Evaluation of existing timber supports in Bogala mine and proposals for alternatives

Rathnapala AVAOC, Perera TSLC, Hetttiarachchi DSW, Gangatheepan B,* Chaminda SP, Dharmaratne PGR and Senanayaka IP

*Corresponding author - chamindaspc@yahoo.com

Abstract: Rock support is an important aspect in underground mining to stabilize the ground rock to provide a safe environment. As it directly influences the safety, it is very important to evaluate the supporting system. As cost is a major issue, it is important to reduce the support cost without compromising safety. Bogala Graphite Lanka Ltd is an important vein-graphite supplier in the world operating an underground mine using Over-hand-Cut-and-Fill mining method. Steel supports, Rock bolts and timber supports are currently used for supports. Eucalyptus Microcorys (Micro) is the main type of timber used for supports. The objective was to find a cost effective type of support with the required level of strength and durability in an underground environment. Rock mass classification using Rock Mass Rating (RMR) was initially used to evaluate the intact rock. Several timber types such as Eucalyptus Microcorys, Eucalyptus Grandis, Oil treated Eucalyptus Grandis, Teak, Eucalyptus Camaldulensis and Hora were selected and their mechanical properties were determined. Concrete beams and Steel beams were also considered. From mathematical and cost analysis, it was evident that Eucalyptus Camaldulensis satisfies the requirements. It was also found to be cost effective than the existing type with a minimum cost saving of about 44%.

Keywords: Mechanical properties, Over-hand-Cut-and-Fill, Rock Mass Rating (RMR), Supporting systems

1. Introduction

Rock failures can be observed in many working faces in Bogala mines therefore ground supporting systems are introduced to stabilize the rocks. Post column type supports are mainly used as the mine roof supporting system which is essential in Over-hand-Cut-and-Fill mining method.

Timber has been used as the main supporting system since the early days. Timber supports mainly function the role of support to stabilize the unstable ground rock and used as a safety sheild to avoid rock The main timber types used in the early days for supports were Naa, Kumbuk, Mee, Moonamal, Milla, Palu, Coconut tree, Mora and Dunumadala. Because of

SP Chaminda B.Sc.(Hons)(Moratuwa), M.Sc(AIT) Lecturer in Department of Earth Resources Engineering, University of Moratuwa.

PGR Dharmaratne, BASc, M.Sc, FIE, FIMM,FGG, FGA,C.Eng, Senior Professor of the Department of Earth Resources Engineering, University of Moratuwa.

IP Senjanayake B.Sc.(Hons)(Moratuwa), Lecturer in Department of Earth Resources Engineering, University of Moratuwa.

AVAOC Rathnapala,TSLC Perera, DSW Hetttiarachchi, B.Gangatheepan Final year Undergraduate students of the Department of Earth Resources Engineering, University of Moratuwa.

the high prices and unavailability of these timber types the mine switched to Eucalyptus Microcorys(Micro) which is a special class timber. Although it has a good durability and sufficient strength,it has high cost. Before evaluation of existing timber supports,

Rock Mass Rating (RMR) was initially performed at several selected places with supports and without supports. Behaviour of those supports were monitored. When implementing an alternative for the existing timber supports, it should be satisfy four requirements-lower cost, strength (should be more or equal to Eucalyptus Microcorys(Micro)),it's ability to fix soon after the blasting and ease with which it can prepare according to shape to fix the side walls. If any other type of timber satisfies the strength requirement, the cost is the only factor to be considered. If the alternative is not a timber, the handling and fixing should also be considered. Therefore, much attention was paid to other timber types.

2. Methodology

Initially literature survey was carried out to cover the areas of mine supporting systems, timber properties, timber tests and treatments and viability of implementing alternative supports system at Bogala mine.

During the preliminary site visit, the supporting system was studied.

2.1 Rock Mass classification

Rock mass classification was carried out for four different locations in the mine - a cross cut and three drives in -158 and -142 fathom levels to evaluate the intact rock.

2.2 Evaluation of Existing Timber Supports

Several samples of Eucalyptus Microcorys(Micro) were collected and prepared as standard test specimens Compression test (parallel to grain, perpendicular to grain, and after water saturation),static bend test, density and moisture content determinations were carried out to determine the mechanical properties of Eucalyptus Microcorys.

2.3 Mathematical evaluation of the suitability of Micro beams as a support.

Mathematical calculations were carried out using determined mechanical properties for evaluate the suitability of Micro beams as supports

2.4 Evaluation of alternatives

Considering their (Bogala mine) requirement some alternatives were found such as

- Other Timber types (Teak, Hora, Eucalyptus Grandis, Treated Eucalyptus Grandis, Eucalyptus Camaldulensis, Kumbuk)
- Steel
- Pre Cast Concrete

Mechanical properties of timber were determined by conducting compression test (parallel to grain, perpendicular to grain, after water saturation), static bend test, density and moisture content determinations (B.S. 373; 1957) by using more than six specimens from each timber type for each test.

Two concrete beams (150mm x 150mm x 1200mm) were prepared and tested.

2.5 Cost analysis

Cost analyses were carried out for concrete beams, steel beams and all alternative timber types considered.

2.6 Selection of Alternative

From the analysis carried out, Eucalyptus Camaldulensis was selected as the most suitable alternative. Further analyses were

conducted to compare alternative with Micro and the alternative cost saving per month was also calculated.

3. Results

3.1 Rock Mass Rating (RMR) Classification

Main cross-cut (-142 fm level) = Very Good Rock

Sub level Drives (-158 fm level) = Good Rock

3.2 Compressive Strength

Table 3.1- Average compressive strength parallel to and perpendicular to grain

Timber type	Average compressive strength parallel to grain (N/mm²)	Average compressive strength perpendicular to grain (N/mm²)
Eucalyptus Microcorys	48.39	11.74
Eucalyptus Cameldulensis	49.38	10.88
Kumbuk	33.32	-
Hora	29.73	-
Teak	39.72	5.15
Grandis	28.28	3.85
Treated Grandis	26.22	2.98

3.3 Bending strength and modulus of elasticity

Table 3.2 - average values of Bending strength and Modulus of elasticity

Timber type	Average bending strength parallel to grain (N/mm²)	Average modulus of elasticity (N/mm²)
Eucalyptus Microcorys	126.21	21326.78
Eucalyptus Cameldulensis	92.18	12106.87
Kumbuk	55.61	5950.9
Hora	58.69	10375.5
Teak	70.68	9985.87
Grandis	71.07	10873.7
Treated Grandis	76.43	13398.15

Table 1.3 - Average Density and Moisture content

Timber type	Average density (kg/m³)	Average moisture content (%)
Eucalyptus Microcorys	1119.27	27.16
Eucalyptus Cameldulensis	1015.36	17.4
Kumbuk	825.82	14.98
Hora	702.67	18.44
Teak	743.51	22.9
Grandis	718.61	38.28
Treated Grandis	495.37	16.2

Price Comparison

Table 1.4 - Maximum and Minimum prices of timber types for 1 dm³

Timber type	Minimum Price (Rs.)	Maximum Price (Rs.)
Eucalyptus Microcorys	40.74	89.63
Eucalyptus Cameldulensis	3.85	8.47
Treated Eucalyptus Cameldulensis	18.46	23.08
Kumbuk	29.47	64.83
Grandis	19.84	43.65
Treated Grandis	34.45	58.26
Concrete		
Second Hand Rails		

Compressive strength parallel to grain when fully saturated with water

Eucalyptus Microcorys = 48.74 N/mm²

Eucalyptus Cameldulensis = 43.32 N/mm²

4. Discussion

Eucalyptus Microcorys (Micro) is the main type of timber used in Bogala mines at present since it gives good stability for the working faces where it was rare to observe any collapse in the supporting system unless under abnormal conditions. Eucalyptus Microcorys provides good strength values, where the minimum bending stress is about 121 N/mm² and, it is much higher than the minimum required value. It also got high compressive strength parallel to and perpendicular to grain and the durability of the timber is also excellent. When Eucalyptus Cameldulensis conceder as an alternative, it shows greater values in compressive strength parallel to grain, compressive strength perpendicular to

grain, bending strength, modulus of elasticity, density and moisture content compared to the other timber types. Those values observed for Eucalyptus Cameldulensis is also much similar to the respective values of Eucalyptus Microcorys, the existing support type used in Bogala Mines at present. The average compressive strength parallel to grain of Eucalyptus Cameldulensis(49 N/mm^2) is similar to the to the strength of Eucalyptus Microcorys(48 N/mm^2) and much higher than Kumbuk(33 N/mm^2) which has been the timber most used in the early days as support. A test has been carried out to verify the change in compressive strength parallel to grain when the timber is saturated with moisture. The values came out prove that it will not give a much different values in damp conditions and it is almost same for both type of timber types -Eucalyptus Microcorys(Micro) and Eucalyptus Cameldulensis. Bending strength also shows the same kind of variation where it is almost same for the Eucalyptus Cameldulensis (92 N/mm^2) and Eucalyptus Microcorys (126 N/mm^2) while timber type such as kumbuk showed much lower values (56 N/mm^2).

In the cost analysis, it showed a vast difference between the prices. While Eucalyptus Microcorys gives Rs. 40.74 per dm^3, Eucalyptus Cameldulensis is only gives Rs. 3.85 per 1 dm^3. Main reason for the large difference in prices is the demand for timber types where the demand for the Eucalyptus Cameldulensis is much lower compared to the Eucalyptus Microcorys because of the unavailability of larger diameter logs of Cameldulensis although it is available in diameters of out 15 - 20 cm. If treated Eucalyptus Cameldulensis to increase the durability of the wood as a supporting system, it will be also much cost effective than the use of Eucalyptus Microcorys at the minimum price where about 44% cost saving can be achived

Although the cost factor is not a concern in concrete beams it is difficult to consider concrete beams, as an alternative because of handling difficulties while the main concern with second hand rails is the cost which is very much higher than all of the alternative types that are timber and concrete.

5. Conclusions

By analysing the result it can be concluded that the existing timber supports (Eucalyptus Microcorys) is suitable as a support, but is not cost effective. Therefore, Eucalyptus Cameldulensis is a better alternative since it is cost effective, as well.

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References

Hoek Evert, Kaiser Peter K., Bawden W. F., 1995, Support of underground excavations in hard rock, 1st ed., Netherlands, Balkema,p.22-152

London 1957, Methods of testing small clear specimens of timber, B.S. 373;1957,British standard house London