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Clay hydration and crystal growth in expansive anhydritic claystone. The Ascó Power Plant case

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A large power plant directly founded on a hard claystone experienced, soon after the construction of the foundation slabs, a continuous heave developing at decreasing rate, which has been active for the last 35 years.
When undisturbed (i.e. at some depth, in the range of several meters) Ascó claystone exhibits high unconfined compressive strengths (30-40 MPa). In high quality cores the rock has a massive aspect and discontinuities are difficult to observe. The rock has a Tertiary origin and horizontal layers at spacing of 1-4 m could be identified. Whitish seams of gypsum, bassanite or anhydrite are also observed within the reddish rock matrix.
Minerals identified in deep cores are quartz (10%), calcite and dolomite (50-70%), clay minerals (10-20%) and gypsum and anhydrite (2-20%). Among the clay minerals, illite dominates (10%). Smectite or smectite-interbedded minerals do not amount in general to more than 5%. The undisturbed rock has a low porosity (6-11%) and low water content (2-5%). Because of the presence of hydrated sulphates, water content and degree of saturation (Sr=0.8-0.9 was found) are somewhat uncertain. However, high suctions were found in recovered cores.
This rock changes into a weathered material at shallow depths. Mineralogy is not much affected but porosity increases to 22-29% and water content increases to 10-19%. Strength drops to small values (soil like) and a lower "in situ" suction has been measured (0.4-7.1 MPa). The added pore volume of the weathered material, if compared with the deep rock, is filled with water.
The heave of the station was attributed to the hydration of undisturbed rock under the building slabs of the power plant. In fact, large excavations preceded the layout of foundations. As a result, atmospheric water had an easy access to the intact rock. The installation of a compacted soil fill around the buildings allowed the presence of a permanent water table which could infiltrate into the rock. Piezometric data provided evidence of a set of open fissures in the marl, which were attributed to the very significant unloading associated with excavations.
Long term oedometer tests on undisturbed cores supported a conceptual swelling model based on two mechanisms: a primary swelling controlled by the bulk permeability of the rock and a secondary swelling attributed to delayed local water transfer mechanisms. However, the presence of anhydrite, the observations of gypsum crystals in specimens after long time tests and the parallelism with other cases suggest that gypsum precipitation in fissures had a significant role in explaining long term heave.
The presentation will describe the case and will show also the results of a computational model which combines the matrix rock expansion, suction controlled, and the crystal growth in discontinuities.