relocate the point of entry for each pilot tube pass. The passes are usually finished with steel casing installations by an auger boring machine but depending on the pipe diameter and ground conditions, the GBM jacking frame can be used as a stand-alone system to install the steel casing. The casing arch is often filled with concrete and rebar and soil improvement is inserted around the outside of the structure.

CONCLUSION

The use of a GBM system to provide accurate and extended length guided auger boring pipe installations has positively changed the trenchless market and granted many auger boring contractors the potential to bid on new and more challenging projects. Future guided auger boring innovation will expand the range of available increase tooling options for longer lengths, larger diameters and harder rock.

NOTES:

AKKERMAN

DRIVEN FOR CUSTOMER SUCCESS

Since 1973, Akkerman has developed, manufactured and supported quality pipe jacking and tunneling solutions that accurately install a variety of underground infrastructure. We are proud to be the only North American manufacturer of our range of equipment and a global competitor.

Symmetry with contractors has been the backbone of our business and a point of distinction above our competition. Before Akkerman the equipment manufacturer there was D. H. Akkerman Construction Company. To satisfy their need to accurately install pipe under crossings, the manufacturing branch of Akkerman was founded forty five years ago.

Our business operates with the highest level of integrity and Akkerman employees have a personal investment in our customers' success. Our highly skilled sales team has a clear understanding of industry demands. Our in-house engineering department applies the most current standards and continually reviews, reassesses and enhances our equipment offerings.

We are committed to making every effort to position our equipment on your next project. As an added benefit, the purchase of a complete equipment system includes crew training and technical support. Akkerman systems are available for purchase, lease-to-purchase, or rent from our rental fleet. Select equipment will be considered for trade-in. Contact us to pair the best option with your requirements.

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