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# **Snowden leads the way in anisotropic modeling**

Years of experience in the assessment of open pit slope stability in Western Australia's Pilbara Iron Ore region have led mining industry consultants, Snowden, to develop a new shear strength criterion to more accurately model the highly anisotropic strength of bedded rock masses.

"The intensively bedded nature of the Pilbara sedimentary rocks result in a high potential for failures to develop in open pit mines and it is essential that we model the anisotropic shear strength of these types of rocks as accurately as possible", commented Dr Ken Mercer, Divisional Manager Geotechnical Engineering - Snowden, on the motivation for the development of the new model. "The propensity for failure in these types of rocks is a result of both the generally weak nature of the rock mass due to intensive bedding and weathering combined with relatively low shear strength of the bedding planes, and is especially relevant in areas where bedding is dipping towards the pit as a result of regional or localised folding."

Snowden's geotechnical team originally developed the modified anisotropic shear strength criterion and through ongoing internal research have continued to improve and better define the criterion. Working together with Rocscience, a Canadian company which has been creating geotechnical software since 1996, and specialises in 2D and 3D analysis and design programs for civil engineering and mining applications, Snowden's geotechnical team have developed the model which Rocscience has implemented as the **Snowden Modified Anisotropic Linear Model**. This has been included as an additional feature of their Slide 6.0 limit state slope stability analysis software and will be available for clients globally. This new model supersedes Snowden's older 2007 **Anisotropic Linear Model** which was also originally implemented in an earlier version of Slide, based on recommendations and specifications developed at the time by Snowden. Both these models were originally developed for analysis of slopes in the highly anisotropic bedded rock masses of the Pilbara iron ore formations but can be applied to similar rock masses elsewhere.

There are two key features of the new model. The first is that bedding and rock mass strength can now be defined directly by non-linear shear-normal functions. This is a significant improvement on the old model which allowed only Mohr Coulomb parameters to be used to represent the shear strengths of the rock mass and bedding. The second key feature is the model now makes provision for anisotropy to be modelled non-symmetrically. Snowden research has shown this to be a critical factor in anisotropic rock mass behaviour.

"The ability to define non-linear strength envelopes for the bedding and rock mass, with a gradual transition between the two is particularly useful," said Rocscience's chief software developer Brent Corkum. "Other anisotropic models have an abrupt strength change at critical orientations, the Snowden model provides a more realistic transition of strength with orientation."

The key benefits of the new model are a much more accurate estimation of the limit state Factor of Safety of a pit slope design, and the prediction of the shape of the critical slip surface (failure mechanism). Corkum describes the inclusion of the model as "a significant addition to the anisotropic strength modelling options available in Slide."

Snowden and Rocscience have developed a close working relationship over the past few years, the synergy of which is clearly illustrated in the release of the **Snowden Modified Anisotropic Linear Model**.

Commenting on the teams' collaboration, Corkum said " Integrating the new strength models into Slide was both straightforward and enjoyable, with the technical details clearly and simply laid out by the Snowden team. During the implementation and testing process, some improvements were made, until the final product matched the initial request to the satisfaction of both parties."

Further developments and improvements with regards to the model will be included as the companies work together to further define potential opportunities.

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## *Background*

### *Snowden*

Snowden delivers a comprehensive range of technical consulting services, software solutions and independent advice to exploration and mining companies, as well as legal and financial institutions with interests in the mining sector. Snowden's services include geology and exploration, mine planning, corporate services, performance management, risk management, benchmarking, mineral processing, extractive metallurgy and specialised mining software. Snowden is well positioned to respond quickly and effectively to on site demands through a network of worldwide offices, ensuring efficient global solutions delivered locally.

### *Rocscience*

Rocscience is a Canadian company based in Toronto. The company has been creating easy to use, reliable geotechnical software since 1996. The Company specialises in 2D and 3D analysis and design programs for civil engineering and mining applications.

*Slide 6.0* is the most comprehensive limit equilibrium slope stability analysis program available, complete with finite element groundwater seepage analysis, rapid drawdown, sensitivity and probabilistic analysis and support design. All types of soil and rock slopes, embankments, earth dams and retaining walls can be analyzed. State of the art CAD capabilities allow you to create and edit complex models very easily.