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BARIK: an extended Hoek–Brown-based anisotropic constitutive model for fractured crystalline rock

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Abstract. The disposal of heat-generating radioactive waste in deep geologic formations is a global concern. Numerical methods play a key role in understanding and assessing the disposal scenarios of radioactive waste in deep geological repositories. However, the complexities of the thermal, hydrological, mechanical, chemical, and biological processes associated with the disposal of radioactive waste in porous and fractured materials constitute significant challenges. One of the most challenging issues in this field is the complex material behavior of fractured crystalline rock. The presence of fractures makes the rock anisotropic, nonlinear, and dependent on loading paths. Additionally, the Biot coefficient cannot be considered constant throughout the critical and subcritical fracture development regions. These factors make the development of an accurate constitutive model for fractured crystalline hard rock a critical component of any deep geological disposal project. Furthermore, to demonstrate the integrity of the containment-providing rock zone in crystalline host rock, the qualitative integrity criteria must be quantified so that numerical simulation can be performed with concrete numerical values. Part of this assessment for a crystalline host rock is a dilatancy criterion, which is currently based on the Hoek–Brown constitutive model. BARIK is the German acronym for the research project on which this paper is based.

This contribution provides an overview of the development and verification of the BARIK constitutive model, an extended Hoek–Brown model for fractured crystalline hard rock that takes into account up to three fracture systems. The model enables the consideration of the matrix and joint behavior of the rock separately, with each component having unique strength characteristics and failure criteria. These criteria are formulated such that suitable consideration of the strength-reducing properties of the respective fracture systems during barrier integrity verification is possible. The BARIK model has been implemented into two computer codes, FLAC3D and MFront for OpenGeoSys, allowing for the identification and evaluation of any inaccuracies that may arise from the use of different codes. The model enables isotropic–elastic, orthotropic–elastic, isotropic–elasto-plastic, and orthotropic–elasto-plastic calculations of the matrix, making it a valuable tool for the site selection process and for the construction and long-term safety of underground repositories. Furthermore, this poster presentation will show how the constitutive model was evaluated in relation to the dilatancy criterion and how the BARIK constitutive model's suitability for conducting an integrity assessment was validated. In conclusion, the development of BARIK is a significant step forward in the understanding and modeling of the complex material behavior of fractured crystalline hard rock. This contribution will provide insights into the development and verification of this model for the safe disposal of radioactive waste.

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