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Influence of parallel and series U-loop configurations on the thermal behaviour of energy piles

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Energy piles are foundation piles that have heat exchanger pipes installed in them for exchanging geothermal energy between buildings and the ground through the use of a ground source heat pump (GSHP). This is a cost-effective and environmentally friendly method to supplement heating and cooling of buildings. Heat transfer occurs between the piles and the ground through a heat transfer fluid circulating in the pipes. The heat exchanger pipes in the piles are commonly made from polyethylene pipes formed into U-loops [e.g., 1, 2, 3, 4, 5, 6, 7]. The U-loops are configured into series or parallel configurations to circulate water in the pipes. A number of studies have investigated the thermal and thermo-mechanical behaviour of energy piles with U-loop heat exchangers [e.g., 1, 2, 3, 4, 5, 6, 7]. Despite this widespread research, the fluid flow and temperature variations in the individual U-loops are not well understood for parallel and series U-loops in the piles. Given that the fluid flow behaviour varies between the two configurations [8], it can be hypothesised that the thermal behaviour of the energy piles may vary as well.

This study investigates the influence of series and parallel U-loop configurations on the variations in fluid temperatures and flowrates in the individual U-loops of energy piles, and the effects of these variations on the geothermal energy extracted by the piles. Heating experiments were conducted on a set of four field-scale energy piles installed below a 5-storey building in Brighton group sandy soils. The energy piles have a length of 15 m and diameter of 0.9 m, but different numbers of U-loops (1, 2, 3, and 4 U-loops in Piles 1, 2, 3, and 4, respectively). The fluid temperatures and flowrates were monitored in the individual U-loops of the piles that were connected to a plumbing manifold located in the monitoring room (Figure 1). A comparative thermal performance analysis of the two configurations was conducted to derive conclusions on the preferred configuration for improved thermal performance of the piles.

Figure 1: The manifold connecting the heat exchanger U-loops of all the piles.

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The flowrate variations and change in fluid temperatures in the individual U-loops at Day 15 of group tests are shown in Figure 2. The flowrates were inconsistent between the U-loops in the parallel configuration but remained constant in the series U-loops. Heat exchange occurred in all the U-loops in parallel, whereas only the first few U-loops in the series configuration exchanged heat with the ground. The results suggest that all the energy piles in the group with parallel U-loops were thermally active and could improve the performance of energy pile systems compared to energy piles with U-loops in series.

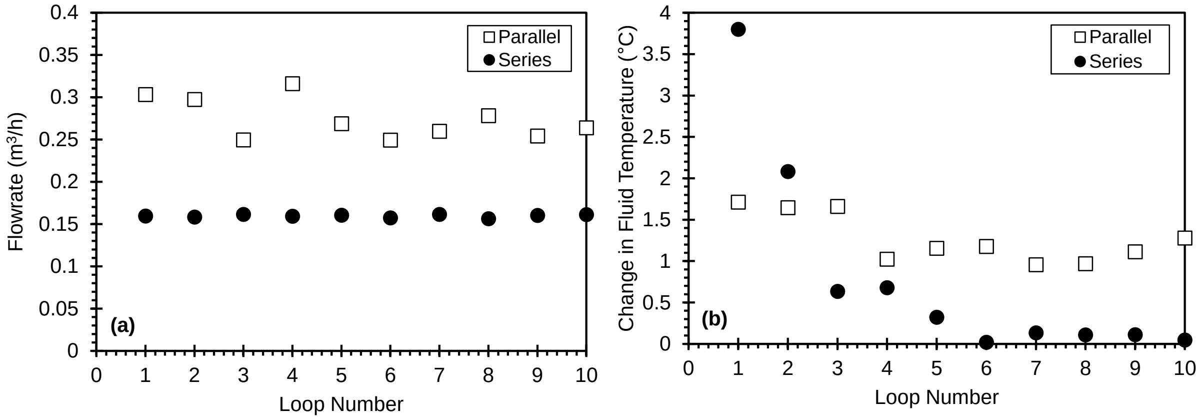

Figure 2: Fluid flowrates and change in fluid temperatures in the U-loops for a group of energy piles (Pile 1 = Loop 1; Pile 2 = Loops 2 and 3; Pile 3 = Loops 4, 5, and 6; Pile 4 = Loops 7, 8, 9, and 10).

Contributor statement

Mohammed Faizal: Conceptualization, Investigation, Methodology, Investigation, Formal analysis, Writing - original draft.
Abdelmalek Bouazza: Conceptualization, Methodology, Resources, Funding acquisition, Writing - review & editing.

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