The noble art of keeping rock in place

International safety standards require underground mines to provide adequate ground support and reinforcement measures to protect their personnel. Selecting the right solution, however, is never an easy task.

There was a time when mines were excavated out with only a minimum of rock support, mostly consisting of wooden posts and beams, and thousands of miners paid the price with their lives. Today, developing a mine without modern rock reinforcement is virtually unthinkable, but even with the best systems in the world, falling rock remains a constant threat.

Fortunately, this threat has been significantly reduced over the last few years thanks to the development of highly effective reinforcement systems, and even better systems can be expected in the years ahead to meet ever-increasing safety standards.

It is important to remember, however, that rock reinforcement is not just a matter of selecting the right rock bolts, shotcrete or other reinforcement tools, to match the behavioral characteristics of the rock mass. These days, it is generally recognized that rock-support thinking is integrated in every stage of the working cycle. This cycle starts with drilling and blasting. Over the past decade, high-productivity, high-precision drill rigs have laid the foundation for smooth and controlled blasting. This is crucial, because precision drilling lays the foundation to minimize fracturing of the rock immediately surrounding the blast area.

Similarly, blasting technology has become much more efficient thanks to the development of bulk-charging trucks and easier detonation systems.

Furthermore, scaling operations, the most hazardous part of the work cycle, have also been improved with mechanized scaling rigs that carefully scale off the surplus rock fragments from roofs and walls after blasting without damaging the stability of other sections. Added to this is the large number of new rock bolt types that have been introduced, capable of tackling every conceivable rock and ground condition together with a wide variety of shotcreting and screening systems.

As a result, today’s mine planner is able to tailor-make a reinforcement system to match his/her rock conditions better than ever before in mining history. However, that does not mean that it is an easy task or that the problems have been solved – far from it. Mining remains a challenging environment and rock fall still poses a serious threat if not taken care of in a professional way. The principles in rock reinforcement include some basic considerations:

- Carefully select the rock support system to meet all require- ments of the mine environment, from bad rock and conver- gence to seismic conditions.
- Always install rock reinforcement close to the face, immedi- ately after excavation. Investigate if the system can be divided into primary and secondary rock reinforcement.
- In unstable rock mass, evaluate the need for forepoling or grouting.
- Choose a rock support system that is adaptable to changing rock mass conditions.
- Make sure that rock bolts and shotcrete interact well with the rock mass.

As a rule, reinforcement work is carried out immediately after each round has been blasted and the blasted rock has been mucked out, although in some cases it is possible to blast several rounds without using any rock reinforcement at all, or only shotcreting.

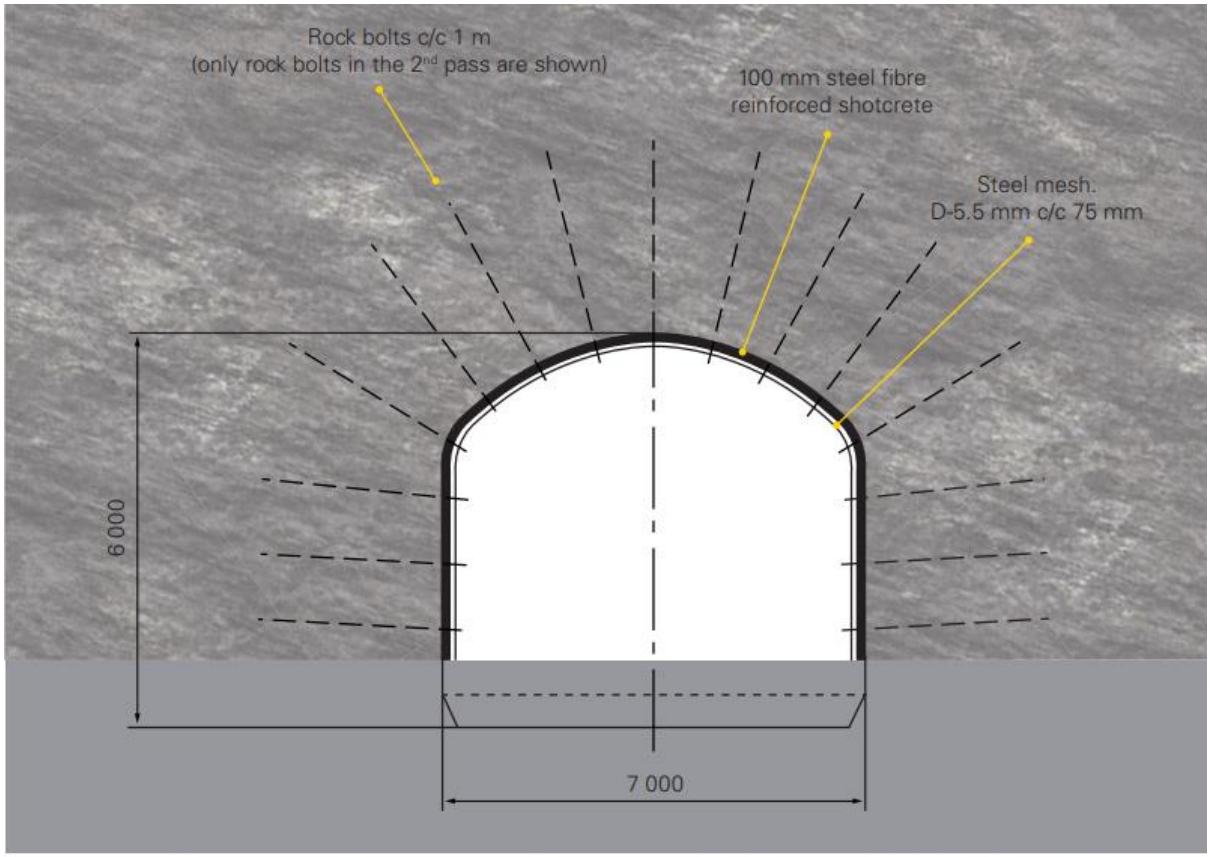


Figure 1: Rock support must be carefully tailored to pre-existing conditions. Here, a combination of mechanized bolting, shotcreting and meshing is applied in a 6 x 7 m diameter drift.

Making the right choices

To make the right choices, modern mine planners know that they must take all parameters into consideration, such as transportation and ore-processing procedures, when choosing which rock bolts to use as, in some cases, bolts entering the system can cause problems downstream.

Under normal stress conditions, cement- or resin-grouted rebar bolts are sufficient. In seismic conditions, on the other hand, it may be necessary to use bolts that are able to absorb more energy and that offer greater ductility.

The bolting process can also be divided into two stages – temporary, (or primary), bolting and secondary, or permanent, bolting. The use of primary bolting will result in fast roundtimes. Permanent bolts can then be installed when it best suits the productivity.

However, this is not an option in tougher conditions where permanent rock reinforcement is required after every blasted round.

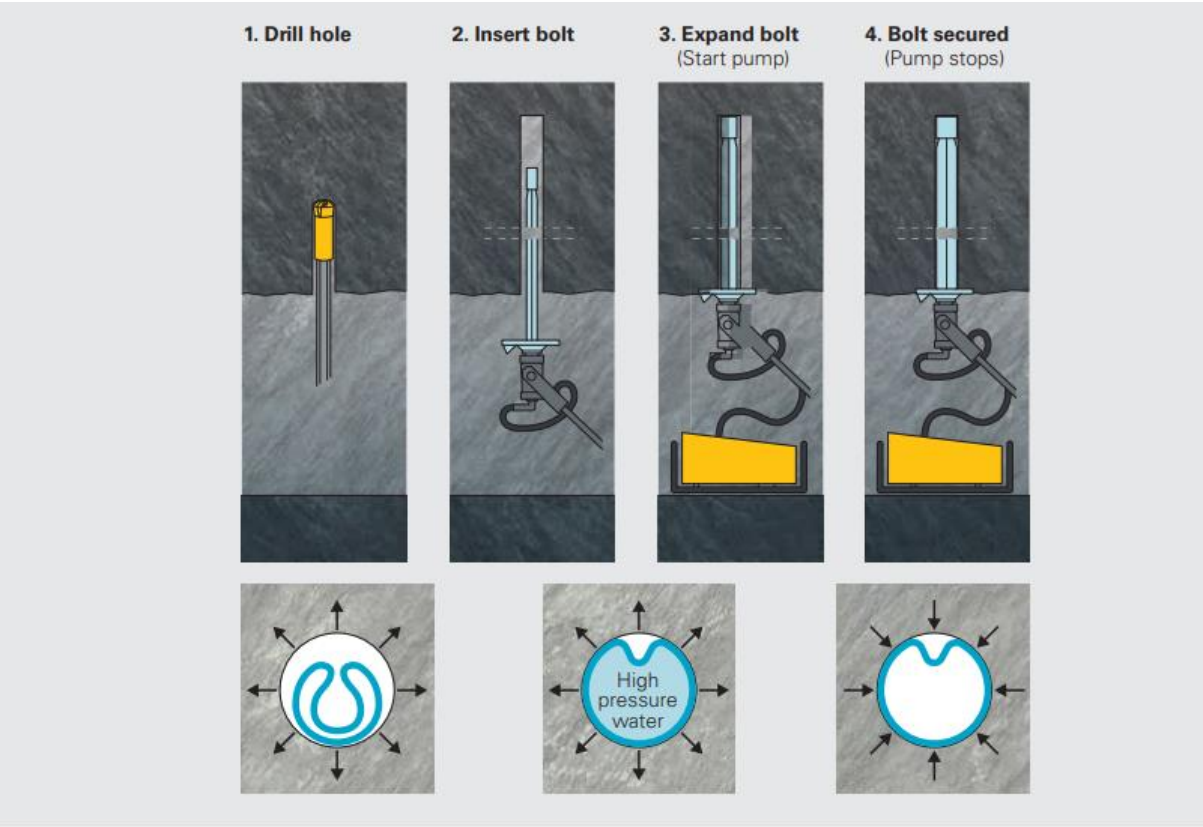


Figure 2: The principle of rock bolting lends itself to a high level of automation using modern equipment, providing safety and efficiency in the work cycle.

Safety is paramount

Safety regulations differ from country to country, but the dangers associated with insufficient rock reinforcement are now universally recognized. Modern rock support limits rock fall and the lost time injuries that have such a profound impact on productivity.

In some countries, regulations stipulate that rock support is mandatory and must be performed after each round. In others, the rules are less specific. Nevertheless, it is clear that the regulations regarding rock reinforcement grow more stringent every year and that mining companies are getting better at implementing them.

The current trend is to not only apply the right ground support for the prevailing conditions but to over-dimension the system in order to minimize the risk of disturbance to day-today operations. Another growing trend is to use more high productivity bolting equipment as the rock bolt installation procedure remains a bottleneck in the development cycle.

In addition, the demands for ductile bolts – i.e. bolts that can move or stretch and withstand the high energy loads of a seismic event – are in increasing demand. In tougher conditions, shotcreting containing steel or plastic fibers is increasingly being used together with cablebolting and meshing, particularly for larger openings.

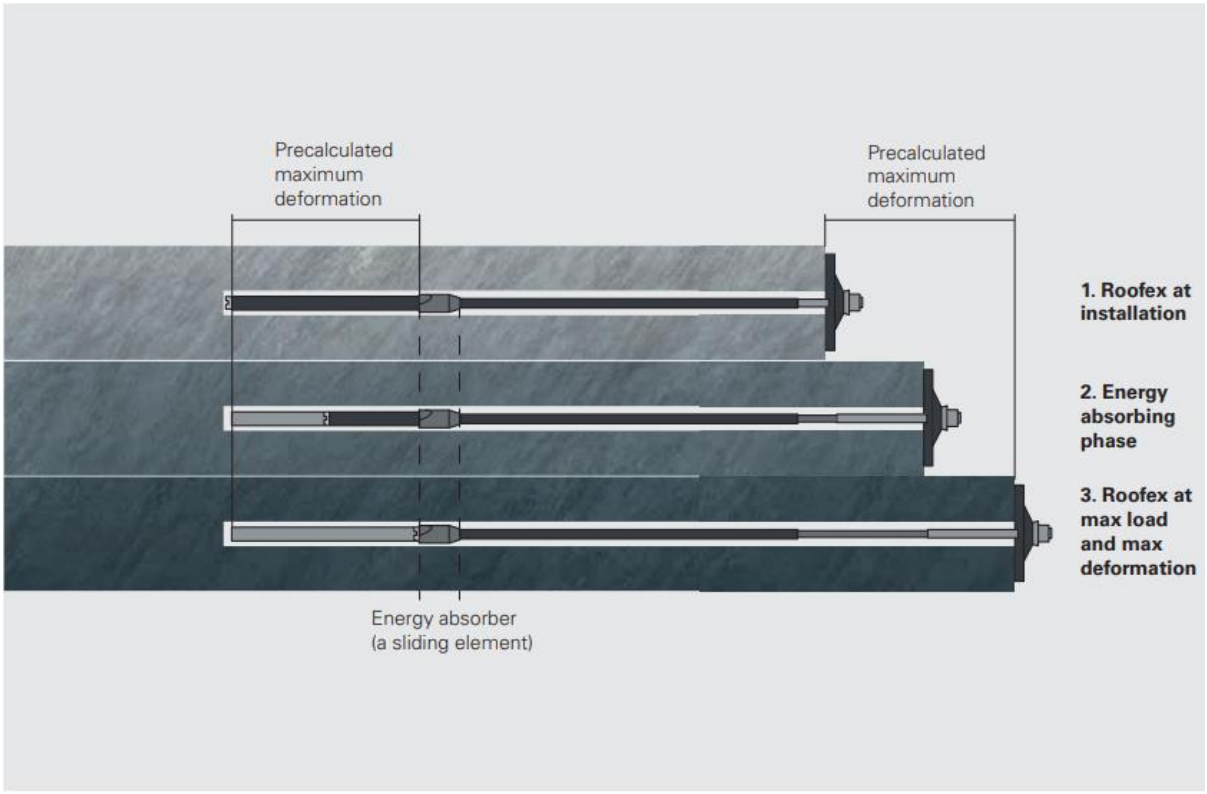


Figure 3: Roofex is a patented rock bolt solution for tough and unstable conditions. It accommodates a wide spectrum of rock mass behavior by absorbing energy.

New thinking is underway

Rock reinforcement is a time consuming and expensive process, in some mines representing half of the total cost of mining. At the same time, there are great opportunities to improve the productivity of these operations. By using highly efficient bolting solutions such as Swellex, both time and cost factors can be minimized as the bolt provides immediate support and grouting is not needed. Another popular rock bolting solution is Roofex (see Figure 3), which is used in extreme rock conditions. This unique bolt is flexible to rock movement and will absorb energy in a controlled way. According to some reports, productivity in rock reinforcement has declined in recent years, despite the use of advanced mechanized equipment, to such a level that even in the best cases it is still equal to that of hand-held operations. In all situations, however, mechanized bolting is a preferred method as it drastically improves operator safety.

This is food for thought, especially for equipment manufacturers, and a large measure of new thinking in this area is required to meet the high safety demands of the future. One approach is to combine mechanized rock bolting with automation to keep operators out of the most dangerous zones. Another is to make rock support a must after each round and to insist on the use of reinforced shotcrete (containing steel or plastic fibers), particularly in mines that are expanding to deeper levels.

The same goes for rock scaling, where equipment such as the Atlas Copco Scaletec LC and MC models (see next page) incorporate all of the benefits of modern computer technology. These fully mechanized scaling rigs are a major step forward in terms of productivity, safety and operator environment, but here, too, there is probably room for new thinking.

The vibrations associated with these machines are hard on the equipment and physically tough on the operators. Regulations governing vibrations are currently met with Atlas Copco scaling rigs but will undoubtedly increase in the years ahead, and scaling equipment manufacturers will have to work hard to find ways to bring the vibrations down to new permissible levels.

New thinking is also underway with regard to shotcrete. This involves the training and licensing of shotcrete operators as a means of increasing the quality of the shotcrete applied to rock walls, as it is not always easy to estimate the applied thickness. That said, having a quality product to begin with is equally essential. Due to deeper operations and increased safety regulations, the demand for high quality, durable sprayed concrete that offers greater safety and reduces health risks and negative impact on the environment is increasing continuously.

For this reason, Atlas Copco has broadened its offering through its recent acquisition of shotcreting specialist Meyco of Switzerland. As part of the Atlas Copco Group, Meyco's core competence in mining relates to ground support, utilizing fiber-reinforced sprayed concrete, rock and cable bolt grouting, specialized injection resins, and grouts for ground consolidation and water stopping.

Among Atlas Copco Meyco's most innovative products for underground mining is Logica, a spraying robot for shotcrete and thin spray-on liners (TSL), which ensures consistent quality through continuous recording of production and machine data. Logica also enables a high level of automation and rapid checking of tunnel profiles by means of onboard visualization and immediate response. This helps to quickly determine and guarantee thickness of the applied shotcrete layer.

Scaling involves the removal of excess loose rock on roofs and walls after blasting – an essential task for safety.

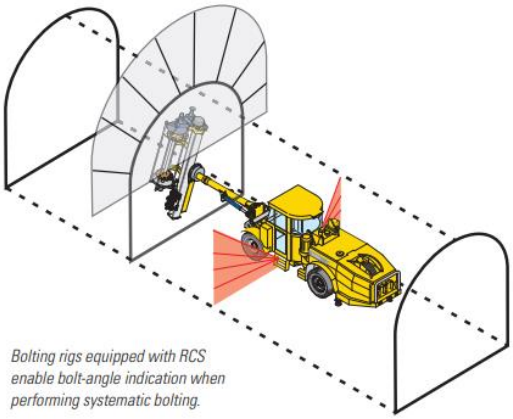
The Meyco Potenza rig delivers high efficiency in shotcreting (sprayed concrete) as it combines reliable performance with good mobility.

Time versus quality

It is fair to say that rock support, including scaling, bolting, screening, and cable bolting, is still a main bottleneck in the working cycle in underground mining. Clearly, any reduction in the time required to install the necessary support will have a direct impact on the overall cycle time and, consequently, the overall productivity and efficiency of the operation.

Geotechnical monitoring techniques indicate that the greatest relaxation or movement of the rock mass occurs immediately following excavation. They confirm that, after a certain period, the rock will establish a new equilibrium based on its own inherent self-supporting capacity and that the best quality rock will remain self-supporting for extensive periods of time without the need for extra support.

The poorer the quality of the rock, the greater the degree of support required, and it becomes increasingly crucial to install reinforcement as quickly as possible after excavation.



Bolting rigs equipped with RCS enable bolt-angle indication when performing systematic bolting.

Quality and time are, therefore, the two main parameters that must be taken into account when determining what type of rock support should be used, and mine planners involved in the design of rock reinforcement systems must satisfy ever- increasing demands to optimize the design to establish maximum safety and economy.

Here, technology has a key role to play and, to mention one example, the computerized platform RCS (Rig Control System) offered on the Atlas Copco Boltec will greatly assist the operator when installing bolts, as sensors located on the boom are able to interpret the drilling and bolting pattern with 100% accuracy and also enable precision collaring of holes.