The Geo-Institute Rock Mechanics and Engineering Technical Committee will live-stream the *session* "Advances in Fractured Rock Engineering – From Characterization and Modeling to Stability and Reinforcement" on Tuesday, December 8, at 11 AM EST. The talks include:

Talk #1: Sealing Cracks in the Ground: Grout Reinforcement of Fractured Rock Masses for Geotechnical and Geo-Energy Systems (presented by Oladoyin Kolawole, Ph.D., M.ASCE - New Jersey Institute of Technology)

Fractures and joints in the surrounding rock of underground excavations reduce mechanical integrity and create leakage pathways that threaten the safety of deep foundations socketed into bedrock, in addition to tunnels, mines, wellbores, and geo-energy storage systems. Grouting is widely applied to reinforce these discontinuities, and eco-friendly grouts have been promoted to replace traditional cement-based grouts, which lead to high carbon emissions. However, how fracture geometry (orientation and aperture) and how eco-friendly grout treatment influence rock strength recovery under the distinct compressive and tensile stress regimes that develop around excavations remains insufficiently understood. This presentation will cover experimental and numerical investigations quantifying the reinforcement of fracture-grouted natural (limestone and dolostone) and 3D-printed synthetic rock masses treated with a sustainable nanomagnetic grout. Uniaxial compression tests, paired with finite element damage-plasticity simulations, show that grouting substantially restores compressive strength (UCS) and stiffness (E), with gains governed by fracture orientation, aperture, and rock fabric. Brazilian disc tests, paired with cohesive-zone (FEM-CZM) simulations, reveal that grouting only partially restores tensile strength but markedly suppresses and redirects crack propagation, reduces total fracture length, and delays damage onset. Together, the findings establish that grout reinforcement operates through distinct mechanisms in compression and tension, and that fracture-control metrics complement conventional strength measures. The integrated framework informs the design of safer, more reliable reinforcement strategies for underground infrastructure, geohazard mitigation, and subsurface geo-systems.

Talk #2: Multi-scale Experimental and Numerical Investigations of Jointed Rock Slope Failure (Presented by Shahrzad Roshankhah, Ph.D., P.E., M.ASCE, University of Utah)

The stability of jointed rock slopes is critical to the resilience and sustainability of civil infrastructure and nearby communities. The mechanical behavior of these slopes emerges from complex interactions among intact rock blocks, natural fractures (NFs), and external loading and boundary conditions. Environmental processes such as weathering progressively degrade the mechanical properties of both the rock matrix and NFs, ultimately triggering progressive slope failure. Understanding how damage initiates and propagates across multiple length scales is therefore essential for improving physics-based prediction of rock slope instability. Our recent numerical investigations at the slope scale demonstrate that conventional strength reduction methods, which assume uniform degradation of only cohesion and friction angle throughout the rock mass, overestimate the factor of safety while underestimating important failure consequences, including runout distance, displaced volume, and runoff velocity. High-fidelity finite-discrete element (FDEM) simulations show that all strength properties, including cohesion, friction angle, tensile strength, and fracture toughness, must be considered and that the relative contributions of the rock matrix and NFs to slope stability depend strongly on the geometric configuration of the fracture network. To complement these slope-scale simulations, ongoing laboratory investigations examine the shear behavior of natural rock joints through direct shear testing. The experimental program evaluates the influence of joint roughness (JRC) on shear strength, dilation, asperity degradation, fracture initiation and propagation, and progressive damage under controlled normal loading. These experiments provide quantitative data for calibrating joint constitutive models and property degradation laws while revealing the mechanisms governing block fragmentation and fracture evolution during shearing. The resulting block size distribution and damage evolution are expected to directly influence failure initiation, fragmentation, and runout behavior at the slope scale. The presentation will integrate numerical simulations with preliminary laboratory results to establish a multiscale framework linking joint-scale damage mechanisms to full-scale slope instability. This integrated experimental–computational framework provides a pathway toward more reliable prediction of progressive failure in jointed rock masses and improved assessment and mitigation of rock slope hazards.

Talk #3: Current Status of Rock Mass Strength (Presented by Pinnaduwa H.S.W. Kulatilake, Ph.D., F.ASCE, University of Arizona)

The presence of complex discontinuity patterns, the inherent statistical nature of their geometrical parameters, the variabilities and uncertainties involved in the estimation of the discontinuity geometrical and geo-mechanical properties, and the complex three-dimensional (3-D) in-situ stress make accurate predictions of rock mass strength a very difficult task. It has been a great challenge for the rock mechanics and rock engineering profession to develop a rock mass strength criterion in 3-D that incorporates the effect of the intermediate principal stress and captures the scale-dependent and anisotropic properties resulting from the discontinuity geometry parameters such as the number of sets of the discontinuities, 3-D discontinuity intensity and the distributions of the discontinuity orientation and size. The presentation provides a critical review of the rock mass strength criteria used in practice and presents recently developed, most advanced 3-D rock mass strength criteria which incorporate the effect of the explicit representation of the aforementioned discontinuity geometry parameters and the minor and intermediate principal stresses, and capture the scale-dependent and anisotropic behavior of rock mass strength.