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Micro-and macro-scale class-II fracture behaviour of brittle rocks in well-controlled Brazilian tests

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Granular Materials' Dynamics and Bio-consolidation

Yuqi Song

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Predicting Peak Shear Strength of Rough Rock Joints via Normal Deformability Test

Abstract

Prediction of the peak shear strength of natural rough rock joints has long been a fundamental and burning issue in rock mechanics and engineering. Physics-driven predictive models within a rigorous and solid theoretical framework have rarely been reported. The shear resistance between contacting rock surfaces under normal confinement is governed by the asperities truly involved in shear, i.e., true-sheared asperities. However, the joint peak shear strength prediction considering the mechanical contributions of true-sheared asperities remains unresolved. We report a three-dimensional (3D) peak shear strength criterion by independently quantifying the dilation and shear-off of true-sheared asperities. The true-sheared asperities were predicted by identifying the asperities with initial apparent dip angles exceeding the evaluated peak dilation angle that was a function of the real contact area ratio and 3D morphological parameters. The real contact area ratio was quantified by the nonlinear reduction of the global joint aperture that is predictable via the statistical distribution of local apertures of joints. Subsequently, the shear area ratio and associated shear-off component were determined by evaluating the shear-off portion of the true-sheared asperities. The new criterion was validated against experimental measurements on the peak shear strength of both natural and artificial joints. The input parameters involved in this criterion are readily acquirable from morphological properties and normal deformability of joints. Therefore, it potentially can serve as a fast and convenient shear strength assessment method for natural rock joints that may complement conventional shear experiments.

Speaker

Yingchun Li joined the Department of Civil Engineering, School of Infrastructure Engineering, Dalian University of Technology in 2017. He obtained a bachelor's degree in engineering from School of Mines, China University of Mining and Technology (CUMT). He accomplished his doctoral dissertation in the School of Mining Engineering, University of New South Wales, Sydney, Australia, during 2012-2016. His research interests primarily gravitate towards the fundamentals and applications of rock mechanics in deep underground space and resources engineering. He has published more than 90 academic articles in both domestic and international-reputable journals such as International Journal of Rock Mechanics and Mining Sciences, Rock Mechanics and Rock Engineering, Energy, Renewable Energy.

Micro-and Macro-scale Class-II Fracture Behaviour of Brittle Rocks in Well-Controlled Brazilian Tests

Abstract

Post-peak behaviour is crucial for the analysis of rock mass fracturing in deep mining operations where hard rocks can exhibit class-II or snap-back responses under loading. Although class-II behaviour has been investigated extensively under compression, the subsequent behaviour under tension has been rarely explored, which is crucial considering the complexity of rock mass fracturing under various stress states. The post-peak response of brittle rocks involves rapid micro-fracturing, leading to brittle macro-scale behaviour. Controlling the fracture process using the Advanced Universal Snap-Back Indirect Tensile test (AUSBIT) allowed the acquisition of the complete macro-scale class-II behaviour in the post-peak stage, enabling the use of advanced techniques for insights into both micro and macro-scale fracture. In this study, AUSBIT tests with digital image correlation (DIC) and acoustic emission (AE) instrumentation were conducted to analyse the progressive tensile failure in class-II rocks. The lateral strain control in AUSBIT enabled controlled cracking with significant lateral strain extension before failure accompanied by gradual energy dissipation and higher rates of AE activity as smaller magnitudes of energy are being released by each microcrack compared to conventional Brazilian tests. The stable microcrack propagation was also identified from scanning electron microscope (SEM) observations with more uniform profiles of microcracks and less debris observed in AUSBIT specimens. Consequently, initial findings from the investigation of specimen size effect in AUSBIT will also be presented, followed by the general comparison of AUSBIT and post-peak UCS characteristics in different rock types.

Speaker

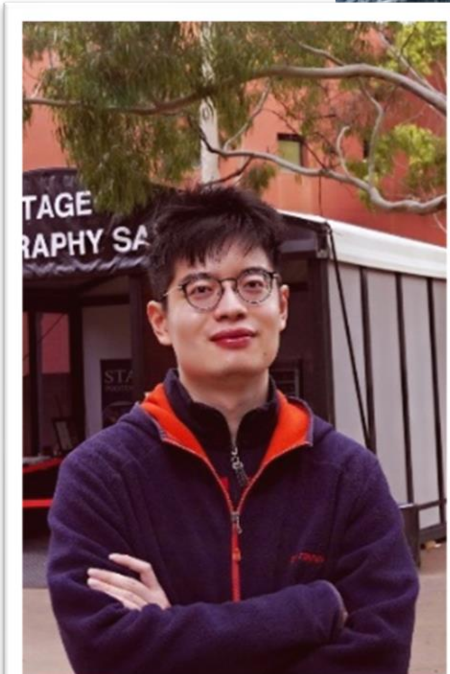
Fauzan Yudho Pratomo is a Ph.D. candidate in mining rock mechanics at the University of Adelaide, Australia. After obtaining his B.Sc. in mining engineering from Bandung Institute of Technology (ITB), Indonesia, he worked for several years in the cave mining industry as an underground geotechnical engineer for Freeport Indonesia. In 2022, he obtained his MEngSc (Research) in rock mechanics from Monash University, Australia, with his research on the numerical study of rock joints and implications to fault-slip mechanics. His current Ph.D. research focuses on the multiscale class-II fracture behaviour of brittle rocks and rock masses for cave mining applications.

Granular Materials' Dynamics and Bio-consolidation

Abstract

Granular dynamics are vital in geotechnical engineering, geo-energy systems, and environmental sustainability, with applications in scenarios such as natural gas hydrate extraction, piping erosion, slope stability, and microplastic pollution transport. Dr. Yuqi Song uses CFD-DEM modeling to explore granular flow, clogging, and sand production in oil and gas reservoirs, providing key insights into reservoir stability and energy management. He will also discuss using Microbially/Enzyme Induced Calcite Precipitation (MICP/EICP) for bio-consolidating granular materials, which shows excellent potential in soil reinforcement, slope stabilization, and dune preservation, contributing to sustainable infrastructure. A groundbreaking aspect of his research is the first-ever use of MICP to immobilize microplastics in soil, offering a novel solution to combat pollution at its source. Additionally, Dr. Song's research on STEM education reform in the AI era advocates for a shift from students being AI competitors to AI collaborators, adhering to a project-based, student-centered teaching philosophy.

Speaker



Dr. Yuqi Song is a passionate interdisciplinary Research Fellow at Monash University, holding a PhD degree under the supervision of Prof. P.G. Ranjith and Dr. Bailin Wu. Dr. Song is drawn to technologies and research that benefit humanity, while he dislikes repetitive and tedious tasks (such as the daily commute). For example, while investigating smart cars at a dealership, he learned that current intelligent driving systems hesitate to drive over plastic bags, unlike human drivers who would simply drive over them. This led him to temporarily abandon his plans to purchase a smart car and instead write a preprint article discussing how computer vision (CV) techniques and impact mechanics experiments could solve this issue. This is just one of many examples of Dr. Song's active engagement with frontier problems. His habit of constantly thinking critically about emerging challenges has attracted extensive, interdisciplinary collaborations worldwide. He has always maintained long-term, mutually beneficial collaborations with his collaborators, students, and supervisors, ensuring these partnerships remain healthy, productive, and enduring.