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Rock behaviour of the Bushveld Merensky Reef and the design of crush pillars

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2011-05-03
http://hdl.handle.net/10539/9629

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ABSTRACT

The aim of this investigation was to provide a proper design procedure for Merensky crush pillars, based primarily on underground measurements. Three sites with a variety of geotechnical conditions were selected. An interaction between the pillars and the rock mass around the stopes was shown by the literature, relevant laboratory tests and numerical modelling. During the investigations, nonlinear rock behaviour was observed at one of the sites. Further studies revealed that nonlinear behaviour also occurred in samples extracted from high stress conditions at the other sites, but the rock mass was not nonlinear at these sites. A methodology for determining stress from strain measured in nonlinear rock was established.

The research also established that there is an approximately linear relationship between peak pillar strength and w/h ratio at ratios between about 1.2 and 8. The so called ‘squat’ effect is not observed because pillar failure is not contained within the pillar but extends into the foundations. A linear peak pillar strength formula was established from back analyses of underground pillar failures and was confirmed by numerical modelling. Pillar behaviour was established from underground measurements on one stability pillar and six crush pillars, which included peak and residual strengths. Also, stable and unstable loading conditions were established from an analysis of pillar bursts and the minimum strata stiffness for stable pillar failure was determined. This stiffness is only achieved near the advancing face and pillars that fail in the back areas are likely to burst. For this reason, pillar design needs to include the peak strength as large pillars may be too strong and fail in the back area. The residual strength also needs to be considered as the load-bearing capacity of these pillars needs to satisfy the criterion of 1 MPa across the stope to prevent back-breaks. This translates into a pillar stress of between 8 MPa and 13 MPa if the pillar lines are spaced 30 m apart. The peak and residual requirements have been included in a design chart, and the relationship between w/h ratio and residual strength is provided in a graph for easy design.