Base Displacement Response of Group of Geothermal Energy Piles

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Abstract

The behavior of geothermal energy piles in a group involves complex relation between change in temperature and deformations, strains and stresses in the pile and soil. The behavior of piles when acting as a group is further complex due to group interaction among the piles. Hence, it becomes important to quantify the displacements and stresses to understand the load transfer mechanism of these piles under thermal and mechanical loads. In the present study, rigorous numerical analyses are performed to investigate the thermo-mechanical behavior of the piles in sand using three dimensional nonlinear finite element analysis procedure in Abaqus software. The stress-strain behavior of piles is considered as linear-elastic. The stress-strain response of sand is reproduced using constitutive model CASM. The raft on the piles is modeled to behave in a linear elastic manner. The state parameter based constitutive model CASM is implemented in finite element based software Abaqus through two user defined material subroutines, UMAT and UMATHT. The energy piles in a group are analyzed by considering different combinations of thermal and mechanical piles in a single layer of Ottawa sand. The results of numerical analyses have been presented for the pile base displacement. Parametric sensitivity analyses are carried out to investigate the influence of pile spacing and soil relative density on the base displacement of the piles. The results conclude that the thermal piles experience higher displacement as compared to the mechanical piles and soil relative density plays a key role in governing the pile response to thermal cycle. Differential settlement is noted for the pile groups containing the thermal and mechanical piles altogether.