The North American Society (NASTT) and the
International Society for Trenchless Technology (ISTT)
International No-Dig Show 2009

Toronto, Ontario Canada
March 29 – April 3, 2009

Paper D-1-04

On Grade, Large Diameter Pipe Ramming Installations

John Currey[1], Gene Woodbridge[1] and Eric Nicholson[2]

[1] Earth Boring Co Limited, Mississauga, ON
[2] HammerHead Trenchless Equipment, Oconomowoc, WI

ABSTRACT: No one element stands alone in the success of trenchless initiatives. Every projects success begins in the design phase but is completed in the field. This sounds like common sense but all too frequently the unknowns of trenchless installations and the limited level of experience with the wide range of trenchless solutions, can limit the success of a project at the very beginning. Fail to plan, plan to fail. The combination of a good soils report, knowledgeable contractor, the right trenchless technology and overall stakeholder understanding are the keys to success for any trenchless project. This paper discusses the challenges with acceptance of the Pipe Ramming methodologies in large diameter on grade installations.

This paper discusses on grade pipe ramming successes in diverse ground conditions with discussion of various successes utilizing pipe ramming installation for large diameter on grade projects. Centered on the head to head application of the ramming method w/ other conventional trenchless means and the resounding success of the ram and the failure of other methodologies.

1. INTRODUCTION

In the early stages of a project, simple review of the landscape can initiate the trenchless planning. Crossing an environmentally sensitive area, major highway, historic site or railway seem like obvious trenchless programs. The real challenge is aligning the right trenchless solution to the trenchless need. Just because one is used to using and familiar with a particular tool doesn't mean that's the right tool for the job. Auger Boring, is the most familiar, most common and typical trenchless installation method. Even though HDD has been in regular and consistent use since the early 90's, its inner working and methods are far less understood, never-mind pipe ramming, the seemingly most frightening solution and the 'star' of this discussion.

Not enough attention is focused on the talent and experience the trenchless contractor brings to the trenchless project. Straight forward, mission critical solutions are readily available to the project design, planning and execution stages with the right trenchless contractor, solid soils investigation and responsible contracting.

On grade pipe ramming can be achieved with high levels of satisfaction, its cost and relative obscurity make it a rare find in the project specification. Trenchless contractors are slowly seeing it specified in the Greater Toronto Area, and largely from design engineers that have seen its tremendous abilities and high success rate.

The duration of this paper discusses in particular the situation encountered with this outfall project. The end result was the selection of the pipe ramming method and the success of hitting the proposed inlet, on line and to grade. Selected examples of other ramming projects are included to underscore and highlight the versatility of the pipe ramming installation method.

2. THE PROJECT - GUINESS PLACE OUTFALLS

Just how is the right trenchless solution selected? It's obvious at design that you can't or shouldn't open cut the trout stream, the railway owner is not about to give you clearance to tear up the line at the expense of rail profits. Pressing design timelines might give way to picking a tried and true solution although all the nuances of the work site are largely unknown.

In the spring of 2004, Earth Boring was contracted to provide two 1200mm on grade tunnels for a subdivision in Ajax, Ontario - outfalls for sanitary and storm water management (Figure 1). A soils report was performed with bore holes within the general area of the works, however the immediate lands adjacent to the railway were not surveyed. The 60m tunnels were to be installed 6m apart at a grade separation of 4m. The crossing was a CPR, high speed, high volume freight line, running regular loads for a major car manufacturer. The design engineer reviewed the available soil reports, and based on the hard grey clay till felt that auger boring was the trenchless solution best suited for the installation. Our estimators felt the same way and priced the job as experience dictated, making note that soils report bore holes were not available (performed) for the areas on either side of the bore start or termination path a spread of about 90m. This is not an atypical situation but still not preferred.

Figure 1 – Guiness Place Outfalls Shaft for Storm – Previously Tunelled Sanitary MH

Tunnel One - Sanitary

The first tunnel was underway in the spring of 2004. A deep shaft (6.8 meters) was installed, and when the auger work neared the influence of the railways, the spoil began to present indications of wet silty sand lenses. Sink holes appeared over the continued duration of the bore on either side of the rail right of way and were filled with low mpa concrete. The bore was complete to grade but not without some difficulty. Methane was prevalent in the excavation seeping into the shaft from shale bedrock 2m below shaft grade, making standard operations more difficult.

Based on the dramatic change in the soils condition, additional bore holes were commissioned in the bore path closer to the influence of the rail right of way.

Tunnel Two – Storm Sewer

Prior to the start of tunnel two – the shallower storm sewer – the project engineer reflected on the results and issues faced in the first tunnel. Armed with the potential threat of a sinkhole on the railway right of way, the engineer was able to convince the railway that further access to that property was required for soils analysis. The impetus was the elevation of this tunnel was at 3.5m below grade compared the much deeper sanitary installation. The proximity being such that overburden soils would not provide the same bridging as the sanitary sewer installation. The majority of the work occurring under railway right of way also underscored the urgency to address issues of sinkholes prior to works.

The results confirmed the in-field experience of wet silty sand lenses, at the elevation of the second bore path and in greater concentration. Earth Boring proposed an alternate method of pipe ramming. Pipe ramming offers the greatest range soils application short of full faced hard rock conditions. The nature of the ramming methodology is such that a full soils plug is developed, mitigating much of the raveling soils risk (that lead to sinkholes). Voids are virtually eliminated. The duration of the work was in line with expectations, but the cost of additional liner (1050mm to telescope thru the 1200mm) and the hammer equipment caused the owner to balk. At the presentation of the price, methodology and schedule for the ram, greater emphasis was placed on the delay that would be caused by materials delivery. Permalok™ quoted a delivery time of two weeks from order. The engineer indicated that this was unacceptable, and that alternative methods would need to be proposed, in the interest of meeting the tight schedule.

Earth Boring was directed to initiate the operation with the specified method of Auger Boring. Operations commenced and after 12m of installation a sinkhole was noted above the bore path. Augers were reversed, pulled and a bulkhead was installed at the tunnel face.

After three weeks, Earth Boring was directed to static push the liner (Pipe jacking). The process, as the engineers understood, would best proceed as it creates a soil plug throughout the length of the casing and prevents further raveling. Pipe ramming also provides a constant soils plug and a thrust block is not required.

After a substantial thrust block was poured behind the shaft the jacking operation commenced. The initial push succeeded for the first 6m length. The next 5 meter length failed to install and only 1.2m of pipe progressed as the frictional pressure proved too great for the 750,000 pound jacking force of the machine. Earth Boring cleaned the spoil out of the casing to a determined distance and attempted to jack again without success. A period of 1 week passed during this operation.

Earth Boring again suggested pipe ramming. After a week of consideration, the engineer had directed the method of hand mine from the opposite end of the bore. The operation would be aligned to connect with the portion already bored. A hand tunneling contractor was hired by the owner and required 1 week to set up and begin work (Figure 2).

At 4.8m, a wet running layer was encountered at the springline of the pipe. It extended transverse to the pipe at a width of 300mm. Above this seam was a sandy silty material that raveled out with the flow, causing layers above to 'pancake' down and continue the raveling Figure 8.

Figure 2 – Hand Mine Set-Up

The tunnel contractor was directed to a 24hr shift and only managed another 1.2m. Chemical grout was attempted to firm up the area for the hand mine, but only another 300mm was achievable. The owner and the engineer even attempted to have foam insulation injected at the face during the mine operation Figure 9.

7 additional weeks had elapsed and an unexpected $520,000 had been spent. Earth Boring was asked to attend a meeting with the owner and engineer to discuss the method of pipe ramming. Earth Boring was asked to guarantee line and grade and provided assurance that the railway would not encounter any sinkhole or voids before the method would be accepted.

1050mm 15.7mm wall Permalok™ casing was delivered 7 days later, coinciding with the preparation time of the starting shaft. The Permalok™ was threaded through the initial 19.8m section of installed 1200mm liner. The shaft and support tracks were set to proper line and grade and the ram operation commenced.

3. THE EQUIPMENT

The project utilized a HammerHead 24" pneumatic hammer. A real utility hammer, it can also be used in pipe bursting, HDD assist (pullback assist, pipe extraction, drill stem recovery) and piling applications. For maximum efficiency and productivity the 24" hammer operates at 110psi and 1,700cfm. In this operation we utilized our 1600cfm compressor, opting to keep our 1900cfm unit on an alternate project. Our analysis of the factors indicated that the hit would be successful with the smaller air system.

Two key features of the HammerHead proved valuable on this as well as previous projects. First, The locking taper on the nose of the HammerHead enables the hammer to lock into the collets. The collets then lock into the casing providing the connection medium between the ramming hammer and the casing. A solid connection is critical to ensure success, a bad connection can result in loss of productivity and fitful starts and stops. In an on-grade large diameter project, these interruptions can make a serious impact on the overall job. Grade is necessarily affected in these instances as the hammer connection directly impacts the installation grade.

A 'good fit' connection with the advanced "self-locking" system enables maximum energy transfer and in turn maximum production.

The second key feature contributing to the efficiency and production is the "Reverse" feature which is standard on all of HammerHead's hammers. Once a segment of casing is properly driven in the ground, our operator is able to "Reverse" the hammer which immediately unlocks the hammer from the collets and the casing. We are then able to immediately begin lowering and attaching another section of casing furthering our efficiencies.

Figure 3. 24'' Pipe Hammer Set and Ready

Figure 4. 24'' Hammerhead Pipe Rammer

4. SET UP

Earth Boring leveraged the existing framework and track structure from the Auger boring methodology. This would provide the necessary support for pipe staging and simplify any spoil cleanout that may be required during and after liner installation. Some ram operations have used compressed air to remove spoils. Best and safe practices in Ontario have established mechanical removal by auger the ideal method.

The 1050mm pipe was lowered into place, prepared and thread thru the 1200mm casing (Figure 5). The previously installed 1200mm liner was at precise line and grade, easily accommodating telescoping the 1050mm liner within the 1200mm liner.

Figure 5 – Preparing Permalok™ Casing for Thread

Left – 1050mm casing is prepared for threading / telescope through existing 1200mm liner. The Permalok™ casing is fitted with a hardened steel, inward bevel, cutting shoe (see Figure 9). This enables boulders and obstructions up to the diameter of the liner to be split and 'swallowed' in-situ. Auger boring obstructions greater than 1/3 diameter of liner require augers to be pulled and manual removal of the obstruction. On auger clean out of a ram, obstruction removal is safer and does not lend to raveling of soils.

As the existing shaft had remained, only remedial works were required to complete the set up for the ram operation. This set up took 5 days and completion was concurrent with the arrival of the Permalok™ casing.

Prior to the start of the ramming operation, several risk mitigation strategies were planned and deployed, kept at the ready in the event of any sinkhole appearing.

5. THE RAMMING OPERATION

The ramming operation proceeded as planned. In a span of 7 days, the pipe was completely installed and the spoil removed (Figures 6 and 7). Subsequent to the clean, the carrier pipe was threaded to completion, a process that required 2 days.

Figure 6

Figure 7

During the course of operation grade was regularly checked. It was determined that the installation was progressing to expectation. Each section of pipe was installed in 6m segments. The Permalok™ solution delivers a water tight, mechanical joint reducing joint make up time and provides an ideal connection for the ramming operation. Ideally suited to this job as a flowing water condition became prevalent during the bore. This water, flowing through the pipe, would make a full penetration weld (essential for ramming) nearly impossible. The mechanical joint removes any concern over this issue.

Various techniques were deployed to ensure the grade was maintained during the ram operation. It was these various techniques in combination with careful initial set up that lead to the success if the job. It is no trade secret that careful set-up lead to the success of any large diameter on-grade ram operation. In many instances, a 6m casing can be driven in less than 30 minutes time. Our quickest installation was a segment of 15m long, 1200mm casing driven on grade in 25 minutes. Upon completion of each section it can take several hours to a entire shift to set the next segment of casing, ensure grade and prepare for the next hitting drive.

The hitting drive connected with the hand mine liner that had been left in-situ(Figure 9). The connection occurred at the outside edge of the casing. The inspecting engineer was quick to note that the ram had come off line and was off grade. The remaining segments were added and the tunnel liner was driven into the mine shaft in dramatic fashion. When the survey crew came to verify the liner installation, they noted that the hammer driven liner was on line and to grade. There was no variation. In fact, the hand mine tunnel had been set at the wrong line and grade, though no fault of that tunnel contractor.

All risk mitigation planning was, at completion, an exercise in development. This was due entirely to the inherent closed system of the pipe ram operation. The volume of soil removed is limited to the volume of the casing. A soil bulkhead is created within the line of the ram which prevents uncontrolled soil loss.

Figure 8 – Mine Bulkhead and Treating

Figure 9 – Ram Connects with Hand Mine Liner

7. CONCLUSION

On grade pipe ramming can be achieved with high levels of satisfaction, its cost and relative obscurity make it a rare find in the project specification. We are slowly seeing it specified in the Greater Toronto Area, and largely from progressive design engineers that have seen its tremendous abilities and high success rate.

The major factor in the shift is the highly versatile nature of the pipe ramming method. Many trenchless designs harken to the tried and true, well defined, well understood methods – hand mining, mechanized tunnelling, auger bore. HDD and to a lesser extent, pipe ramming suffer at the design stage as a choice for installation. The standard on many trenchless crossings seems to be auger boring. Often the soils conditions do not marry well with this solution, and many times the soils report bore holes are outside the area of the crossing and on site or at auger mobilization we as contractors are left to make challenging alternative suggestions. Wet running ground, cobble loose pack, etc are challenging to the auger bore. Success can be achieved but not without substantial risk. The proven ability of ramming to attack wet running ground and cobble boulder filled soils alike make it an ideal alternative to auger boring. Success has been growing and designers are starting to pay attention.

Pipe Ramming is ideal for

1. Split face soils conditions
2. Tough rock and boulder filled ground
3. Wet running soils conditions – suitable for active or passive water conditions – required no bore path de-watering

Key Lessons Learned

1. Education is the key to understanding pipe ramming – but it is the toughest class to deliver
2. Money spent on additional soils conditions can save you money in the long run – provided stakeholders pay attention to the results
3. Patience and steady dedication can result in achieving the right solution
4. Chasing costs at the expense of managing schedule variance will eventually cost more money, and severely impact the project bottom line.