Symposium on Energy Geotechnics
Accelerating the energy transition
3-5 October 2023, Delft, the Netherlands

Peer-reviewed Conference Contribution

Casting and installation of segmental precast quadratic concrete driven geothermal energy piles

Habibollah Sadeghi[1,*] and Rao Martand Singh[1]

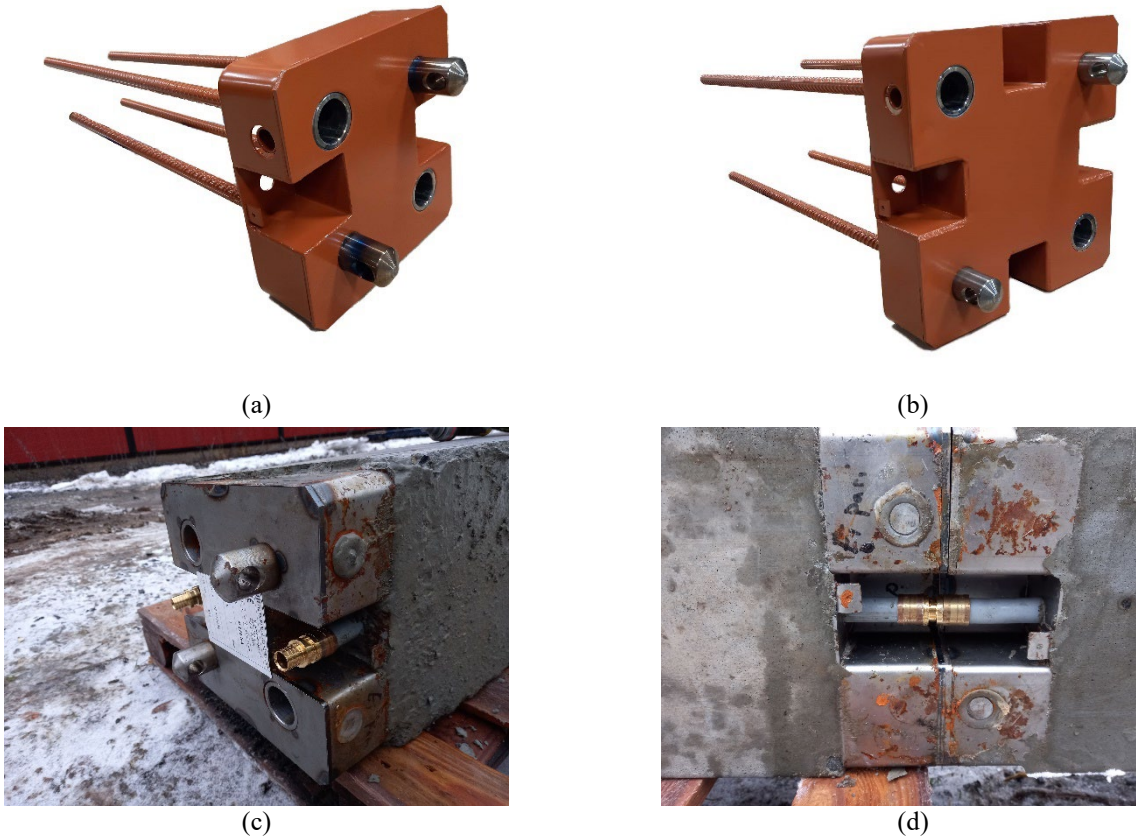
[1] Department of Civil and Environmental Engineering, Norwegian University of Science and Technology, Trondheim, Norway
* Corresponding author: habibollah.sadeghi@ntnu.no

Geothermal energy pile foundations are used both for structural purposes and to provide sustainable, clean, and cost-effective ground energy for heating and cooling buildings [1]. The majority of energy piles are cast-in-place concrete piles, which require extensive and expensive drilling during construction. A better alternative is to use precast concrete segmental driven energy piles, which can be cast in large quantities with high-quality assurance at a concrete factory, after which they are transported and installed into the ground [2]. This study aims to present a novel method of casting and installing segmental energy piles that utilize an innovative steel joint [3] for connecting the precast concrete segments on-site. In addition to structural integrity, the steel joint provides the possibility of a leak-proof coupling and continuity for heat-exchanging pipes embedded in concrete segments. The precast-driven pile foundations are made of high-strength concrete with a 14-day compressive strength of almost 80 MPa and have a quadratic shape with a maximum length of 12 m and a square width of 270 mm or 350 mm. In the 270-mm piles, a single U-loop can be used, while in the 350-mm piles, two U-loops can be used as presented in Figure 1.

The heat-exchanging pipes are coupled inside the sidewall channels of the steel joint which are shielded using a steel cover plate, riveted to the joint. At the tip of the bottom segment of the piles, there is a strong steel rock shoe with a hardened steel point that allows the piles to penetrate the bedrock [4]. At a construction site, the joint and pipes can be connected quickly without any welding or electric equipment that expedites the installation work and obsoletes the health and safety risk associated with electricity. Utilizing the precast energy piles presented in this study increases the quality, and speed of installation while decreasing the overall cost of the project compared to cast-in-place energy piles.

To prove the proper performance of the piles under real construction conditions, structural integrity tests and hydraulic pressure tests were performed according to BS EN 12794:2005 [5] and ASTM F2164–21 [6], and the results are briefly presented and discussed in the present study. Structural integrity tests consisted of impact tests in which 1000 blows imposing a minimum stress level of 28 MPa were applied on the pile segments connected using the new driven energy pile joint. During the impact tests, the pile structure and the joints remained undamaged. After the impact tests, the pipes were pressurized up to 100 psi (690 kPa) and no leakage or pressure drop was observed. Then the pile segments were cut according to the standard into shorter segments and subsequent bending tests were performed to measure the bending capacity. The bending tests show that the driven energy pile joints have a similar bending capacity as conventional normal joints. The results of this study show that segmental precast concrete energy piles using the new steel driven energy pile joints, are a perfect alternative for cast-in-place energy piles, which can provide sufficient structural and bearing capacity and can be used both for heating and cooling buildings.

DOI: https://doi.org/10.59490/seg23.2023.498



(a) (b)

(c) (d)

Figure 1: Driven energy pile (DEP) Joint, (a) 270 mm with a single loop, (b) 350 mm with two loops, (c) 270 mm segment with a single loop before connection, (d) two segments connected structurally and hydraulically.

Data Availability Statement

No data was used for the research described in the article.

Contributor statement

Habibollah Sadeghi: Writing – Original Draft, Visualization, Investigation. **Rao Martand Singh:** Writing – Review & Editing, Supervision.

Acknowledgments

The authors of this paper are grateful for receiving funding from the Research Council of Norway (Project Number: 332839) and the Faculty of Engineering at NTNU. The authors of this paper highly appreciated the support of Leimet Oy in Finland for manufacturing the joints and Sandnes og Jærbetong AS in Norway for casting the concrete pile segments.

References

[1] H. Sadeghi, A. Ijaz, and R. M. Singh, “Current status of heat pumps in Norway and analysis of their performance and payback time,” Sustain. Energy Technol. Assessments, 2022, doi: 10.1016/j.seta.2022.102829.
[2] H. Sadeghi and R. M. Singh, “Driven precast concrete geothermal energy piles: current state of knowledge,” Build. Environ., vol. 228, no. 109790, 2023, doi: 10.1016/j.buildenv.2022.109790.
[3] H. Sadeghi and R. M. Singh, “Joints For Pre-Cast Driven Piles,” WO2023084125A1, 2023.
[4] M. Tomlinson and J. Woodward, Pile Design and Construction Practice, 6th ed. CRC Press, Taylor & Francis Group, 2015.
[5] BS EN 12794:2005, Precast concrete products - Foundation piles BS EN 12794:2005, vol. 3. 2005.
[6] ASTM, “Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure (Designation: F2164 − 21),” ASTM Int., no. F2164 − 21, pp. 1–5, 2021, doi: 10.1520/F2164-21.