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BARIK: An Extended Hoek-Brown-Based Anisotropic Constitutive Model for Fractured Crystalline Rock

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I Introduction

Fractured crystalline hard rock poses challenges for radioactive waste disposal. Existing models fall short in accounting for its anisotropic, nonlinear behaviour. The BARIK model, extending the Hoek-Brown (HB) approach, captures these complexities, offering improved insights for deep geological repositories.

II Implementation Approaches

BARIK is integrated into FLAC3D (explicit stress integration) and MFront for OGS (implicit). Fractures are treated implicitly in both. Distinct anisotropic matrix and joint behaviours with specific strengths are pivotal. This results in a model that enables isotropic-elastic, orthotropic-elastic, isotropic-elasto-plastic, and orthotropic-elasto-plastic calculations.

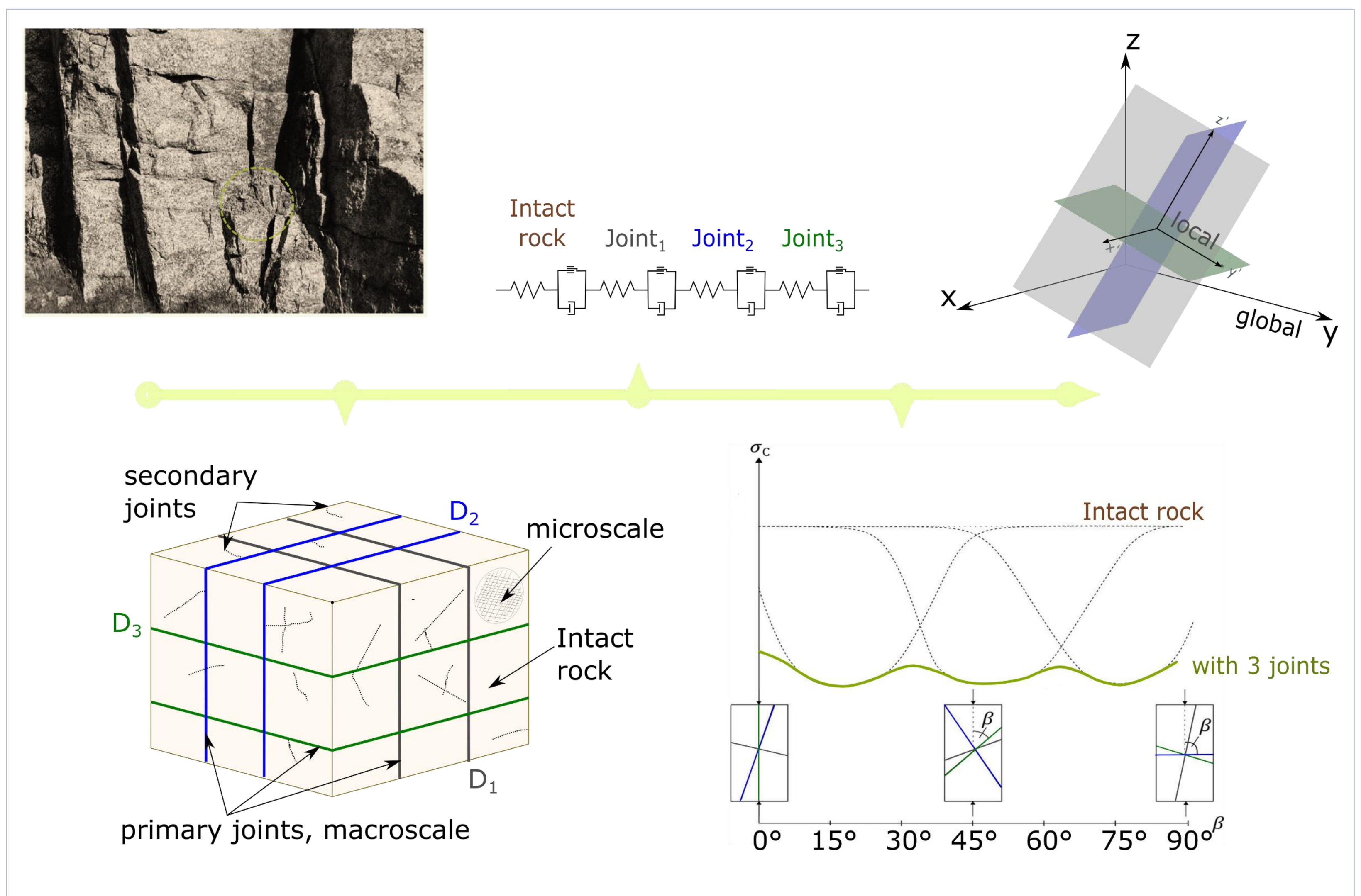

*Fig. 1. Schematic representation of the rock matrix with multiple fault systems (D_i) for the initial conceptualization of the BARIK constitutive model **

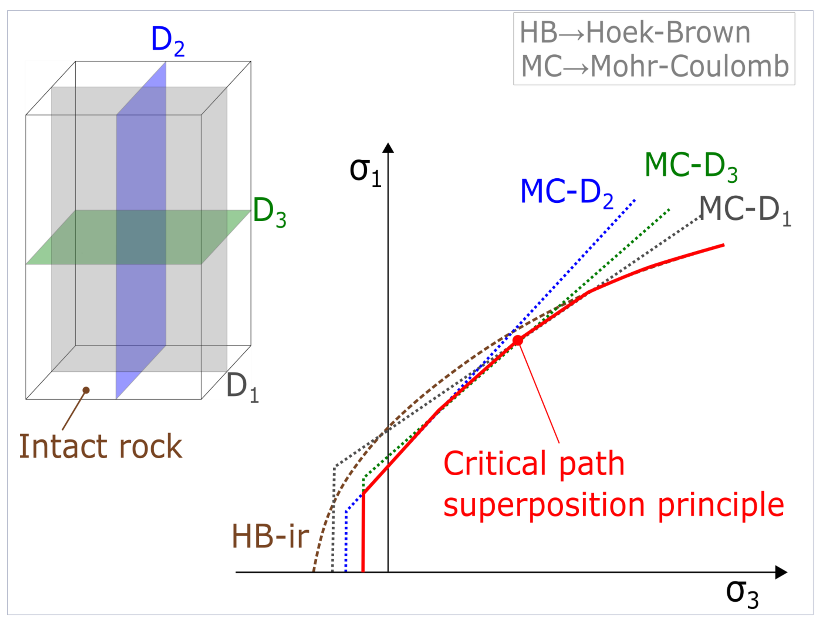

Fig. 2. Principle of superposition using the example of matrix multiple fault systems

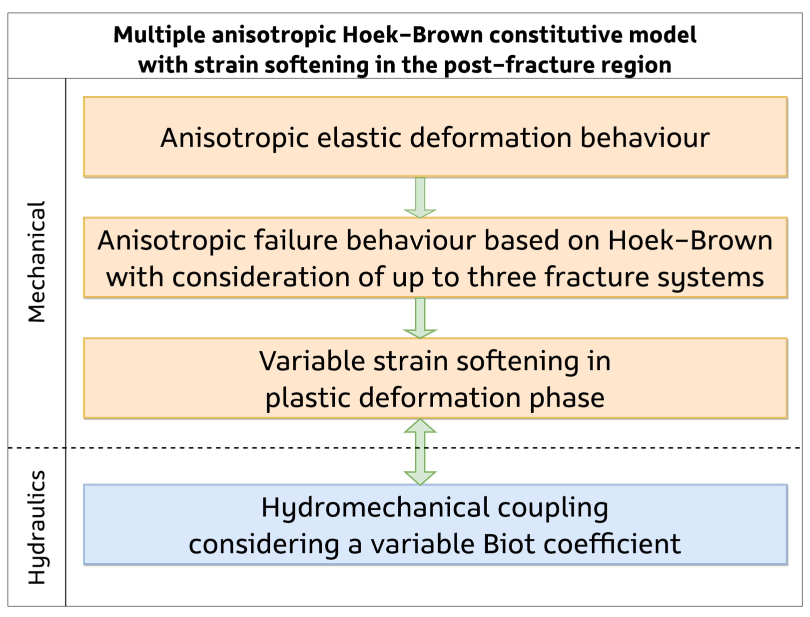

Fig. 3. Basic structure of the constitutive model BARIK

References

Dai, Zi-Hang; You, Tao; Xu, Xiang; Zhu, Qiao-Chuan (2018): Removal of Singularities in Hoek-Brown Criterion and Its Numerical Implementation and Applications. In: International Journal of Geomechanics 18 (10), Artikel 04018127. DOI: 10.1061/(ASCE)GM.1943-5622.0001201.

*Wittke, Walter (1984): Felsmechanik. Grundlagen für wirtschaftliches Bauen im Fels. Berlin, Heidelberg, s.l.: Springer. *(Photo, top left corner)*

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III Verification

The accuracy of the BARIK model implementation in FLAC3D was evaluated through two distinct setups: a triaxial test on a cubic rock sample (Fig. 4) and a cylindrical hole set within an infinite medium (Fig. 5). These verifications reinforce the reliability and robustness of BARIK across varied computational scenarios.

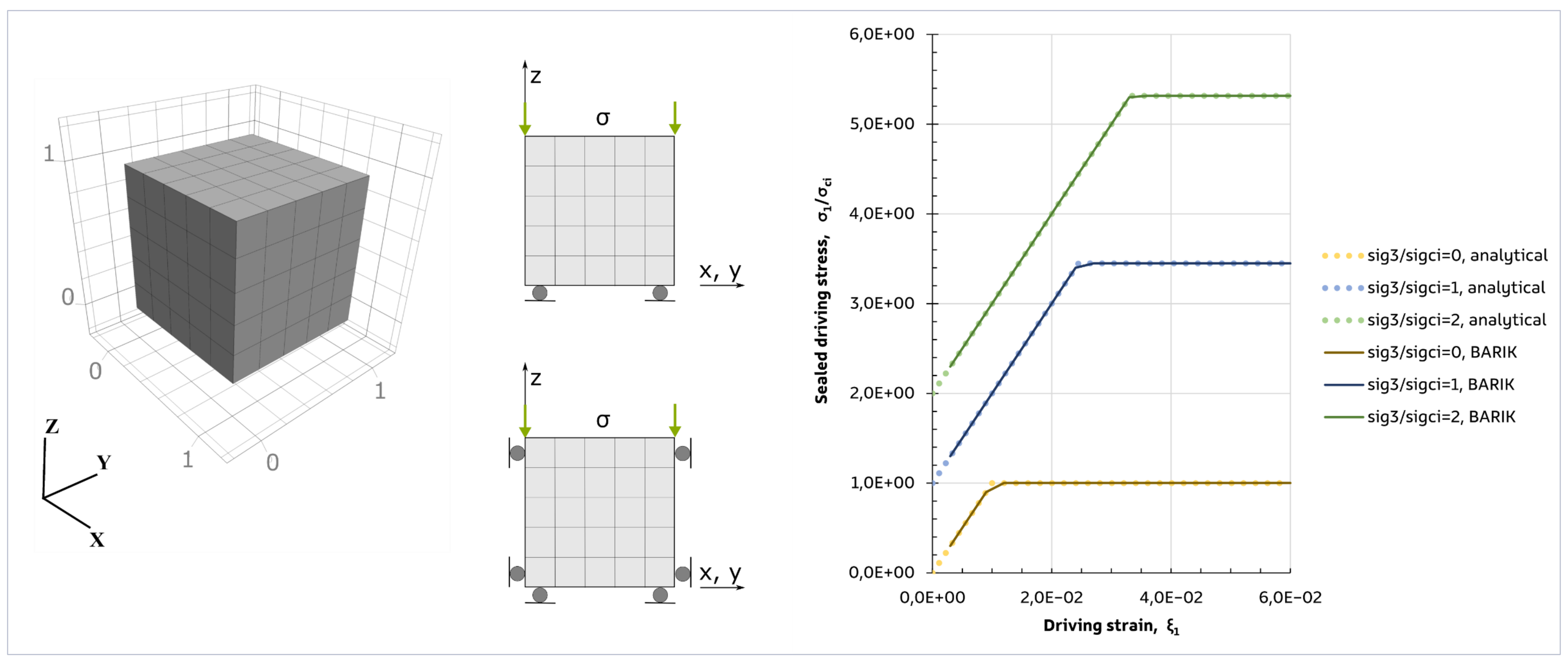

Fig. 4. Grid and boundary conditions (BC) of the cubic rock sample used to verify the BARIK constitutive model performance

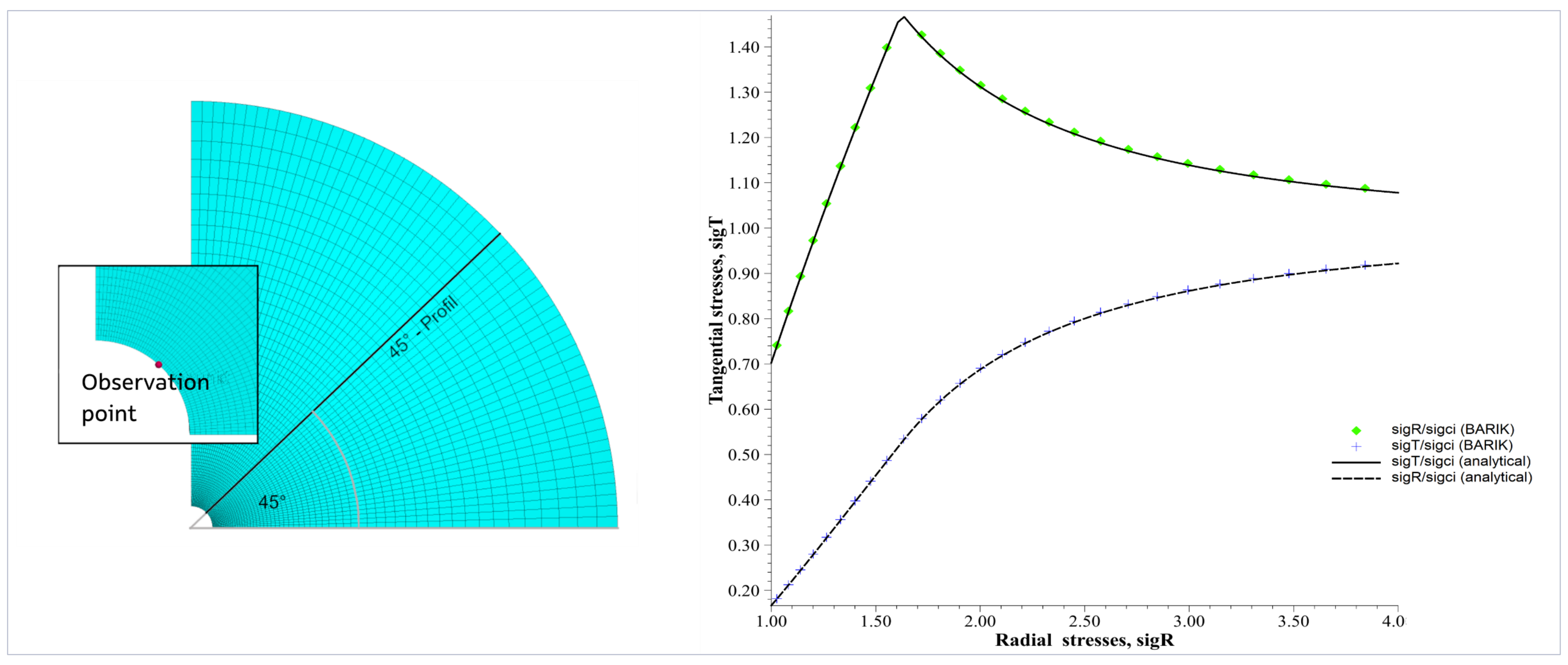

Fig. 5. Grid of a cylindrical hole in an infinite medium used to verify the BARIK constitutive model's performance

IV Benchmark Cases

For a comprehensive evaluation of the BARIK model, we leveraged two benchmark scenarios. The OpenGeoSys (OGS) platform was tested with both uniaxial and triaxial laboratory experiments (Fig. 6). In contrast, BARIK's accuracy in FLAC3D was gauged using an emplacement drift from a deep geological repository model.

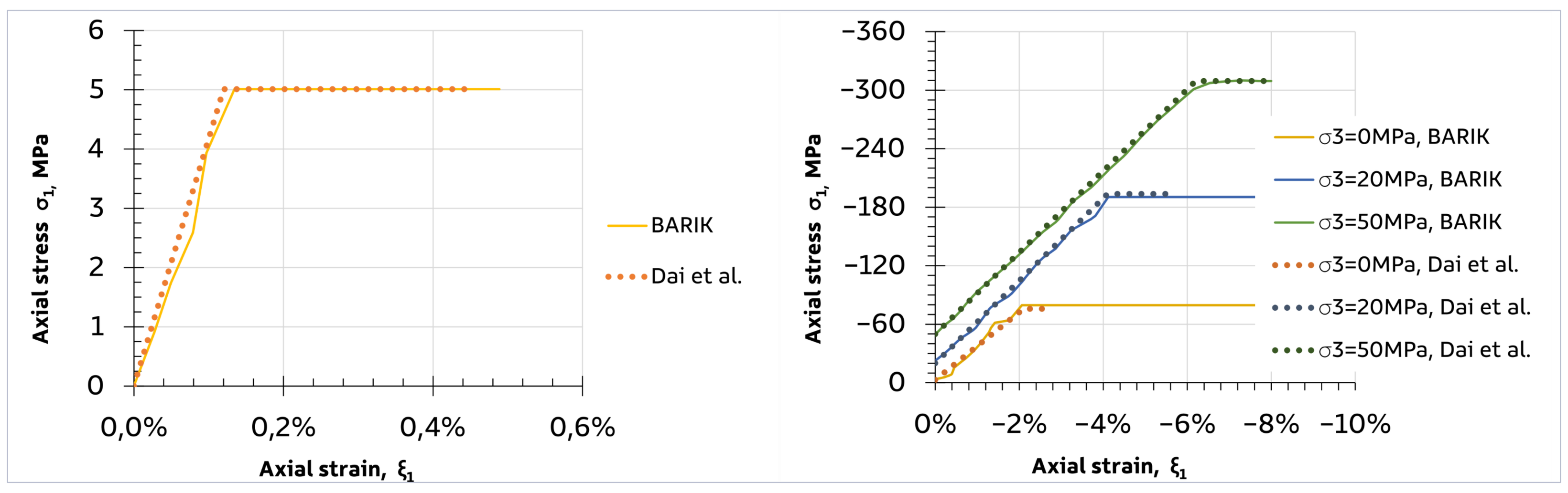

Fig. 6. Uniaxial (left) and triaxial (right) laboratory tests based on Dai et al. (2018) to verify the BARIK constitutive model's performance

V Further steps

- Incorporate multiple discontinuity planes into the actual state of the BARIK constitutive model.
- Enhance the BARIK model by introducing hydromechanical coupling and incorporating strain-softening functions.