International Society for Rock Mechanics and Rock Engineering

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# ISRM YOUNG MEMBERS' SEMINAR SERIES

## Directional and 3-D Confinement-Dependent Fracturing, Strength and Dilation Mobilization in Brittle Rocks

Masoud Rahjoo

(AECOM-Canada )

## Stochastic Discrete Element Modeling for Pillar Strength Determination: A First Step in a Risk Based Pillar Design Approach

Juan Josè Monsalve

(Virginia Tech University - USA)

**27th May 2022**

**18:00 GMT**

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**Next session: June 2022**

Extended Finite Element Procedures for the Analysis of Reinforced Dual-Permeable Rock Media
*Dr. Yashwanth Kumar Gujjala (India)*

A probabilistic-based approach to rock slope stability analysis in open-pit mine using numerical modelling
*Mr. Lewis Mathe (South Africa)*

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# Directional and 3-D Confinement-Dependent Fracturing, Strength and Dilation Mobilization in Brittle Rocks


## Abstract

Failure of massive brittle rock masses is composed of loss of their cohesive strength during the fracturing process, followed by mobilization of frictional resistance along the newly-formed fractures only if they are closed. Critical is recognizing the dual nature of brittle failure, incorporating i) the extensional fracturing mechanism that dominates rock behavior under tension and low to intermediate confinements and ii) the shear fracturing mechanism that governs rock behavior under high confinements. Once the stress/strain state exceeds specific micro-mechanical criteria, fractures propagate in the 3D rock body in specific favorable orientations with respect to the orientation of the applied 3D polyaxial stress state. These favorable orientations dictate the macro-mechanical strength and dilation characteristics of the failing rock body.

The existing shear failure paradigm based on the Mohr-Coulomb Criterion neither accounts for the possibility of extensional fracturing under confinement nor the 3D directionality of shear fracturing under different polyaxial stress states. In this presentation, a new theoretical framework that associates rock strength and dilation mobilization characteristics with the directionality and 3D confinement-dependency of rock fracturing mechanisms is presented.


## Speaker

**Dr. Masoud Rahjoo** is a rock engineer with special interest in the mechanics of rock failure and numerical modelling. He is currently a Rock Mechanics Specialist at AECOM-Canada and contributes to the tunnelling projects in North America and beyond. He has BSc in Mining Engineering and MSc in Mining Rock Mechanics. He received his PhD in Rock Engineering from UBC where he developed a new theoretical framework for understanding and modelling the 3D directionality of brittle rock fracturing, and mobilization of rock strength and dilation. During his Mitacs Postdoc Fellowship at UBC, he developed a new tool for evaluation of brittle fracturing for the Grasberg DMLZ Block Cave Mine. Since then, he has been developing a new method for estimation of rock mass peak and residual strengths with application to jointed and veined rock masses.”

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# Stochastic Discrete Element Modeling for Pillar Strength Determination: A First Step in a Risk Based Pillar Design Approach

## Abstract

The collapse of a mine pillar is a catastrophic event with great consequences for a mining operation. These events are not uncommon and have been reported to produce air blasts able to knock down, seriously injury or kill miners; cause cascade pillar failures which involve the collapse of neighboring pillars; produce surface subsidence; and sterilize valuable reserves. Just in the United States, the Mine Safety and Health Administration (MSHA) has reported four of these events since October 2020. Fortunately, none of these recent events have had an impact in miner's safety. Due to the persistent occurrence of these events and their severe consequences, the design, excavation and monitoring of these structural elements should be performed from a risk-based perspective. However, most of the current pillar design methods such as pillar strength equations, or even basic numerical modeling only consider deterministic results neglecting the intrinsic variability in the rock mass, increasing the uncertainty in the design process. This work introduces a stochastic discrete element modeling approach for characterizing the effect of discontinuities in pillar strength. Laser scanning is used to characterize discontinuities for discrete fracture network (DFN) generation. The Discrete Element Modeling Software 3DEC is used along with the DFNs to simulate fractured rock pillars and estimate pillar strength variability due to the presence of discontinuities. The proposed method enables the integration of pillar design into the risk analysis framework of the mining operation, ultimately improving safety by preventing future pillar collapses.

## Speaker

**Juan Josè Monsalve** is a Colombian Mining and Metallurgical Engineer from the National University of Colombia with a M.Sc. in Mining Engineering from Virginia Tech. Juan has worked as engineer assistant in geotechnical design companies in Colombia gaining experience in rock mass characterization and numerical modeling for underground excavations. He is currently pursuing a PhD degree at the Virginia Tech. His current research is focused on the integration of laser scanning with stochastic discrete element numerical modeling to evaluate and assess rock fall hazards in underground tunnels, and pillar failure in underground mines. He is also interested in the design and application of ground control management plans as an administrative control tool for reducing ground-control-related accidents and improve safety in underground excavations.  Juan has served as the president of the ARMA Student Chapter at Virginia Tech.