



A critical evaluation of the installation equipment of in-stope rock bolts and the effectiveness thereof in the Merensky stoping areas

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Synopsis

The Union Section of Anglo Platinum is situated ± 18 km west of the town of Northam on the north-western rim of the Bushveld Igneous Complex. Both the Merensky and UG2 reefs are mined.

Support of the Merensky stoping areas with rock bolts is specifically problematic due to the stoping width restrictions varying around 90 cm.

The installation equipment of in-stope rock bolts and the effectiveness thereof in the Merensky stoping areas was critically evaluated.

In order to do this a background research on the need for better on-the-face support had to be conducted. The need for improving the rock bolt drilling and the equipment had to be investigated and the financial implications and justifications for the improved equipment examined.

To conduct the search an overall study was done on the rock falls and safety aspects throughout the platinum industry in South Africa and specifically Union Section. It was found that most of the rock falls in the Merensky stoping areas of which $\pm 70\%$ are less than 1.2 m in thickness generally occurs within 4 m from the face and causes $\pm 60\%$ of the in-stope injuries.

Serious shortcomings had been identified with respect to the airleg, rock drill machine and the drill steels used in the drilling of the rock bolt holes. Through experimentation, using a testing frame built for this purpose on surface and with the co-operation of mine staff and suppliers, a number of possible modifications were identified and tested. This resulted in the final product with which it was possible to drill a 1.2 m hole in the hangingwall of the stopes ranging with an angle to the hanging from 90° for a 90 cm stoping width and 67° for a 80 cm stoping width.

It is confidently concluded that this system will effectively improve the total face support and result in a substantial reduction of rock falls and consequently the occurrence of injuries and fatalities in the Merensky stoping areas.

The installation of rock bolts on the face with the modified drilling equipment will increase the direct support, but the system has a potential of a substantial reduction in the profile stick support density and an increase in productivity in the stoping areas due to fewer occurrences of rock falls.

It was finally concluded that effective modifications to the drilling equipment for rock bolt in-hole drilling could be made and the installation thereof in the stope face is adequately justified.

elongates are installed a maximum distance of 4.6 m from the face. Temporary support in the form of mechanical jacks is used to support the area before the permanent support is installed. This temporary support is removed before blasting operations proceed. When the cleaning operations start, there is a large span of unsupported hangingwall.

A need was developed to install rock bolts in the hangingwall of the low stoping width Merensky reef panels, where the average stoping width is ± 90 cm, as additional support. The motivation for this in-stope bolting is two-fold.

- There is an urgency to protect the workers on the stope face between the blast and at the end of the cleaning cycle, as well as providing protection at the start of a new cycle during which the working area is made safe and temporary support is installed.
- It is very important that the large numbers of falls of ground, which generally occur during the blast, are reduced between the face and the first row of permanent support.

Lack of discipline on dayshift resulted in improper rig holes drilled for night shift's cleaning operations, as well as the cleaning equipment, such as the scraper and scraper ropes, were not placed in the correct positions as per mine standard. When night shift arrives they were forced to enter the stope face to drill their own rig holes and move the equipment to the desired positions. They had to crawl over the blasted rock and underneath a totally unsupported, unbarred area to install the equipment. Only thereafter can the cleaning of the face proceed. This resulted in faces not been properly cleaned, or not even been

Introduction

Project background

Permanent support in the form of pre-stressed

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cleaned at all due to the fact that the cleaners did not have enough time to complete their job for the shift.

Most of the falls of ground occurred in that unsupported area close to the face. Only when day shift resumed their tasks, the face was made properly safe through barring down and by installing temporary support. Then for the first time in the cycle, the workers were working underneath supported hangingwall.

The new method will not prevent the inherent poor discipline. However, it could well reduce the risks related to this poor discipline.

By installing the rock bolts during day shift as close as 0.5 m from the face, prior to the blast, will ensure that the night shift cleaners and early day shift workers will be working underneath supported hangingwall.

Thus, the bolting is needed to reduce the unsupported span throughout the cycle, in particular during the cleaning cycle when temporary and permanent support cannot be installed.

Analysis of literature research

The available data of historical falls of ground that were studied and analysed covered the period 4/4/1998 to 17/10/2000. It should be noted that most of the fall thicknesses are estimated, and it is the author's belief that over estimation is more likely than under estimation. Nevertheless, the figures given have not been adjusted in any

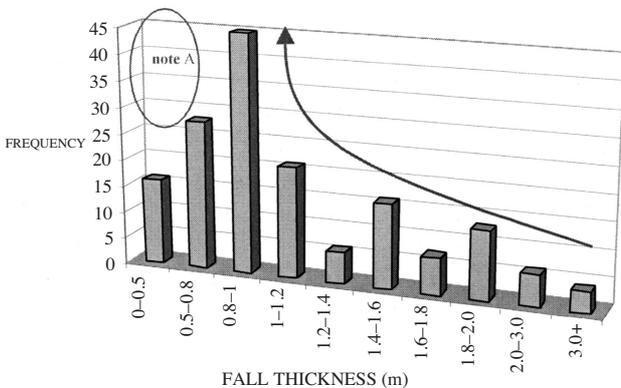


Figure 1—Fall of ground thickness in the Merensky stopes

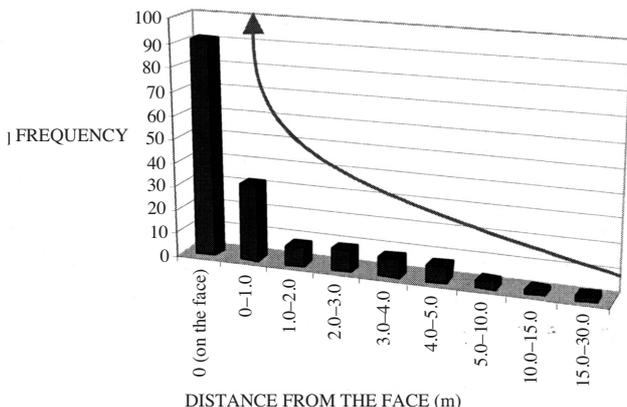


Figure 1a—Falls of ground relative to the face in the Merensky stopes

way since a minor adjustment will be critical for this evaluation. The data represented the recorded major falls which were responsible for an incident, i.e. injury, fatal, lost time, etc. It is believed that numerous smaller falls were not recorded and hence the statistics were negatively affected. (Refer to note A - Figure 1)

There were 162 reported falls of ground during the stated period. The prominent source of the falls of ground was the hangingwall, with little sidewall and face failures. 68% of all the reported falls of ground had a thickness of less than 1.2 m and 96% of all the falls of ground occurred within 5.0 m from the face. A definite tendency was identified (Refer to Figure 1 and Figure 1a)

COST OF INJURIES PER CATEGORY AT SPUD SHAFT DURING THE PERIOD 1/1/2000 AND 15/12/2000

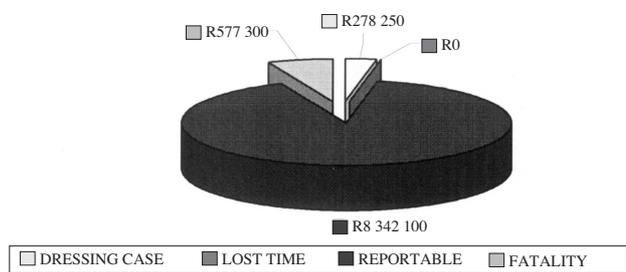


Figure 2—Cost of incidents related to falls of ground within the Spud Business Area

FALL OF GROUND DISTANCE FROM FACE (ALL F.O.G. INJURIES) AT SPUD SHAFT DURING THE PERIOD 1/1/2000 AND 15/12/2000

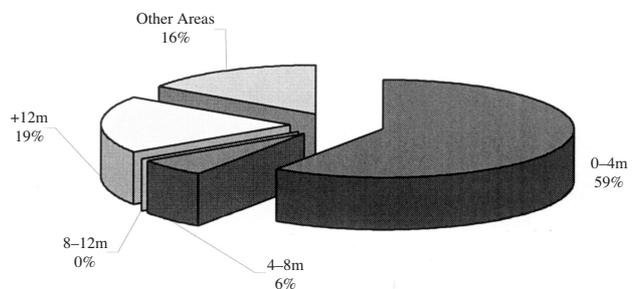


Figure 2a—Fall of ground distance from the face within the Spud Business Area

OCCUPATIONAL (ALL INJURIES DUE TO F.O.G.'s) SPUD SHAFT DURING THE PERIOD 1/1/2000 AND 15/12/2000

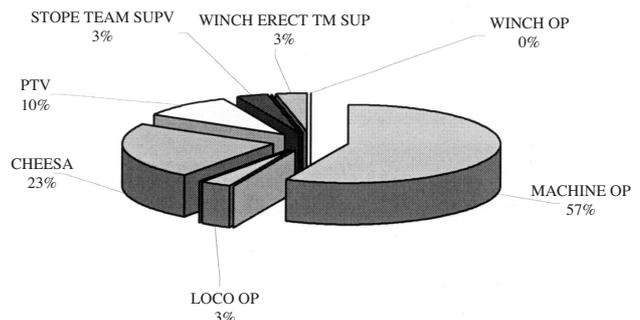


Figure 2b—Occupation (injuries due to falls of ground) within the Spud Business Area

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During the same period of time, there were only 28 reported falls of ground in the UG2 stope areas that has an average stope width of 1.5 m. This could mainly be attributed to the fact that split sets have been installed since middle 1997, and changed to 1.2 m mechanical rock bolts in middle 2000.

During the period 1/1/2000 to 15/12/2000, ± R9.2 million were spent on incidents related to falls of ground within the Spud Business Area. (Refer to Figure 2) It was difficult to determine the **lost time** during the stated period. For this specific exercise the lost time was taken as zero.

In the stoping areas, the first 4 m were responsible for 59% of all the injuries occurring in the stopes. (Refer to Figure 2a)

Of all injuries, 57% occurred to the machine operators and 23% to the blasting assistants (Cheesas). In total 80% of the injuries happened to those people who spend most of their day in the area between the face and the first row of permanent support. (Refer to Figure 2b)

Equipment and modifications

The objective was to drill the holes 90° to the dip of the strata. With the initial equipment that was available, drilling the holes was only possible at a maximum angle of 65° in a stope width of well over 90 cm. There was a dramatic need for improvement. The rock drill machine used at that moment in time was the SECO S215 with the 159 mm fronthead as supplied by the manufacturers, Boart Longyear. The airleg used was the DTE740TM2 double telescopic as supplied by Rock Tool Services. The initial drill steels consisted out of an



Figure 3—The adjustable testing frame

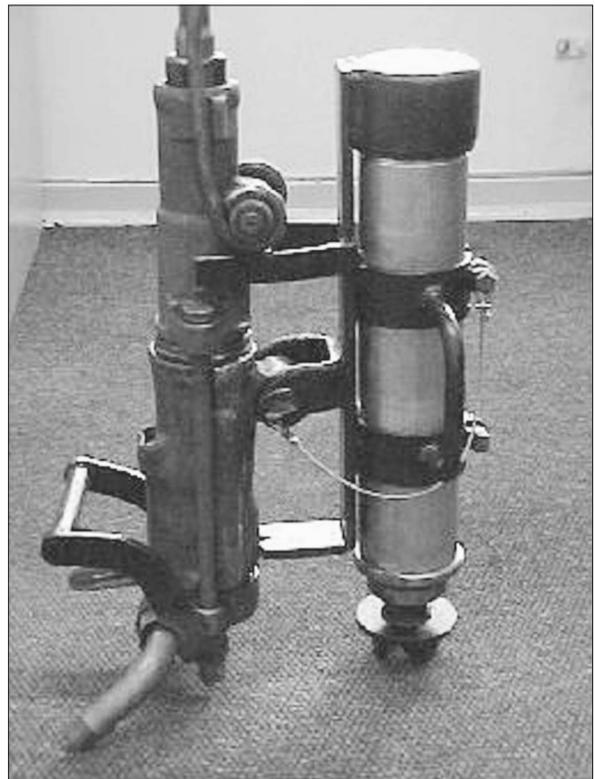


Figure 4—Final coupled equipment after all modification

Table 1

Summarized modifications

	Initial specifications	Modified specifications
1. Airleg	655mm	550mm
2. Rock drill machine (Top of chuck measured from footwall)	685mm	565mm
3. Drill steels	Starter – 350mm Extensions – 350mm	Starter – 415mm Extensions – 300mm
4. Possible drilling angle	Stoping width: 80cm – 42° 85cm – 53° 90cm – 65°	Stoping width: 80cm – 67° 85cm – 78° 90cm – 90°

initial starter and four extensions, each being 350 mm in length, to drill an effective 1.25 m vertical hole. It was manufactured by Tungrok Africa. The drill bits used were the R25 36 mm diameter threaded knock off drill bit also manufactured by Tungrok Africa. Videx, S.A, supplied the rock bolts. The 1.2 m, M16 coupling bolt (50% split) has a forged 27 mm hex head with a 32 mm diameter expansion shell and a 30 mm coupling.

An adjustable testing frame representing the different stope widths between 75 and 120 cm and different drilling angles between zero and 90° was built to carry out the needed simulation and testing of equipment before sending it underground for further testing. The purpose of the frame was to save valuable time and money. (Refer to Figure 3).

The rock drill machine was modified in terms of a new handle and a 92° water connection. This resulted in a substantial reduction in the length of the machine. Initial possible modifications to the airleg were identified and the proposed changes were given to the manufacturers.

The initial foot tended to swivel around the sharp point of

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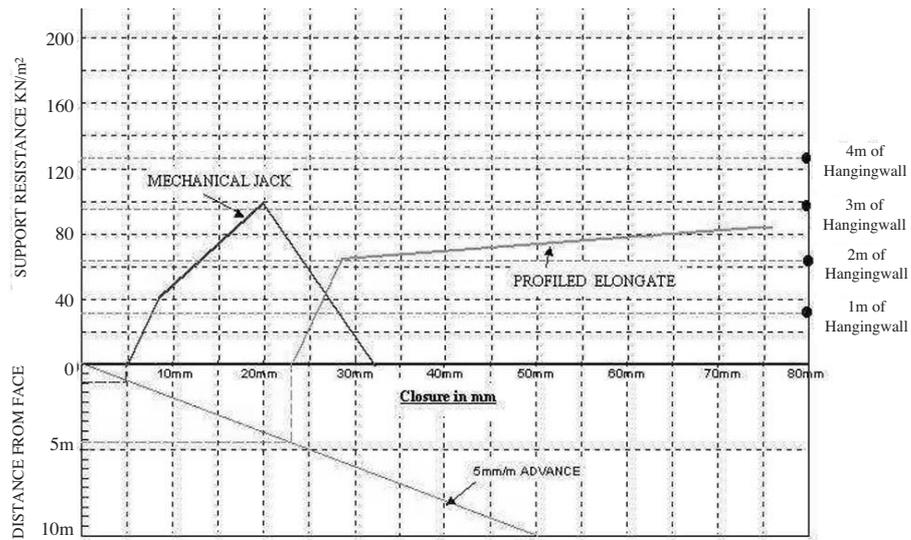


Figure 5—Support resistance curve of the conventional support system

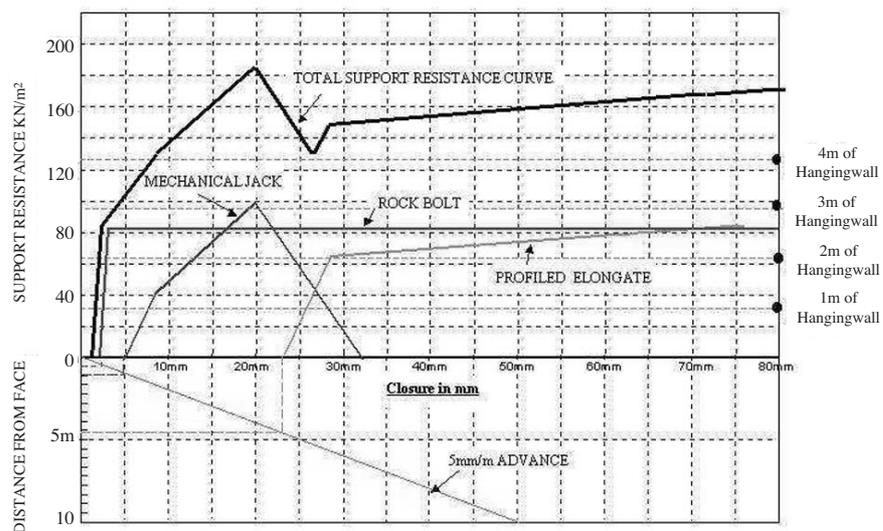


Figure 5a—Support resistance curve of the new in-stope support system

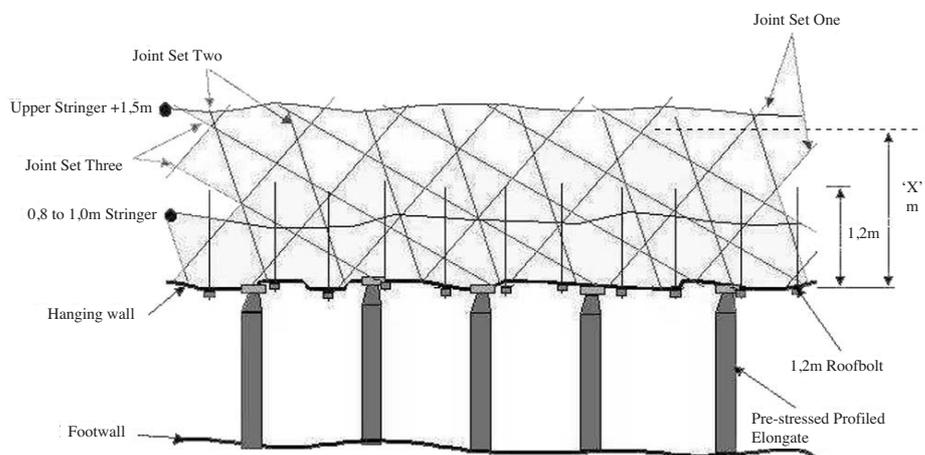


Figure 6—Merensky hangingwall with the in-stope rock bolts

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the foot. The equipment seemed to be quite unstable resulting in drill steels getting bent and stuck in the holes. The newly designed airleg foot especially favours the drilling of 90° holes with the hangingwall due to the fact that the coupled equipment will be able to stand on its own, relieving extra physical strength to handle the quite heavy equipment. A need was identified to move the initial mounting brackets on the airleg as well as add some additional stabilizing brackets to secure the drill machine when coupled. A new end-swiveling steel shaft with a 2 mm cable suspension replaced the old ineffective, time consuming Clevis bolt.

The modifications to the drill machine and airleg resulted in the initial drill steels being ineffective. A complete set of drill steels needed to be designed to suit the equipment and to be as effective and efficient as possible. The objective was to minimize the handling time during the coupling of the different extensions through having a lengthier starter and fewer extensions. The proposed modifications were given to the manufacturers to manufacture the desired set of drill steels.

Summarized modifications to equipment

During the final stages of the project a SECO S215 drill machine with a 108 mm fronthead was available from Boart Longyear. The manufacturers claimed that they could supply the mine with these machines at exactly the same price as the standard machine. This machine was only available for export purposes. None of these machines have ever been used in any South African mine. This machine could have a major contribution to the success of the project in future. (Alternative machines with the same specifications could also be considered.)

The manufacturers of the airleg claimed that they could supply the mine with a airleg having a length of less than 500 mm.

With the above-mentioned equipment, a complete set of drill steels needs to be designed to suit the specific equipment. This set of drill steels will even be more effective and efficient than the previously designed sets.

A small rig manufactured by Sulzer was lately identified as an alternative for future investigation. This specific rig is very user friendly and requires normal air pressure and only a single operator. The cost of the rig is very competitive.

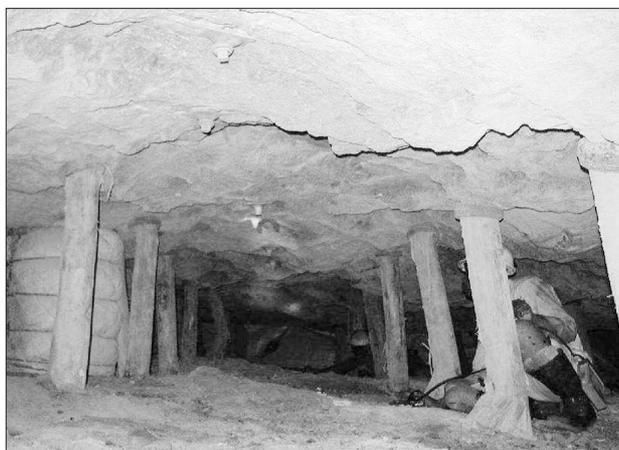


Figure 7—Installed rock bolts within the Merensky stope areas

Support cost comparative

An additional rock drill operator and assistant will be required for every two panels. The new support system will have a substantial 42% increase when using contract workers and a 51% increase when using Anglo Platinum employees. This was calculated with an unchanged elongate spacing of 1.5 m on dip and 2.0 m on strike. When the spacing was changed to 2.0 m on both dip and strike just to illustrate the saving possibilities with a small change as 0.5 m, it resulted in an increase of 31% and 40% respectively. The support resistance curves indicate that the new support system is way over-designed (refer Figure 5a). A study should be done to determine the effective spacing of the elongates. This could result in a saving of at least 30% in the elongate support cost.

When the mechanical jack (temporary support) is removed before the blast, there is a large unsupported high-risk area in which night shift workers enter to perform their work. Thus, there is a NIL support resistance when the temporary support is not in place. The rock bolts provided the solution. The support resistance of a rock bolt on a 1.2 x 1.5 m pattern is $\pm 45\text{kN/m}^2$ (Support resistance of the rock bolts is $\pm 80\text{kN}$). Thus the installation of the rock bolts will provide an additional support resistance in the initial totally unsupported area (5 m from the stope face).

Motivation for using in-stope rock bolts

- The rock bolts will provide adequate support resistance.
- 68% of the reported falls of ground had an estimated thickness of 1.2 m.
- $\pm R8$ million was spent on incidents related to falls of ground in the stoping areas during 2000.
- The rock bolts will provide an overall safer working environment, a very significant improvement in overall productivity and an overall revenue increase.
- Further modifications to the equipment will result in a substantial improvement in the drilling angle, even at a low stoping width.
- It can be said with confidence that the rock bolts will support the very important 0.8 to 1.0 m stringer. (Refer to Figure 6).
- The rock bolts will support the wedges formed by the different joint sets. (Refer to Figure 6).

Conclusions

- Through the literature search that was done it was concluded that there was a great need for improved support in the area between the face and the first row of permanent support.
- Drilling perpendicular in a low stoping area proven to be one of the major hurdles to overcome due to the limitations to the handling height and equipment.
- The systematic approach allowed the identification of a number of possible modifications to the airleg, rock drill machine and drill steels, to shorten the overall length of the drilling equipment.
- The modifications were made, tested and proven to be successful. Drilling in a 90 cm stoping width, at an

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angle of 90° was possible resulting in an overall support height of 1.2 m.

- ▶ An additional machine operator and assistant will be required for every two panels which will only be responsible for the drilling of the support holes and the installation of the rock bolts.
- ▶ Re-designing the spacing of the elongates could result in a dramatic decrease in the overall support cost in future.
- ▶ The improved support system will eliminate most of the 68% of rock falls which is less than 1.2 m in thickness along the stope faces and hence result in a substantial reduction in the accident rate resulting in improved productivity and possible future savings.

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