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SMALL BORING UNIT – A GROUND BREAKING ALTERNATIVE TO HAND DIG INSTALLATIONS

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ABSTRACT: SBU (Small Boring Unit) is a small diameter cutter-head and thrust bearing assembly that extends the capabilities of the Auger Boring Machine and can easily cut through hard rock faster in small diameter drives than any other method available. Although SBUs have been in use for over 10 years on hundreds of projects around the world, they have not until recently been put to the test in Arizona, known to host the most extreme soils in the world.

This paper discusses typical utility installations in hard rock, caliche and cemented cobbles and compares in two case studies the benefits of SBU over the longstanding hand-dig method. Equipment and labor costs are considered, as well as increases in daily production, drive limitations, and adaptation with the standard boring machines.

1. INTRODUCTION: The SBU (Small Boring Unit) is a small diameter cutterhead and thrust bearing assembly that extends the capabilities of the Auger Boring Machine and can easily cut through hard rock faster than any other method available. Although SBUs have been in use for over 10 years on hundreds of projects around the world, they have not until recently been put to the test in Arizona, known to host the most extreme soils in the world.

Figure 1 Small Boring Unit

This paper discusses typical utility installations in hard rock, caliche and cemented cobbles and compares in two case studies the benefits of the SBU over the longstanding hand-dig method. Equipment and labor costs are considered, as well as increases in daily production, drive limitations, and adaptation with the standard boring machines.

2. HISTORY OF THE SBU:

The Small Boring Unit was developed by The Robbins Company in 1996, while excavating a 914 mm diameter tunnel in hard rock as part of work on the Pennsylvania Turnpike. Crews from John Fithian Contracting Co. of Youngstown, OH, USA got into some rock that proved too tough for the carbide bit Christmas tree head on their auger boring machine. Facing an impasse, Fithian brought the problem to Robbins and the device that would ultimately become the Small Boring Unit completed the drive in less than one week.

Recognizing its potential in the auger boring market, engineers modified the SBU design and targeted auger boring contractors as early adaptors. The first wave of SBUs was known as the SBU-A, the A referencing its deployment as an attachment to an auger boring rig. SBUs carved a new niche in the auger boring market, as they allowed contractors to use existing equipment to bore in rock from 25 to more than 175 MPa UCS using disc cutter technology.

As the market responded to the technology, designers began to develop specialized equipment capable of completing more complex projects. The Motorized SBU (SBU-M), in diameters from 1.2 to 1.8 m, is specialized for line- and grade-critical bores such as gravity sewers. For even longer bores in difficult ground conditions, the Rockhead (SBU-RH) was developed, in both single and double shield models.

3. CURRENT SBU TECHNOLOGY

Figure 2: SBU-A

The SBU-A is available in diameters from 600 mm-1800 mm and is used primarily in competent rock ranging in hardness from 25-175 MPa UCS.

The SBU-A is adaptable to a contractor's current auger boring machine, eliminating the need for special crew training and additional equipment mobilized to the site. The ABM provides both the torque and the thrust to the cutterhead. The SBU-A and all other SBU machines utilize disc cutter technology, much like larger diameter tunnel boring machines. Disc cutters, in diameters from 6.5 inches to 11.5 inches, penetrate the rock face to create a 'crush zone' through which fractures propagate. Material between adjacent crush zones is then chipped from the face. Muck scrapers scoop the muck into openings on the cutterhead, which then transfer the material to a full-face auger. On SBU-As 900 mm in diameter and larger, a mixed-ground cutterhead can also be used consisting of both ripper teeth and disc cutters in combination.

Figure 3: SBU-M (Motorized)

The SBU-Motorized is available in diameters from 1200 mm-1800 mm and is designed for line and grade sensitive crossings such as gravity sewers. The machine is capable of longer drives than the SBU-A and is much more accurate, since it uses a laser target at the front of the machine. The machine can be steered from the operator's console inside the shield. The SBU-M uses varying sizes of invert auger for spoil removal depending on the diameter of the machine. The SBU-M is typically used on crossings from 90 m-200 m and can be fitted with a variety of cutterheads depending on ground conditions and rock hardness. The SBU-M has an electric or hydraulic motor built inside the machine to provide torque and uses an ABM to provide the thrust and spoil removal via the invert auger.

Figure 4: SBU-RH (Rockhead)

The Rockhead, in diameters from 1500 mm-2100 mm, is designed for long crossings (up to 300 m). The machine can be designed as either a single shield (SBU-RHSS) or double shield (SBU-RHDS) machine. Double shield machines are self-propelled using a gripper system, while single shield machines are used with a pipe-jacking system or any other primary liner. Like the SBU-M, the Rockhead utilizes an internal motor for torque and offers continuous steering using articulation cylinders. This machine is also monitored all the time via a typical pipe laser and target at the front of the machine. Muck is removed using either an invert auger or muck cars. In addition, the Rockhead allows for installation of various pipe types including steel casing, concrete, Hobas, and ring beam and board.

4. CURRENT USERS:

The SBU product line is currently being used throughout the world but is most widely used in the US and Canada. A typical SBU-A and SBU-M user is an established and experienced auger boring contractor. The SBU-RH is most widely used by experienced auger boring contractors and tunneling contractors because of the support equipment required onsite, which is similar to that of a soft ground tunneling contractor.

SBU machines have been used on hundreds of projects in the Eastern U.S. and have in recent years begun to gain popularity in Western states as well as Canada. SBU machines are also tackling a wider range of ground conditions including the extremely difficult cemented cobbles and mixed face ground in Arizona. The first use of Small Boring Units in Arizona was with Specialized Services Company (SSC) on several highway crossings in 2007.

5. COST OF SBU VS. HAND DIG:

The SBU's ability to cut a variety of materials efficiently has made previously time-consuming bores much more efficient. In the past, crews often needed a 1000 mm to 1200 mm minimum casing to allow for tools and crew to hand dig at the front of the bore, with advance rates of only 1.5 m-2.5 m per day. The SBU allows for smaller diameter crossings (the smallest sizes are 600 mm and 760 mm) and provides both material and labor cost savings because typical daily production rates are in the range of 9 m-12 m. The SBU-A is also much safer than hand mining in a confined space and requires fewer crew members to operate.

Figure 5 : SBU to install casing for fiber optic

6. QWEST CASE STUDY:

Overview: The purpose of the projects was to install 260' and 290' of 24" fiber optics for QWEST Communications, at Interstate 17 & Dixiletta in Phoenix, AZ, in extremely challenging soil conditions. Proven effective in similar installations on the east coast, the SBU was recommended by the Arizona contractor as an alternative to traditional hand-tunnel.

Challenges: Soil was extremely loose in unexpected locations, but mainly consisted of cemented cobbles and hard caliche

Design: Hand tunnel, HDD, and SBU were the design approaches considered. It was determined that although hand tunnel had the advantage of accuracy, time to complete would make it too costly. Because of the size of the casing and the soil conditions, HDD was ruled out. SBU was selected as the most cost and time effective.

Construction :

- Dug Bore Pit: Different than the standard bore pit – 50' versus 38'. The SBU is 4' plus casing 24' and additional footage for 5' pilot block (cement wall used to ensure the SBU's accuracy).

- Attached the small boring unit to the auger casing by welding it to the lead piece.

- Casing Installation: Bore machine turns the auger, which turns the SBU. Unlike a standard auger bore, the thrust is generated through the casing not the auger. Every 20' pulled the auger and checked grade with a laser.

Figure 6: SBU attached to casing.

- Set joint, welded, and proceeded with the next 20’ section until the full length of casing was installed.

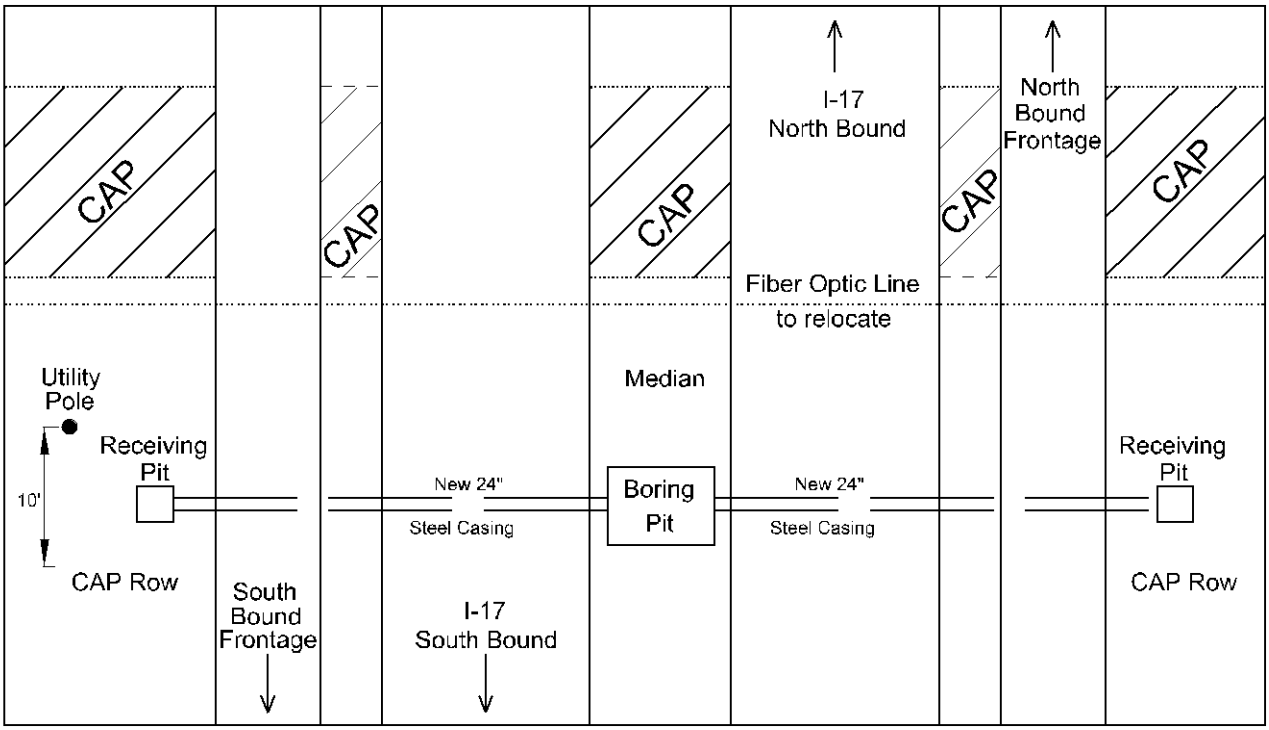
- Cut off the SBU unit at the lead piece. Filled voids with grout.

Results : The project was completed on schedule, within line and grade, without complications. The results of this first SBU application were positive and the contractor recommended it for a similar installation for the Arizona Department of Transportation.

7. RELOCATION OF FIBER OPTIC:

Overview: The purpose of the project was to installed over 200' of 24" x .375 wall steel casing under I-17 North and South bound highways for the Arizona Dept. of Transportation.

Challenges: Inconsistent soil conditions (dirt, cobble, blue granite). Accuracy was very important in this case because the fiber optic casing needed to be installed within a 10’ span between a telephone pole and the ROW on the south side of the interstate.



Design: Hand tunnel, HDD, and SBU were the design approaches considered. It was determined that although hand tunnel had the advantage of accuracy, time to complete would make it too costly. HDD was also ruled out because of the cost and the soil conditions. SBU was selected for its proven advantages and success in a similar application.

Construction : Method was similar to QWEST project. Project site was located a few miles North of (case #1). Design originally called for 8" steel casing, however due to the success of the previous installation using the SBU, ADOT approved recommendation for 24" casing which is the smallest casing SBU can accommodate.

- Dug Bore Pit: Different than the standard bore pit – 50' versus 38'. The SBU is 4' plus casing 24' and additional footage for 5' pilot block (cement wall used to ensure the SBU's accuracy).

Figure 7: SBU 50' bore pit, 24-in casing

- Attached the small boring unit to the auger casing by welding it to the lead piece.
- Casing Installation: Bore machine turns the auger, which turns the SBU. Unlike a standard auger bore, the thrust is generated through the casing not the auger. Every 20' pulled the auger and checked grade with a laser.
- Set joint, welded, and proceeded with the next 20' section until the full length of casing was installed.
- Cut off the SBU unit at the lead piece. Filled voids with grout.

Results : The project was completed on schedule, within line and grade, without complications. The results of this second SBU application were also positive and the contractor continues to recommended the SBU for installations in hard, rocky soil conditions.

SUMMARY : Using the SBU, in both cases the contractor was able to extend the capabilities of horizontal earth auger boring methodology and cut through hard rock and cemented cobbles in caliche, which otherwise would have required a more costly hand-tunnel. The SBU increased production ten-fold from 4' per day to 40'. Prior to both installations described in this paper, the SBU had never before been used in Arizona. Due to the proven success, the SBU is now a cost-effective trenchless alternative for hard soil installations where conventional hand tunneling would traditionally be utilized.