

## **Design spans — underhand cut-and-fill mining**

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**Technical paper will be available shortly.**

This paper describes a focus of work presently being conducted by the Rock Mechanics Research Group at the University of British Columbia. The underhand method under consolidated fill ensures a high recovery under an engineered back that is comprised of cemented rock fill and/or cemented paste fill. This method of mining is generally necessary either due to a weak rock mass comprizing the immediate back and/or high induced back stresses. A major concern in the design of sill mats is the loading and strengths associated with the overlying sill mat. This paper reviews past practices coupled with present observations and measurements from over ten mines throughout North America. It also outlines areas of concern in terms of design requirements.

The methodology of span design under consolidated fill is complex as many factors control the overall stability, as identified in this paper. The failure modes and combination thereof must be analyzed with respect to the placed fill, stope geometry, loading conditions, seismic effects, stope closure, and support placement, as well as other factors that are due to filling practices such as cold joints and gaps between successive lifts, among others. This paper employs analytical, numerical, and empirical tools to attempt to provide an initial tool for the operator for design. The database of underhand stopes observed by the authors is shown in this paper and compiled in the figure. It is comprised of 12 operations which include seven cemented rock fill and five having paste within the immediate back. Flexural instability was found to be most critical in the absence of rotational instability and closure stresses ( $\sigma_h$ ), which have to be evaluated separately. The figure shows the database that has been compiled and plotted onto a stability chart based upon flexural instability employing fixed beam analysis with surcharge loading. It also shows the unconfined compressive strength required ( $FS=2$ ) for a given sill thickness and span exposed and related to actual field observations.

This paper summarizes a FLAC2D simulation that relates the potential failure modes that result for a given stope span, sill height, and cohesive strength for various assumptions on wall friction. The results show the importance of wall shear strength on overall stability and the results related to analytical approaches.

A case study is presented employing underhand cut-and-fill within a highly stressed sill (Lucky Friday mine) that is largely the first operation to incorporate paste to mitigate burst damage. The method has been adopted at mines throughout North America such as the Red Lake mine and the Stillwater mine in Montana.

Mining under consolidated fills is becoming competitive with conventional cut-and-fill mining as increased spans and productivities are realized through reduced placement of ground support and more control on the mine cycle due to working under an engineered back. This requires a thorough understanding of the mechanism of support that one is relying upon, which is the consolidated fill immediately above. The fill may be supported in terms of conventional bolts and screen in order to counter "cold joints" that may develop in the fill,

account for variability in fill quality control, and/or increase the overall factor of safety required due to seismic events in close proximity. This requires an understanding of the stabilization effect of the consolidated fill and the mine environment that it is placed within. Through the gathering of site data and modelling of behaviour, either analytically and/or numerically, coupled with observation and measurement, one will be able to advance the overall design criteria to provide a safe and cost-effective workplace.

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