Simulation of Deformation Induced Anisotropic Permeability

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In the analysis of significant flow and transport processes in natural rocks the hydraulic anisotropy plays a prominent role. The intact rock can be anisotropic in its properties caused by its genesis as well as by the in situ stress conditions. This contribution deals with the latter: the simulation of anisotropic permeability caused by a change of stress conditions.

In previous works the hydro mechanically coupled formulation implemented in the finite element code RockFlow has been enhanced by a relation between porosity and permeability (see [1]). There, a change of porosity is calculated by the volumetric strain and the permeability as a function of the porosity by the Kozeny-Carman equation. This approach leads to an isotropic change of the hydraulic conductivity. The influence of anisotropic deformation is neglected in this model.
In order to describe the influence of an anisotropic geometry of voids, flow effective surfaces are introduced. They are defined by the ratio between voids and grains in a cross sectional surface and can be calculated by the initial porosity and the strain tensor. Based on this description of the soil, anisotropy in the permeability tensor will be investigated.
In a first approach the flow effective surfaces are used to determine the anisotropy of the permeability in a linear matter, whereby the mean value of the permeability remains unchanged in comparison with the previous isotropic model. Hereby the change of the permeability tensor can be directly calculated by the strain tensor, as proposed in [2].
In an advanced approach, the permeability is calculated separately in each principle strain direction. Thus a non-linear relation between the flow effective surface and the corresponding permeability can be used, as for instance provided by a capillary tube or a fissure model. By this means the effect on the hydraulic properties of strongly anisotropic strains, for example as a result of a mechanical failure model, can be modeled.

In this contribution the impact of an anisotropic change of strain, for example initialized by an excavation process, on the permeability is investigated in numerical examples.

REFERENCES

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