PD55™
Pretec - Drillpipe

For efficient pipe umbrella, canopy tube or fore-poling support (Integrated with the jumbo rod-handling system)

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INTRODUCTION

When tunneling in hard rock you may run into unexpected sections of extremely poor ground, like fault zones, or even occasionally into soil deposits above the rock surface profile. Ground freezing or horizontal jet grouting may solve the problem, but at very high cost and with loss of time. Pre-strengthening of the ground by spiling bolts (normally 6 m or less), or pipe umbrellas (mostly 15 m to 30 m long) is often the selected mitigation method, at lower cost and requiring less time. The typical mitigation will depend on how poor and unstable the ground ahead turns out to be, which is often quite variable and hard to predict.

Pre-strengthening alternatives

- Pre-strengthening with PD55, a pipe umbrella system, typically up to 15 m long spiles and with a pipe diameter of 55 mm. Longer spiles are possible.
- Spiling by relatively short rebar bolts set in mortar (boreholes need to be reasonably stable).
- Spiling by self-drilling anchors set in mortar pumped through the center hole. May be longer than rebar bolts.
- Pre-strengthening with pipe umbrellas typically up to 3 m long pipes and with a pipe diameter of typically > 100 mm.
- Pre-strengthening with horizontal jet grouting or ground freezing.

Pipe umbrella system

Most pipe umbrella systems use steel pipes with outer diameter of 100 mm or more. Some systems depend on dedicated heavy equipment, while others may use an ordinary drill jumbo with some degree of special adaptation. If the need for installation of pipe umbrellas arises as a surprise the preparation time before installation can start may take weeks. Frequent occurrence of such situations can become seriously difficult.

The outer diameter of the PD55 pipes is 55 mm, which can be handled by rod handling magazines normally used for long hole drilling, typically up to about 15 m length per one magazine filling. An unexpected need for such pre-support takes only about 3 hours of installation of necessary adapters to start drilling of PD55 pipes, using a sacrificial drill bit on the first pipe. Once drilled to full length, grout is pumped through the central hole to come back through the space between pipe and rock.

Advantage of the PD55 system

- High installation output - one umbrella (175 pipes) may be installed during an 8-hour shift using 2 booms for drilling. This saves both cost, time and work labor.
- Usage flexibility - provides lower physical load for the operators in comparison with similar system.
- Quick and easy change of existing rod handling magazine - requires only minor adjustments.
- Flexible system – smaller diameter of pipe makes it easy to handle.
- Minimal impact in loss of pipe stiffness - due to tight joints.
- Unique solution to improve rock mass - by pressure injecting through the PD55 pipe, any loose mass is stabilized, the risk of collapse is minimized and the pipe becomes fully embedded.

Because of just 5.5 mm annular space around the pipe, the directional deviation is typically very small. This allows tight spacing of pipes, when necessary down to less than 100 mm, which can be very important to prevent loss of ground between the pipes. Note that the risk of losing ground between the pipes will basically be the same also for large diameter pipes. Close pipe spacing may compensate for lower pipe strength and stiffness compared to larger diameter pipe umbrellas, depending on the design requirements in each case. Because of the very high efficiencyof the PD55 system, 100% umbrella overlap will also be a possible and realistic mitigation alternative, if needed.

Installing pipe umbrellas can be hard manual labour, depending on the weight of individual pipes, arrangement of pipe handling and number of pipe joints per umbrella. To pass longer tunnel sections using pipe umbrellas, the HMS aspects will become very important. Using the PD55 system, the pipes are loaded into the rod handling magazine at the tunnel invert, then lifted to the drilling position by the drilling boom and the 15 m length will be placed without manual intervention by miners working at height. Miners having worked with normal pipe umbrella installation as well as the PD55 system are unanimous that it offers substantially reduced workloads.

ADVANTAGES OF PD55 IN VARIOUS CONDITIONS

Dry conditions
A pipe shield with PD55 is installed to reinforce and stabilize extremely poor rock or loose material from the rockface, before the tunnel is driven forward. The PD55 string (usually 15 m long) is drilled to full depth. The hose is connected to the PD55 pipe and grouting is pumped through the pipe until the grouting returns to the borehole opening, along the outside of the pipe. The process is repeated for the number of tubes present in the screen, with a specified centre distance between the tubes (for example, 0.5 m). After the grouting has hardened, the screen is ready.

Wet conditions
During drilling of a PD55 string, leakage of water into the borehole is found to varying degrees. Depending on the amount of water and water pressure, this can create problems when grouting. If a large part of the grouting, between pipes and rock, is flushed out of the hole along with the leaking water, the PD55 pipe will not be anchored properly. The pipe then loses much of its intended effect/strenght. In these conditions, there are a couple of measures to use in connection with PD55.

An alternative is to drill about 0.5 to 1.0 m deeper into the rock, and then install a grouting packer in the hole. The hole is pressurized with grouting to stop both water flow and to grout the drill string. Another option is to use a gasket/bushing that is intended for the PD55. The bushing is installed around the drill string in the borehole and acts as a brake for leaking water and grout.

Normal case
PD55 is normally installed below groundwater level in extremely poor rock or sediment. This allows some of the PD55 strings in the monitor to be drilled in and molded in without water issues, while other strings encounter a lot of water. An important point is that it is normally not possible to predict which holes will cause problems or to what extent. After drilling, however, this can be determined visually because PD55 is a simple, unique and effective solution to the problem.

Special case
In other cases, or in cases similar to the *"Normal case"*, the designer may, after assessing the geological and geotechnical information, decide that all pipe strings in the screen should be provided with a gasket regardless. This then enables all boreholes to be injected with overpressure along the entire length, between the bottom of the borehole and the gasket at the end of the PD55 pipe. Grouting can be carried out in the rock mass around and between each tube in the screen, which of course reduces the risk of collapse.

PD55 in comparison with other solutions
There are many other technical solutions for installing pipe screens. Most of these solutions use thin-walled pipes with a diameter greater than about 90-100 mm. Increasing the pipe diameter will not in itself change the risks described in this chapter, for the development of instability and collapse between the pipes.

Compared to the PD55, there is no known solution that is good and easy for pressure grouting of surrounding rock, although this is something that is claimed by manufacturers. The method that is most often mentioned is the use of pipes with perforations and/or valves. This method allows for the use of double gaskets that enclose individual rows of valves in the pipe, which in turn are pressurized to press mortar to the outside of the pipe. This solution can ensure the spreading of mortar along the outside of the pipe, but it cannot without special measures ensure overpressure for casting of the surrounding rock mass.

When installing such large diameter pipes, a drill bit with diameter larger than the outer diameter of the pipe must also be used. Even if the surrounding rock and loose mass settles against the pipe, there is still a path of least resistance for the grout to flow along the outside of the pipe towards the hole opening, rather then penetrating the surrounding rock.

Pipe umbrellas with valves in the pipes can be used for pressure injection into surrounding rock, but then one or more valve rows near the borehole opening must first be injected to create a blockage against the borehole opening that allows the use of overpressure in the rest of the valve rows. This is doable but will require significantly more time than descried above for PD55. And as a result, the costs will also increase.

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ACCESSORIES

PIPE PD55

DRILL BIT PD55/T45/66 MM

GROUTING ADAPTER PD55

NECK ADAPTER PD55/T45

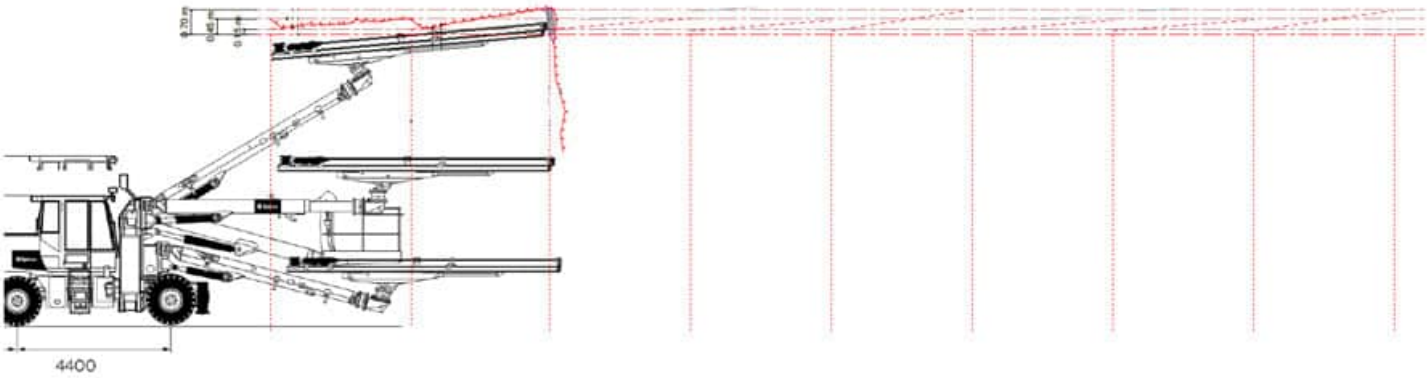
RUBBER-BUSHING PD55

STAR PD55

HEDGE PD55

PREPARATIONS BEFORE USE OF THE PD55 SYSTEM

To be able to use PD55 system outside the theoretical tunnel contour, preparations at the tunnel face are required.



ROCK DRILLING MACHINE

It is important to have the right drill-settings for the PD55 system.

Typical settings of drilling parameters:

Operator settings

- Feed pressure, drilling – 60 bar
- RPCF
- Automatic air flushing
- Time air flushing – 2,0 seconds
- Flush distance from the hole bottom – 5 cm
- Extra water flushing – deactivated
- Extra water flushing only for long holes
- Time-water, extra flushing
- Number of turns (2) back and forth during extra flushing
- Cleansing drill bit

Feeding speed

- Maximum speed, collaring – 360 mA
- Maximum speed, drilling – 380 mA
- Minimum speed, lever – 300 mA
- Maximum speed, lever – 650 mA
- Minimum speed, positioning – 370 mA
- Maximum speed, positioning – 600 mA
- Starting speed, collaring with positioning lever – 320 mA

Feeding pressure

- Feeding pressure, collaring – 30 bar
- Feeding pressure, drilling – 60 bar
- Minimum feeding pressure, drilling – 25 bar
- Maximum feeding pressure, drilling – 115 bar
- Feeding pressure, contact with rock – 15 bar
- Maximum power, forward – 450 mA

Percussion

- Percussion pressure, collaring – 125 bar
- Percussion pressure, drilling – 150 bar
- Percussion pressure, splicing – 205 bar
- Reduce percussion pressure before end of hole – 0,00 m

Rotation

- Rotation speed, drilling – 450 mA
- Rotation speed, right – 470 mA
- Fixed rotation pressure, RPCF – 75 bar
- Increase of pressure, RPCF – 35 bar
- Increase of pressure, fixed drilling – 20 bar
- Increase of pressure, unfixed drilling – 10 bar
- RPCF

Settings for your type of rock drilling machine should be created together with operator.

Work description for drilling with PD55 pipes:

1. Check the status of the drill feeder with original connecting rods so that everything is straight from the rock drilling machine through the middle drill support and the end rod support (in case of any misalignments, adjust as needed).

2. Dismantle the bushings (2 pcs) on the lifting arms and install PD55 bushings.

3. Change to the star plates in the carousel that are intended for PD55 tubes and adjust the plates to position one from the previous calibration, as calibration cannot be performed with PD55 star plates. Test-run between the lifter and the tubes in the carousel to see that all positions are correct.

4. Change from original neck adapter to PD55/T45 neck adapter.

5. Fill the carousel with 4 pcs PD55 pipes, which have their positions, in position 1, 3, 5 and 7. Place 1 or 2 pcs of PD55 pipes in the drilling boom feeder (drilling position) and install PD55 drill bit on the first pipe.

6. Observation of the pipes always rotating freely and centrally in the started borehole is important. Make sure to always keep the starting position intact during the whole drilling process, if the beam moves, it can cause troubles connecting the pipes.

7. When PD55 string has reached full depth, pull back the drill bit from the hole bottom by 5-10 mm to ensure free flow of grout. To free the neck adapter from the last PD55 pipe, it is sometimes necessary to use the splicing jaws.

WORK DISPOSITION PLAN

To work easier with the PD55 system, it's important to place the equipment in a way that makes every loading of the rod handling system as smooth as possible. You can either use our telpher and one operator for loading, or use two workers to load pipes manually.

Place the pipes as the picture shows below (pipes with male thread forward in the same direction as the drilling rig).

If you use the telpher, make sure it is standing stable by placing pipes on both sides.

EXECUTION

When the drill rig is loaded with pipes, either for 15 m or 18 m drilling, follow the drill plan and make sure to keep the drilling straight for the whole string.

A qualified and experienced drillrig operator will have no problem placing a PD55 umbrella. However, to avoid unnecessary beginner's mistakes, possible loss of spiles and breakages, it is strongly recommended to take advantage of the Pretec offer of on-site training for a couple of days. This will ensure that even a first-time use of PD55 will start smoothly and at high output, without higher-than-normal cost of parts and accessories.

There are more than one type of drillrod magazine for drill jumbos in the market. Depending on which drilling rig is used, some items need to be replaced, but should be considered a relatively simple task.

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