Supplement of Saf. Nucl. Waste Disposal, 2, 113–113, 2023
https://doi.org/10.5194/sand-2-113-2023-supplement

Supplement of

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2nd International Research Symposium of BASE on Safety of Nuclear Disposal (SafeND), Berlin, 13–15 September, 2023

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Feasibility Studies of Continuum Modelling Approach Using Ubiquitous Joint Model in Modelling Fractured Crystalline Rock

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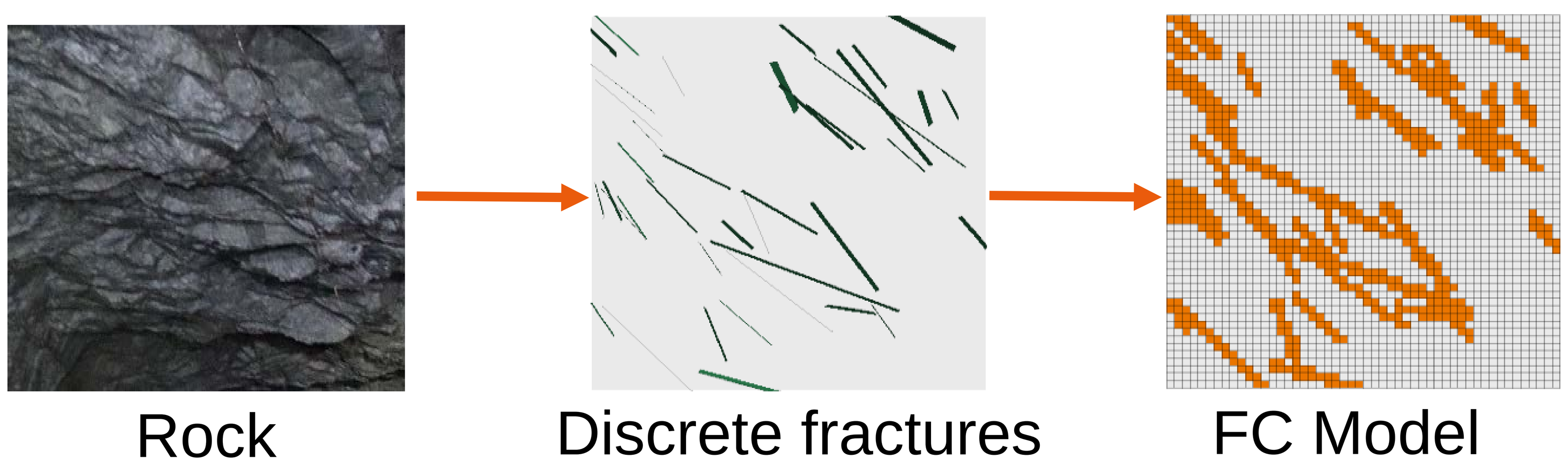
I Introduction

Crystalline rock is one of the potential host rocks considered for the disposal of high-level radioactive waste in Germany, although it is inherently anisotropic and heterogeneous due to the presence of discontinuities. Realistic representation of fractures in modelling plays an important role in the context of integrity assessment of the geological barrier function of the host rock. As continuum-based approaches provide high computational efficiency, a Fracture Continuum (FC) approach is chosen for preliminary integrity analyses.

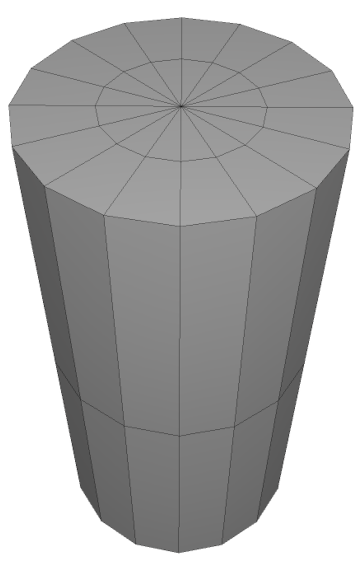
II Fracture Continuum (FC) Approach

The FC approach maps the fractures onto a regular continuum mesh. Each continuum zone explicitly representing fractures is assigned a Ubiquitous Joint (UJ) model with equivalent fracture properties. This UJ model considers a direction of weak plane (ubiquitous-joint) in a Mohr-Coulomb model on which shear failure can be initiated (Itasca, 2023). The intact rock matrix is modelled as isotropic Mohr-Coulomb material.

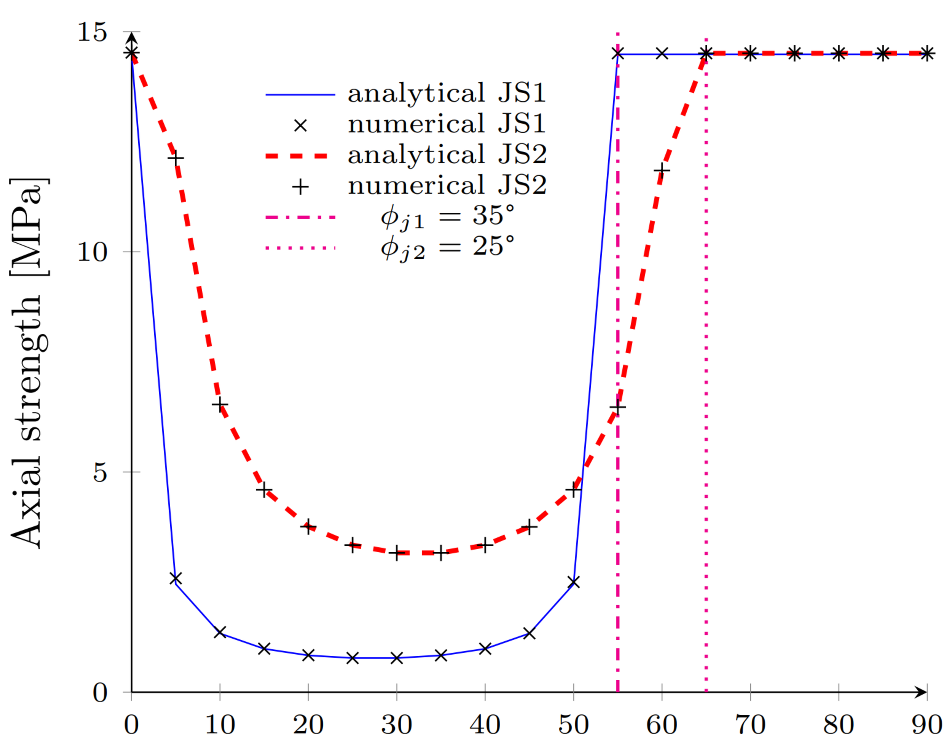


Why Ubiquitous Joint (UJ) Model?

For verification of the UJ model, several numerical simulations of uniaxial strength tests on samples were performed. The model captures the strength anisotropy induced due to the fracture orientations for the selected material and two joint set (JS) parameters, and the results are compared with the analytical prediction of Jaeger and Cook (1979).

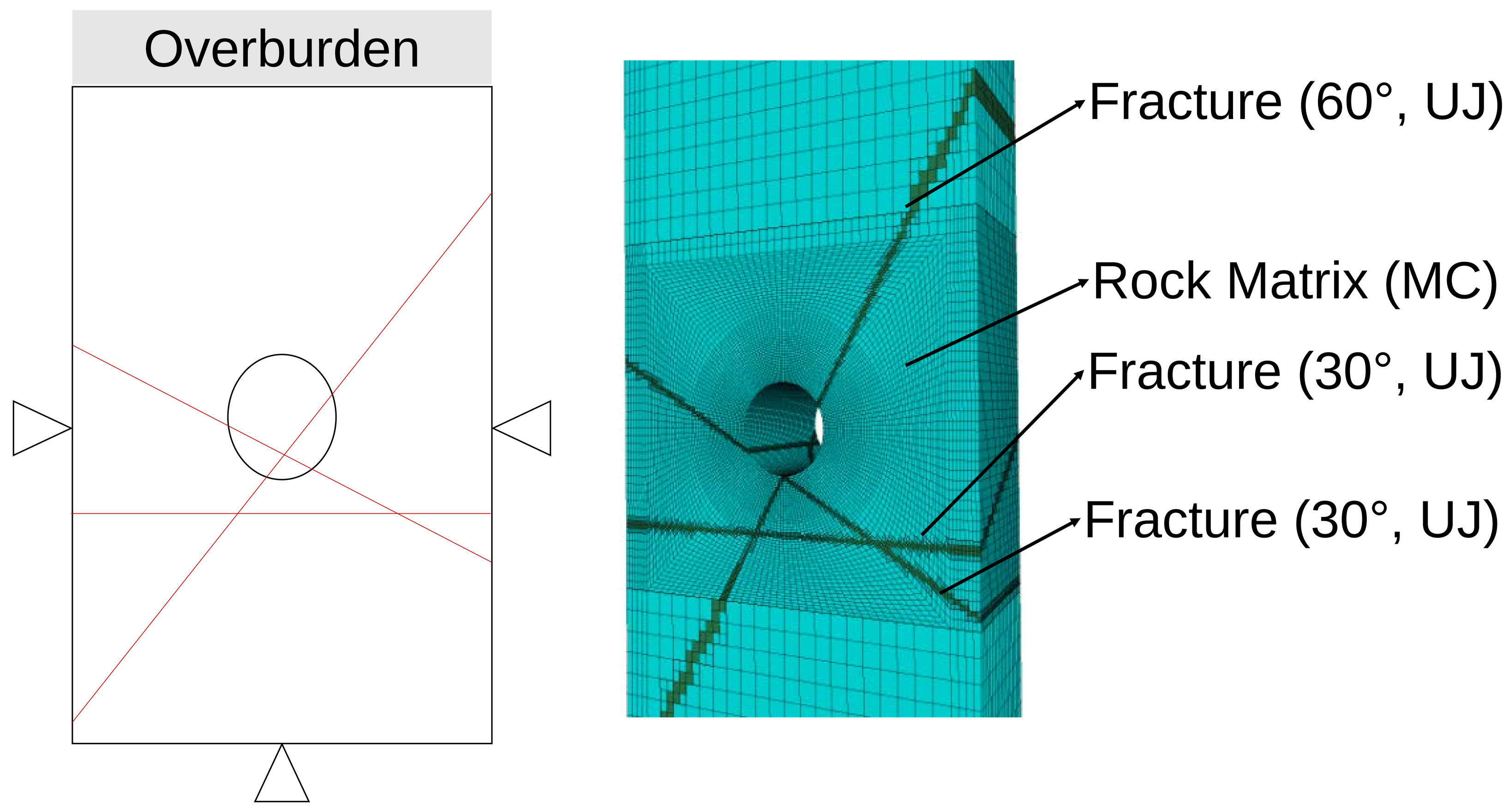


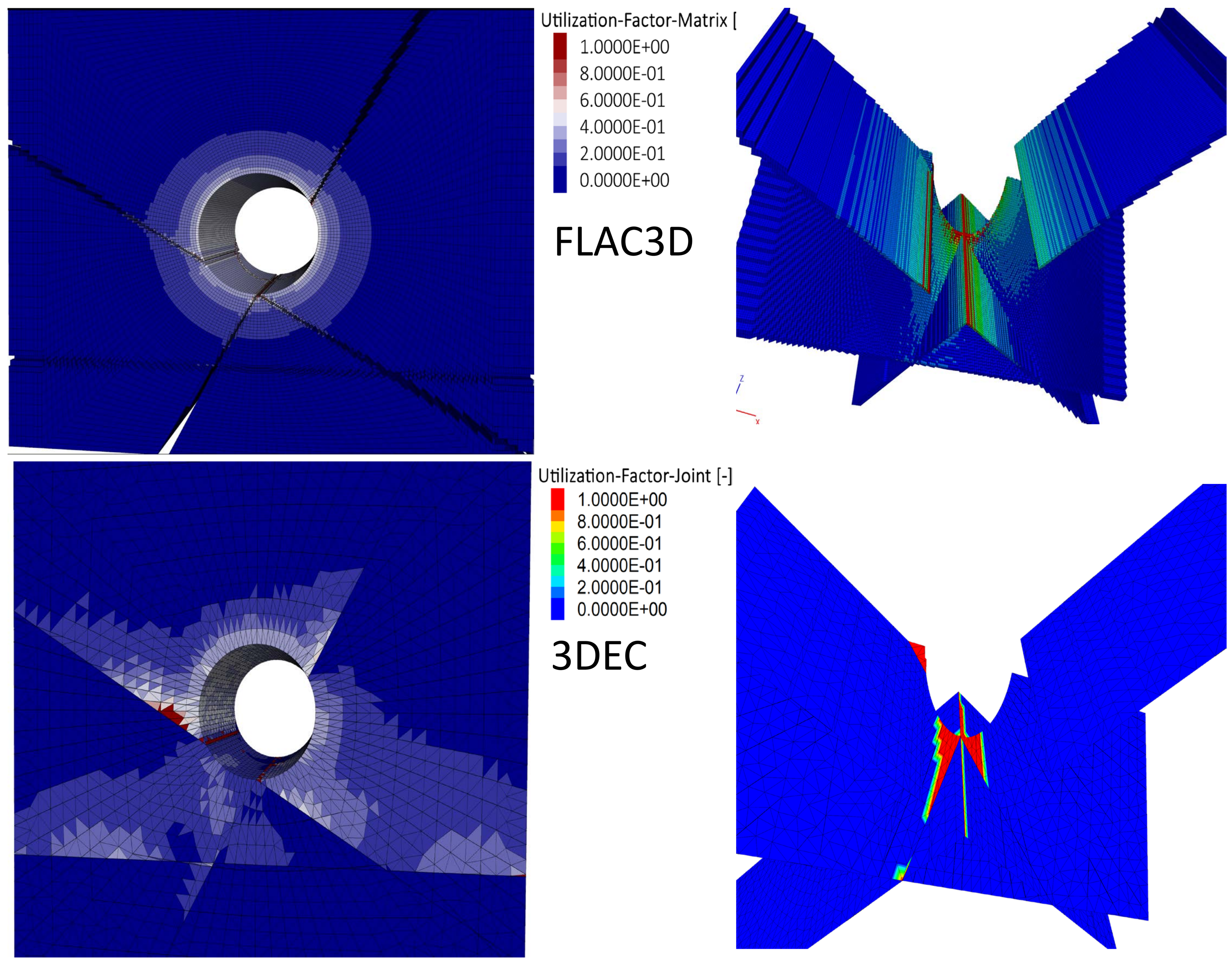
Cylindrical sample under uniaxial compression



III Benchmark Case: Emplacement Drift Model

A Benchmark model with boundary conditions and three fractures as shown assesses the chosen FC modelling approach. The rock model, 25 m x 10 m x 100 m, has a circular emplacement drift at a depth of 900 m with 25 m spacing between two parallel drifts.





Intact rock matrix (left) and fractures (right)

IV Results and Discussion

Preliminary results of the simulation are qualitatively validated with the results of a replicated 3DEC (Discrete Element Method) model simulation. The figures illustrate the evaluated utilisation factors for shear failure of zone groups of matrix and fractures of the simulated rock models. As noticed in the comparison of results, the FC approach has the potential to capture the regions of failure in which the plasticity failure occurs. Nevertheless, an explicit modelling of fracture networks may necessitate a fine mesh along the fractures, which causes extensive computational effort.

The work is part of the project PRECODE, which is funded by the German Federal Company for Radioactive Waste Disposal (BGE).