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Probabilistic risk assessment of rockburst phenomenon during deep tunnel design

Dr. Baptiste Fenneteau, tunnel engineer at WSP in France.

How the Chemistry threatens the Mechanical Integrity of Underground Reservoirs

Dr. Alexandre Sac-Morane, Postdoctoral fellow

Navier Laboratory, Ecole Nationale des Ponts et Chaussées, IPP, UniEiffel, CNRS.

Failure of fractured rock masses in periglacial environments. Experimental investigations on freeze-thaw induced damage

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Probabilistic risk assessment of rockburst phenomenon during deep tunnel design

Abstract

As civil engineering tunnel projects become deeper and deeper, new challenges and risks arise. For these projects, the risk of brittle failure, and in particular dynamic failure such as rockburst, is becoming increasingly important as several projects have already experienced moderate to severe rockburst events during construction. This presentation aims to briefly present this rockburst phenomenon and how the associated risk can be easily anticipated, assessed, and mitigated. One important element of the rockburst risk assessment during preliminary tunnel design is being able to correctly account for the existing uncertainties. To illustrate the importance of this consideration, a rockburst risk assessment is performed on the deepest section (15 km) of the Mont-Cenis base tunnel (TELT project, between France and Italy). The analysis is performed using an improvement of the method proposed by Diederichs (2018), allowing an explicit consideration of the geological and geotechnical uncertainties. The results indicate that two zones are potentially prone to minor to moderate rockburst. Because of the large existing uncertainty, the first area was not initially considered at risk in previous studies, but the probabilistic analysis suggests that the risk of rockburst cannot be excluded mostly due to the large uncertainties. The second area was already identified as being at risk, but the results provide a more refined interpretation of the risk, while allowing also discussions and a critical analysis of the input hypotheses.

Speaker

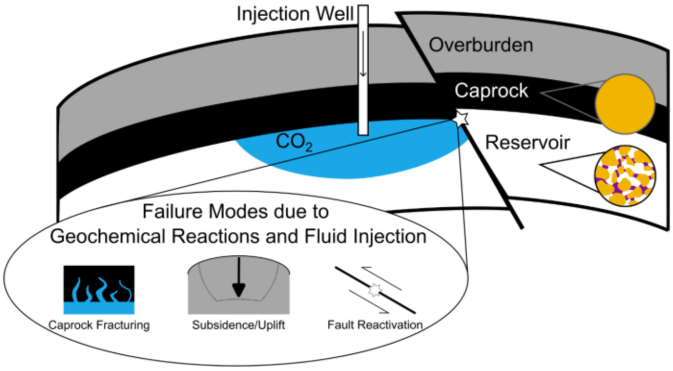
Dr. Baptiste Fenneteau is a tunnel engineer at WSP in France. He just finished his PhD thesis (an industrial thesis) which was funded by WSP (formerly BG Consulting Engineers) in France, in partnership with the GeoResources Laboratory of the University of Lorraine (France). He started is PhD in October 2022, entitled “Preliminary Design of Deep Tunnels in Continuous Rock Mass by Combining Numerical and Probabilistic Approaches”. During his PhD, he also worked part-time as a tunnel engineer on WSP projects, mostly for the French underground research laboratory associated with the future nuclear waste repository (ANDRA/CIGEO), and for the Mont-Cenis base tunnel (TELT, Construction site number 5). He graduated in October 2022 with an engineering degree in “Geoscience and Civil Engineering” from the French engineering school Mines Nancy and a master’s degree in civil engineering with a specialization in geotechnics and risk management from the University of Lorraine.

How the Chemistry threatens the Mechanical Integrity of Underground Reservoirs

Abstract

To face the climate evolution, the underground reservoirs are promising candidates to store greenhouse gas such as CO2. This injection into the geomaterial induces a modification of the fluid chemical composition. By affecting its reactivity with the surrounding solid phases, these reactions lead to mineral dissolution/precipitation that can modify the different properties of the sample and threaten the mechanical integrity of the system.

This presentation focuses on two chemo-mechanical couplings: the debonding of a cemented granular sample (one way relation) and the pressure-solution phenomenon (two ways relation). These phenomena are investigated using existing and newly developed numerical models, considering the couplings between chemistry and mechanics at the microscale. These explorations offer new insight into the behavior of geomaterials under chemical solicitations.



Speaker

Dr. Alexandre Sac-Morane started his undergraduate journey in 2015 at Lycée Déodat de Séverac, Toulouse, France, into "classes préparatoires aux grandes écoles", major Physics and Technologies. This program represents highly selective classes to prepare for the competitive exams of french "grandes écoles". After the national exams, he integrated in 2017 the Ecole Normale Supérieure Paris-Saclay, Cachan, France, to follow the Engineering Bachelor. Between 2018 and 2020, he did at the same university the Civil Engineering Master. In 2020, he started at the Université Grenoble Alpes, Saint-Martin-d'hères, France, the Geomechanics, Civil Engineering and Risks Master. He did his PhD between 2021 and 2025 under the supervision of Manolis Veveakis (Duke University, Durham, NC, USA) and Hadrien Rattez (Université Catholique de Louvain, Louvain-la-Neuve, Belgium). He is currently a postdoct researcher at Navier laboratory at Ecole Nationale des Ponts et Chaussées, Champs-sur-Marne, France.

Failure of fractured rock masses in periglacial environments. Experimental investigations on freeze-thaw induced damage

Abstract

Global warming significantly impacts periglacial environments, where increasing ground temperatures reduce permafrost thickness and expand the active layer. Freeze-thaw cycles within the active layer can induce fatigue stresses in rock masses, potentially promoting damage accumulation in intact rock bridges. When rock bridges exist between the tips of non-persistent fractures, their progressive degradation can trigger fracture propagation, coalescence, and ultimately lead to the detachment of rock volumes. Understanding the mechanical behaviour and weakening of rock bridges is therefore crucial for rockfall hazard assessment, including the estimation of representative volumes and failure probabilities. In this presentation, the time-dependent response of rock bridges is investigated through the evaluation of Mode I fracture toughness, a parameter controlling fracture propagation. The focus is on a fine-grained, low-porosity quartzite from the Italian Western Alps where long-term temperature monitoring provides a realistic basis for defining representative freeze-thaw cycles at the rock mass surface. Laboratory experiments using semi-circular bend specimens investigate thermal stresses induced by freeze-thaw cycles and cyclic loading. The presentation highlights how thermal and mechanical cycling can affect fracture toughness in hard rocks, providing experimental insight into rock bridge failure and the evolution of rockfall hazard in periglacial high-mountain environments.

Speaker

Dr. Giulia Torsello is a Postdoctoral Research Fellow at the University of British Columbia (Canada), where she works on data-driven modelling of time-dependent damage in natural and engineered slopes. Dr. Torsello earned her PhD in Civil and Environmental Engineering from the Polytechnic of Turin (Italy) in 2025, including one year as a Visiting PhD Candidate at RWTH Aachen University (Germany). During a Research Fellowship at the Polytechnic of Turin, she contributed to the development and optimization of QPROTO, an open-source QGIS plugin for preliminary rockfall hazard and risk mapping. Her expertise includes laboratory testing of rocks, rock fracture mechanics, numerical modelling, and GIS-based natural hazard and risk assessment.