Support Cost-efficiency Comparisons of Grout Pack and Timber Pack Systems

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ABSTRACT

To allow a comparison of support cost-efficiency all factors contributing to the total installed cost and performance of a product need to be considered. Apart from the direct material costs of the support, other factors such as labour cost, transportation cost (vertical, inclined and horizontal transport costs), capital expenditure costs and in-situ performance and risks of the support need to be considered and then compared on a cost / benefit rationale. This paper presents a brief analysis of this problem for grout-based and timber based packs as used in tabular South African mines, and concludes that grout-based support systems are typically 3 times as cost-effective.

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1 INTRODUCTION

To evaluate the cost-benefit of pack support systems all significant costs need to be assessed and the support benefit (support resistance generated for the cost) evaluated in a cost/benefit rationale. In this paper two very different support systems are briefly analysed and compared, namely grout based packs, and timber based packs. The data for the grout based packs is for the RSS pack as supplied by Norsenet (Pty) Ltd and is accurate. Data for the timber based pack systems is from various recent sources and is used for illustrative purposes and does not refer to any particular timber based or composite pack. Interested parties should enter their own costs into the spreadsheet for their own analysis and circumstances, which may be unique. An introduction to the grout packs is given below:

A typical RSS grout pack is shown in Fig. 1

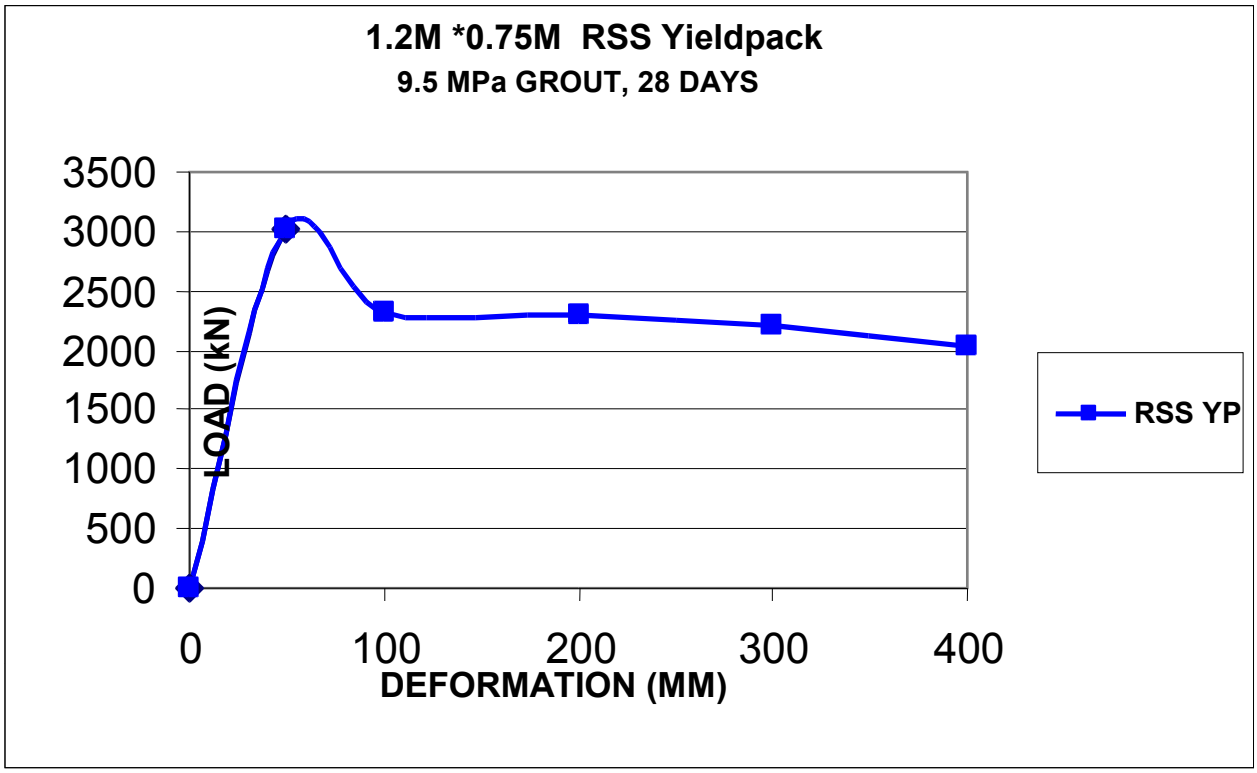
Figure 1. Typical standard RSS grout pack

A typical grout mix to achieve cube strengths of 9 MPa after 28 days curing is shown in the table below.

Table 1. Typical grout mix to achieve 9 MPa cube strengths after 28 days

Composition	OPC	PFA	Tailings	Water
Kg	118	184	603	270
Weight %	10%	15.7%	51.3%	23%

A typical load-deformation graph for a RSS Yieldpack with two 150mm diameter minepoles (suitable for high closure conditions) with this grout mix after 28 days is shown in Fig.2



- Plant throughput costs (maintenance and wear and tear of equipment)
- Labour costs (installation and placement of packs)
- Transportation costs of pack to underground site (e.g. vertical and incline shaft transport costs, horizontal transport costs)

The time dependency behaviour of support materials needs to be incorporated.

For grout-based packs there is an increase in support resistance with time as further curing occurs.

For timber based-packs there is the problem of timber creep with rapid loss of active support over relatively short periods of time, as well as the reduction in load due to fungal decay in a moist athmosphere in the medium to long term. It is left up to the individual rock engineer to account for these effects in his analysis. Furthermore, where timber pack systems are used along gullies, gully shoulder damage may result due to strain hardening behaviour of timber pack types with high width to height ratios.

One further item needs to be incorporated in the cost analysis:

- The combustion risk involved in using timber packs in South African tabular mines. This combustion can occur as a result of spontaneous combustion or sabotage by the work force. Whilst the occurrence of large-scale fires in timber supported stopes is infrequent, the financial consequences are severe.

An example of this cost comes from DRD Gold, and was obtained from the company website:

On 1 February 2003 at Durban Roodepoort Deeps Far East vertical Shaft of Crown Gold Recovery's ERPM, a fire was started on the 70 West longwall after a normal blast. While "the precise cause of the fire has not yet been established, there is evidence that it was premeditated. A total of 226 proto teams were involved in extinguishing the fire…The estimated cost of the fire to Crown Gold Recoveries was R 15.2 million…"

This is a small shaft with an approximate usage of 400 timber packs per month. The cost of the resultant damage, calculated and attributed equally per timber pack used over the downtime, is approximately R 38 000-00 per pack. Production returned approximately to normal after February's production dropping to almost half of the usual output.

More recently there has been a well known recent large underground fire in Goldfield's Kloof mine, were similarly large and costly intervention of proto team callouts was necessary, with large production losses. Similarly a few years ago, Libanon Mine had suffered severe losses due to underground fires.

It is a difficult task to assign a risk monetary value to the use of timber pack support in underground tabular stopes. The severity of the problem is taken as the value given above. The frequency or likelihood of this problem occurring on the mine should be estimated by the mine's personnel. In the following example it is assumed that the cost per pack due to fire damage is R 30-00 each.

Fire retardant costs are taken as 2.5% of the timber raw material cost. This treatment is effective in preventing unassisted combustion of timber, and retards the severity of outbreaks but is not effective where deliberate sabotage is the root cause of the problem.

2.2 Averaged support resistance (benefit for the cost incurred)

The average support resistance of the packs to be compared over a specified deformation range should be calculated. In practise, taking force loads at every 25mm along the load-deformation graph should suffice. It is proposed that the arithmetic value obtained is used in the R/kN cost efficiency calculation.

2.3 Other benefits of grout pack systems

An additional benefit of using grout packs instead of timber packs is the possibility to redeploy the increased availability of material cars (or vehicles) for transporting other items (e.g. explosives, rails) or hoisting ore, or people. The deeper the mining and the further the working stopes are from the shafts the more attractive grout support systems become in terms of their transportation efficiency. The benefits of grout based pack systems for the South African gold mines can thus be very attractive. The additional transportation capacity can be redeployed in increasing production output in most mines, with a large additional pofit. This factor can be very large and has not yet been estimated in the spreadsheet.

Furthermore, grout packs can be engineered to give performances to suit the clients requirements and quality control assurance systems are reliable. Additional benefits are in using the grout plants admixtures for shotcreting and construction work underground.

2.3 Total installed cost spreadsheet example

Table 2 shows a generalised cost comparison for the two systems. All grout plant capital costs are included (over 5 years). Validity of costs is for running the grout plant at 850 packs per month.

Table 2. Total cost comparison of grout packs (RSS Yieldpack) and timber packs (deep mining).

TOTAL COST BENEFIT CALCULATOR		**User inputs (timber pack)**		**User inputs (enter own variables here)**	
		timber cost	420		
test dates :	2004/2005	prestress pan cost	120	grout cost per cubic metre :	260
pack size :	see table	monowinch labour	45	stick cost :	17
deformation range:	0-500mm	build labour	160	labour cost (for 1.2m high) :	120
grout strength :	9.5 Mpa	matl. Car labour	22	vertical hoist cost :	4,000
curing time :	28 days	totl. Labour	**227**	incline hoist cost	0
tested :	CSIR	fire risk cost	38	horizontal transport cost :	500
				rss per material car :	50
				grout throughput cost per m^3	400

	Timber 0.75m sq. 1.3	**RSS YieldPack (0.75m) 0.4**	**Comments :**
pack	480.00	311.00	…enter price of pack here.
bag	0.00	33.00	…enter price of bag here.
sticks	0.00	34.00	… 2 sticks per rss yield pack.
mine pole radius	0.00	0.08	
stoping width (m)	1.40	1.40	
diameter (m) or width	0.75	0.75	
grout volume (m^3)	0.00	0.57	…grout volumes for sticks have been deducted.
labour	227.00	147.00	
plant cost	0.00	227.70	
grout cost per PACK	0.00	148.01	
vert. transp. cost	2,000.00	80.00	...2 TIMBER PACKS PER CAR ONLY
inclined transp. cost	0.00	0.00	
horizontal transp. cost	250.00	10.00	…25 times as many rss packs per car.
pre stressing pan	120.00	0.00	…2 pans per timber pack
fire retardant cost	12.00	0.85	
fire risk cost	38.00	0.00	
total installed cost	3,127	992	
RSS saving (rands) on :	**2,135.45**	**0.00**	
RSS saves (%) on :	***215.36***	***0.00***	
	TIMBER	**RSS YieldPack**	**…the true measure of client value**
installed costs :			…averaged every 100mm up to 500mm deformation.
load (kN)	2,410	2,410	…user to put in own average load for timber pack
total installed cost	**3,127.00**	**991.56**	**…rss YIELDPACK lowest cost superior efficiency.**
R/kN	**1.30**	**0.41**	**…USING RSS packs frees shaft time for production**
RSS saves (%) on :	***215.4***	***0.0***	**…grout packs do not burn!**

3 CONCLUSIONS

Grout packs are typically three times as cost effective as timber packs.

A new type of high yield grout pack (the RSS YIELDPACK from Norsenet Pty (Ltd)) makes it possible to use these pack types at depth under high closure conditions. Furthermore, grout plant technology has advanced to a state of high reliability and efficiency.

Grout packs have very low transportation costs, are not susceptible to burning, and offer the possibility of redeploying transportation capacity where it matters, to increase production of ore.

Furthermore, grout packs can be engineered to give performances to suit the clients requirements and quality control assurance systems are reliable. Additional benefits are in using the grout plants admixtures for shotcreting and construction work underground.

REFERENCES

DRD Gold Ltd company website press release Graulich, I and Duncan, J. 205/03 31 March 2003