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Field tests of horizontal ground heat exchangers under tidal influence

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INTRODUCTION

<Background>

-- In ground source heat pump (GSHP) systems, horizontal ground heat exchangers (HGHEs) are commonly used in areas with sufficient land availability.

-- However, because HGHEs are typically installed at shallow depths (1–2 m), the ground is often unsaturated and lacks groundwater flow, resulting in lower heat exchange efficiency compared to vertical ground heat exchangers.



Installation of Horizontal Ground Heat Exchangers (HGHEs) for GSHP

<Objectives>

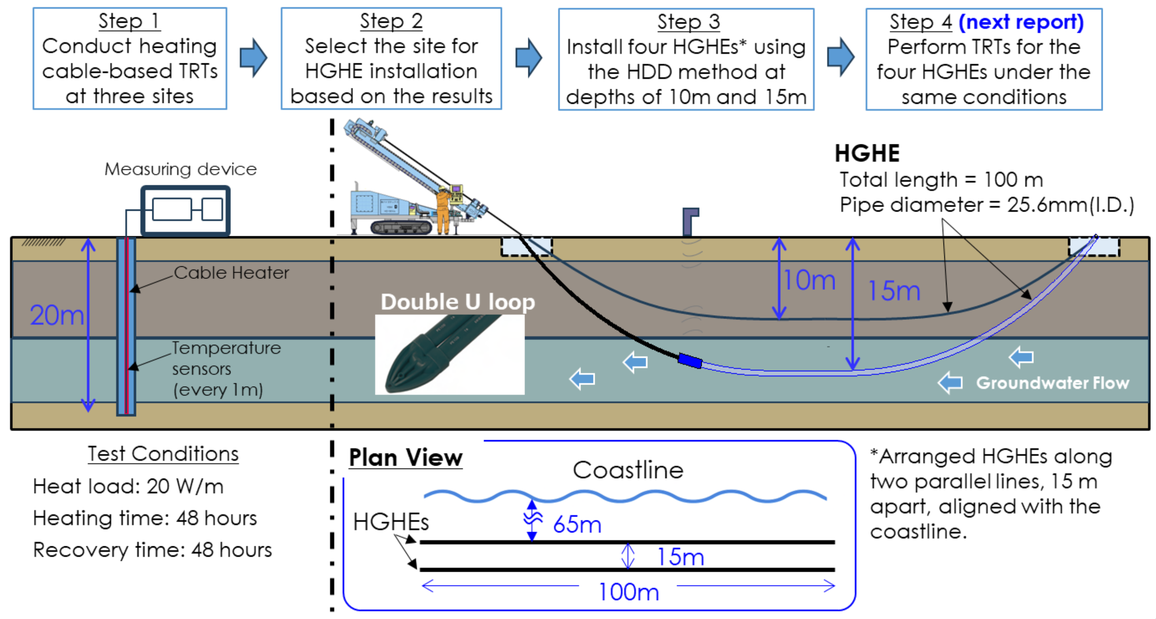
-- To determine the optimal site and installation depth that can utilize the advection effect caused by groundwater flow associated with tidal influence.

-- To evaluate the performance of HGHE*s installed at the selected site and depth.

**In this research, HGHE refers to horizontal ground heat exchanger installed using the HDD (Horizontal Directional Drilling) technology.*

METHODS

-- Field tests at coastal sites were conducted to evaluate geological suitability and tidal impact through thermal response tests.



RESULTS

Step 1 The results of TRTs at three sites

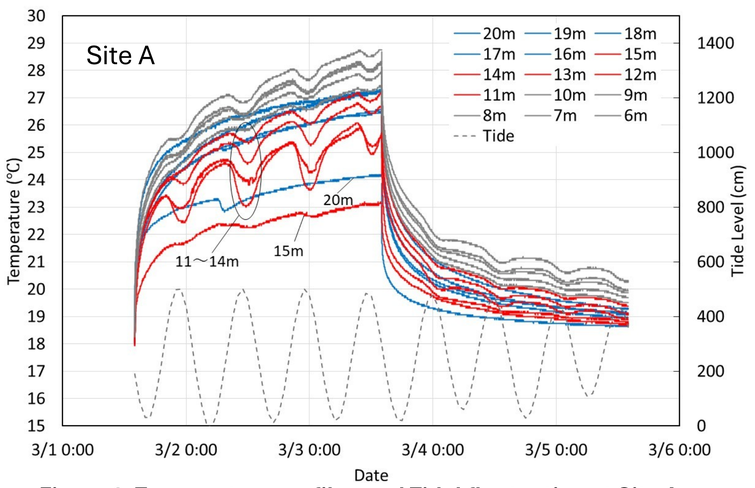


Figure 1. Temperature profiles and Tidal fluctuation at Site A

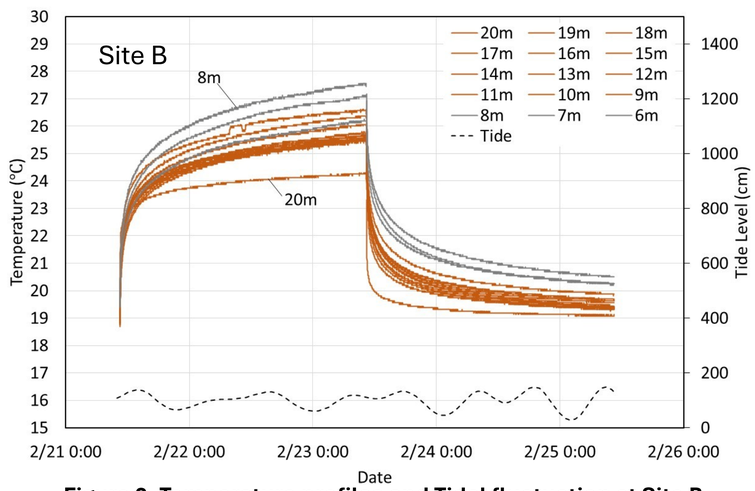


Figure 2. Temperature profiles and Tidal fluctuation at Site B

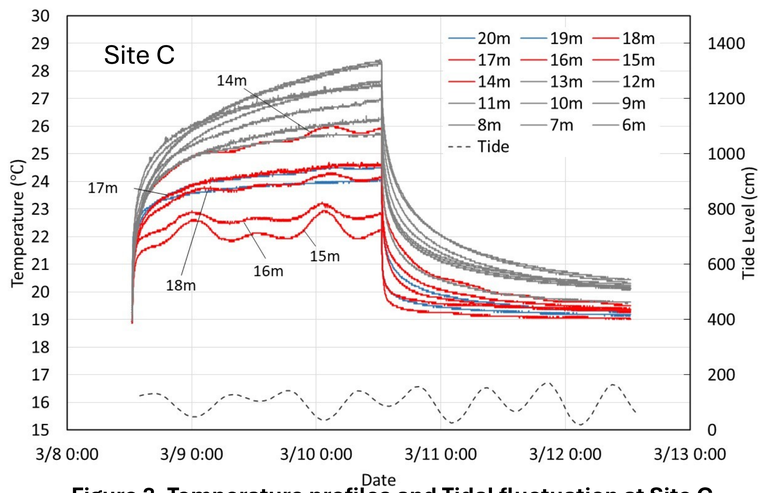


Figure 3. Temperature profiles and Tidal fluctuation at Site C

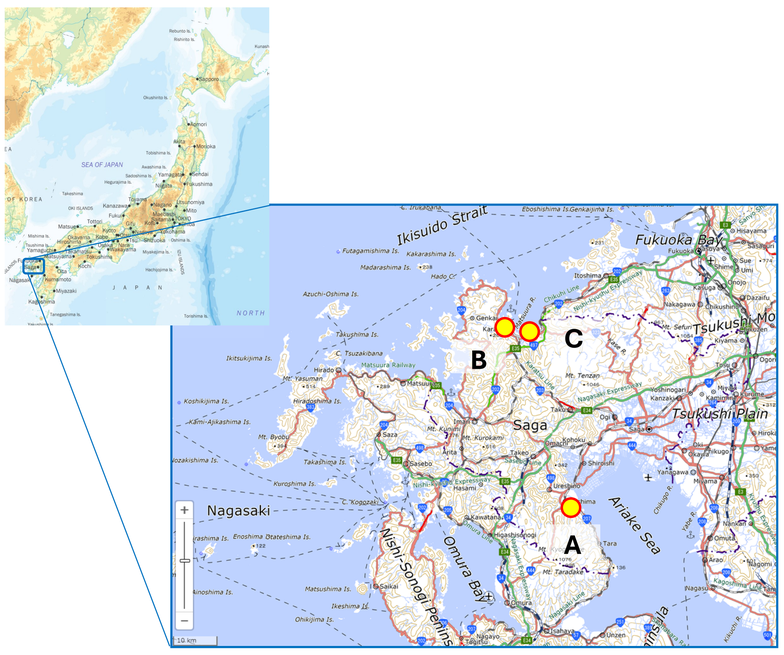


Figure 4. Field Test Location (Saga prefecture, Western Japan)

Step 2 Site selection for HGHE installation

Table 1. Summary of TRT Results and Geological columns

Item	Site A	Site B	Site C
TRT Result	✓✓	✓	✓✓
Main Geological Features	Clay layer to gravel layer	Weathered granite (soft rock)	**Sandy soil to soft rock**
Depth with Significant Change	11–15 m	–	**14–18 m**
Interval with possible water flow	15 m (gravel)	–	**14–18 m (sand)**
Drilling difficulty	? (Gravel layer)	X	✓
Remarks	Large tidal range	–	**Small temperature rise/ Versatile site**

Step 3 Installing four HDD-GHEs

-- Based on TRT results, HGHEs were installed at a depth of 15 m, where improved ground heat exchange is expected due to tidal fluctuation. This fluctuation is specifically caused by groundwater flow associated with tidal changes.

-- For comparative evaluation, additional HGHEs were installed at a depth of 10 m.

-- To investigate the tidal influence range on HGHEs installed parallel to the coastline, each HGHE was placed 15 m apart (see Plan view).



Drilling progress by HDD

DISCUSSION

-- The TRT results at Sites A and C indicated periodic temperature fluctuations, suggesting the presence of groundwater flow influenced by tidal fluctuations.

-- This tide-driven groundwater movement can enhance heat transfer through advection, particularly at deeper layers (around 15 m), where HGHEs were installed.

-- Understanding the extent of tidal influence is crucial for optimizing HGHE placement and improving system performance in coastal regions.

<Result of Groundwater level>

Groundwater level measurements at two monitoring points revealed that, at the site where HGHEs were installed, the groundwater level fluctuated in response to tidal fluctuations. This observation confirms that tidal influence induces groundwater movement, which enhances heat transfer through advection in the surrounding ground.

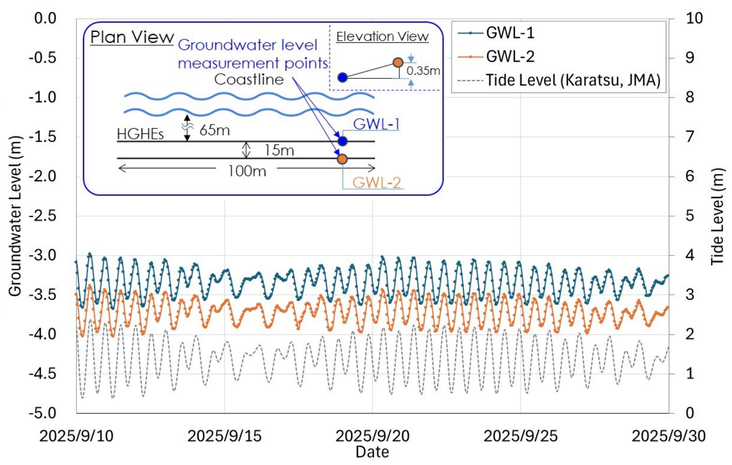


Figure 5. Relationship Between Tide Level and Groundwater Level

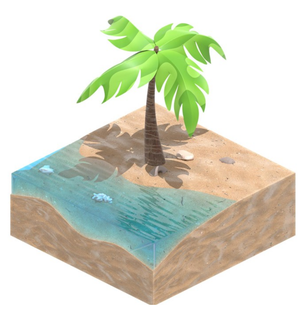
CONCLUSION

TRTs have demonstrated that the performance of HGHEs can be improved by utilizing groundwater flow in coastal areas affected by tidal fluctuation.

-- Heating cable-based TRTs conducted at three sites revealed tidal influence at two locations.

-- Groundwater level monitoring in coastal areas confirmed that groundwater levels fluctuate in response to tidal fluctuations.

-- Utilizing groundwater flow induced by tidal fluctuations has the potential to significantly enhance the performance of HGHEs.



Acknowledgements

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