IMPROVING SMALL DIAMETER DRILL RIG FRONT END SAFETY

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ABSTRACT

During 2017 and 2018, Keller Foundations Ltd. (KFL) was involved on projects working for the mining industry in the Sudbury, Ontario area, installing micropile foundations for various new structures within their surface works facilities. The mining regulations in Canada are currently more stringent with regard to safety when it comes to drill rigs, and especially rotating components, compared to that of the construction industry. Various adjustments therefore had to be made to our installation procedure and equipment to adhere to these standards. Firstly, we will look at the state of practice of drilling safety in the construction industry in Canada compared to that of the mining industry. Then the paper will discuss two foundation projects within the same mining facility, the access restrictions, the training, and the adjustments made from year 1 to year 2. The first project was completed in 2017 using simple construction barricades. The second foundation project was completed in 2018 using drill rig mount protective cages that encased the lower portion of the drill rig mast. Installation techniques, impact on productivity, and quality control will also be addressed.

1.0 INTRODUCTION

Keller Foundations Ltd. (KFL) prides itself on always being the leader in terms of Health and Safety in the construction industry. Given the current demands of our clients and the continuously changing local regulations, KFL has evolved to focus on continual improvement. Such improvements are ways in which we can change our drilling techniques to make them safer for the personnel operating these various types of equipment. On most projects, we are also required to follow safety protocols unique to the client or industry, which requires us to adapt. One such client that focuses heavily on health and safety and wants to ensure everyone returns home in the same condition as they arrived to work is Glencore Mine.

2.0 PROJECT OVERVIEW

Sudbury Integrated Nickel Operations (INO), a Glencore Company, is a nickel smelter facility located in Falconbridge, Ontario. The smelter site was previously known as the Falconbridge Smelter and later the Xstrata Nickel smelter. The Process Gas Project (PGP) has been initiated by INO to reduce sulphur dioxide emissions and associated environmental impact from the smelter operation. As part of the PGP project, a 65m tall exhaust stack, conveying structure, and various mechanical and mixing system structures were to be installed. Due to subsurface conditions and restricted access at some areas of the site, micropiles were chosen as the preferred deep foundation solution for the structures. The foundations package for the overall project was separated into two contracts that were executed in the summers of 2017 and 2018. The foundation contracts were specified to be

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design/built by a specialty contractor with adequate experience in micropiling work and good safety records.

2017 – Stack, Fan Building And Rack Foundations Project

In the summer of 2017, the first foundations package was awarded to KFL (operating as Geo-Foundations at the time). KFL conducted three sacrificial pre-production micropile load tests and installed 234 production micropiles for 11 structures within the courtyard of the smelter plant. At peak, four drill rigs were working concurrently installing piles, with over 14 workers from KFL on site. Overall, KFL put in over 10000 person-hours on this project.

2018 – Custom Feed And Mixing Station Project

In the summer of 2018, KFL was awarded the second foundations package. This package included two sacrificial pre-production micropile load tests and 135 production micropiles for five structures and rack foundations. KFL deployed two drill rigs and put in over 4200 person-hours on this project.

3.0 SUBSURFACE CONDITIONS

The smelter site is located at the boundary of Sudbury Basin and has been in operation since the 1930s. At shallow depth, a thick layer of consolidated slag deposit can be found. The slag layer was formed from decades of mining activity at this site. Some part of the slag fill is classified as moderately corrosive to highly corrosive due to the high sulphate content. Underlaying the slag fill is the overburden of the Sudbury basin which consists of native dense silty sand to gravely sand (typical SPT “N” value of 50 to 100+). All boreholes on this site were reported dry and free of ground water. The native soil was classified as non-corrosive.

4.0 MICROPILE DESIGN

Most structures on this project house the various components of the smelter gas processing equipment which are designed to withstand high dynamic loads and lateral loads. The structural engineer resolved the complex structural loading condition into simple axial tension and compression load in combination with various battered angles. The micropiles contractor was responsible for the design of individual micropiles. The individual micropile load ranged from factored axial compression load of 1300kN and factored axial tension load of 890kN, with battered angles from vertical to 30 degree from vertical.

The micropiles design features for this project consisted of a fully cased free zone through the non-native fill zone and with a soil bond zone in the native dense granular soil. The sizing of the micropiles took into consideration the loading and stiffness requirement. The micropiles diameters ranged from 194mm to 301mm, with bond lengths ranging from 3m up to 13.4m. The micropile structural component sizing was governed by the corrosion protection design requirement. Given the highly corrosive environment, especially in the slag fill, the corrosion protection of the micropiles was designed in threefold; micropiles through the fill to be fully cased and without considering the load contribution from the steel casing, the central reinforcement bar to be designed to carry the full pile loads with 4mm of sacrificial

steel throughout, and the micropile grout to consist of high sulphate resistant cement.

5.0 INSTALLATION METHOD

Given the non-cohesive soil with interlayering of hard, consolidated slag layer, the micropiles on this project were installed using a double head drilling system with threaded micropile casing. The double head drilling system features independent rotary heads for the inner drill string and drill casing, with opposite rotation to limit drill hole deviation. The two rotary heads are also able to travel independently to provide the flexibility of adjusting the distance between the drill bit and the casing tip during drilling. In hard soil layers, the inner string with the down-the-hole hammer advances ahead of the casing to penetrate through boulders and hard soil layers to ease casing advancement. In soft soil layers, the inner drill string can be retracted inside the casing to prevent excessive soil disturbance. To install the pile, a cased hole was advanced to the full depth. A combination of compressed air and water was used to clean the casing and evacuate drill cuttings throughout the drilling process. Upon reaching the design depth, the bar reinforcement and micropile grout were installed. After grouting, the micropiles casing was retracted partially to create the uncased bond zone, with some casing length left in place to create the micropile cased zone.

6.0 MINING VS CONSTRUCTION SAFETY REQUIREMENTS

KFL was awarded the first project at Sudbury INO in 2017 and underwent an extensive pre-planning process with the owners, general contractor and various safety team members. During this planning phase, all parties involved had an interest in how to meet the requirements set forth in the Ontario Mining Regulation, more specifically how would Keller provide suitable controls for the rotating of the drill string during the micropile drilling process. The mining regulation that would be enforced on site reads as follows:

Ontario Mining Regulations:

R.R.O. 1990, Reg. 854: MINES AND MINING PLANTS – March 2, 2018

185(2) A machine that has an exposed moving part that may endanger the safety of any person shall be fenced or guarded unless its position, construction or attachment provides equivalent protection. O. Reg. 31/04, s. 10.

The current regulations that Keller works to day to day on constructions sites reads:

Ontario Construction Regulations:

O. Reg. 213/91: CONSTRUCTION PROJECTS – March 2, 2018

109. Every gear, pulley, belt, chain, shaft, flywheel, saw and other mechanically-operated part of a machine to which a worker has access shall

be guarded or fenced so that it will not endanger a worker. O. Reg. 213/91, s. 109.

So, as written, the regulations are very similar. But currently the construction industry has allowed other safety measures to be used other than guarding and fencing. Currently, the following are utilized on most construction sites:

- Multiple E-stops
- Trip wires
- Exclusion Zone
- Remote Control Operation
- Automated Rod Handlers

7.0 SAFETY MEASURES UTILIZED - 2017 STACK PROJECT

KFL proposed the use of “Construction Barricades.” The theory behind using these barricades (e.g. safety fence) was to allow individuals to enter the drill area to prepare drill tooling but still maintain the requirements set forth in the above regulations and keep individuals away from the rotation of the drill string.

Another concern raised, and a common hazard within the small diameter drilling field, is how was KFL going to safely load the drill tooling for the purpose of micropiling. Common methods in the construction industry within Canada are to use a drill mounted winch system to assist the drill helper to manually load the drill tooling. This can be hazardous to the individual as it requires manually touching the drill tooling. Common injuries seen with this task are: pinch points, crushing injuries, soft tissue injuries from overexertion, and lacerations.

For KFL to be allowed to use common methods of loading drill tooling, detailed Risk Registers and Job Hazard Analysis documents had to be reviewed and approved by all parties to allow KFL to proceed with production activities. The Risk Registers is a detailed list of all potential risks on the project and the controls put into place to minimize them.

Once all approvals were in place, KFL began the process of mobilization to the Glencore property and successfully put the hazard control of construction barricades into practice. These barricades were mobile fencing that would allow for easy set-up and allow for the capability to see how drilling activities were progressing.

One of the greatest challenges was training the crew to work within the mine safety culture efficiently. At the beginning of the job it was a slow start, with multiple infractions for rotating parts, seat belts, burn permits, improper daily task cards, and safety glasses, since the site was always being monitored by more than one safety officer from the mine and from the owner. Within a month, the crew showed 100% compliance with the issues. The owner was very appreciative that we were able to come together and work as a team within the mining environment.

Upon arrival on site, it was discovered that the working platform drastically changed from that proposed during the planning process. It was understood that KFL would be working on a flat asphalt surface. However, the ground was excavated to approximately 2m below grade, with 3/1 sloping techniques used. This made the use of construction barricades more difficult as many of the drill locations were along the outer edges of the excavation.

Furthermore, the over-excavation made loading the drill tooling extremely difficult. KFL personnel were working on non-flat surfaces and had to deal with existing structures. Once the client saw the difficult time they were having with the existing working conditions that resulted in two minor incidents, all parties decided to stop and re-evaluate the approach to this project.

After a series of discussions with the owners, project managers, engineers, HSE staff, drillers and labourers, the following improvements were implemented immediately:

- Design an engineered rubber fork to allow the casing/rods to be temporarily secured together. This would allow for the safe hoisting operations into the drill string.
- Remove the “swamper” from the front of the drill (when possible) and use a casing manipulator. This would eliminate the hazard of having to physically touch the casing/rods.

After these improvements were put into place, KFL was successful in completing this project on time, and with no further incidents. However, it was clear to KFL that engineered improvements to our drill tooling needed to be made to ensure the requirements set forth by the Ontario Mining Regulations were fully met moving forward.

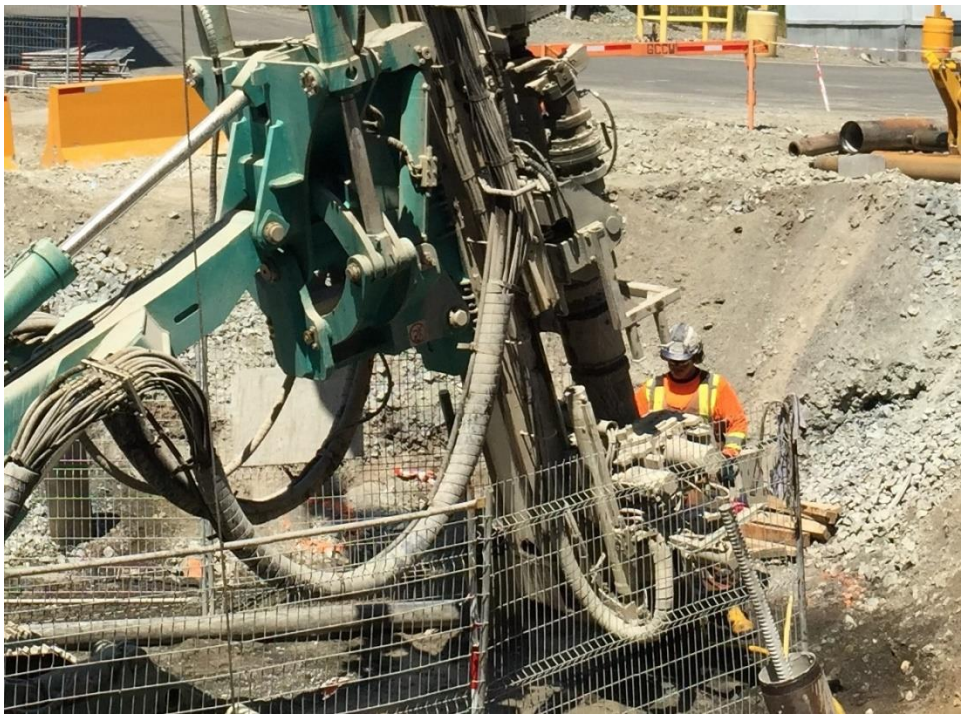

Figure 1: Use of Construction Fencing for Exclusion Zone

8.0 SAFETY MEASURES UTILIZED - 2018 CUSTOM FEED AND MIXING STATION PROJECT

The next year, KFL was approached to bid another scope of work at this same mine, but this time the client wanted KFL to show what improvements have been made since the first project.

KFL's project manager and the HSEQ department began the process of researching the different requirements that Keller faces across the world. For example, Keller companies in Europe are faced with requirements that state any drill equipment manufactured after 2015 must have guarding in place to prevent access to the rotating drill string. These requirements are similar throughout the world. Most jurisdictions require some sort of protection to prevent unintentional exposure to the rotating drilling tooling. Such accepted safeguards are manufactured "Trip Wires" and E-Stop Buttons.

Once a better understanding was obtained of the requirements that the rest of Keller faces, the drill equipment manufacturer was contacted. The manufacturer had the ability to provide engineered cages for different drill models. This would eliminate the hazard of exposure to rotating parts and fully meet the requirements set forth in the Ontario Mining Regulations.

A further safety innovation KFL decided to implement was an engineered casing crane on the side of the drill rigs. This would allow for multiple means of control when dealing with the risk of entanglement or crushing injuries from the drill string. More so, KFL would still utilize the casing manipulator as much as possible but due to the site layout this secondary means of handling casing was needed.

During the planning process for each drill location, the crew would clearly specify what method(s) of control they would use for the loading of drilling tooling (e.g. toolbox talk). The goal was to ensure that each hole location was reviewed to ensure ALL potential hazards were discussed and controlled.

These proposed improvements were presented to the client and the job was awarded to KFL.

Figure 2: Engineered Cage

KFL had zero incidents on this project and was able to beat the budget and timeframe. 2018 production rates were even slightly improved compared to using the fencing barriers in 2017.

9.0 DISCUSSION ON DRILLING REGULATIONS IN OTHER PARTS OF THE WORLD

We have looked at what is done in both the mining and the construction industry in Ontario, but how does this compare with other major micropile markets? Below are the codes that apply to rotating equipment in three major drilling markets.

Great Britain: ***Provision and Use of Work Equipment Regulations 1998 – November2014, amendments made 2018***

Regulation 11 Dangerous parts of machinery:

(1) Every employer shall ensure that measures are taken in accordance with paragraph (2) which are effective—

(a) to prevent access to any dangerous part of machinery or to any rotating stock-bar; or

(b) to stop the movement of any dangerous part of machinery or rotating stock-bar before any part of a person enters a danger zone

Figure 3: Drilling with Cages Confined Access – Keller UK

Europe: ***EN 16228***

Where access to moving parts directly involved in the drilling and piling process is foreseeable during normal operation of the machinery, safeguards shall be selected from the following:

- ***Fixed guard, or***
- ***interlocking movable guard with or without guard locking, or***
- ***sensitive protective devices, e.g. electro-sensitive protective equipment, or***
- ***pressure sensitive devices, or***
- ***a combination of the above.***

Australia: ***Model Work Health and Safety Regulations – January 15, 2019***

208 Guarding

(1) This clause applies if guarding is used as a control measure in relation to plant at a workplace.

(2) The person with management or control of the plant must ensure that:

(a) if access to the area of the plant requiring guarding is not necessary during operation, maintenance or cleaning of the plant, the guarding is a permanently fixed physical barrier, or

(b) if access to the area of the plant requiring guarding is necessary during operation, maintenance or cleaning of the plant, the guarding is an interlocked physical barrier that allows access to the area being guarded at times when that area does not present a risk and prevents access to that area at any other time, or

(c) if it is not reasonably practicable to use guarding referred to in paragraph (a) or (b), the guarding used is a physical barrier that can only be altered or removed by the use of tools, or

(d) if it is not reasonably practicable to use guarding referred to in paragraph (a), (b) or (c), the guarding includes a presence-sensing safeguarding system that eliminates any risk arising from the area of the plant requiring guarding while a person or any part of a person is in the area being guarded.

Figure 4: Common Drilling Practice in Australia – E-Stops and Trip Wires

As can be seen, all regulations, including those in Canada, are similar in wording, but are not all interpreted in the same manner. Also, except for the EN 16228, none of them are specific to drill rigs.

10.0 CONCLUSIONS

Contractors are typically the innovators when it comes to product improvements and quality. This could also be said with regard to improved safety measures as they are the most affected by injuries. That being said though, there is always the need to be commercially competitive in the market. That is why when safety measures are regulated it creates an even commercial playing field. Contractors should work closely with manufacturers and association groups and help lobby regulators to provide proper, efficient and, most of all, effective laws governing the safety or our industry.