PhD Position in Engineering Geology at RWTH Aachen University, Germany

Project title: Understanding Failure Mechanism of Non-Persistent Discontinuities Using 3D-Printed Synthetic Rock Mass

Introduction: We are looking for a competent Research Assistant (PhD Candidate) for our newly funded DFG project. Duration of the project is 3 years, starting in September 2021.

Project description: Rock mass consists of a complex interplay of two components: the intact rock and spatially distributed rock joints of various orientation and persistence. It is of paramount importance to understand the "rock mass" behaviour in the field of geo-engineering, as an adequate design of structures i.e. tunnels, slopes etc. relies on the rock mass strength and deformation characteristics. There is currently no direct way of estimating the mechanical characteristics of rock mass and it is quite common in practice to estimate the rock mass strength indirectly using empirical classification. The aim of this project is to understand the mechanical characteristics and failure mechanism of rock mass through use of additive manufacturing (3D printing) method. Using 3D printing, it is aimed to build "synthetic rock mass samples" with known configurations (i.e. strength and the spatial distribution of rock joints) and systematically test them in laboratory. The key advantage of the proposed method is to allow for the execution of "repeatable" laboratory testing on samples with similar physical conditions, reducing the level of uncertainties and increasing the reliability of results. Subsequently, the results obtained from laboratory testing of the 3D-printed samples are used as a basis for calibrating/verifying the numerical results, with the goal of developing a new constitutive model to estimate the rock mass strength.

The project is divided into five (5) work packages (WP) with the ultimate goal of understanding the mechanical and deformational characteristics of a rock mass with complex non-persistent discontinuities:

- **WP 1 – Systematic Improvement and Quantification**: Determine the most representative printing configurations that result in production of a synthetic material with behaviour similar to geomaterials.
- **WP 2 – Strength of Fully Persistent Discontinuity:** Involves carrying out a series of direct shear tests on 3D printed synthetic samples with known discontinuity surface characteristics to derive key strength parameters: base friction, dilation angle and apparent cohesion.
- **WP 3 – Influence of Rock Bridge on Non-Persistent Joint Strength:** In this part of the project, we aim to carry out a systematic approach to estimate non-persistent discontinuities strength and quantify the impact of rock bridges on the shear strength of a rock mass. The impact of two key parameters*: i) rock bridge percentage* and *ii) spatial location* are evaluated.
- **WP 4 – Synthetic Rock Mass (SRM) Strength:** This phase of work aims to directly measure the rock mass strength comprising a complex network of non-persistent discontinuities at laboratory scale. Discrete Fracture Network (DFN) models with known input parameters will be designed, printed in 3D and systematically tested at laboratory.
- **WP 5 – Advanced Numerical Modelling:** In this phase of work, calibrations and verifications against laboratory testing results (obtained from previous WPs) will be carried out using advanced numerical modelling such as combined finite/discrete element method (FDEM). The ultimate goal is to derive a constitutive model that can estimate the strength and deformation characteristics of rock mass with complex DFNs.

Project team: Chair of Engineering Geology and Hydrogeology at RWTH Aachen University (Germany), Chair of Reservoir Geomechanics at University of Alberta (Canada)

Tasks:

- **Laboratory Testing:** Performing and analyzing a complete suite of rock mechanics testing including uniaxial/triaxial compression, direct shear, indirect tension (Brazilian), fracture toughness on 3D printed sandstone. The laboratory testing will be conducted on a wide variety of 3D printed samples from intact rock samples to samples with complex non-persistent discrete fracture networks (DFNs).
- **Advanced Numerical Modelling:** Continuous calibrations and verifications of the experimental results as they become available using advanced numerical modelling such as the combined finite/discrete element method (FDEM). The ultimate goal is to derive a constitutive model that can estimate the strength and deformation characteristics of rock mass with complex DFNs.

Candidate Requirements:

- MSc. degree in a project-related discipline (e.g. applied geosciences, engineering geology, geotechnical engineering, geology, etc.)
- Good knowledge of rock mechanics and laboratory testing
- Experience in the use of advanced numerical modelling (FDEM or DEM)
- Excellent English language skills
- Ability to quickly develop related research skills and knowledge
- Creativity, flexibility, team orientation

Position description: This is a three-year research assistant position with the option of pursuing a PhD degree at the RWTH Aachen University. The salary corresponds to pay grade TV-L13 Level 1 of the German public service salary scale (TV-L).

Contact for Enquiries and Application: Please email a CV (max. 2 pages) and a cover letter (max. 1 page) outlining your experience and motivation to Dr. Pooya Hamdi (hamdi@lih.rwth-aachen.de). The deadline for application is the **30th of April 2021**. Intended start date is the 1st of September 2021.

Link to LIH website:
https://www.lih.rwth-aachen.de

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As RWTH is committed to equality of opportunity, we ask you not to include a photo in your application. You can find information on the personal data we collect from applicants in accordance with Articles 13 and 14 of the European Union's General Data Protection Regulation (GDPR) at http://www.rwth-aachen.de/dsgvo-information-bewerbung