A NEW ROCK BOLTING CONCEPT FOR UNDERGROUND ROADWAYS

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ABSTRACT

The Skybolt is a new bolt concept, point anchored with resin in large diameter holes of specific sizes 38 mm and 45 mm. The new design achieves the optimum annular spacing required for mixing the resin anchor components which is essential for optimum resin bonding of the bolt to the surrounding rock.

This paper explains the load transfer mechanisms between bolt/resin/rock, unique to this bolt concept. It compares the pull-out test results to those of paddle and expansion shell type bolts, and highlights the versatility of Skybolt over existing, currently used, rock support systems and the benefits mine operators can achieve when using the Skybolt.

INTRODUCTION

The development and subsequent introduction of the Skybolt as a new rock bolt concept to the mining industry has met a number of objectives. Firstly: Achieves the optimum annular spacing for adequate mixing of resin anchor components in the hole, secondly: Improves roof support versatility for mine operator. Thirdly: allows for cement grout injection after installation of the bolt.

Resin anchored roof bolts for ground support applications in mine roadways have been largely confined to small hole diameter i.e. 27-29 mm which provides the optimum annular spacing of 3-4 mm recommended for safe installation of resin anchored roof bolts. To install a standard roof bolt in large hole diameter i.e. 38 mm an alternative line of development has been pursued in which the anchor section of the bolt was enlarged to achieve the optimum annular spacing required. In large annular

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DESCRIPTION OF THE SKYBOLT COMPONENTS

The Skybolt consists of high yield fully threaded steel bar, a plastic sleeve attached to the anchor end of the bar, held in place by a flanged nut to ensure that the sleeve will rotate with the bolt during installation (Figure 1).

The sleeve is 300 mm in length, 30 mm in diameter, creating a 4 mm annular spacing in a 38 mm hole diameter.
PLASTIC SLEEVE PROPERTIES

The sleeve, as the most important component, is made of Du Pont Acetal resin, which enjoys the following characteristics:

- High mechanical strength and rigidity at ambient temperature.
- Tensile strength: 68.9 Mpa
- Compressive strength: 117.0 Mpa
- Tensile impact resistance: 123 joule/m
- Izod impact
- Rockwell hardness: R 120
- Density: 1.4 g/cm³

- Good resilience and resistance to creep.
- High fatigue endurance.
- Wide working temperature range from -55°C to +122°C.
- High resistance to weathering.
- Excellent resistance to solvents.

![Graph showing bolt loading in tonnes vs. bolt deflection in mm](image)

FIG. 3: Bolt of 300 mm long and 25 mm diameter, reinforcing bar protected in various tendons. Numbers at each curve indicates borehole diameter

Hole diameter is approximately 6 tonnes. The curve shows that the bolt is pulling through the resin indicating resin failure.

DESCRIPTION OF LOAD TRANSFER MECHANISM OF THE SKYBOLT

The Skybolt is a point anchor rock bolt, which is installed in the usual fashion by rotating it through the resin to mix the cartridge's components and fill the annular space between the outer sleeve and the hole. Once the bolt is loaded, the induced load will be transmitted to the flanged nut and thence to the bonded sleeve and cured resin in the hole (Fig. 3). The applied load is in compression rather than tension, since the compressive strength of cured resin is ten to fifteen times higher than the tensile strength, therefore it is more advantageous to apply compressive rather than tensile load on the cured resin.

This method of load transfer is unique to this bolt concept. It increases the loading capacity per
mm of encapsulation from 4.5 KN/mm to 10.12 KN/mm. This increases the safety margin of roof bolts and optimises resin anchor usage.

With the paddle type bolt it is possible to obtain a situation where a relatively high stress concentration is induced in the outer end of the anchor plug and progressive failure of the bonded anchor can occur, especially in soft ground. In poor ground conditions the Skybolt offers the capacity to add extra sleeves thereby increasing the length of encapsulation. A further advantage of the Skybolt, is that, it is difficult to push the bolt through the resin cartridges without rotation and consequently the possibility of inadequate mixing of the resin cartridge on insertion of the bolt is virtually eliminated.

FIELD TRIALS AND BOLT TESTING ANALYSIS

The Skybolt was trialled in a number of mines throughout Australia. It was conducted in different rock types to determine the following aspects:
- optimum anchor length for a particular rock type
- ultimate anchor loading i.e. KN of load per mm of encapsulation
- installation of rock bolt with existing rock bolting machinery.

Destuctive tests were applied on most of the bolts tested during the trial. It was observed that all bolts were consistent in their performance under load irrespective of rock types in which the bolts were installed in. Some of the results were graphed and presented in Fig 4.

The performance of the Skybolt under load was compared to that of paddle bolt and expansion shell.

The load on paddle varied from 0.85 tonnes to 10.5 tonnes (Fig 5). This variation is due to:
- poor mixing of the resin in the hole due to large annular spacing
- inadequate distribution of resin around the paddle section of the bolt
- high stress concentration occurring at the outer end of anchor plug.

The expansion shell anchored bolt exhibited consistent loading, however the deflection was very high (Fig 6), 40 mm which is 20 mm higher than that measured on the Skybolt for the corresponding load of 14 tonnes.

Large deflections are caused by anchor slippages inside the hole. Anchor slippage reduces the anchorage capacity of the bolt and minimises its efficiency in roadway support.
CONCLUSIONS

The tests show that the Skybolt is an advanced concept of rock bolting, i.e., provides an efficient and long-term roadway support. This is achieved by creating the optimum annular spacing for proper mixing of the resin anchor cartridge components, which is essential for attaining maximum bonding to the rock.

The load transfer mechanism maximizes the loading capacity of the resin from 6 KN/mm to 12 KN/mm. This increases bolt load capacity and its safety margin by 50%.

The Skybolt eliminates the practices of pushing bolts through resin without rotation and subsequently the possibility of inadequate mixing of resin in the hole.

The Skybolt is a very versatile type of bolt, the load-bearing plates can be repositioned to a new position in case of rock fall, hence minimizing the need for high cost rebuilding of affected areas of roadway.

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