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ROBIT® NON-STOP CASING SYSTEM FOR ANCHORING AND MICROPILING

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ABSTRACT

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Robit® Non-Stop casing system is a concentric ring bit system which enables drilling with casing and beyond the casing without any tool changes. The system is normally used in anchoring and micropiling operations. The major benefit of the system is that it saves the total time of the operation. It was successfully applied in the Sea-to-Sky Highway Improvement Project in British Columbia, Canada.

In this paper the system parts and the working principle of the Robit® Non-Stop system are described.

PREFACE

When starting this project I first proposed an idea of comparing the Robit® Non-Stop system with the other drilling systems or methods. After digesting the subject and consulting professor Jouko Lehtonen, I reached a conclusion that I will only describe the drilling system and its working principle. There were mainly two reasons: First, there are dozens of drilling methods in the world so comparing them would result in a very thick paper. Second (and probably more important), as an employee of Robit Rocktools Ltd a comparison done by me would not reach very high credibility among the readers. So, I decided to describe the product as objectively as I could and let the reader to reach own conclusions.

I would like to thank everyone contributing in this paper, especially professor Jouko Lehtonen, who shared his valuable knowledge and experience particularly during the planning of the contents. I would also like to thank our AD Jari Silver for preparing most of the excellent pictures included in this paper. Also all my colleagues in Robit Rocktools Ltd deserve my gratitude.

Tampere, June 1, 2010

Veikko Kuosa

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1. INTRODUCTION

In modern world efficiency is highly appreciated. Time is money in every industrial operation. In drilling operation major part of the costs are directly or indirectly in relation with the time consumed like investment costs, salaries, gasoline consumed, etc. Therefore it is important to find the ways to minimize the total operation time – it has a direct impact to the company profit.

Robit® Non-Stop system, a new drilling tool combining overburden and rock drilling bit, is presented in this paper. There are several factors reducing the total operation time. As a concentric ring bit system the drilling can be operated reliably in any ground conditions, and therefore very little preparation is required before starting the drilling operation. The drilling with casing and beyond the casing can be done by single operation without tool changes, which saves time. The recovery of the casing is fast because of the smooth outer surface of the retrievable parts.

2. TECHNICAL FEATURES

2.1. System description

Robit® Non-Stop system is a concentric ring bit system for drilling casing through the overburden (Fig. 1a) and continuing beyond it into solid rock (Fig. 1b).

Figure 1. a) The casing is drilled to required depth. b) The drilling is continued beyond the casing.

The complete cycle is achieved with a single pass of the drill string, that is, without any tool changes. Only single rotary head is required.

2.2. System parts

Robit® Non-Stop system consists of three parts: pilot bit, casing extension, and ring bit. Pilot bit (Fig. 2) transfers the impact and the rotation to the casing extension and the ring bit. Pilot is connected to the DTH hammer.

Figure 2. Pilot bit.

Pilot bit is heat treated Scandinavian steel. The buttons are tungsten carbides.

Casing extension is made of heat treated steel, and it is assembled with a heat treated drive ring (Fig. 3). Drive ring rotates freely inside the casing extension. There is a slight taper between the drive ring and the casing extension which locks when drive ring – or the pilot bit - is pulled backwards. This is to prevent the drive ring to rotate when unlocking the pilot.

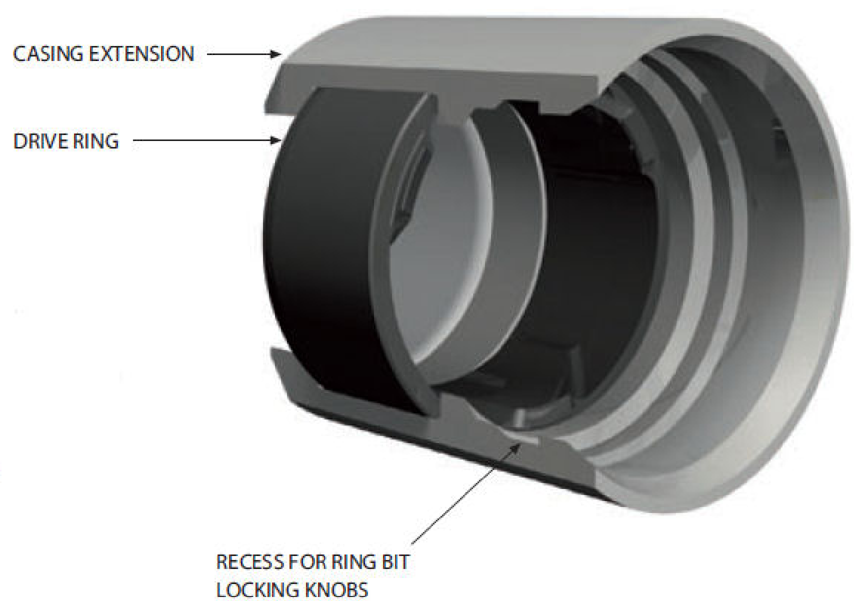

Figure 3. Casing extension assembly.

Casing extension is welded to the casing. The pilot bit locks to the drive ring thus advancing the casing. The design of the drive ring allows pilot bit to unlock from it so that the drilling can be continued without the casing.

Ring bit penetrates through the overburden and rock with the pilot bit. It also reams space for the casing to advance.

Figure 4. Ring bit.

Ring bit is locked to the pilot bit by its shoulders, and to the casing extension by its locking knobs. The ring bit is heat treated Scandinavian steel, and the buttons are made of tungsten carbide.

2.3. Working principle

2.3.1. System preparation

The casing extension is welded to the casing, preferably by a professional welder and in proper welding conditions like a workshop. A normal metal arc welding with covered electrode can be applied. The following electordes can be used:

- DIN EN 1600: E 29 9R 12
- DIN 8556: E 29 9 R(B) 23
- DIN 8556: E 29 9 R 23
- AWS: E 312-16
- W.-Nr.: 1.4337

Figure 5 features how the welding should be done.

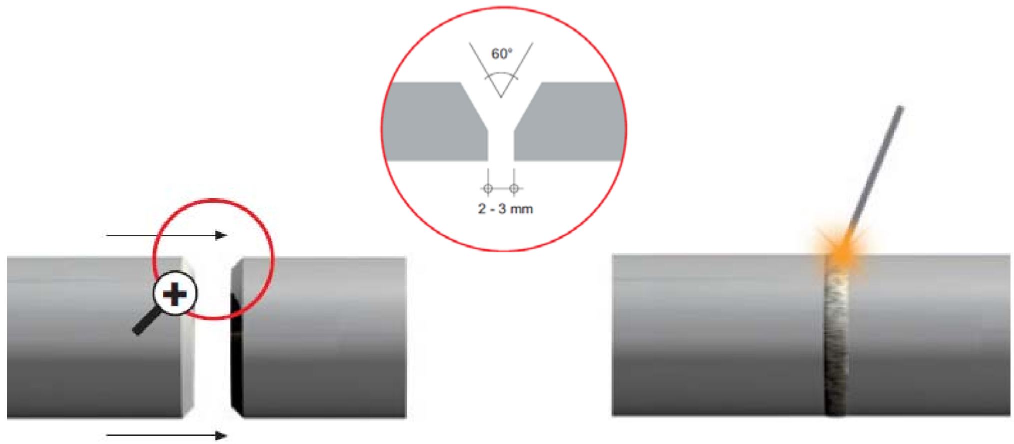

Figure 5. Welding the casing extension to the casing.

When preparing for the welding the casing and the casing extension should be placed shoulder to shoulder so that they are parallel to each other, and there should be a small gap between them (2-3mm). Neither the casing nor the casing extension should be pre-heated as it weakens the properties of the casing extension. Depending on the diameter and wall thickness of the casing, it is recommended to weld several runs.

2.3.2. Preparing for drilling

When preparing for the drilling the pilot is first connected to the drill string by the DTH hammer. Then it is driven through the casing tube and the casing extension as shown in the Figure 6.

Figure 6. Driving the pilot through the casing and the casing extension.

After that, the ring bit is placed on the pilot by its shoulders (Fig. 7a). When the ring bit is in its place the drill string is pulled backwards until the ring bit knobs lock to the re-cess in the casing extension (Fig. 7b).

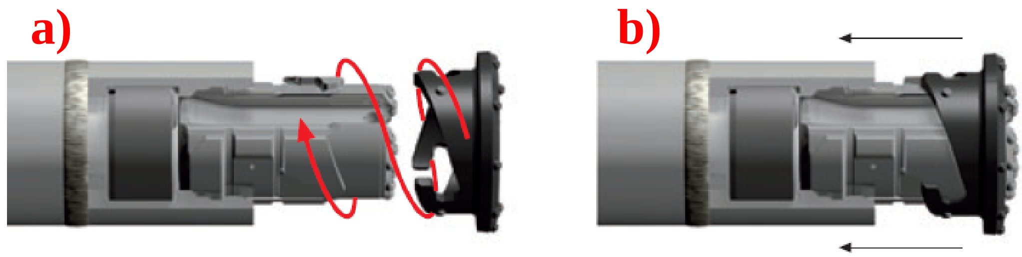

Figure 7. a) Placing the ring bit on the pilot bit. b) Pulling the drill string back and locking the ring bit in the casing extension.

After locking the ring bit to the casing extension the drill string is rotated clockwise to lock the pilot bit with the drive ring (Fig. 8).

Figure 8. Locking the pilot bit with the drive ring.

Now the system is ready for drilling.

2.3.3. Drilling with casing

Drilling with the casing is run as with any concentric ring bit system. Drilling is started with lower drilling pressure and increased gradually. The drilling parameters are adjusted according to the system size and drilling conditions. Casing is usually advanced until the bedrock or slightly beyond (Fig. 9).

Figure 9. Drilling with casing until reaching the bedrock.

2.3.4. Drilling beyond the casing

The drilling beyond the casing is done together with the pilot bit and the ring bit. Thus the diameter of the hole is the same from the top to the bottom. First the pilot bit needs to be unlocked from the drive ring. First the pilot (drill string) is pulled slightly backwards to lock the taper connection between the drive ring and the casing extension (Fig. 10).

Figure 10. Pulling the drill string backwards to lock the drive ring to the casing extension.

Second, the pilot bit is rotated counter clockwise, that is, reverse to the drilling rotation (Fig. 11). This unlocks the pilot bit from the drive ring and positions in so that the pilot can be pushed through the drive ring.

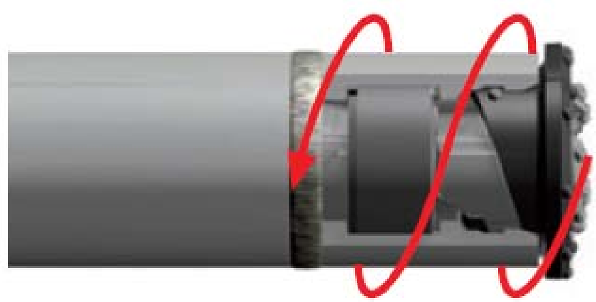

Figure 11. Rotating the pilot to the reverse direction (counter clockwise).

Third, the drill string is fed forward (Fig. 12). The pilot bit should pass freely through the drive ring. From the surface this is easily observed as the casing should not move forward. If the pilot has not unlocked properly the previous procedure should be repeated.

Figure 12. Feeding the drill string forward to slide the pilot through the drive ring.

Finally the drilling can be continued normally without the casing (Fig. 13). Like in overburden drilling lower pressure levels should be applied in the beginning increasing them gradually.

Figure 13. Continuing drilling with the pilot and the ring bit.

2.3.5. Finishing the drilling operation

When the targeted depth has been reached the pilot bit is rotated to reverse direction (counter clock-wise) and pulled up (Fig. 14a). The ring bit is left in the bottom of the hole (Fig. 14b).

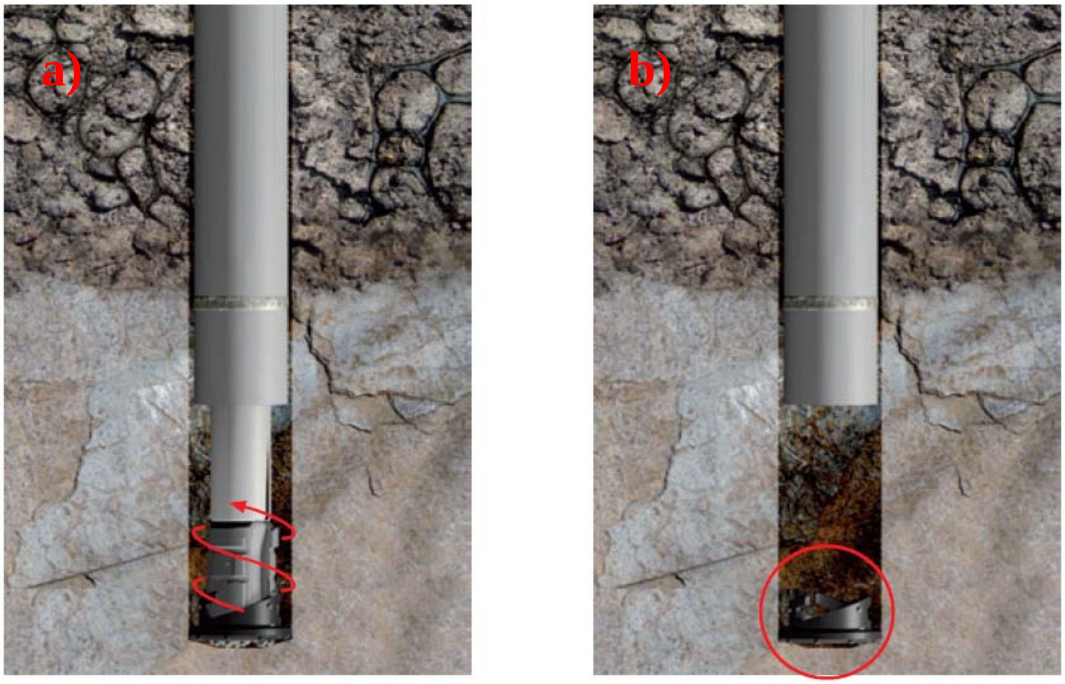

Figure 14. a) The pilot bit is rotated counter clock-wise and pulled up. b) The ring bit is left in the hole.

When the drill string has been removed the pile or anchor element can be installed (Fig. 15a). To finish, the casing is removed from the hole (Fig. 15b).

Figure 15. a) The pile or the anchor is installed. b) The casing is removed.

2.4. System specifications

To select correct Robit® Non-Stop system the casing diameter and the casing wall thickness has to be known. In Table 1 there are three systems presented for different casings specified.

Table 1. Robit® Non-Stop system specifications.

Order code	casing od		casing wall max.		casing extension id		ring bit od		pilot bit od		DTH-hammer
	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	
DTH-RoX NS 139,7/10	139,7	5 ½	10	0.394	104	4.094	150	5.906	116	4.567	4"
DTH-RoX NS 152,4/12,7	152,4	6	12,7	0.500	114	4.488	160	6.299	126	4.961	4"
DTH-RoX NS 177,8/10	177,8	7	10	0.394	142	5.591	191	7.520	152	5.984	5"

Casing od is the outer diameter of the casing in mm and inches. Casing wall max. indicates the maximum thickness for the casing wall. Casing extension id gives the drill through diameter of the casing extension. Ring bit od is the outer diameter of the ring bit, and it should be greater than casing od. Pilot bit od is the biggest outer diameter of the pilot bit, and should be smaller than casing od deducted by 2 times the casing wall max. DTH hammer indicates the size of the DTH hammer in inches for each system (e.g. 4”: IR/DHD 340). In figure 16 the dimensions of the system parts are explained. Ring bit id is the same as the casing extension id.

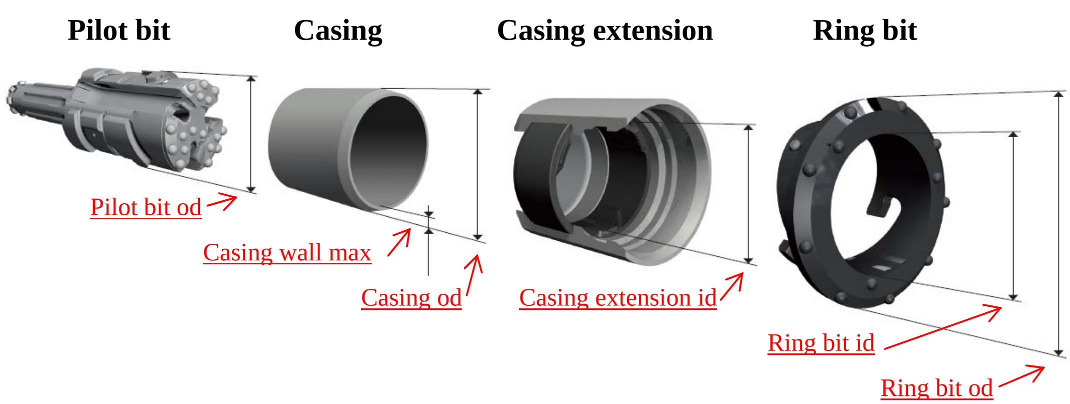

Figure 16. Robit® Non-Stop system dimensions explanation.

3. CASE STUDY: SEA-TO-SKY

The Sea-to-Sky Highway Improvement Project is located in the southwest corner of mainland British Columbia, Canada. The project aim was to reduce hazards, shorten travel times and increase capacity of the highway. The project was scheduled to be finished in 2009, just before the 2010 Winter Olympic Games. The map in figure 17 shows the location of the project.

Figure 17. Sea-to-Sky Highway Improvement Project map. (Source: http://www.th.gov.bc.ca/seatosky/index.htm).

The project faced several challenges. The highway had to be built in tight, confined areas with very limited options with routing as the highway is surrounded by mountains, a railway line, and the ocean. There are also strict limitations regarding road closures because during the peak season the highway could not be closed for more than two minutes during the day and ten minutes at night. Therefore blasting and clearing had to be well controlled and coordinated.

The project involved anchoring to “tie-back” the footing for the new highway (see Figure 18).

Figure 18. Installing the anchors to the footing of the new highway.

The entire project ended up requiring 3000 anchors. The anchors installed were a DCP bar anchor. These anchors were all typically 15 m long and were drilled at 2 m spacing. For drilling through the overburden a 152,4mm casing was temporarily installed to support the walls of the hole from collapsing.

The difficulty in the project was that the overburden was blast rock boulders with smaller fill. This blast rock varied in size from 4 meters thick to .5 meter thick. The overburden was very un-consolidated (see Figure 19).

Figure 19. The anchors were installed through the overburden which consisted of very various materials.

There were many large voids and gravel/sand fills between the boulders. Sometimes the holes needed to be drilled were 15 meters deep, at times the bedrock was encountered at only 4m. There were other spots where the hole needed casing the entire 15m and a grout sock was required around the anchor.

Most of the project was drilled with competitors drill-through ring bit system. Robit® Non-Stop system was applied in the end of the anchoring project so the last 236 anchors were installed with this system. Table 2 shows the total time consumed for drilling the hole, installing the anchor, and pulling out the casing with both competitors system and Robit® Non-Stop system.

Table 2. Time consumed in anchor installation with competitors drill through system and Robit® Non-Stop system.

	Average time consumed per anchor
Competitors system	60 – 75 minutes
Robit® Non-Stop system.	25 – 30 minutes

With the competitors system only 2-3 anchors could be installed per each day. The competitors system was very difficult to pull in the conditions described. The ring bits would sometimes last only 2 holes due to “hanging up” and sticking in the hole while being pulled. This would cause the ring to fail as it was pulled. This had a great increasing effect on the costs.

When the customer changed to the Robit® Non-Stop system, drilling and installation times were reduced remarkably. Most of the time was saved in the process of pulling the casing as the ring bit was left in the hole and the casing extension is smooth from its outer surface. With Robit® Non-Stop system the customer was able to install 5-7 anchors per day. In these extremely difficult conditions the casing extensions lasted from 180m to 225m, and the pilot bits roughly 750-850 meters.

SOURCES

Robit® Non-Stop system related pictures and texts:

Robit® Non-Stop system – Instruction Manual, 01/2010

Case "Sea-to Sky":

Brett Illidge, Pacific Bit Ltd, 12/2009.

Sea-to-Sky Highway Improvement Project website [http://www.th.gov.bc.ca/seatosky/]