EGU24-11181, updated on 03 Oct 2024
https://doi.org/10.5194/egusphere-egu24-11181
EGU General Assembly 2024

Optimizing Energy Quay Walls: Insights from Comprehensive Thermal Analysis and Turbulent Flow Enhancement

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In recent decades, there has been a notable rise in the utilization of the subsurface as a source for heating and cooling through shallow geothermal installations. This trend is exemplified by the emergence of Energy Geostructures (EGs), an innovative technology that not only provides structural support to the ground or buildings but also facilitates the exchange of heat with the subsurface. EGs offer versatile applications for various energy needs, including their integration with ground source heat pumps for space heating, cooling, and domestic hot water provision.

Energy Quay Walls (EQWs) represent a promising type of energy Geostructures that demonstrate a unique ability to exchange heat with both the surrounding soil and open water. Despite the considerable potential for energy efficiency that EQWs hold, their limited implementation underscores the need for extensive research to comprehend their thermal behavior.

This study conducts an in-depth examination of EQWs, employing two Finite Element numerical models to reconstruct the undisturbed temperature profile within the soil and conduct a detailed 3D analysis of heat exchange processes in an EQW application. These models are validated using real data obtained from a full-scale test in Delft, The Netherlands. The results emphasize the significance of transitioning from laminar to turbulent flow regimes within the heat exchanger pipes, showcasing improved energy extraction efficiency, particularly from the open water layer.

Moreover, the study underscores the critical role of open water movement in the energy extraction process. This finding emphasizes the dynamic nature of open water in contributing to the overall effectiveness of EQWs as an EG. The study's outcomes provide important considerations for optimizing the design and implementation of EQWs, pointing towards the benefits of promoting turbulent flow regimes within the heat exchanger pipes and emphasizing the advantages of harnessing energy from actively moving open water layers. As the implementation of EQWs continues to expand, these insights contribute to advancing our understanding and enhancing the energy efficiency of this innovative technology.