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Comparing Guided Auger Boring Techniques under Challenging Conditions

Matthew Pease, Staheli Trenchless Consultants, Bothell, WA
Laura Wetter, Staheli Trenchless Consultants, Bothell, WA

1. ABSTRACT

A Southern California water district is currently building portions of a regional Salinity Management Pipeline (SMP) in Ventura County, California. The SMP will collect and convey salty water generated by groundwater desalting facilities and excess recycled water for reuse, or for discharge into the ocean when there is no demand for reuse. The pipeline is being constructed in multiple phases over the course of several years.

Phases 2A and 2C of the project used two types of guided auger boring methods – auger boring with a pilot tube and auger boring with a steerable head – to install pipelines to tight line and grade requirements. Both of the methods were used in challenging geotechnical conditions that included silty sands containing gravel seams and occasional cobbles. This paper presents two case histories – one for each of the guided auger boring methods – and compares and contrasts the two methods. It compares production rates, difficulties during construction, and the accuracy of each method.

2. INTRODUCTION

The Salinity Management Pipeline (SMP) is currently being constructed in multiple phases by a water district in Ventura County, California. Phases 2A and 2C of the pipeline were both installations of 42-inch diameter steel casing less than 100 feet in length, to be constructed within silty clay, silty sand, and sandy silt with gravel seams and occasional cobbles. Both casings were originally specified to be installed using pilot tube guided auger boring. Phase 2A was ultimately installed per the specification using the pilot tube auger boring approach. However, for Phase 2C, the boring subcontractor requested that they be allowed to use a steerable head in lieu of the pilot tubes for guidance control. This request was reviewed by the project team and was approved as an acceptable alternative for the casing installation.

This unique situation provided a rare opportunity to directly compare two similar methods in nearly identical conditions. It was hoped to learn how the differences between the two methods would impact the installation of the casing in terms of accuracy, overall production rates, and difficulties encountered during construction.

3. GUIDED AUGER BORING METHODS: PILOT TUBE VS. STEERABLE HEAD

Two types of guided auger boring techniques – pilot tube auger boring and auger boring with a steerable head – were utilized throughout Phases 2A and 2C to install casings for the SMP. Although both guided auger boring techniques rely on passive soil resistance to deflect the installation in the desired direction, there are fundamental differences between the guidance components of each method.

Pilot tube auger boring, also commonly referred to as guided auger boring, pilot tube microtunneling, or more simply the pilot tube method, utilizes a pilot bore to obtain high levels of accuracy in line and grade before proceeding with jacking of steel casing and excavation of the borehole via auger flights. The guidance system incorporates a camera mounted on a digital theodolite set to the design line and grade, an LED illuminated target located within the lead pilot tube identifying the center of the pilot tubes and the direction of the slant-faced steering head, and a monitor mounted to the guided boring machine (GBM) to display the camera's image of the LED target (Figure 1). To correct for any deviation in line and grade, the slanted steering head is positioned so that the slant points towards the intended direction of travel and the pilot tubes are jacked forwards without rotation. To advance at constant line and grade, pilot tubes are continuously rotated during jacking. This guidance method commonly enables accuracy in line and grade of plus or minus 0.25 inches over drive lengths up to 400 feet.

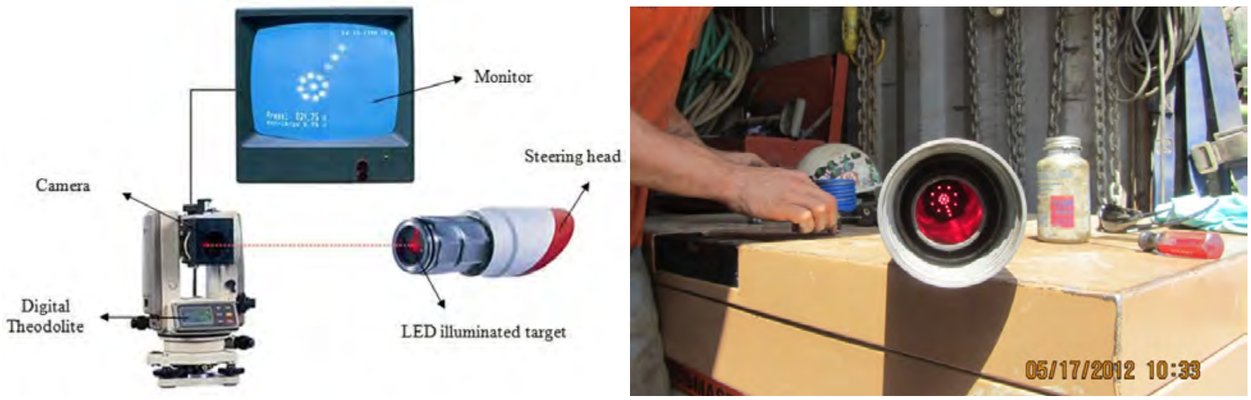

Figure 1. Pilot tube guidance system (left) and LED illuminated target (right).

Successful jacking of pilot tubes relies on being able to displace the soil. This generally limits pilot tube applications to soils with standard penetration (SPT) blow counts (N-values) less than 50. Cobbles and boulders can also pose difficulties to this installation method. An expansion/load transfer device, typically referred to as a "reaming head" or "spider," is used to link the larger diameter casing to the last pilot tube and transfer jacking forces from the former to the latter. Although use of the reaming head is fundamental to the methodology, it decreases the size of rock able to be ingested into the casings.

Steerable heads provide a more simplistic guidance methodology in comparison to the pilot tube method. Guidance with a steerable head is achieved using a lead casing section fitted with four hydraulically powered wedges, or deflection panels, located at 12, 3, 6, and 9 o'clock positions that push outwards against the soil to deflect the lead casing in the desired direction (Figure 2, left). According to the developer of this technology, the panels are capable of delivering 240,000 pounds of thrust. Four hydraulic lines and a tube for the water level are placed on top of the casing and run from the head back to the hydraulic power unit located in the launch shaft. The lines are protected by a 5-inch steel "C" channel tack welded in place on top of the casing (Figure 2, right). Deviations from the design grade are determined through monitoring of the water level, which indicates the change in elevation of the installed casing as it advances along the design alignment. Horizontal deflections are determined by a string line placed across the launch shaft centered on the bore alignment, and two plumbs that can be lined up with a light or target-located within the steering head.

Figure 2. Steerable head with a hydraulic wedge at the 12 o'clock position (left). Steel "C" channel to protect the hydraulic lines and water level running along the top of the steel casing (right).

4. PHASE 2A; PILOT TUBE AUGER BORING

Phase 2A consisted of a 75-foot long crossing of an unimproved drainage way referred to in the plans as the "Long Grade Canyon Crossing" (Figure 3). The required casing diameter was 42 inches, with a wall thickness of 0.75 inches. The Contractor elected to employ an Akkerman 240A GBM to install the pilot tubes, and an American Augers 36-600 auger boring machine (ABM) to install the casing sections behind the pilot tubes. Due to the size of the final casing, the Contractor installed a 24-inch intermediate casing before advancing the final 42-inch casing.

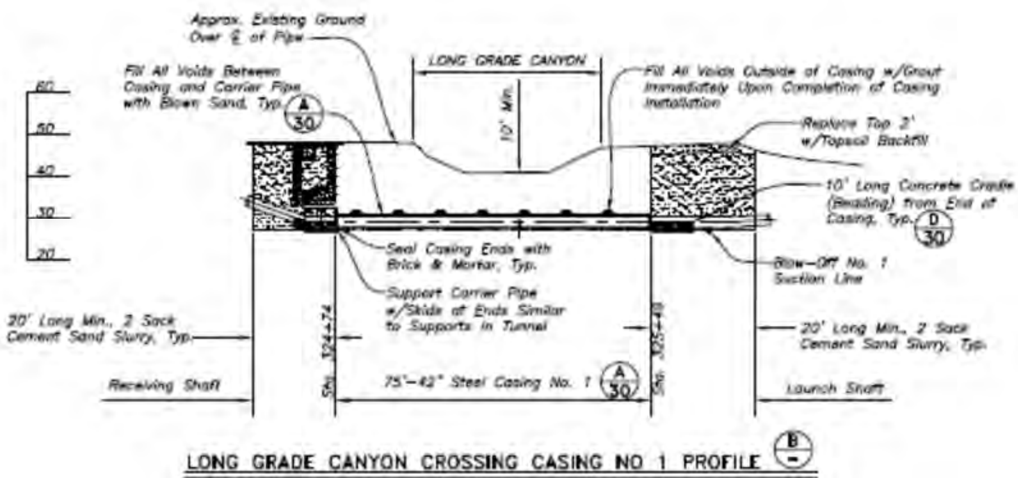

Figure 3. Profile view of the Long Grade Canyon Crossing.

Once the construction of the jacking shaft was complete and the Akkerman 240A GBM had been set up in front of the ABM, the Contractor began installing the 30-inch long pilot tubes. The installation of the tubes occurred without difficulty, was completed precisely to the design line and grade, and took a little over an hour for the full 75 feet.

The next step was to install the "reaming head," which allowed the 24-inch diameter casing to link up with the pilot tubes that had already been installed (Figure 4). The reaming head included an adaptor tube in front in order to more easily transfer jacking loads from the casing to the pilot tubes.

Figure 4. Twenty four-inch "reaming head" with adaptor tube.

The first four 20-foot lengths of casing were installed while pushing the pilot tubes into the reception shaft without difficulty. However, almost immediately upon starting to advance the fifth and final section of 24-inch casing, the 10-foot long adapter tube began to visibly deflect downward as it entered into the reception shaft. It was inferred that the 24-inch casing had encountered some object causing it to deflect upward, which in turn caused the adapter tube to deflect downward in the shaft as it encountered the top of the exit hole cut in the shaft wall (Figure 5). As a result, the Contractor had to enlarge the hole in the shaft wall in order to allow the 24-inch reaming head to exit into the shaft. Once the reaming head had been removed, the Contractor took an elevation reading which determined that the 24-inch casing had been deflected upward by approximately 4 inches. Despite these difficulties, the installation of the 24-inch casing took a little over 6 hours in total.


Figure 5. Bent adapter tube in front of the 24-inch reaming head after removal from the reception shaft.

The third and final step in the process was to jack forward the 42-inch casing while pushing the 24-inch intermediate casing out into the reception shaft. Although the 24-inch casing had been installed 4 inches high, it was decided to allow the Contractor to move forward with the 42-inch casing, the thought being that whatever had caused the 24-inch casing to deflect upward would likely be engulfed within the larger 42-inch casing without causing additional deflection. The first section of the 42-inch casing was fitted with another reaming head, this one utilizing an adaptor to transfer the loads from the 42-inch casing to the 24-inch casing (Figure 6).

After cutting a larger hole in the steel plate for the 24-inch casing to pass through, the Contractor began to jack the 42-inch casing across the length of the bore while pushing the 24-inch casing out into the reception shaft. The Contractor used a trackhoe bucket to hold down the 24-inch casing while it entered into the reception shaft in an attempt to keep the 24-inch casing from deflecting further upwards. As 20-foot long sections of 24-inch casing were pushed into the reception shaft, they were cut off from the casing string and removed from the shaft. The amount of time to fully install the 42-inch casing between the launch and reception shafts was just over 13.5 hours in total. Once the casing was installed, the Contractor performed a survey of the casing invert and determined the casing to be approximately 5 inches high at the reception shaft, which was within the tolerance required for installation of the 30-inch product pipe ultimately installed within the 42-inch casing.

Figure 6. Forty two-inch reaming head installed behind the intermediate 24-inch casing.

5. PHASE 2C; AUGER BORING WITH A STEERABLE HEAD

Phase 2C consisted of a 45-foot crossing beneath a 10-foot wide by 5-foot high concrete box drainage culvert referred to as the Somis Drain Crossing (Figure 7). The required casing diameter was 42 inches, with a wall thickness of 0.75 inches. The Contractor employed a steerable head to achieve the required line and grade and an American Augers 36-600 ABM to jack the casing forward. This was the same model of ABM used on the Phase 2A bore discussed above. One primary difference between the guided head versus the pilot tube method is that the steerable head allows the installation of the 42-inch casing in a single pass, rather than the three passes (pilot tubes, intermediate 24-inch casing, final 42-inch casing) required for the pilot tube method.

This crossing was completed with very little difficulties. After completion of the jacking shaft and set up of the ABM, the Contractor was able to install the 45 feet of casing in 17.5 hours, including the time to weld up the three sections of casing. Once the steerable head reached the reception shaft, it was separated from the casing and removed from the shaft (Figure 8). The completed bore was within 1 inch of design line and grade, which was well within the required tolerance for the 30-inch product pipe ultimately installed within the casing.

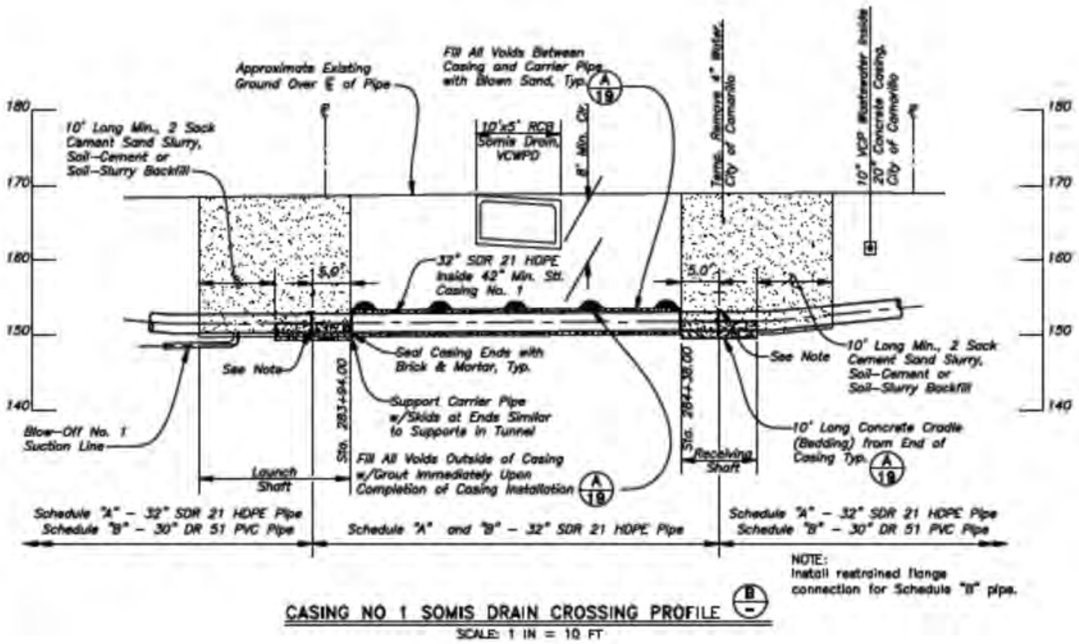

Figure 7. Profile view of the Somis Drain Crossing.

Figure 8. Steerable head being removed from the 42-inch casing within the reception shaft.

6. CONCLUSION

After completion of both of the drives, some conclusions can be drawn regarding the similarity between the two methods. The authors had hoped to have discovered more disparities between the two methods, but the fact of the matter is that the two methods were quite comparable for the two project phases discussed herein.

In terms of production rates, the pilot tube auger boring employed in Phase 2A had a cumulative production rate for the 75-foot installation, inclusive of all three passes, of 3.7 feet per hour. In contrast, the steerable head method utilized in Phase 2C had an overall production rate for the installation of 2.6 feet per hour. The disparity between the two methods is slight, but is reasonably attributed to the single pass of the steerable head versus the three-pass pilot tube method.

As far as accuracy is concerned, it was decided to discount the "obstruction" that caused the intermediate 24-inch casing to deflect during Phase 2A, since the pilot tubes were installed precisely on line and grade. Although the pilot tube method resulted in a greater inaccuracy in this particular case, it is the overall experience of the authors both on subsequent phases of this project and on other projects that the pilot tube method has an edge over the steerable head, which commonly experiences accuracy problems due to issues with the water level. However, both guidance methods offer significantly higher degrees of accuracy in line and grade than are available with conventional (non-guided) auger boring.

And lastly, with regards to difficulties during construction, there was no clear winner between the two methods. Both methods experience their share of problems, but neither method is more prone to have difficulties over the other. In the end, both methods worked equally well within the soil conditions encountered on this project, and both methods were successful in installing the product pipe within required line and grade tolerances.

7. REFERENCES

Calleguas Municipal Water District, (2011) - Construction Drawings, Salinity Management Pipeline, Phase 2A, Specification Number 486

Calleguas Municipal Water District, (2011) - Construction Drawings, Salinity Management Pipeline, Phase 2C, Specification Number 496