THE INTRODUCTION OF NEW GENERATION SUPPORT PRODUCTS IN A TYPICAL SUB-LEVEL BLOCK CAVE MINING METHOD TO REDUCE THE SAFETY RISKS AND ENHANCE PRODUCTIVITY

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ABSTRACT

In typical block cave layouts as found in most underground diamond mines, an undercut level below the block cave area is developed to allow for caving in a controlled manner. This undercut development in the orebody is sacrificial and support items eventually will end up in crushers and perhaps conveyor belt system for transportation to surface. The support products installed in the undercut development thus should take cognizance of the detrimental effect these could have on the mining system such as cutting of the conveyor belts, obstructing the crushers etc.

The author wishes to explore the probability and practicality of making use of new generation support products so to make the operation a safer one, as well as to enhance productivity in the development phase as well as during the real undercut operation. This paper will attempt to propose the use of Glass Reinforced Plastic rock bolts instead of conventional steel bolts, as well as the application of resin or cement grouting products with the installation of these support items. Thin Spray Liner application as another means of creating a safer operating environment as well as a productive support medium in combination with the GRP rock bolts will also be addressed. These proposed items are envisaged to reduce production down time and improve the safety of the workers.

INTRODUCTION

In 1985 Weidmann AG, a company in Switzerland started with the development and manufacture of a range of GRP rockbolts which were then used for the first time in tunneling projects in Switzerland. The GRP bolts were installed as permanent support together with steel mesh and shotcrete in numerous tunnels constructed in the single shell method.

GRP bolt technology has since found widespread application in the mining and civil engineering industries. Compared to steel, glass fibre reinforced plastics (GRP) have advantages that can be traced to the properties of the composite material. It offers high resistance to corrosion, high tensile strength, light weight and is easily cut through.
The application of glass fibre reinforced plastics offers various possibilities. In cooperation with Rockbolt Systems (Switzerland), the Minova group offers a range of GRP bolts suitable for various rock support applications. Minova RSA has also developed a range of thin sprayed liners suitable for use as underground containment support or for weathering protection.

**GRP DESCRIPTION**

GRP bolts simply consist of a composite of resin and fibre that is manufactured through the pultrusion manufacturing process which were developed in the early seventies. The raw materials (fiber and resin) are pulled through a die, which gives the rods its shape and dimension. The rods consist of approximately 75% glass fiber and 25% resin. The fiber threads are continuous without damage or cutting of fibers during the manufacturing process.

**Fig 1** illustrates a typical pultrusion process used in the manufacture of GRP bolts.

**GRP PROPERTIES**

Due to the high tensile strength and relative high modules of GRP, the bolt has a high and immediate load bearing capacity if applied with fast setting resin capsules. The high flexibility is well suited for application without couplings in confined locations and the low weight facilitates ease of handling. The high resistance to corrosion of GRP bolts makes it ideal to be used in highly corrosive environments.

GRP bolts have several advantages if compared to steel bolts:

- Corrosion Resistance – durable material and as part of the final lining supports a structure during its whole life span
- Cutability – avoids damage to cutter heads and does not delay excavation
- Continuous Thread – threaded over the whole length facilitates coupling
- High Tensile Strength – approximately double the load of a steel bar with the same diameter (Refer to fig 2, 3 and 3.1)

- Flexibility – GRP Bolts can bent and therefore be used in confined spaces without the use of coupling elements

- Low weight – weight is only a fourth of steel bolts of the same dimensions

![Graph](image-url)

**Fig 2.** Comparison of material characteristics of GRP bolts vs Steel Bolts
Fig 3  Comparison of GRP bolts vs various Steel Bolts
Tests carried out at the Technical University of LULEA, Sweden

<table>
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<tr>
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<th>GRP</th>
<th>Steel</th>
<th>Aluminium</th>
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<tr>
<td><strong>Specific weight</strong></td>
<td>1.9</td>
<td>7.8</td>
<td>2.7</td>
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<td>(kg/dm³)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Tensile strength</strong></td>
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<tr>
<td>(N/mm²)</td>
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<tr>
<td><strong>E-Modul</strong></td>
<td>44'000</td>
<td>207'000</td>
<td>69'000</td>
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<tr>
<td>(N/mm²)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Ultimate strain</strong></td>
<td>2.5 - 3.5</td>
<td>&gt; 10</td>
<td>&gt; 10</td>
</tr>
<tr>
<td>(%)</td>
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Fig 3.1 Comparison material characteristics for Weidmann GRP bolts
TYPES OF GRP BOLTS

GRP bolts are well suited to be used as primary or secondary support as a stand alone support unit or as an integral part of support systems. There are four different types of GRP bolts available namely the all tread bolt K60 and J 64, the self drilling tubular rod and the cable bolt.

K60 and J 64 bolt

The all thread K60 bolt can easily be installed using polyester resin capsules which lends its self very well towards mechanization or it can be grouted into place by the use of cement capsules or pumpable grout.

The J64 injection bolt (tube) was developed to facilitate the injection of cementitious grout, epoxy or silicate resin for ground consolidation or water sealing applications.

Self drilling bolt

The self drilling bolt was developed for use in weak rock or soil and can be coupled to lengths up to 20m, depending on rock or soil conditions. The bolts are suitable for use with a rotary drilling machine and can effectively penetrate rock with a hardness of approximately 60 MPa.

The bolts are set in place with cementitious grout or chemical grout and are most suitable for piling ahead of an advancing face developed in poor ground conditions.
Cable bolt

The GRP cable bolt was developed as an alternative to conventional cable anchor and can be produced in lengths to suit all requirements. The cable bolt can be coiled for ease of handling and transportation purposes, has a load capacity of up to 55 tons and provide excellent bondage with grouting material due to its large surface area.
APPLICATIONS OF GRP

GRP bolt technology is especially well suited for use as temporary support units where cutter heads are used for excavation in hard or soft ground conditions. The cutability of GRP allows for the cutters to cut through the bolt without causing damage to the cutting heads and costly delays.

GRP bolts are typically used at collieries during stooping operations, the collar and holing positions for raise boring machines or at the collar and holing position for tunnel boring machines.

Fig 6.1 GRP bolts with mesh

Fig 7 Typical example of GRP bolts where cutter heads are used
GRP bolts can be used as a stand alone support or in combination with various types of support mediums. In poor or friable ground conditions, GRP can be used in combination with wire-mesh, shotcrete or thin sprayed liners.

Fig 8 Typical example of GRP bolts used in combination with wire mesh

GRP bolts can also be used as self-drilling bolts in the appropriate applications. Resin injection is generally used to inject consolidation resin through the bolt to consolidate the very weak or friable rock.

Fig 8.1 Typical application of self-drilling bolts
The very nature of the Block Cave Mining Method makes it ideal for exploring the benefits that could be derived from the use of GRP technology. The undercut development is sacrificial and the installed support will be destroyed once the undercut blasting and ore production commences.

The installed support will eventually report to the draw points where it could cause obstruction or worse end up on the conveyor belt systems with the potential of cutting the belts or cause obstructions in the crusher. The inherent properties of GRP can overcome the shortcomings of conventional steel type support and enhance safety and productivity.

In areas where poor or friable ground conditions are encountered, it is often necessary to consider the use of containment support in addition to tendon support. Common practice is to install wire-mesh and lacing or shotcrete or a combination of wire-mesh and shotcrete. Although these types of support are generally very effective in stabilizing very weak ground conditions, it is time consuming and costly, not to mention the logistical problems these may create.

Several Thin Spayed Liners suitable for various mining environments and geotechnical conditions are available and could be well suited as additional support or consolidation medium in the undercut level development in a block cave where this may be required. It offers a cost effective support solution as alternative to shotcrete in areas where the building of a structure is not a requirement.

The main advantages of thin sprayed liners if compared to shotcrete is the ease of application, speed of application, early strength, much reduced transportation of material, less labour intensive and cost effective. Thin Spayed Liners can be used as a temporary or permanent support medium depending on the requirements and prevailing geotechnical conditions.

As a temporary support medium it can be incorporated into the daily production cycle to maintain safe mining conditions at the face. This allows permanent support to be installed at a later stage without causing unnecessary production delays.

**TYPICAL UNDERCUT DEVELOPMENT SUPPORT STRATEGY AND ALTERNATE CONSIDERATIONS**

The support strategy selected for a block cave undercut level is generally site specific and to a large extend depends on the undercut level design and local conditions. Drift support and reinforcement typically consists of resin anchored bolts. Resin bolting offers immediate active and permanent support and the support regime is enhanced by the addition of an appropriate TSL applied directly at the development face after the blast. GRP bolts can be installed with a dedicated bolter making use of a carrousel bolting unit. The use of containment support such as shotcrete or wire-mesh is considered only if conditions warrant its use.
GRP bolts is well suited to be used in the mechanized environment and hence can be used as an alternative to conventional steel bolts without compromising productivity or safety. It can also be used in combination with shotcrete and wire-mesh. GRP bolts are approximately 40% more expensive than resin anchored steel bolts of the same diameter; however in some mining applications the benefits that are being derived from GRP far outweighs the additional cost.

Shotcrete and/or wire-mesh are commonly used to support undercut drifts where the containment of rock between retention support may be required to ensure that excavations remain open and safe for their designed life. However, shotcrete or wire-mesh does not readily fit in with the development cycle and often result in reduced development efficiencies or support backlog.

Should the mining conditions permit, thin sprayed liners may be considered as a cost effective alternative to shotcrete and other types of containment support. The main advantage of thin sprayed liners is that it can easily be integrated into the mining cycle providing support concurrent with the face.

CONCLUSION

GRP bolt technology has been available for the past 20 years and is extensively been used in the civil construction industry as reinforcement for concrete, construction of tunnels or slope stabilization and yet to a lesser extent in the mining industry. It is the author’s intension to create awareness amongst the mining community about the potential of GRP technology to enhance safety and improve productivity in the day to day operations at a mine.

REFERENCES


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