Clarification Summary in response to a reader's query: 'Installation of resin-grouted rock bolts in hard rock mining: Challenges and solutions for improved safety'

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Annulus size

Hagan (2003) stated that the relationship between the diameter of the support hole and the diameter of the rockbolt has a large effect on the efficiency of reinforcement. The difference between the radius of the support hole and the radius of the bolt is known as the annulus size. Since the design diameter of the rockbolt is 25 mm, the design annulus size is 3.5 mm. According to the mine support standard, the required annulus size should not be greater than 5 mm. The design annulus size of 3.5 mm is within the required range as stipulated in the mine's code of practice. The design annulus size is also within the manufacturer's recommended optimal design annulus size of between 3–4 mm. From this observation, the design is anticipated to be highly efficient.

Optimizing the support design

In practice, the support holes require 8% more resin per hole. Possible solutions to this problem would be to increase the sizes of the rockbolts, increase the sizes of the resin capsules, or reduce the sizes of the support holes. Increasing the sizes of the rockbolts and resin capsules will have serious cost implications. Therefore, the size of the support holes should be reduced. Many authors have suggested different optimal ranges of annulus size. The manufacturer of the resin capsules that are used at the mine suggested an optimal design annulus size between 3 mm and 4 mm. While Hagan (2003) suggested an optimal practical annulus size ranging from 4 mm to 6 mm. The specifications from the manufacturer also state that the optimal length of the support holes for the resin bolt installation should be 50–60 mm shorter than the bolt length.

The support holes should be drilled at an optimal length of 2.34 m with a drill bit of 30.5 mm in diameter. This will result in a design annulus size of 3.15 mm [(30.5–24.2)/2], which is within the manufacturer's recommendations of between 3 mm and 4 mm. Taking into account the reaming of the support holes, the final diameter of the support holes will be 32 mm. This results in a practical annulus size of 4 mm, which is also within the optimal practical annulus size ranging from 4 mm to 6 mm.

Summary of the optimal support design:

- Bolt length: 2 400mm
- Bolt diameter: 24.2mm
- Support hole length: 2 340mm
- Final support hole diameter: 32mm (30.5mm diameter drill bit plus 5% reaming)

The authors' recommended support design is presented in Table V. The design will not only enhance safety at the mine but it will also reduce the costs associated with mine support. With such an optimal support system, the mine can save costs by reducing the size of the slow setting resin capsules from 500 mm by 25 m to 400 mm by 24 mm. The system is still efficient in terms of support, with 2% excess resin resulting in a waste of R1.20 per hole. The 2% excess resin will come in handy where there are geological discontinuities and resin may seep into the discontinuities. With the decrease in drill bit diameter and the length of the support hole, the mine will also reduce costs associated with drilling.

Table V

The efficiency of support based on the authors' optimal design of the support system

Andre se Resin anchor calculation

Bolt		**Hole**		**Resin**		
Bolt length	2400 mm	Hole Length	2340 mm	Fast Capsule Length	500 mm	
Protruding	130 mm	Hole Diameter	32 mm	Fast Capsule Diameter	25 mm	
Bolt Diameter	24.2 mm			Fast of Green capsules	2 units	
Bolt Volume	1044.11 cm3	Hole Volume	1881.94 cm3	Slow Capsule Length	400 mm	
				Slow Capsule Diameter	24 mm	
				Slow of Yellow capsules	2 units	% resin
Required resin volume	837.83 cm3	GOOD!!		Resin Volume	852.79 cm3	102%
Resin excess	14.96 cm3	You are waisting resin!! R 1.20 per hole!!				

Unit Cost	R/Box	Installation
Bolt Cost		R 50.00
Fast Resin Cost	R 223.00	R 9.29
Slow Resin Cost	R 223.00	R 9.29
Cost		R 68.58

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Economic benefits of the investigation

With the standard mine support design, the Andre Se Resin Anchor calculation indicated that the mine is wasting resin and losing R12.61 per support hole. The optimal design recommended by the authors will provide the mine with an efficient support system with a loss of only R1.20 per support hole, thus saving R11.41 per hole. This is a huge reduction in costs considering that the design is till efficient and providing full security. A total of 5 021 rockbolts were installed in the last quarter of 2015 (Table I in the paper). With a cost reduction of R11.41 per support hole, the mine could have saved R57 289.61, sufficient for the installation of 47 741 more rockbolts.

Figure 8 shows the total amount that could have been saved per month based on Table I and the reduction of R11.41 per support hole, as a result of the optimal design. Furthermore, addressing the design and operational inefficiencies will also result in a decrease in number of rockbolts that are installed incorrectly at the mine. The costs associated with the replacement of incorrectly installed resin-grouted rockbolts will thus be reduced significantly.

Conclusions

Decreasing the design diameter of the support holes from 32 mm to 30.5 mm, supplemented by a decrease in design length from 2.4 m to 2.36 m, result in an optimal support design and a reduction of money wasted per support hole from R12.61 to R1.20.

➤ The standard mine support design should be optimized by reducing the diameter of the drill bit from 32 mm to 30.5 mm and reducing the length of the support hole from 2.4 m to 2.36 m. These changes will enable the mine to use different combinations of resin capsules to reduce the cost of installation per support hole.

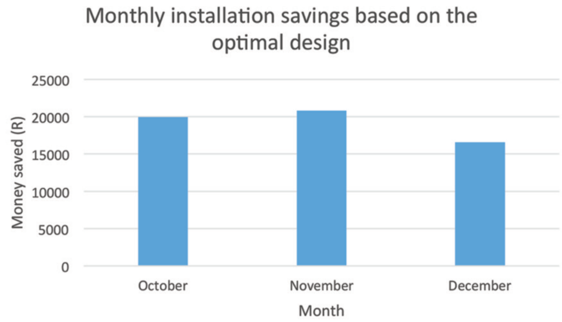

Figure 8—Monthly installation savings based on the proposed optimal support design

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Johannesburg and its Holey Mining Heritage

Johannesburg is probably unique in the world, in that it is now a major city that developed on and around the gold reefs discovered in 1886. Today these mined reefs run directly through the CBD and adjacent areas. It is probable that very few residents of the city know that they cross old mine workings on a daily basis, and that there are stopes of these old mine workings that are still open below surface. Surface development was not permitted in the region of the outcrops and shallow mining, and these open areas, close to the city and industry, have resulted in areas on which informal settlements have developed over the past two decades. Although most of the old mine openings were closed when mining ceased, the quality of the closure was often inadequate, and over time many holes into the old mine workings have appeared on surface. These can be a significant hazard to residents of the informal settlements, which prompted a recent investigation of old mine openings in the Johannesburg and Central Witwatersrand area. In this investigation 244 mine openings were located, and 80 of the more hazardous openings were subsequently sealed. This investigation provided a large source of information, which is considered to be of significant historical value. To document this valuable historical information regarding the city of Johannesburg and the Central Witwatersrand area, the Southern African Institute of Mining and Metallurgy is planning a special publication (book). In addition to details of the investigation and sealing project, additional material will be included, describing cases of stabilisation of mine workings that have taken place in past years to facilitate surface development. One such example is the Standard Bank building to the east of Simmonds Street and south of Frederick Street. Details are available of the investigation of the mine workings for this site, and the foundation stabilisation work carried out. This was the first major building to be developed across the mining outcrops, and Standard Bank must take great credit for proceeding with this project 30 years ago. The experience gained from this pioneering project subsequently facilitated the development of adjacent major buildings. It is planned that descriptions of these other developments will also be included in the publication, as well as historical information associated with other cases of instability and sealing of mine openings. The book will preserve some of the unique mining heritage associated with Johannesburg's past, and make a significant contribution regarding this aspect of the history of a holey City.

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