



## **Bolt Down on Quality – New rock bolting technology for faster and higher quality tunnel development for longwall mining**

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# BOLT DOWN ON QUALITY

**Uwe Wyink, Master Builders Solutions, Germany, explains how new rock bolting technology promises faster and higher quality tunnel development for longwall mining.**

**R**ock bolts are a vital element of ground support in longwall mining, providing structural support to the roof and ribs of main and tail gates. They are also a common source of problems since they can be difficult to install in poorer ground and sometimes fail in operation.

At the very least, such issues slow down the gates' development rate. At worst, they can lead to roof or tunnel collapse. In some countries, roof falls remain a common cause of injuries and fatalities.

However, it is rarely the rock bolt itself that is at fault. The problem comes from poor encapsulation: the grout or resin used to fix the bolt into the strata is not filling all the space between the bolt and the ground or it has not been properly mixed.

A new form of pumpable resin has been developed which overcomes this problem, ensuring total encapsulation for every bolt. Using resin in this form brings other advantages too: the installation process is safer; it can improve the quality of poor ground, reducing the need for maintenance and lowering the

risk of falls or collapses and it speeds up gate development rates, even more so in poor ground.

The resin, which is both pumpable and thixotropic, is already demonstrating significant benefits for tunnel development in hard rock mines. For coal mines, where the ground, by definition, is lower quality, the potential for improvement is far greater.

In introducing this new system to coal mines, the goal is to reduce the technology gap between the processes and equipment used to extract coal and that used to construct the access gates. While the last 10 - 15 years have seen significant advances made in equipment and automation at the longwall and in the transport of coal underground, the same cannot exactly be said for the access tunnels. This means that the development of the gates often becomes the bottleneck in the whole coal production process.

As mines go deeper, production rates for tunnel development decrease, using standard rock bolting technology. At greater depths there are increased stresses in the strata, making

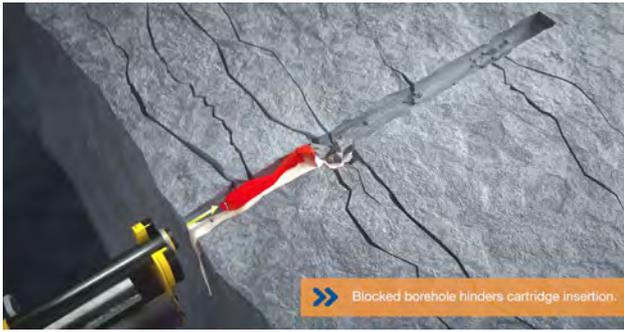


Figure 1. Resin cartridges can slow down production in poor ground; here, the borehole has collapsed and the resin cannot be properly inserted.



Figure 2. While equipment for mining has advanced in the last 15 years, technology for gate development has lagged behind. Source: RAG.

installation of rock bolts more challenging and increasing the likelihood of failure in poorly installed bolts.

## A significant problem

The most widely used primary rock support method in underground coal mining today is rebar anchored by resin from polyester cartridges. Research and anecdotal evidence from quality control professionals suggests that a significant proportion of rock bolts installed in this way will not be fully encapsulated.

The installation process using polyester cartridges involves drilling a hole into the ground that penetrates through the weaker strata into stronger ones above, inserting the cartridge and then rotating a bolt into the cartridge. The rotation of the bolt ruptures the cartridge, mixing two components - the resin and a catalyst - which are separated by a membrane, so that they react.

A rock bolt's purpose is to limit movement of the ground; if the strata around the bolt moves, it resists the movement through shear action in the resin around the bolt. The goal is for the resin to be perfectly mixed, completely filling the gap between bolt and ground so that loads are distributed uniformly. However, there are several reasons why this may not happen.

If the bolt is rotated too little when inserting it into the cartridge, the resin will not be correctly mixed. This means that the bolt is surrounded by a mixture of reacted and unreacted resin. If it is rotated too much, it can destroy the partially cured resin. Sometimes the plastic membrane inside the cartridge

remains intact, wrapped around the bolt so that the grout is not connected to the bolt, a situation referred to as 'finger gloving'.

The polyester cartridge system can also fail if the drilled hole is larger than intended, due to loose strata or even a worn drill bit. Just a few millimetres make a significant difference: an increase in dia. of 2 mm on a 32 mm dia. bolt hole requires 15% more grout to fill the annulus. Since there is a fixed amount of grout in a cartridge, the hole will not be completely filled.

If the diameter of the drilled hole is significantly bigger than that of the cartridge, the bolt may even slide along one side of the cartridge, only partially mixing the resin or failing to penetrate the plastic sleeve at all.

With poor ground, there are more potential problems. Not only could there be overbreak of the drill hole, but material may crumble into the hole, preventing the cartridge from being pushed in up to the end. If the hole cannot be cleared, re-drilling and flushing is required. This is highly time consuming and success is not always a given. If re-drilling does not work, a new hole needs to be drilled, with a high chance of the same issue. Clearly, this slows down the cycle time and construction progress severely.

Even though it may appear that rock bolts have been successfully installed, problems may emerge days, weeks, months or even years later. Once the ground starts moving, as the coal deposits are mined, the loading on the bolt will not be even if it is not fully encapsulated. That could mean that the bolt will fail, leading to increased safety risks and the need for costly repair. In addition to the potential human cost of such failures, there is a large capital cost too: repairing a tunnel is five times more expensive than constructing in it the first place.

Rock bolt failures due to corrosion are a widely reported problem, which is currently the topic of several research projects in Australia and China. Uneven encapsulation allows aggressive ground water to come into contact with exposed parts of the bolt, leading to corrosion and possibly failure.

## Technology transfer

Master Builders Solutions began developing its pumpable resin technology around 5 years ago in response to feedback from customers about the problems with polyester cartridges that have been outlined. In developing its MasterRoc RBA 38X series, the goal was to create a fast-setting resin in order to allow early load transfer between the rock, the bolt and the resin. The resin also had to be thixotropic so that it could be installed overhead without dripping out.

One of the biggest challenges the company's chemists faced was to create a range of resins with different setting times - to work in different temperatures and with different bolt lengths - but which developed the same final properties. Currently there are three versions in the series with open times of between 30 sec. - 4.5 min. A fourth version with a longer opening time is currently under development.

It was important that these resins developed the same performance regardless of the temperature they were installed and stored at. One of the limitations of polyester cartridges is that they are susceptible to heat: if they are stored or transported at temperatures above 25°C, their shelf life is reduced. Using degraded cartridges can lead to the issues explained above.

Again, this becomes more of a problem in deeper coal mines, as earth temperatures increase.

These new pumpable resins can be used with cable bolts, hollow bolts and self-drilling anchors. They have been formulated to be compatible with steel and glass fibre. This means that they can be used in the ribs of the main gates and tail gates where glass fibre bolts are used for ground support. This is to prevent damage to conveyor belts or other equipment when the bolts are cut through by the shearer as the longwall retreats.

### Faster, safer, stronger

Trials with the new resin began in 2016, with the commercial launch of the MasterRoc RBA 38X series in 2019. Today, there are several major hard rock mines using the pumpable resin. Some are deploying it using existing equipment which has been adapted with the addition of pumps, others with specially designed plant. One mine, which is operating three newly designed machines with inbuilt resin pumps, reports that they will save 4 months in mine development time, allowing mining to start earlier.

There are two reasons why cycle times for tunnel construction are faster using the pumpable resin. First, the time taken to install and grout bolts in poor ground is far faster; there is no work to clear out collapsing drillholes or drill replacement ones. Second, the bolt installation could take place in parallel with the cutting of the next section of tunnel, rather than the cutting and then bolt installation taking place sequentially as happens using polyester cartridges.



Figure 3. The MasterRoc RBA 38X series of pumpable grouts have been designed to be thixotropic so that they can be installed with overhead rock bolts.



Figure 4. The high penetration rate of MasterRoc RBA 380, part of the MasterRox RBA 38X series, means it flows into cracks and fissures, effectively increasing the strength of poor strata.

Comparing pumpable resin with self-drilling anchors and polyester cartridges, installation times in good ground are similar. However, in poor ground, the difference is significant. The installation time for cartridges can be 10 - 15 mins., whereas with pumpable resin it is always between 2.5 - 3 mins.

Combining the pumpable resin with self-drilling anchors turns rock-bolting into a semi-automatic process. It also makes it far safer because there is no need for an operator to approach the rock face. As equipment manufacturers make further developments with software and controls, this system has the potential to be fully automated.

Material costs are higher for pumpable resins, but not significantly. Some hard rock mines are finding that it makes economic sense to use pumpable resins throughout (whatever the condition of the rock) rather than switching between two different systems, because it delivers a reliable production rate.

One mine operator reports that in a tunnel development where both methods are being deployed, operatives are competing to work with the pumpable resin rather than the polyester cartridges. This is because it is far easier to work with – for the same reasons that make it much safer.

From a quality control perspective, the big benefit of pumpable resin is that the process itself ensures full encapsulation, as the resin fills the bolt hole from the far end to the opening. As soon as the resin reaches the open end of the bolt hole, the operator can visually confirm that it is full because they can see it.

Aside from ensuring the rock bolt is in contact with the resin and hence the ground, using a pumpable resin offers another structural benefit: the opportunity to improve the quality of the ground as a byproduct of the rock support process. The resin penetrates into cracks in the strata, consolidate the rock and effectively increasing its quality and strength. The penetration capacity of the MasterRoc RBA 38X grouts are high: they will travel into cracks as thin as 0.14 mm.

The other point worth noting is that the resin does not react with water while it is still in liquid form. Nor does water impact on its strength development or its final characteristics, unlike, for example, polyurethanes.

### A future in coal

MasterRoc RBA 380, part of the MasterRoc RBA 38X series, has been tested in accordance with German regional mining inspectorate Bezirksregierung Arnsberg (formerly LOBA) and deemed safe for use in coal mines. The resin has been used on a small scale in coal mines to stabilise discrete areas but not yet in a semi-automatic process for rock bolting in tunnel development.

The next step for the company will be to work with a roadheader manufacturer to create a bespoke machine that will incorporate pumps for the resin. Working with a manufacturer, our engineers will provide input and insight into the pump technology that will be most appropriate for coal mines, given the risks and constraints of the working environment.

In conclusion, thixotropic pumpable resins offer several benefits which will lead to better levels of safety, faster access tunnel development, a quicker return on investment for the operator and lower maintenance and repair costs. <sup>W</sup>C