Adaptive and Predictive Geologic Modeling for Transportation Tunnel Design

Grantee: Colorado School of Mines

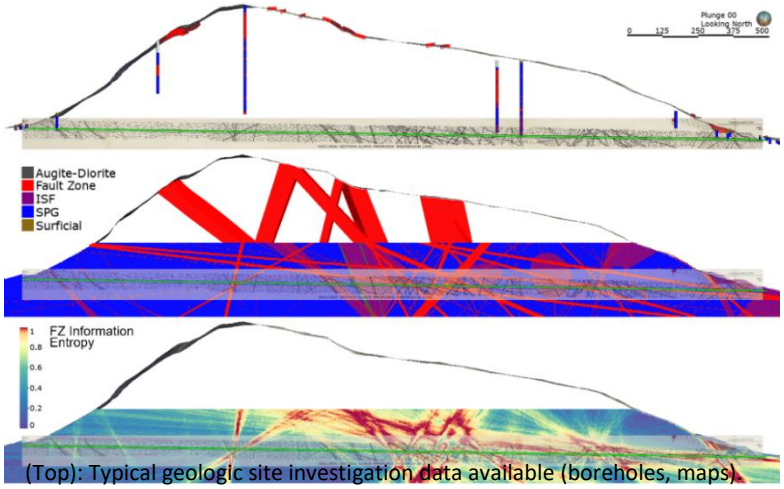
Center Name: University Transportation Center for Underground Transportation Infrastructure

Research Priority: Improving the Durability and Extending the Life of Transportation Infrastructure

Research Project Funding: $300,000

Project End Date: May 31, 2021

Project Description: Geologic models are powerful characterization tools used to understand and communicate various aspects of subsurface geology (e.g., rock formations, faults, and geotechnical engineering properties), serving as a baseline for subsequent design and analysis of transportation systems in the subsurface. As predictive models of the subsurface geology, uncertainties affecting the three-dimensional geologic model obtained from geologic interpretations, sparse data, and modeling limitations must be characterized to ensure responsible use in geotechnical design projects. A unique opportunity in tunneling is the availability of new information on the encountered geologic conditions collected during tunnel excavation from the exposed tunnel face and walls before the installation of final supports. This project sets out to investigate probabilistic geologic modeling methods for characterizing the uncertainties affecting a 3D geologic model of the Eisenhower-Johnson Memorial Tunnel in Colorado. The uncertainty characterization is also a component in a broader, dynamic workflow for incorporating the new information on encountered ground conditions to validate and update initially uncertain geologic models.



(Top): Typical geologic site investigation data available (boreholes, maps).
(Middle): Comparison of initial and excavation stage geologic models.
(Bottom): Modeled uncertainty of fault zones encountered along the EJMT.

Outputs:

1. Geologic uncertainty assessment tool for faulted hard rock tunnel alignments, developed in collaboration with 3D geologic modeling software industry leader Seequent Limited as a beta research branch.
2. Dynamic updating and validation of uncertain geologic models using new information from tunneling excavation.
3. Joint framework for geologic site characterization combining lithologic and structural geologic models with data from modern rock mass classification system.
4. Semi-automated workflow for point cloud-derived rock mass mapping, providing a powerful tool for converting high-quality point cloud datasets to practical structural geologic modeling insights.
5. Demonstration of developed methodologies applied to a real-life transportation tunnel project, the Eisenhower-Johnson Memorial Tunnel in Colorado.

Outcomes/Impacts: This project demonstrates and improves the effectiveness of 3D geologic modeling for characterizing and communicating subsurface geology for tunneling projects. In particular, the research highlights the critical importance of addressing geologic uncertainty, a subject often underrepresented when initial 3D geologic models are treated as a static baseline upon which detailed geotechnical engineering designs are founded. Characterizing geologic model uncertainty creates an opportunity for subsequent design to account for potentially unforeseen ground conditions and helps in safer operations in construction procedures. Furthermore, when unforeseen ground conditions are encountered, the new information on encountered geology can be used to validate and update the initially uncertain geologic model, dynamically improving the quality of the geologic model as the life of the tunneling project progresses.