Numerical analyses of lining systems for a future German repository in claystone based on a time-dependent nonlocal constitutive model

Philipp Herold[1], Eric Simo[1], Miguel A. Manica[2]

[1]*BGE TECHNOLOGY GmbH, Peine, Germany*
[2]*Institute of Engineering, National Autonomous University of Mexico, Mexico City, Mexico*

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Introduction

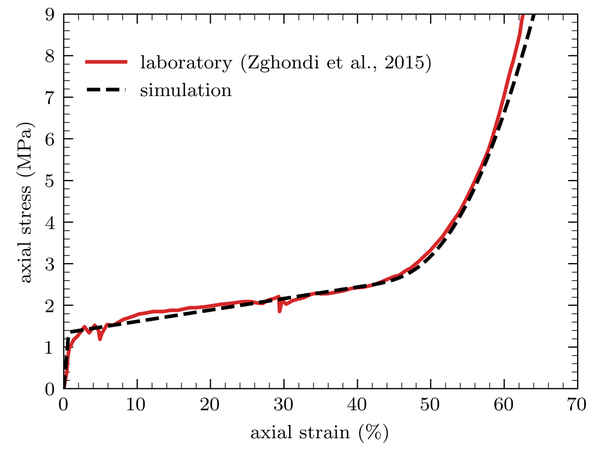
Through the R&D project "Support Structures of Underground Openings in a HLW/SF Repository in Claystone – AGEnT", jointly carried out by BGE TECHNOLOGY GmbH and DMT GmbH & Co. KG, fundamental information regarding the influence of geotechnical conditions on the design and operation of a repository in German claystone formations was gained. In this context, detailed numerical analyses were performed to assess the hydromechanical behaviour of a representative drift. The latter corresponds to a concrete-based support structure made of wedge blocks, combined with a compressible grout material in the extrados. This work focuses on the potential of the compressible material to moderate the interactions between the host rock and the support structure.

Host Rock Formation Model

- The constitutive model employed to characterise the behaviour of the host rock formation is that put forward by Mánica et al. (2021).
- It incorporates a number of features that are considered relevant for the satisfactory description of indurated clays:
  - a nonlinear yield criterion
  - strength and stiffness anisotropy
  - strain-softening
  - a non-associated flow rule
  - rate-dependency
  - creep deformations
  - permeability increase with damage
  - **nonlocal regularisation** (for the objective simulation of localised deformations)

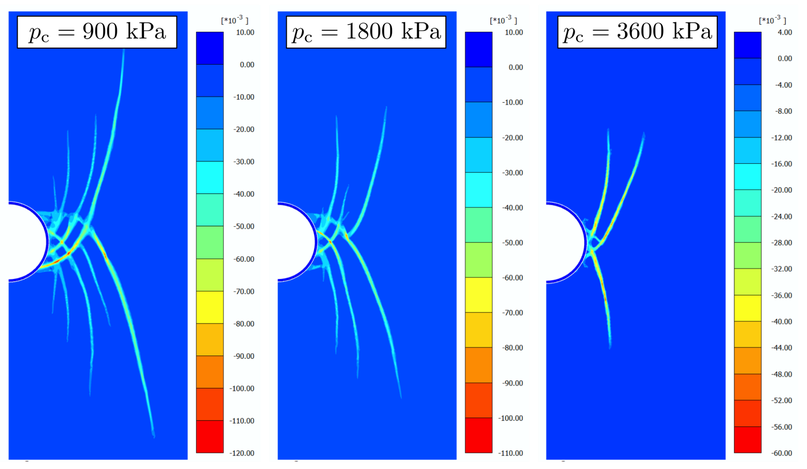
Compressible Grout Material Model

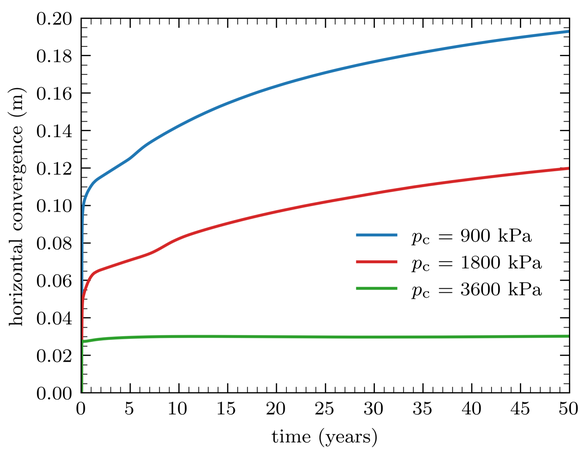
- Simple elastoplastic model
- The assumed hardening law accounts for the observed behaviour in oedometric tests on a compressible grout from Zghondi et al. (2015).
- Once the yield pressure is reached, the material can deform substantially with a small increase in stresses.



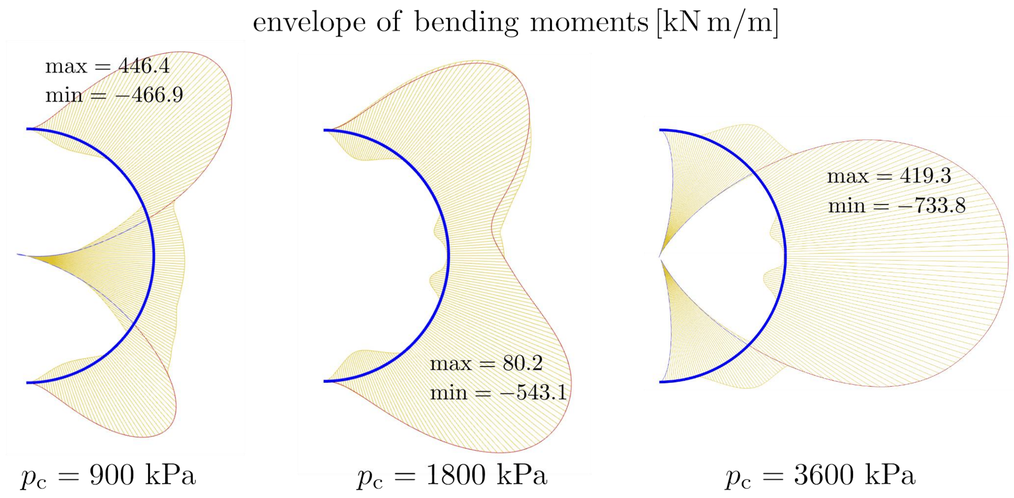
Results Obtained

- Localisation pattern obtained, in terms of shear strains, for different yield pressures of the compressible grout.
- A smaller yield pressure allows further relaxation of the host rock, resulting in a larger fractured zone.





- Horizontal convergences of the rock for different yield pressures of the grout
- Rock displacements are reduced considerably by increasing the yield pressure of the grout material.



- Bending moments in the lining for different yield pressures of the grout
- The higher the yield pressure, the higher the resulting bending moments.

Conclusions

- Characteristics of the support system play a major role in the behaviour of the excavation and in the resulting configuration of the fractured zone.
- The compressible grout can limit the load transferred to the lining and, therefore, can significantly reduce internal forces. However, the latter causes further relaxation of the claystone resulting in a larger fractured zone.
- The results obtained suggest that the use of the compressible grout entails finding a balance between the amount of relaxation allowed in the host rock and the magnitude of internal forces in the lining.

References

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