Design and Fabrication of Cable Bolt for Excavation in a Fractured Rock

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Abstract: In fractured rock masses, large excavations have an unsupported stand-up times less than the minimum time required to support the roof after the excavation. Therefore, the principal objective in the design of a support system is to help the rock mass to support itself. The use of rock bolts is a very flexible supporting method that can be combined with wire mesh, shotcrete and concrete lining. During past years a wide variety of dowels and bolt types were developed but most of them failed within a short period and the cost were high. Advantages of cable strand supports have been well documented and include flexibility, strength, and ease of installation. Main objective of this project is to design rock bolts using discarded wire ropes or cables at a low cost. A detailed designing methodology was carried out to fabricate this bolt. The bolt consists of nearly 1.6m long cable and 16 cm of anchored part and cable tightening part . Outer diameter of bolt is 33 mm and inner diameter is 12 mm and used cable diameter is 5mm. Field data illustrated the amount of load measurements that the bolt can carry is 5 kN. Suggestions were made to improve the design, which will enhance bolt performance. Field tests carried out at Bogala Lanka Graphite Ltd proved that cable bolts are effective in Sri Lankan conditions.

Keywords: Fractured rock, Flexibility, Support, Low cost

1. Introduction

In Sri Lanka today, many underground construction projects and mining activities are going on. During such excavations, ground instability (Harrison, J. P. et al, 2000) can occur due to fractured rock masses. Several measures such as installing wire mesh, shotcreting, concrete lining and rock bolting can be done to overcome this problem.

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Today rock bolting has become the primary support system in underground mining (Spang, and Egger, 1990). The use of rock bolts has resulted in a great reduction in the number of fatal and non-fatal roof-fall accidents. Furthermore, since the bolted roof can provide an unobstructed opening with minimum maintenance, the production has increased, costs have decreased and ventilation has improved.

Cable bolts have been used in hard rock mines for many years. Today, rock bolts are imported to Sri Lanka from foreign countries at a considerably high cost. In Sri Lanka no data are available on performance of bolts or about their uses. Also cable bolts have many advantages compared to other bolt types. Therefore, the main objective of this project is to design low cost rock bolts using discarded wire ropes or cables.

2. Methodology

2.1 Design and Fabrication

Design and fabrication was carried out at the Mechanical Engineering Workshop of the University of Moratuwa. Initially, parts shown in Figure 1 were fabricated with the aid of cutting grinding, drilling, lathing, nut and bolting using 35 mm iron rod (Mild steel). Gas welding method was used in special occasions such as cutting metal sheet into required size when manufacturing face plate. The fabricated bolt are given in Figure 2 and dimensions are calculated for 33mm diameter drill holes, which is the most common type of drill holes size found in the industry.

Discarded wire ropes from Bogala Graphite Lanka Ltd were cleaned and used for the fabrication of the proposed bolt.

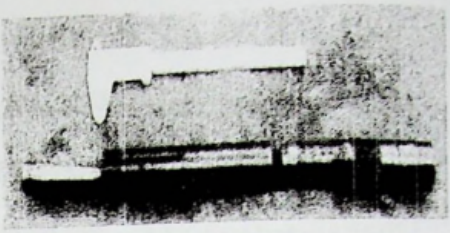

Figure 1. Anchoring and tightening parts of fabricated rock bolt

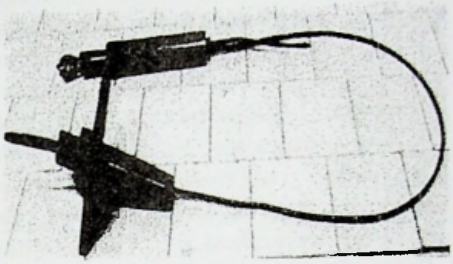

Figure 2. Fabricated cable bolt

2.2 Installation and Testing

All the testings were carried out at the Bogala Graphite Lanka Ltd. Tests were carried out using jack hammer drill and a winch to pull out the installed bolt.

A 90cm long vertical dill hole was drilled to measure direct tension of the cable when bolt failed and anchoring part was inserted to the drill hole. Then wire rope was attached to the winch and a tension load was applied on the bolt gradually until it fails. The winch works with the changes of air pressure applied on it. Compressed air flow line of winch releases some amount of air pressure when a load is applied. Therefore, drop of air pressure was calculated using a known weight and the drop of air pressure was observed when pulling the bolt.

2.3 Material and Testing of Rock Properties

Tensile strength of the iron rod and a strand of cable were tested and the maximum load was calculated. Rock core sample was subjected to uniaxial

compressive test and point load test to find out the rock strength properties.

3. Results

3.1 Local Geology of the area

Local geology of this area consisted of rock joints in-filled with graphite continuously plagued with stability problems. Underground water flow could be seen. Surrounding rock type was metamorphic with minerals such as graphite, quartz and, garnet.

Properties of cable, rock, iron rod and cost of bolt are given in Tables 1 to 4.

Table 1. Cable properties

Property	Value
Type	Lang Lay
No of strands	6
No of wires in each strand	7
Diameter of cable	5mm
Diameter of wire	0.6mm
Length of cable	1.67m
Nominal Tensile strength	14kN

Table 2. Rock properties

Property	Value
Uniaxial compressive strength	16MPa
Point load Index	10.27MPa

Table 3. Mild Steel properties

Property	Value
Tensile strength	0.49 tons

Table 4 shows the installation costs associated with labour and drilling are similar to other bolts. Cost of ordinary rock bolt (25mm diameter) in Bogala Graphite Mine is Rs.800.00.

Table 4. Total cost for Cable Bolt

Cost Item	Value (Rs.)
Mild steel rod (30cm)	200.00
Fabrication labour cost	170.00
Iron face plate	100.00
Clips (Bulldog and wire hose)	240.00
GI pipe length	50.00
Total cost	760.00

3.2 Bolt testing

Maximum breaking load obtained from pull out test was 5kN. Design drawing of the cable bolt is as shown in Figure 3.

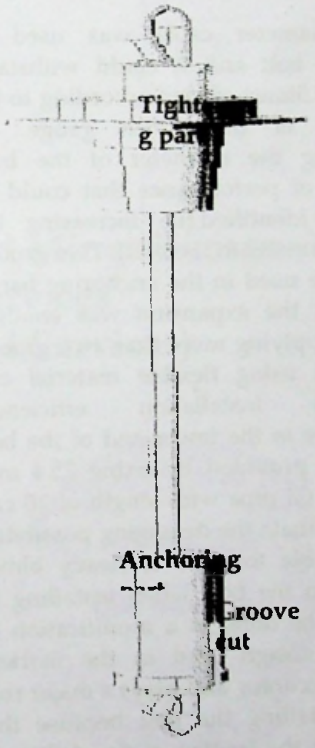

Figure 3. Drawing of the designed cable bolt

4. Discussion

Currently Sri Lankan mining industry does not use cable bolts due high costs.

Therefore, designing a cable bolt at lower cost with good performances would lead to save money.

It was anticipated that problems could occur during the process of making the bolt and fixing and hence properties of the materials, properties of the cable, max diameter of the bolt, most suitable number of groove cuttings in the barrel part had be monitored closely. Three bolts were fabricated with different thicknesses of anchoring parts and above properties were checked. After installation of one of the selected bolts in the Bogala Graphite mine, proper adjustments necessary were identified to make the bolt into commercially viable commodity.

5mm diameter cable was used in installed bolt and it could withstand 500Kg (0.5tons) of load according to the readings of the winch gauge. By increasing the diameter of the bolt, changes of performance that could be effected identified.(i.e increasing the bored diameter in the bolt). Two groove cuts were used in the anchoring barrel part and the expansion was enough. But by applying more than two groove cuts and using flexible material can increased installation efficiency. Assistance to the lower end of the bolt could be provided by fixing 25.4 mm diameter GI pipe with length of 10 cm, as to eliminate the damaging possibility of the cable toe due to heavy blows applied to the bolt when installing it. This can be done as a modification to the bolt design used in the market. Drilling accuracy also plays a major role when installing the bolt because this minimizes the friction of the drill hole to insert the barrel and wedge into the hole.

To check the long term stability, post installation survey should be carried out in suitable time intervals. Corrosion resistance also higher in cables compared with steel rod bolts so their lifetime is higher.

5. Conclusion

Cable bolt performances observed is satisfactory on compared with the existing rock bolts. The cable bolt is easy to install, simple and therefore a suitable method of mine support for underground mining industry.

Acknowledgement

We are thankful to Prof. UGA Puswewala, Head, Department of Earth Resources Engineering and the staff of the Department of Earth Resources Engineering of University of Moratuwa for facilitating this work. We are very much grateful to Mr. ES Dahanayaka, General Manager of Bogala Graphite Lanka Ltd, G. Kumburahena, AGM of Bogala Graphite Lanka Ltd and AMADM Senadhira, Mining Engineer for providing the opportunity to carry out our work and extending necessary facilities. Our project could not have possible without the support of Mr. KDSD Udula Kumara ,Technical officer of Department of Mechanical Engineering of University of Moratuwa and Mr. SD Sumith, Lab attendant of Department of Earth Resources Engineering of University of Moratuwa

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