EGU22-7617
https://doi.org/10.5194/egusphere-egu22-7617
EGU General Assembly 2022

Fully coupled 3D Thermo-Hydro-Mechanical analyses of a single Energy Micropile subjected to heating-cooling cycles

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Energy Geo-Structures are being increasingly employed over the last decade. They combine the structural and energetic function, allowing the savings related to the absence of additional drilling, required instead by the common geothermal boreholes. Currently, they are a rather mature and deeply investigated technology, with a number of successful applications worldwide; however, some issues related to the thermo-hydro-mechanical (THM) effects induced in soils during heating/cooling cycles still deserve some more analyses, particularly for what concerns the possible non-linear behavior of soil under thermal loading. In this work, this issue has been investigated by means of fully coupled 3D FE modeling, considering a single, small diameter Energy Pile. The emphasis of the FE numerical modeling activity is the investigation of the effects induced by the pore pressure variations close to the pile during the thermal loading stage, and the assessment of the potential influence of the soil thermal softening effect on the pile behavior. Two different constitutive models have been adopted for the considered fine–grained soil, both based on the standard critical state theory: i) the classical Modified Cam Clay (MCC) model; and, ii) a similar critical state model incorporating a thermal hardening/softening mechanism for the critical friction angle, assumed as an internal variable that can be modified with temperature. In the FE model, first the mechanical load is applied at the pile head in almost undrained conditions, followed by a consolidation period during which the excess pore pressure dissipates. Thus, the pile is thermally loaded, with the temperature that is assumed to vary with a harmonic function law over periods of 1, 5 and 10 years, to investigate the short term and long–term effects. The results show that: *a)* for the considered case study, the thermal loading conditions produce very small changes in pore water pressure at the pile-soil interface; and no effects observed on the pile head displacements can be related to thermally-induced pore pressure changes; on the contrary, b) significant additional pile head settlements are observed in presence of thermal softening, due to by plastic shear deformations at the soil-pile interface.