Observations of Opening, Mixed, and Sliding Modes in Rock Fracture

November 7, 2024

Joseph Labuz

Professor, Department of Civil, Environmental and Geo-Engineering, University of Minnesota

Seminar Details

Friday, November 7, 2024 2:30pm – 4:00pm

UH Campus Classroom & Business Building Room CBB 104

Online via Teams https://www.cive.uh.edu/research/beyer-distinguished-lecture

ABSTRACT: Rock fracture is of importance because of the many geoengineering processes (e.g. enhanced geothermal energy, mineral carbon storage, waste isolation) associated with promoting or preventing fracture. The fracture mode most often studied is one of opening crack displacement using a specimen loaded by uniaxial tension, flexure, or cavity expansion. It is observed that a tensile fracture ($KI > 0$) does not initiate instantaneously at a particular value of load; rather a localized zone of microcracking, detected by acoustic emission, develops prior to crack propagation. Further, high-resolution measurements of surface displacements using speckle methods provide details of the near-tip region in terms of length and opening displacement. Discrete element modeling gives insight into the fracture process.

Another fracture mode of great interest involves tangential crack displacement, although generating shear fracture ($KII \neq 0$) under ambient conditions (low mean stress) has proved to be difficult. Theoretically, mixed-mode loading, where KI and KII are present, generates normal and tangential displacements near the crack tip. However, fracture tests with rock and detailed measurements of the near-tip region show opening displacement but no differential tangential displacement, at least for mode mixity $KII/KI < 15\%$. Thus, the specimen with a single inclined crack loaded in uniaxial compression propagates due to tensile fracture.

A feature missing in many shear fracture experiments is a closed or closing crack, $KI \leq 0$, which can be produced in confined-compression testing. Several researchers have shown that part of the post-peak response of a specimen loaded under confined compression (with sufficient mean stress) is characterized by propagation of a shear fracture. To quantify mode II crack propagation, plane-strain compression tests are conducted using a closed-loop, servo-hydraulic load frame and control of the test is maintained with lateral displacement as the feedback signal. Finite element analysis and linear fracture mechanics show that the mechanical response is consistent with mode II crack growth.

BIOGRAPHY: Joseph Labuz is a Professor in the Department of Civil, Environmental, and Geo- Engineering at the University of Minnesota. He received his degrees in civil engineering, with BS from Illinois Tech, MS and PhD from Northwestern University. In 1987, he joined the faculty at the University of Minnesota. His awards include best papers (48th US Rock Mechanics Symposium, 2014; Giovanni Barla Best Paper, Rock Mechanics and Rock Engineering, 2022) and an honorary chair (Department of Civil and Construction Engineering, National Taiwan University of Science and Technology, 2016). He is a Fellow of the American Society of Civil Engineers and the American Rock Mechanics Association. His research activities are focused on experimental geomechanics, lately dealing with fluid-rock interactions related to mineral carbon storage.