**Sensitive Infrastructure Sites - Sonic Drilling Offers Quality Control and Non-Destructive Advantages to Geotechnical Construction Drilling**

J.P. Davis[1] August 4, 2005

## Abstract

The use of conventional circulatory air rotary and fluid rotary, cased and uncased drilling methods in the vicinity of sensitive infrastructure can have deleterious effects on the ground conditions surrounding and supporting structures. Furthermore, the use of these methods offers little valuable information, while numerous production boreholes are advanced, regarding the actual subsurface conditions that exist which can be used to evaluate actual conditions and progress during construction. This paper will discuss the history and properties of Sonic drilling and explore case histories of Sonic drilling use to advance boreholes within vulnerable structures and on sensitive sites for several recent infrastructure projects – a tunnel and railroad project, a dam grout curtain project and a bridge micropile exploration project. Project summaries will discuss the advantages realized when the application of Sonic drilling techniques demonstrated superior accuracy, quality control, efficiency, productivity, penetrability, waste minimization and adaptability when drilling adjacent to or within infrastructure. Sonic drilling was used to install casings at over 2,000 locations within the active train track structure at Boston's South Station on the jacked-tunnel, ground freezing subcontract to the Central Artery/Tunnel Project. The paper will also discuss the benefits of using Sonic drilling to advance grout curtain boreholes through overburden within sensitive earthen dam structures, such as the recent application at Clearwater Dam in Missouri. The paper will then address the on-going exploration of a Pennsylvania bridge overpass experiencing settlement due to deep Karstic solution features. Finally, suggestions will be made regarding the application of Sonic drilling for future use in the installation of micropiles (*SonicPiles*$^{SM}$), earth retention and grouting where the quality control benefits provided by the inherent soil cores, measurement while drilling systems and non-destructive production drilling features will be advantageous.

## Introduction

Drilling within the vicinity of existing infrastructure often requires a non-destructive method to facilitate careful exploration or geotechnical construction. Conventional air rotary and fluid rotary, cased and uncased, circulatory drilling practices have resulted in disturbance to ground and subsequent damage to existing structures or ground conditions. Particularly vulnerable structures and sensitive soil conditions can be adversely affected by the use of such methods that circulate air or water, even when advancing a cased borehole and can have deleterious effects on ground conditions, including hydraulic fracturing and undermining.

Furthermore, if geological and infrastructure conditions are of a complex, vulnerable or sensitive nature, quality control is of paramount importance. Beyond the typical quality

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control practices which are commonly performed subsequent to the installation of geotechnical elements, *measurement while drilling* (MWD) is now possible through the use of computerized instrumentation installed on the Sonic drill rig. This process can be used as a comparative mechanism for exploration and evaluation across a given site, as well as to determine if construction practices are achieving their intended goals while ground improvement or element installation is performed (i.e., micropiles, anchors, grout). MWD quality control methods can be enhanced, if a drilling method is selected which also provides soil samples.

Therefore, both records of the drilling parameters, as well as a physical record of the soil conditions are preserved across the site to evaluate the actual conditions while production is underway. The Sonic drilling method is one such approach, which can provide these and other advantages, both for the exploration phase and for the construction phase of drilling and geotechnical element installation.

**Sonic Drilling History - Boart Longyear Company**

Research on rotary-vibratory (Sonic) drilling techniques began in the late 1940's. The best-documented work in the U.S. was performed by the Drilling Research Institute (DRI). Russia also worked on developing Sonic drilling prior to 1950. At a meeting in 1957 at the Moscow Drilling Institute, drilling rates of three to 20 times that of conventional methods were reported. Supported by the petroleum industry, DRI started research and development in 1946 and terminated their efforts in 1958 when funding was discontinued. The goal of this effort was to speed up oil well drilling operations by adding vibrations to the rotary motion of the drill pipe and to enhance well development or rejuvenation.

In the early 1960's, an inventor in the United States, supported by Shell Oil Company, continued the research and development efforts. He developed a downhole device that used a series of eccentric weights driven by drilling fluid to generate vibration. He also developed a top-head, high horsepower vibrator to be used for pile driving and a smaller oscillator for driving smaller pilings, installing casing under roadways, and drilling seismic shot holes. This and other activity continued until the late 1960's, when Shell stopped funding the project.

A British manufacturer continued development efforts until 1983 using the inventor's prototypes. Several patents were applied for and received. All have since expired. From 1976 to 1983 when activity was suspended, the British company was successful in developing a small Sonic drill rig. They built approximately 10 drill rigs and 15 Sonic heads. These heads are some of the basic units used on the drill rigs in operation today.

North Star Drilling Company (North Star), MN, U.S.A., was the first to operate Sonic equipment in the U.S.A. for geotechnical and environmental purposes, beginning in 1985 and became a division of Boart Longyear in 1994 *(Boart Longyear Company, Environmental Drilling Division, Sonic Drilling, 2005)*.

## Sonic Methodology

Sonic Drilling, RotaSonic, RotoSonic, Sonicore, Vibratory or ResonantSonic Drilling, are some of the many names given to a dual cased drilling system that employs the use of high frequency mechanical vibration to continuously core overburden and most bedrock formations, and to advance casing into the subsurface. The word Sonic appears in most of these names because this drilling technique vibrates the entire drill string at a frequency rate between 50 and 150 hertz or cycles per second. This frequency falls within the lower range of sound vibration that can be detected by the human ear, thus the term Sonic has been commonly used to describe this drilling system. The Rota- or Roto- part of the drilling technique refers to the rotational power that can be applied in hard formations to slowly rotate the drill string to evenly distribute the energy and the wear at the drill bit face.

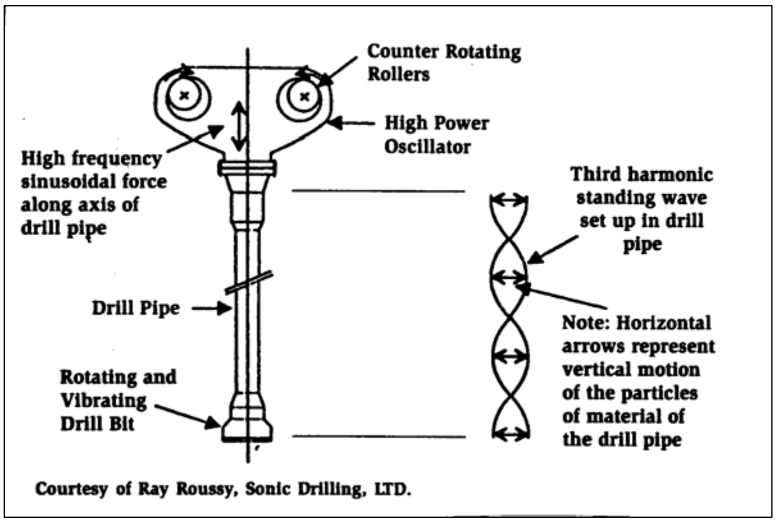



Figure 1. Principles of Sonic drilling (Roussy, 2002).

A Sonic drill rig looks and operates very much like any conventional top-drive rotary rig. The main difference is that a Sonic drill rig has a specially designed hydraulically powered drill head or oscillator, which generates adjustable high frequency vibratory forces. The Sonic head is attached directly to the core barrel, drill pipe or outer casing, sending the high frequency vibrations down through the drill steel to the face of the drill bit creating the displacement, fracturing or shearing action depending upon the foundation being drilled. The oscillator uses two eccentric, counter rotating balance weights or rollers that are timed to direct 100 percent of the vibration at 0 degrees and 180 degrees. There is an insulator to separate the vibration from the drill rig itself.

The vibratory frequency is controlled to suit operating conditions and to achieve optimum drilling rates. When the vibrations coincide with the natural resonate frequency of the steel drill rod or casing a natural phenomenon called “resonance” occurs, therefore the word resonant is used. A complete or detailed discussion of resonance is beyond the scope of this article. However, with regard to the Sonic drilling system, resonance can briefly be explained as allowing the rig to transfer timed vibratory energy into the top of the drill string, utilizing the natural stored energy of the steel, to cause the drill string to act like a flywheel or a spring delivering tremendous amounts of energy directly to the bit face. In many overburden formations, a Sonic drill rig can achieve rates of one foot per second *(Boart Longyear Company, Environmental Drilling Division, Sonic Drilling, 2005)*.

Though the Sonic rig differs significantly in design from conventional rigs, there are enough similarities built into the equipment by certain operators and manufacturers to promote versatility across several drilling methods and configurations. Such versatility is offered by the ability to quickly alternate between Sonic and conventional fluid rotary, air rotary and high-speed coring methods. Additionally, certain operators have configured equipment for a range of strokes depending on the production requirements and access issues of sites, as well as provided the equipment on skids, crawlers (tracks), all-terrain carriers (rubber-tires), high-rail undercarriages (railroad), turn-tables, heli-portable modules, barges and climate-controlled enclosed-trailers. Sonic drilling may be performed from vertical to horizontal orientations.

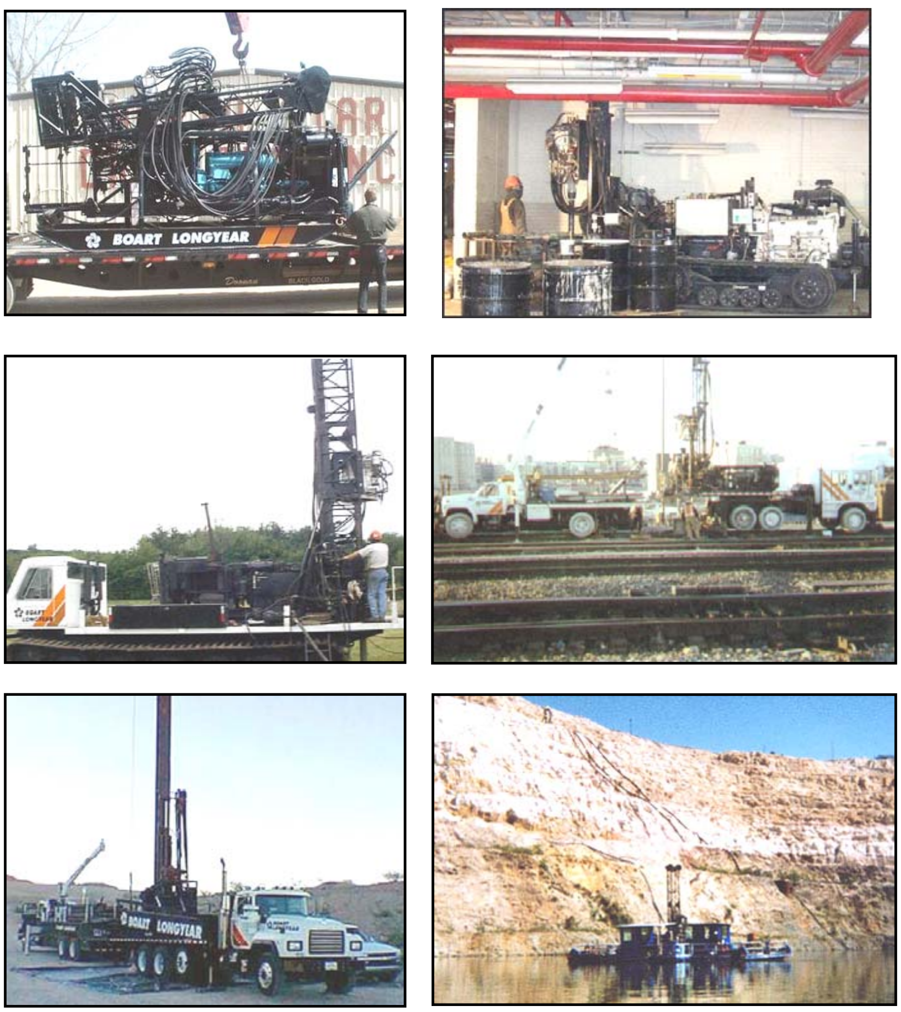



Figure 2. Common Sonic Rig Configurations (Boart Longyear Company)

### Sonic Drilling Process

The processes resulting in borehole advancement are fracturing, shearing and displacement. Drilling through cobbles, boulders, fill and bedrock is caused by fracturing of the material by the inertial moment of the drill bit. Shearing takes place in dense silts, clay and shales, provided the amplitude of the drill bit is high enough to overcome the elasticity of the formation material. Displacement occurs when unconsolidated formation material is moved away by the vibrating drill bit. Boart Longyear has developed three basic drill bit face designs:

1) "Crowd in" - moves all the bit face material into the core barrel.
2) "Crowd out" - moves all the bit face material into the borehole wall.
3) "Neutral" - lets the bit face material seek the path of least resistance.

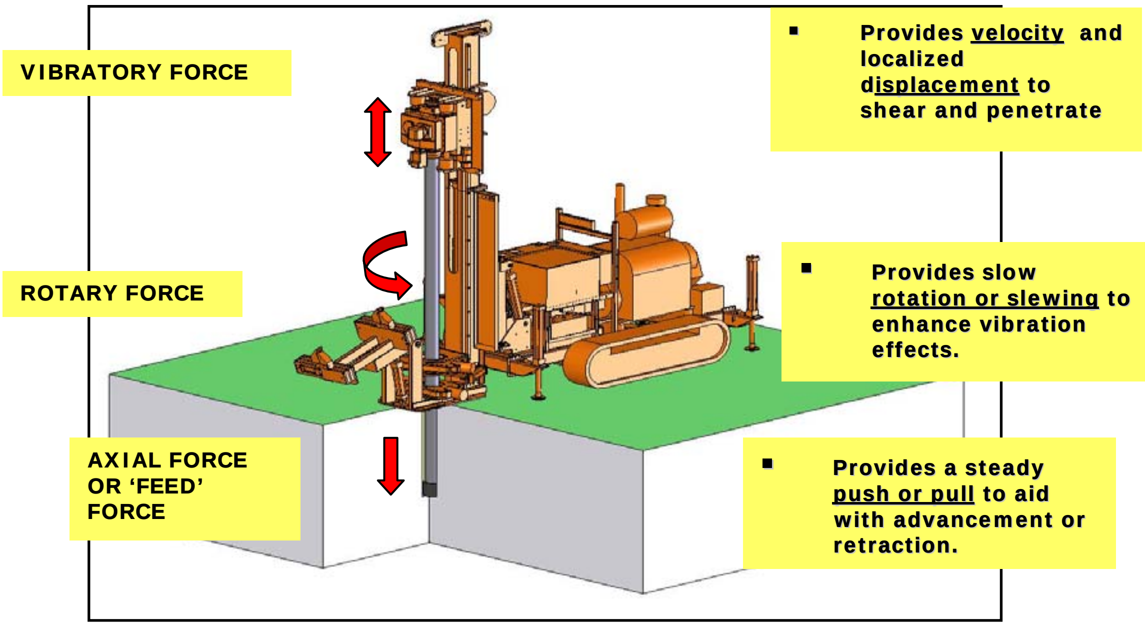



Figure 3. Illustrated principals of Sonic operation *(Boart Longyear Company, 2002)*.

Very few, if any, drill cuttings are conveyed to the surface, except for the core sample itself. As a result the volume of drill cuttings generated during Sonic drilling is in most cases only 10% to 20% of the volume created by hollow stem auger, rotary, or cable tool methods. Optimum penetration rates are obtained when the vibration frequency and down-pressure work in harmony. Experienced drillers monitor the oil pressure gauges in the system to adjust the frequency, the rotation, or the down pressure for the conditions encountered. *(Boart Longyear Co., Environmental Drilling Div., Sonic Drilling, 2005)*

As discussed, the Sonic drilling system employs simultaneous, high-frequency, vibratory energy and the optional/adjustable application of low speed rotational motion and down-pressure to advance the cutting edge of a Sonic drill bit. This action produces a uniform borehole while providing continuous, representative, relatively undisturbed core samples of both overburden and most bedrock formations. The Sonic system has many advantages, but the most unique is the inherent ability to obtain large diameter (three inch to ten inch) continuous core samples of almost any overburden formation without the use of air, fluid or additive circulation, and with or without rotation. Sonic can also drill and sample through boulders, wood, concrete and other construction debris which with conventional rigs usually causes refusal and necessitates moving and re-drilling.

The Sonic system can drill and sample softer bedrock formations such as sandstone, limestone, shale and slate with excellent results. Harder bedrock such as granite can be drilled and sampled, though the costs are higher due to excessive wear on bits, drill pipe and the drill head. If large amounts of hard bedrock need to be drilled and sampled the Sonic rig can be quickly adapted for diamond wire-line or air hammer drilling. Most bedrock drilling and sampling requires the addition of water or air or both to remove drill cuttings as with any other rock drilling system. However, this does not imply that Sonic requires "circulation" through this addition of water, but rather lubrication and cleansing of the bit generally with low volumes and pressures, which generally dissipate into the formation easily.

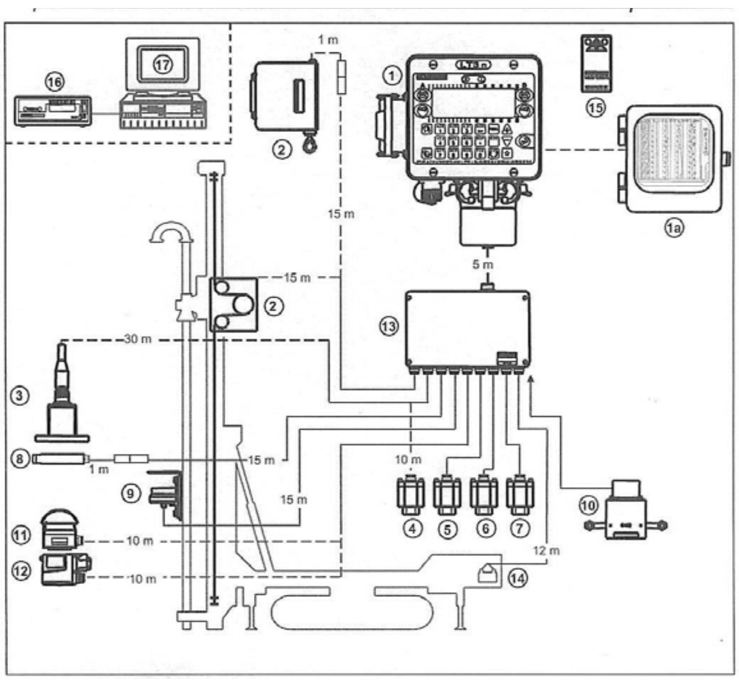
A Sonic drill rig advances a three-inch to ten inch diameter (nominal) core barrel for sampling and can advance up to a twelve-inch diameter outer casing for the construction of wells, casings, micropiles (***SonicPiles***SM), anchors and grout holes. When drilling, the core barrel is advanced ahead of the outer casing, micropile or anchor in one to thirty foot increments. The outer casing can be advanced down over the inner drill rods and core barrel, to collect a relatively undisturbed core sample as an inherent part of the drilling process. The outer casing can be advanced completely dry in most situations, or it can be advanced with water, air or drilling fluid additives, depending upon the formations being drilled, the depth and the diameter of the borehole. Nominal outer casing diameters are 3.5-inch, 4.5-inch, 5.5-inch, 7.5-inch, 8.5-inch, 10.5-inch and 12.5-inch, although a variety of casing sizes and combinations are possible. *(Boart Longyear Company, Environmental Drilling Division, Sonic Drilling, 2005)*

**Quality Control, Sonic Soil Cores and Monitoring While Drilling**

Every production hole has the potential to be a valuable source of information for engineers to determine if the actual subsurface matches the theoretical intentions of the borehole or geotechnical element. This confirmation of the subsurface may be accomplished during the construction drilling process at each of the many locations across a given site. Enhanced quality control is therefore possible through the inherent production of a Sonic core (soil, rock or obstruction) along every foot of the subsurface drilled allowing for a detailed record of subsurface conditions and anomalies, concurrent with geotechnical construction and installation.

Since historically a relatively few preliminary geotechnical soil borings are performed across a given site prior to the production phase of construction, augmentation of the approach to ground treatment while grouting, installing micropiles (***SonicPile***SM) and applying earth retention (anchors, ground freezing) is thereby possible using Sonic production drilling through the evaluation of real-time data using soil cores and monitoring while drilling systems.  Site engineers may review soil data and core samples to determine if, for instance, the micropile (***SonicPile***[SM]) has truly encountered the required thickness of the intended bearing zone or if the soils are appropriate for the intended compaction or permeation grouting requirements.

Data may be converted into specific energy through the use of calculations incorporating thrust (kN), cross sectional area of the borehole ($m^2$), rotational speed (revolutions per second), torque (kN)-m) and penetration rate (m/second), *(Weaver, 1991; Bruce, D.A. and Davis, J.D., 2004)*.  MWD-equipped Sonic drilling equipment can offer both drilling parameter data as well as actual soil cores to corroborate with data.  This dual quality control method can enable a more efficient approach to the construction process, which will help avoid the pitfalls occasionally experienced due to previously unknown variations in geology.  More precise construction and installation is thereby possible on the more critical, vulnerable and sensitive sites and structures.




**Drilling parameter**

| | Measure |
|---|---|
| 1 | LT3 / EPF |
| 1a | Printer (option) |
| 2 | Depth |
| 3 | Vibration |
| 4 | or Holding pressure |
| 5 | Grouting pressure |
| 6 | Weight on bit |
| 7 | Torque |
| 8 | Rotation speed |
| 9 | Inclinometer XY |
| 10 | Grout flow |
| 11 | Driller's button |
| 12 | or Pressostat |
| 13 | Junction box |
| 14 | Power supply |
| 15 | Digital memory card |
| 16 | Memory card reader |
| 17 | Processing software |

Figure 4.  *Jean Lutz, S.A.* Measurement While Drilling System (Davey Kent Inc.).

**Advantages of the Sonic Method for Geotechnical Construction**

Sonic methods allow for a number of advantages.  High penetration rates are possible through conditions, such as loose flowing soils, sands and clays.  In addition, mixed fill is penetrable, such as steel reinforcements, concrete foundations and wooden timber piles. Natural obstructions are also penetrable, such as boulders and bedrock.  Sonic drilling provides advantages in extraordinarily challenging conditions:

- Existing foundations
- Wood
- Metals
- Voids

- Unconsolidated formations that risk undermining
- Karstic solution features
- Boulders
- Bedrock

There is a reduced risk of over excavation and undermining through the elimination of air and water circulation. The Sonic method does not rely on air or water circulation. Where resistance is met through such elements as dense formations, obstructions, boulders or bedrock, low volumes of water may be added to cleanse the drilling face of cuttings. Where permissible, low volumes of drilling mud may be added to the water to increase productivity. However, the method can be performed without the addition of water, although this will at times be at the expense of depth, diameter and productivity.

Accurate drilling tolerances are possible in both vertical and horizontal orientations, since the Sonic method may be performed with a minimal annular area around the outer casing. An annulus is often responsible for the deviation of conventional drilling methods. Additionally, most conventional drilling methods rely on rotation speed and bit pressure, among other factors to advance in soil and rock. However, rotation and bit pressure can contribute to borehole deviation. Deviation is usually in the direction of rotation. Bit pressure can contribute to the degree of deviation where variations in soil or rock resistance and features will offer the bit a path of least resistance.

Finally, where an annulus above or behind the drill bit exists, the degree of bit pressure and drill string rigidity can allow the drill string to key into the borehole or outer casing inner wall causing the trajectory of the bit to deviate. Stabilizers may minimize this deviation, although any annular area will result in the potential for inner bit or outer casing movement off of its intended path. Tight tolerances between Sonic inner and outer casings, as well as special bits with minimal exterior gauge, allow for less opportunity for deviation due to a reduction in the annular space surrounding the casing. Controlled drilling is also possible since the method does not rely on high rotation speeds and down pressure. Additionally, Sonic energy causes a gentle, push/pull, spring action at the bit face, which allows the bit to carve through soils and rock using rotation, at the operator's discretion, to distribute bit wear. Each of these features promotes greater accuracy and tighter tolerances.

Other sites which benefit are active sites such as railroads, light rails and over-water projects. When using conventional air rotary or fluid rotary, direct or reverse circulation, cased or uncased methods, the circulatory effect on unconsolidated soils can be substantial. Less dense soils have the potential to wash-out and erode with fluid rotary methods and over excavation and hydraulic fracturing can result. Short-circuiting is possible outside of the temporary or outer casing or through weak soils to grade. Hydraulic fracturing may take place due to soil properties in combination with circulation pressure.

Air rotary techniques do not offer the fluid weight and balance features against unconsolidated formations or voided rock that fluid methods offer. Therefore, air rotary techniques can be far more deleterious due to high pressure and volume circulation, which can greatly disturb, erode and undermine.

Neither method offers the benefits of Sonic drillingwhich relieves the formation of the negative properties brought about by circulation. Less drilling waste is also possible with the Sonic method, resulting in a substantially cleaner construction site of up to a 75% reduction in drilling waste. These features are also important on sensitive ecological and environmentally contaminated projects.

**Examples of Sonic Drilling on Vulnerable Structures and Sensitive Sites**

**Tunnel/Railroad:** <u>Casing Installation, Central Artery/Tunnel Project, Boston (1997)</u>
Casing installations (2,200 locations for 110,000 linear-feet total) for a ground freezing system were performed in an active track structure through railroad ballast, historical fill, reinforced concrete slabs and granite seawalls using high-rail, turn-table mounted Sonic rigs for Boston CA/T Project CO9A4. As part of the process of installing three jacked-tunnels under the 13 railroad tracks at South Station in Boston, MA, a specialized casing installation method was required. The drilling process would need to be fast, nimble and capable of advancing through many obstructions with tight tolerances and no disturbance to the live track structure.

A significant challenge was that the 4-1/2 inch (11.43 cm) outer diameter casings had to be installed to depths from 40 to 140 feet in an active train station, where hundreds of thousands of people commuted daily. The drilling was performed through some of the most horrific combinations of historical fill materials – steel rails, brick tanks, wood piles, granite seawalls, depressed concrete slabs, track ballast crushed rock, clay, stratified sands, till and weathered bedrock. All of the holes had to be installed within a strict tolerance vertically to allow for equal spacing for the ground freeze migration. Each location was verified with down-hole survey equipment. The Sonic drilling method was selected due to its ability to penetrate through the obstructions, maintain high production, perform nimbly and efficiently when surrounded by train traffic, maintain 1% tolerances, and preserve the track ballast in an undisturbed state.

The elimination of air and water circulation in the Sonic drilling process allowed the drilling to be performed without the risk of undermining the track structure and without producing any waste or fouling of the track ballast that is used to level the tracks. Two Sonic drill rigs were specially modified with rail gear to work on the tracks. The rigs were able to detach from an active borehole and rotate away on a turntable within just a few minutes, on a regular basis, to allow trains to pass. The crews also performed void testing and void grouting. None of the casings necessitated relocation due to obstructions using Sonic drilling.

High-rail, turn-table mounted Sonic rigs

Buried steel railroad rails cored with Sonic

Figure 5. Penetration of Sonic drilling directly through wood piles, granite seawalls and brick foundations, Central Artery/Tunnel Project, Boston, MA (Boart Longyear, 1999)

**Earthen Dam:** Grout Curtain Pre-drilling for Sink Hole, Clearwater Dam, MO (2004)

Sonic drilling was used to drill 15-degree battered grout holes through embankment fill. In January 2003, a 10-foot (3.05 m) diameter, 8-foot (2.44 m) deep sinkhole developed suddenly, near the crest on the upstream side of Clearwater Dam in Missouri. Its appearance prompted action for immediate subsurface investigation and, in turn, to affect a remedial plan involving a grout curtain installation. The project required a drilling method with multiple capabilities. It must have the ability to penetrate and sample both the body of the dam and its foundation without the use of air or water circulation. The core of the dam's body was comprised of materials, which ranged from heavy cobbles and rip rap to gravel and boulders. As the Sonic borehole approached the foundation, it would advance through an interface layer of hard clay, before terminating in Dolomitic bedrock, which offered occasional Karst characteristics and Chert layers.

Avoiding the use of air and water circulation prevented the potential for hydraulic fracturing of the sensitive dam prior to grouting. Sonic drilling was selected from a range of proposed drilling methods due to its versatility in both drilling (rate of penetration) and its sampling capabilities through a diverse array of materials and geology. Sonic was also preferred due to its non-invasive drilling properties which use limited or no fluids and low amplitude vibration to advance the cased boring. In addition, Sonic offers the ability to drill on a batter (angle) with accurate tolerances on a closely spaced grout hole alignment. The unique ability of Sonic to recover a complete, continuous sample through each of the various materials, provided the data necessary to accurately identify questionable dam interfaces and highlight locations of piping and/or erosion of the foundation materials. In the initial phase, a grid of 37 borings was drilled through the dam's body and into the underlying rock foundation. The objectives of the drilling were twofold.

The first objective was to delineate the dam’s stratigraphy by drilling deep into the dam's foundation to retrieve samples for laboratory testing and analysis. The samples were used to determine the mechanism for sinkhole development. Secondly, the borings were utilized as pilot holes necessary for the construction of a bedrock grout curtain installation. The Sonic borings were accurately drilled at an angle of 15 degrees off of vertical. The 15 degree angle was necessary to maximize the number of intersections with foundation crevices, thus increasing the effectiveness of the grout curtain.

The borings were advanced through the gravel- to cobble-sized materials in the dam's body to an average depth of 135 feet (41.15 m) and then, through the underlying 65-foot (19.81 m) thick hard clay layer, and finally through an additional 5 feet (1.52 m) into bedrock (using PQ size coring tools). After each borehole was drilled, a 4-inch (10.16 cm) PVC pipe was installed and grouted full depth. A partner contractor then drilled each borehole to a depth of 195 feet (59.44 m) into the bedrock for the construction of the grout curtain.

Figure 6. Long-stroke, truck-mounted rigs and tenders were used to pre-drill for the grout curtain at Clearwater Dam, MO (Boart Longyear Company, 2004)

**Bridge:** Karstic Limestone Drilling, PennDOT, SR-33, Stockertown, PA (2005)

An exploratory investigation of new micropiles and subsurface conditions is currently being performed at a bridge overpass north of Allentown, PA for the Pennsylvania Department of Transportation. The new overpass has been experiencing unacceptable settlement. Potentially, this settelement is due to Karstic solution features surrounding the supportive 7-inch micropiles, which extend to a maximum of 350 linear-feet below grade. In the past, settlement has lead to the shut-down of the highly traveled bridge and highway. Drilling is being performed with multiple rigs from each side of the stream embankment which the bridge overpass crosses. Vertical and battered Sonic drilling is being used to parallel micropiles to depths of over 450-ft through alternating Karstic limestone and voids containing silt, sand and clay. Sonic rigs are able to alternate between Sonic, PQ high-speed coring and air rotary under-reaming depending on the subsurface conditions and the intention of the boreholes. Sonic casing and coring diameters of 10.5-inch, 8.5-inch, 7.5-inch, 6-inch, 5.5-inch and 4.5-inch are being used to strategically case-off unstable subsurface strata and aid in advancing through numerous Karstic layers and highly variable rock depths without opening additional voids and pathways within the rock.

Sonic enables the advancement of a stable, cased borehole, which provides for the installation of inclinometer instrumentation in each borehole. This is achieved through the alternating soils and rock layers to depths of over 450 feet and with tight tolerances.

By limiting or eliminating the use of air and water circulation, large diameter Sonic cores are clearly demonstrating the location of Karstic voids and defining the actual rock profile below the bridge. Further, sinkholes are being avoided by using Sonic rather than air rotary methods, as performed previously during the micropile installation or wash methods, as performed previously during investigations.

In the past, the use of air rotary at the site has resulted in promoting large sinkholes by opening and over-excavating silt and clay filled Karstic pathways and voids. The Sonic method has minimized the deleterious effects of conventional drilling practices and the risk to further damaging the vulnerable bridge structure and worsening the sensitive subsurface conditions.

The success of the use of Sonic in this capacity suggests great promise for its future use to install micropiles (***SonicPiles***SM), earth retention anchors and grout curtain holes for remedial measures on similar vulnerable structures and geologically sensitive sites.

Figure 7. The use of Sonic methods to explore alternating Karstic voids to 450-ft below a bridge overpass foundation at PennDOT SR-33 (Boart Longyear Company, 2005)

## New Applications in Construction

The use of Sonic drilling methods offers quality control in conjunction with production installation of geotechnical construction elements. It is now being recognized that where best value practices are required for the performance of construction on vulnerable structures and sensitive sites, Sonic drilling can offer quality control information and a less invasive approach. The following geotechnical practices are now being met with Sonic drilling methods, measurement while drilling (MWD) data and appropriately matched drill rig configurations (i.e., crawler-mounted and other rigs):

- Micropile installation (***SonicPiles***℠)
- Grout injection
- Soil and rock anchors
- Temporary earth retention (i.e., ground freezing)
- Pre-drilling
- Exploratory soil sampling
- Confirmation coring

Figure 8. New crawler-mounted modular Sonic rigs (Boart Longyear, 2004)

## Summary

Sonic is beneficial to the drilling process and geotechnical conditions on sensitive infrastructure projects. Low amplitude and high frequency Sonic energy can limit the impact to structures. Penetration and productivity are increased by the cutting and coring action of the bit and casing. By simultaneously coring and casing with Sonic methods, without the use of air or water circulation, problems associated with undermining, over-excavation and hydraulic fracturing that are common to conventional external flush and eccentric air rotary drilling techniques within or below sensitive structures, are eliminated.

The continuous Sonic coring and casing process provides quality control with precise core observation of the strata for simultaneous confirmation of micropile and anchor bond zones or grout application. Measurement while drilling (MWD) computers and instrumentation are now being added to the Sonic rigs to provide comparative data acquisition for evaluation across large sites while production is underway. Air and water circulatory elimination also minimizes waste production and waste handling by up to 75%, allowing for a cleaner construction site and increased savings on handling and disposal costs. This feature is additionally significant to ecologically restrictive and environmental contaminated sites.

Accurate tolerances are achieved by the elimination of a casing annulus for vertical, inclined and horizontal orientations. Numerous crawler-mounted, compact drill rigs, are now available for operation in areas with 8-ft of overhead clearance and for use on rough terrain using crawlers. Vertical, inclined and horizontal drilling capabilities are now possible for use in installing geotechnical elements or battered grout holes. Conversion of rigs to air rotary, fluid rotary or high-speed rock coring is also possible in order to combine methodologies on complex and multi-faceted drilling projects. Finally, simplicity is permitted in challenging, complex and variable conditions through the use of a single drilling system – Sonic Drilling.

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John Davis began his career twenty-years ago in the eastern United States working in the construction industry as a laborer, supervisor and manager on the building of water supply sources, water treatment systems, environmental remediation systems and various other types of heavy construction and geotechnical projects. He later earned his Master of Science degree from the Engineering Department of Tufts University. From the mid-1990's through 2002, he functioned as a construction project manager for Moretrench American Corporation on several large infrastructure projects, including the ground stabilization (ground freezing) contract to the world's three largest jacked-tunnels for the Central Artery/Tunnel Project in Boston, Massachusetts (The Big Dig) and on another ground stabilization contract for the Narragansett Bay CSO Tunnel Project in Providence, Rhode Island. It was during this time that he had his first introduction to Boart Longyear Company, a subcontractor to Moretrench American. Boart Longyear is a 7,000 person international drilling contractor and manufacturer owned by Advent International, providing services to the mining, construction, geotechnical, environmental, oil & gas and water supply market sectors. Mr. Davis now manages Boart Longyear's growing venture into the specialized geotechnical construction drilling market in the United States, focusing primarily on such projects as dams, tunnels, bridges and other critical infrastructure sites.

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