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Stress-strain relations for swelling anhydritic clay rocks – A review

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The swelling of clay-sulfate rocks is a major threat in tunnel engineering, causing serious damage to tunnels and producing high additional costs during tunnel construction and operation. The swelling leads to geomechanical processes that may result in heave of the tunnel invert, destruction of the lining or uplift of the entire tunnel section. Heave-pressure-time relations are needed when predictions should be made about the mechanical behavior of swelling rock. For pure clay rocks, there is a linear relation between the swelling heave (strain) and the logarithm of pressure (Grob 1972). A generally accepted relation for clay-sulfate rocks, however, is still lacking to date. Therefore, finding appropriate and sustainable counter measures for an actual tunneling project affected by swelling remains extremely difficult.

Grob (1972) proposed the linear relation between heave and the logarithm of pressure ("semi-logarithmic swelling law") not only for clay rocks, but also for clay-sulfate rocks. Pimentel (2007), however, presented laboratory experiments indicating that the semi-logarithmic swelling law may be inadequate for describing the swelling of clay-sulfate rocks. The laboratory tests revealed three different stages in the swelling process, including minimal deformation and prevented gypsum crystallization at high pressures (> 6 MPa); large deformation and gypsum crystallization at medium pressures; and only small deformation, possibly along with gypsum dissolution, at low pressures (< 4 MPa). He pointed at a "tri-linear" relation to describe the different stages. Kirschke (1995) generally doubts the existence of a fixed relation between swelling strain and (final) pressure. According to him, swelling pressures and their temporal development are controlled by water inflow into the rock, which cannot be reflected by general strain-stress relations.

The present study critically reviews stress-strain relations for swelling anhydritic clay rocks proposed by various authors. Subsequently, published laboratory data from oedometric swelling tests are presented that may confirm the proposed stress-strain relationships. Finally, these data are re-examined by comparing each of the proposed relations with the same data set. Based on these results, a unified concept is proposed, which describes the stress-strain relation for swelling anhydritic clay rocks and its temporal development.

References

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