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Lessons learnt from a full-scale installation of energy walls

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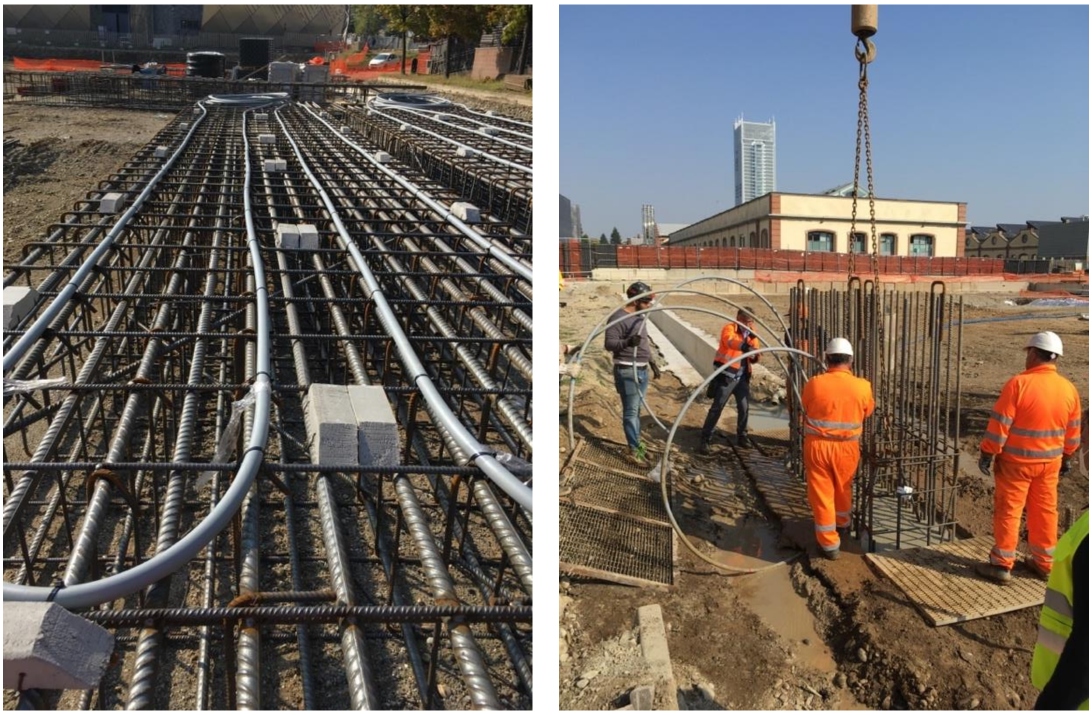
The possibility of equipping diaphragm walls as ground heat exchangers to meet the full or partial heating and cooling demand of overlying or adjacent buildings has been explored in recent years [1, 2, 3, 4]. In this extended abstract a specific installation of energy diaphragm walls is described and the lessons learnt during the implementation discussed.

The construction site is located in the city of Torino, in the campus of the Politecnico di Torino, where a new underground car park is under construction. The structure consists of four underground floors to be used as a car park for the staff at the academic site. The area of the excavation corresponds to a rectangle 173 m long and 35 m wide. The excavation is supported by more than 170 diaphragm walls. The maximum depth reached by the bulkheads is 17,65 m, while the excavation reaches approximately 15 m below the current ground level and above the water table. The ground at the site is an alluvial deposit consisting of sand and gravel locally cemented to form layers of conglomerate [5]. The construction process involves excavation by means of clamshell buckets, filling by bentonite slurry, lowering of the steel cage in two sections and bottom up filling by concrete.



(a) (b)

Figure 1: (a) View of the set-up of the pipes on the steel cage of the energy diaphragm walls; (b) lowering of the steel cage in the excavated void filled with bentonite.

To boost the sustainability of its campuses, the Politecnico decided to make effective use of energy geostructures and to equip all single diaphragm walls with heat exchangers. A series of PE-Xa (cross-linked polyethylene) pipes of reduced diameter (32 mm) was introduced to allow the circulation of a heat transfer fluid.

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Considering that the steel cage of the diaphragm walls is constituted of two elements, the pipes were binded to the lower section of the rebar cages while laying in the construction site, before being lowered into the excavation. Two U-shaped pipes are installed for each diaphragm wall so that a distance of 60 cm separates each pipe. The inner pipes will be connected to the inlet, while the external pipes will be connected to the outlet. Pipes were placed on site with spacers to ensure the adequate passage of the concrete aggregates and avoid problems due to contacts with the ground at the excavation contour (Figure 1(a)). A distance of about 10 cm is achieved thanks to the spacers. An extra length of pipes is fixed to the rebar cage for later use.

The steel cage is lifted by the crane and then lowered into the excavation. Once in place, it is hung to be connected with the upper part of the cage. Then lowering starts again. In this case, the extra pipe, previously hung onto the lower steel cage are unrolled and connected to the upper part of the steel cage by hand by the workers. This process requires the lowering of the cage to be interrupted systematically to allow for the workers to quickly make fast connections (Figure 1(b)). Once the whole steel cage is within the ground, the pipes are placed at rest with a protective coating. All pipes will be connected to inlet and outlet header pipes running outside the car park excavating area and directed to the central thermal power plant of the campus.

The pipes' condition was tested several times during the installation. First, a visual check, a pressurization and an emptying were performed before connecting the pipes to the lower part of the steel cage. Then, the pipes were filled with water before concrete casting and kept under pressure at 4 bar for 12 hours minimun during curing. The installation was considered successful if the pressure didn't reduce by more than 0.1 bar. Despite the design considered the risk of losing up to 10% of the pipes due to unpredictable failures (e.g. crush, failures, contact, etc.), the final result, due to the careful workmanship, was that none of them had to be abandoned.

The excavation of the area started in 2022, while completion and commissioning of the underground car park are expected for 2024. Connection of the heat exchangers to the heating system will take place after completion resulting in the largest application of energy walls in Italy.

Contributor statement

Marco Barla: conceptualization, writing, review and editing; Alessandra Insana: writing, review and editing; Andrea Benincasa di Caravacio: project administration, review and editing.

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References

[1] Brandl, H. (2006). Energy foundations and other thermo-active ground structures. *Géotechnique* 56(2), 81–122.

[2] Brunner, A., Markiewicz, R., Pistrol, J.,, Adam, D. Langzeiterfahrungen zur geothermischen Nutzung der U-Bahn-Station Taborstraße in Wien. In: Bauingenieur, Band 97 (2022), Heft 7–8, 248–261 (https://doi.org/10.37544/0005-6650-2022-07-08-68).

[3] Di Donna, A., Cecinato, F., Loveridge, F. & Barla, M. (2016). Energy performance of diaphragm walls used as heat exchangers. *Geotech. Eng. Proc. of ICE* 170(3), 232-245.

[4] Sterpi, D., Angelotti, A., Corti, D. & Ramus, M. (2014). Numerical analysis of heat transfer in thermo-active diaphragm walls. *Numerical Methods in Geotechnical Engineering* (Hicks MA, Brinkgreve RBJ and Rohe A (eds)). CRC Press, Boca Raton, FL, USA (pp. 1043–1048).

[5] Barla, M., Barla, G. (2012). Torino subsoil characterization by combining site investigations and numerical modelling. *Geomechanik und Tunnelbau* 5(3).