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A numerical study of the effect of groundwater on spiral coil energy piles

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Numerical simulations were performed to investigate effects of groundwater on the thermal performance of the geothermal energy pile. Energy piles, a part of the closed-loop geothermal heat pump systems, are used to exchange heat between the ground and the heat pump. A heat-carrying fluid circulates the ground through a coiled pipe installed in pile foundations. The COMSOL multiphysics was used as a simulator, which can solve the equations for the temperature and fluid flow in the pipe system, as well as those in the ground. Water temperatures at the pipe outlet after 90-day injection of warm water (30 [U+2103]) were calculated from following cases: (1) one energy pile installed at the fully saturated medium with regional groundwater flow (100 m/year), (2) one energy pile installed at the partially saturated medium (water table is located 13.5 m below the ground surface) with regional groundwater flow (1,000 m/year), (3) one energy pile installed at the fully saturated medium with no regional groundwater flow, (4) one energy pile installed at the partially saturated medium with no regional groundwater flow, (5), (6), (7) four energy piles (distance between energy piles is 10, 5 ,2 m) installed at the fully saturated medium with regional groundwater flow, and (8), (9), (10) four energy piles installed at the partially saturated medium with regional groundwater flow. The outlet temperature of each case is (1) 28.11 [U+2103], (2) 28.84 [U+2103], (3) 28.97 [U+2103], (4) 29.09 [U+2103], (5) 28.19 [U+2103] (mean value), (6) 28.24 [U+2103] (mean value), (7) 28.33 [U+2103] (mean value), (8) 28.84 [U+2103] (mean value), (9) 28.90 [U+2103] (mean value), and (10) 29.10 [U+2103] (mean value), respectively. The thermal power ratio of the energy pile of each case (standard case is case 1) is (1) 0%, (2) -46%, (3) -39%, (4) -52%, (5) -4%, (6) -7%, (7) -12%, (8) -39%, (9) -42%, and (10) -53%, respectively. Numerical results show that the performance of the energy pile installed at the fully saturated medium with regional groundwater flow (case 1) is the best. Both the groundwater flow and saturation should be considered to design the energy pile correctly. In the case of that the distance between energy piles is less than 5 m, borehole thermal resistance is not negligible.