

7 Development of a design methodology to determine the requirements of temporary and face area support systems

7.1 Introduction

As part of the GAP606 work, SRK was subcontracted to develop a probabilistic analysis to determine the requirements of temporary and face area support systems. A brief summary of the work, as well as a review of the salient findings of the investigation, is given below. The complete report detailing SRK's contribution is submitted as GAP606 Final Project Report Volume II.

7.2 Summary

The risk of injury depends upon the type of support, condition of the rock, mechanisms of deformation of the rock and support, support installation constraints and personnel exposure. The risk of injury is underlain by the probability of support failure or of excavation instability. Sections on the basics of probability theory, current supports, classes of strata conditions, support installation constraints and deformation mechanisms are accordingly presented as a basis for the proposed support design methodology.

The methodology as it affects stope support, tendon support and hanging and footwall stability is then developed in detail. The risks of injury associated with a selection of current supports and with supports recommended as optimal for representative classes of strata conditions are then determined by means of the methodology. Detailed guidelines for applying the methodology and extensive recommendations on the verification, calibration and expansion of the methodology are given in conclusion. These aspects are presented in the order and towards the satisfaction of the enabling outputs required.

The classes of strata conditions can be defined in terms of 96 combinations of two ranges of values for 9 key parameters. 32 of the combinations apply to shallow mines and 64 to intermediate/deep mines. The values for the two ranges of the parameters are determined from the data collected by CSIR Miningtek during its visits and consultations with a number of mines.

The deformation mechanisms are defined in terms of stope convergence and closure, stope dip and strike ride, support loading, distribution of load in detached slab, load-deformation characteristic of support and modes and failure criteria for hanging and footwall slabs.

Stope support is considered to fail in compression and rotation. Provision is made in the methodology for static and seismic loading and for perfectly plastic, work hardening and work softening post peak behaviour. The effects that failure of the hanging and footwall slabs may have on support loading are also investigated. Rotational instability is considered to be due to skew inclination, irregular bearing surface and stope ride.

Tendon support is considered to fail in tension and anchorage subject to static or seismic loading conditions. It is alternatively considered to suspend the weight of the rock or to reinforce the rock against shear and tension on planes of weakness.

Hanging and footwall instability is considered to be due to failure in bending, shearing, slipping, punching, bearing and buckling. Separate provision is made for static and seismic loading conditions.

7.3 Principal findings

The principal findings of the probabilistic analyses to quantify support requirements in the immediate vicinity of the stope face are as follows:

- 1) For rock burst conditions the probabilities of hanging and footwall failure are somewhat higher than for the support.
- 2) The probability of support failure due to loading from the hangingwall is slightly higher than for loading from the footwall.
- 3) The probability of diagonal tensile failure of the hanging and footwall predominates the overall probability of failure.
- 4) The probability of diagonal tensile failure of the hanging and footwall is sensitive to a critical dip angle for discontinuities dipping into the face.
- 5) The probability of diagonal tensile failure of the hanging and footwall is also sensitive to a critical spacing for the diagonal tensile reinforcement.
- 6) The probability of diagonal tensile failure of the hanging and footwall is not sensitive to the capacity of the diagonal tensile reinforcement, but more to the presence of such reinforcement or not.
- 7) The probability of compression failure of the support exceeds that of rotational failure.
- 8) The probability of failure of yielding support is governed by deformation and not load.
- 9) The probability of failure of non-yielding support is governed by load and not deformation.
- 10) At between 10 and 20 per cent, the absolute magnitudes of the probabilities of failure are comparatively high.

Further work is recommended with regard to geotechnical parameters, seismic parameters, mining parameters, support installation statistics, support properties, operational statistics, refinement of the methodology and application of the methodology.

The methodology may be refined with regard to a number of aspects including confirmation of the probabilities of ejection freedom, determination of its sensitivity to the various mechanisms of deformation, non-symmetrical adjoining spans, inequalities in adjoining supports and stability of the face as support. Application of the methodology may be promoted by providing systematic training throughout the industry.