Mehrdad Imani Tilenoei
PhD Student in Rock Mechanics
Civil and Environmental Engineering Department
Colorado School of Mines, Golden, Co

Email: mimanitilenoei@mines.edu
Phone: 720-808-3494

Research Topic: Monitoring of time-dependent progressive damage in rocks

Abstract

Mining structures (surface and underground) are commonly constructed within or on rock formations for prolonged periods. Enhancing the efficiency of monitoring these structures and controlling of ground remains pivotal in mitigating potential risks and maintaining their stability over time. Furthermore, monitoring plays the critical role of early damage detection in ensuring the stability of structures and ground control, consequently, improving and optimizing monitoring performance can significantly reduce the cost of projects and keep people safe by serving as a precursor to potential failures. Damage process in rocks is a complex phenomenon and the comprehensive understanding and monitoring of the crack nucleation and propagation mechanism has a direct effect on the stability of structures. Failure in rocks commonly occurs by accommodation of deformation through cracking, and it usually takes place when there are sufficient microcracks to create a distinct fracture causing failure. Among many factors affecting brittle failure in rocks (pore pressures, temperature, confining pressure, etc.) time is the least well-understood parameters, for this reason the characterization of time-dependent behavior of brittle rocks is fundamental to monitoring of rock structures designed for a long period of time. Creep is one of the most widely discussed time-dependent phenomena in which the deformation in rocks takes place under constant stress less than its short-term strength.

Hence, the main objective of this study is to monitor and enhance our comprehensive comprehension of time-dependent damage progression at the in rocks through the utilization of non-destructive test methods (NDT). In this project, we are using Digital Image Correlation (DIC), and Ultrasonic Transmitted waves as non-destructive test methods to monitor and understand the mechanisms of rock fracture and damage, which scientists and engineers can improve the design and safety of structures and have better control on ground. Both DIC and ultrasonic testing contribute to improving structural monitoring by providing a more comprehensive understanding of how structures respond to external forces, environmental conditions, and time-dependent effects. This enhanced understanding allows for more informed decision-making regarding, ground control, maintenance, and even redesign of structures to ensure their safety and longevity. Additionally, the non-destructive nature of these techniques means that they can be applied repeatedly without causing damage to the structure, making them ideal tools for long-term monitoring and assessment.

DIC analysis monitors surface deformations and provides a full-filed profile of strains which can show the strain localizations, and ultrasonic transmitted wave parameters, such as amplitude, frequency, and velocity reveal the microstructural and stiffness change of internal structure. Therefore, in this project, mechanical behavior and damage evolution of specimens are tracked using 2D-DIC in-sync with active ultrasonic monitoring to understand and monitor the fracturing process in rocks, which provide valuable insights on the large-scale monitoring of structures and ground control. Moreover, we intend to establish a correlation between acousto-visual observations of microcrack accumulation at the grain scale in brittle rocks, with the aim of identifying precursors to failure. The projected duration of this project is three years. During the initial year, we employed DIC to investigate and monitor the progression of damage processes, effectively showcasing the spatial and temporal evolution of damage during creep. Furthermore, we employed DIC images to quantify the damage mechanisms occurring in the primary, secondary, and tertiary stages of creep. Over the subsequent two years, our plan entails identifying the critical level of damage as potential precursors to failure in rocks. This will be accomplished through continuous monitoring of changes in ultrasonic wave parameters.