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Hydro-mechanical modeling of swelling processes in clay–sulfate rocks: comparison of swelling laws

Swelling of clay-sulfate rocks is a serious problem in geotechnical projects. In Staufen (Baden-Württemberg), the heave of the land surface occurred as a result of clay-sulfate rock swelling, triggered by water inflow in Triassic Grabfeld Formation. Clay-sulfate swelling is controlled by clay swelling due to osmotic processes, combined with chemical swelling due to the transformation of anhydrite into gypsum. We developed coupled HM models to reproduce the heave observed at the Staufen site. We implemented two swelling laws, namely semi-logarithmic and sigmoidal constitutive relations between stress and strain. We compared the model calculations with the measured long-term heave records at the study site. We then calculated the residuals associated with each modeling approach, and compared the heave calculations with a HM model developed based on a linear swelling law. The findings showed that the semi-logarithmic and sigmoidal HM models were able to reproduce the observed ground heave in Staufen within reasonable accuracy. The linear HM model showed the lowest performance, but its predictions were still sufficiently accurate from a practical point of view. Furthermore, the statistical analyses revealed the influence of geological complexity and spatial heterogeneity of material properties on the swelling behavior.terogeneity of material properties on the swelling behavior.

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