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Impact of thermal cycles on the mobilization of shear strength for energy piles

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Understanding the long-term soil-structure interface behavior is particularly important for axially loaded piles. In these foundations, the frictional resistance between the pile and the soil provides one part of the pile's total capacity (shaft resistance). Regarding energy piles – double purpose structures consisting in the integration of heat exchanger pipes within the foundation – the response of the pile-soil interface is additionally influenced bydaily and seasonal temperature variations. In order to assess the impact of the thermal cycles on the mobilization of shear strength, a series of direct shear testson saturated sand-concrete interface were performed under different temperature gradients.

An interface direct shear device, equipped with a temperature control system, was used to investigate the shear behavior of the soil–concrete interface. A picture of the device and one of the container accommodating the shear box in which a concrete plate is installed,are shown in Figure 1 (a) and (b). The tested specimen is heated through a closed loop system (connected to a thermostat) that is installed under the support of the lower box, containing the structural element. The experimental campaign is divided in three parts: (i) concrete-sand direct shear tests at 13°C (constant temperature) to be used as the reference case (this temperature corresponds to the average soil temperature under 5m with respect to the ground level in France) (ii) concrete-sand direct shear test after 10 temperature cycles with a temperature amplitude of ΔT=±5°C, (iii) concrete-sand direct shear test after 10 temperature cycles with a temperature amplitude of ΔT=±7.5°C.

The experiments are then reproduced numerically using a 2D thermo-hydro-mechanical (THM) model with thefinite element code LAGAMINE. The soil-pile behavior is modelled using 2D fully THM interface finite elements that belongto the

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zero thickness family and for which the contact conditions are imposed using a penalty method. These types of elements are able to reproduce the fluid flow in the interface as well as the contact/loss of contact between two solids and the shearing/sliding of the interface. The penalty coefficients were adapted to match the experimental results thus obtaining a more efficient prediction tool for the behavior of energypiles.

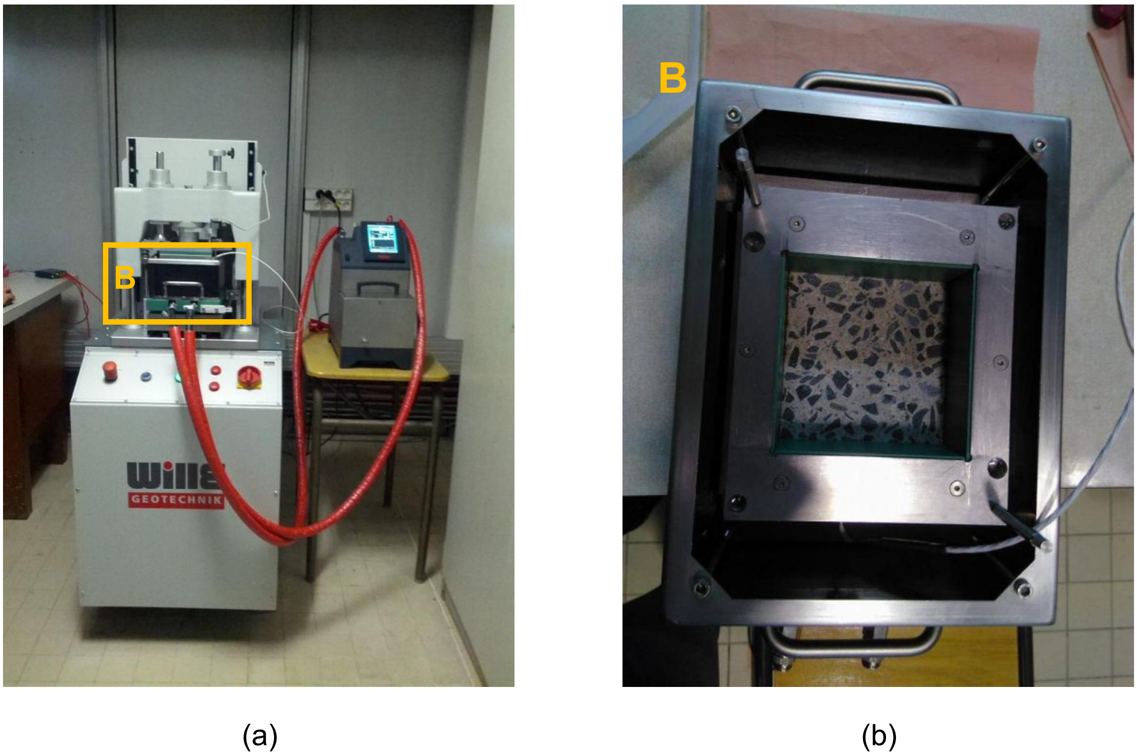

Figure 1. Interface direct shear device was adapted to incorporate the thermal loading of the sample

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