A permeability model for the excavation damage zone

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February 15, 2019

As shown in Fig. 1, the fluid permeability increases significantly in the vicinity of excavation zone. Obviously, the permeability change is caused by the mechanical

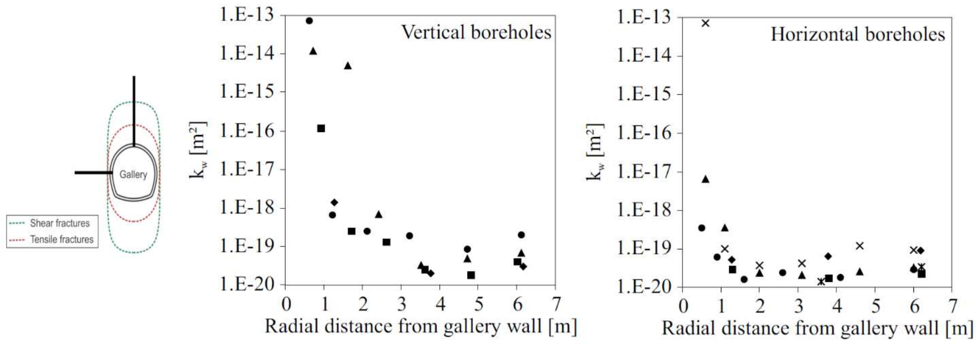

Figure 1: Permeability in the near field of gallery (Pardoen, 2016).

process. There are several mechanical process dependent impermeability models available, such as stress or strain dependent models (reference). However, these models do not explicitly reflect the fact that the change of the permeability in the excavation zone is due to the damage.

Hereby, a new permeability model for excavation damage zone is presented. In the presented model, the permeability is defined as a function of failure index as

$$\mathbf{k} = \left\{ \begin{array}{ll} \mathbf{k}_0 + k_r \mathrm{e}^{bf}\mathbf{I}, & f >= 1 \\ \mathbf{k}_0, & f < 1 \end{array} \right. \tag{1}$$

where $\mathbf{k}_0$ is the intrinsic permeability before the excavation, k_r is a reference permeability, b is a factor. k_r and b can be calibrated by experiment data. The failure index can be calculated by a failure criterion.

In the present study, the Mohr Coulumb failure criterion is used to calculate the failure index f as

$$f = \frac{\tau}{\sigma_n \cdot \tan\phi + c}, \quad f \geq 1 : \text{failure} \tag{2}$$

with

$$\tau = \sigma_n \cdot \tan\phi + c$$

where σ_n is the normal stress onto the failure plane, c is the cohesion, ϕ is the internal friction angle.

The purpose to present this model is to improve the pressure results of Step 3, task E of the DECOVALEX 2019 by taking account of the permeability change in the excavation damage zone.

As a validation, we now apply the permeability model to Step 3, task E. According to the stress status in Step 3, task E, the parameters are assigned with the following values:

$$c = 10^6\,\mathrm{MPa},\ \phi = 15°,\ k_r = 10^{-19}\,\mathrm{m}^2,\ b = 5.5$$

Fig. 2 shows the contour plots of failure index (>1) and the permeability by the model. One can see that both failure index and permeability have the similar distributions.

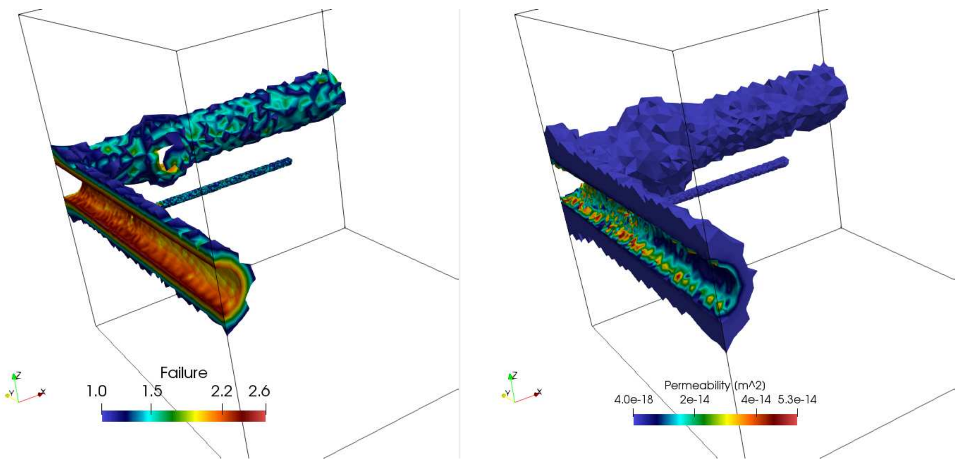

Figure 2: Contour plot of failure index > 1 (left) and its associated permeability in a threshold of $[4.0 \cdot 10^{-18}, \sup \mathbf{k}]$ (right).

Fig. 3 gives profiles of failure index and permeability along a horizontal line from the center of GAN drift. One can see that the curve of failure index is similar to that of permeability. Moreover, the permeability presented in Fig. 3 is close to the experimental one shown in Fig. 1.

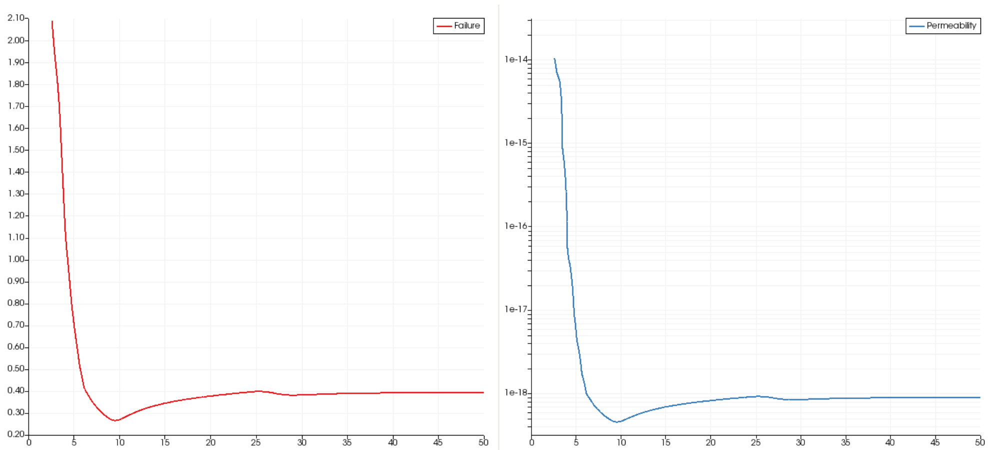

Figure 3: Profiles of failure index (left) and its associated permeability (right) along a horizontal line from the center of GAN.

1 References

References

Pardoen, B., 2016. Hydro-mechanical analysis of the fracturing induced by the excavation of nuclear waste repository galleries using shear banding.