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Steel tubular piling by the Gyropress Method in proximity to obstructive existing H-shaped piles

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ABSTRACT: This construction project was aimed at reinforcing the seismic resistance of an existing river dike. Among the 42 steel tubular piles installed, 11 were installed by press-in piling with a GRB System, and 31 were installed by a normal press-in piling. There were existing H-shaped piles in the northern end river section (Benten Bridge) where four new piles were to be installed, and these H-shaped piles were planned to be removed beforehand. An attempt to pull out and remove the existing piles using a vibratory hammer failed, as the piles broke at a depth of about 3m from the riverbed. Therefore, steel tubular piles were installed at deviated locations by rotary-pressing with a Reaction Stand in proximity to the existing H-shaped piles.

1 SUMMARY OF THE PROJECT

1.1 *Outline of the project*

This construction project was aimed at reinforcing the seismic resistance of an existing river wall. It involved block-based soil improvement for the liquefaction prevention by high-pressure jet agitation immediately below an existing river dike; construction of a steel tubular pile earth retaining wall by the Gyropress Method (GIKEN, 2018) on the river side of the existing dike, and soil improvement by high-pressure jet agitation within the river.

The construction site is located on the left bank of the Ebitori River, a national Class A river, adjacent to the area of Haneda 5-chome, Ota-ku, Tokyo. The site is in the uppermost section of the Ebitori River, which is a branch of the Tama River, another Class A river. Haneda Airport is located to the east of the construction site.

1.2 *Objective of the project*

In light of the Great East Japan Earthquake, the Tokyo Metropolitan Government has been working to maintain various facility functions and to prevent flooding caused by tsunamis or other factors, even in the event of the largest possible earthquake in the future.

To reinforce the river dike, an continuous steel tubular pile earth retaining wall was to be constructed by the Gyropress Method on the river side of the dike, and soil improvement was to be carried out by high-pressure jet agitation on the riverbed. The main body of the river dike was designed to be reinforced by block-based soil improvement, which is as liquefaction prevention, immediately below the dike using high-pressure jet agitation.

2 CONDITIONS AND STRUCTURAL TYPE

2.1 *Site condition*

The site conditions for the pile installation were below:

- Limit noise and vibration in consideration of neighboring residential areas.
- Limit working hours in consideration of neighboring residential areas.
- Do not obstruct the navigation of vessels (fishing boats, houseboats, etc.) and keep a river width of 6.0m during the pile installation.
- The JR Tokaido Freight Line subway with a tunnel diameter of 7,000mm is located on the south (upstream) side of the river section at a depth of A.P. -8.54m or deeper.
- Keep a working distance in the north (downstream) side river section due to proximity to the Benten Bridge.

2.2 *Ground condition*

Figure 1 shows a borehole log obtained on the land (west) side of the embankment at the construction site. The river area where the steel tubular piles (hereinafter called tubular piles) were installed had a riverbed height of A.P. -3.0m, corresponding to a level stuff reading of 7.34m. The soil beneath the

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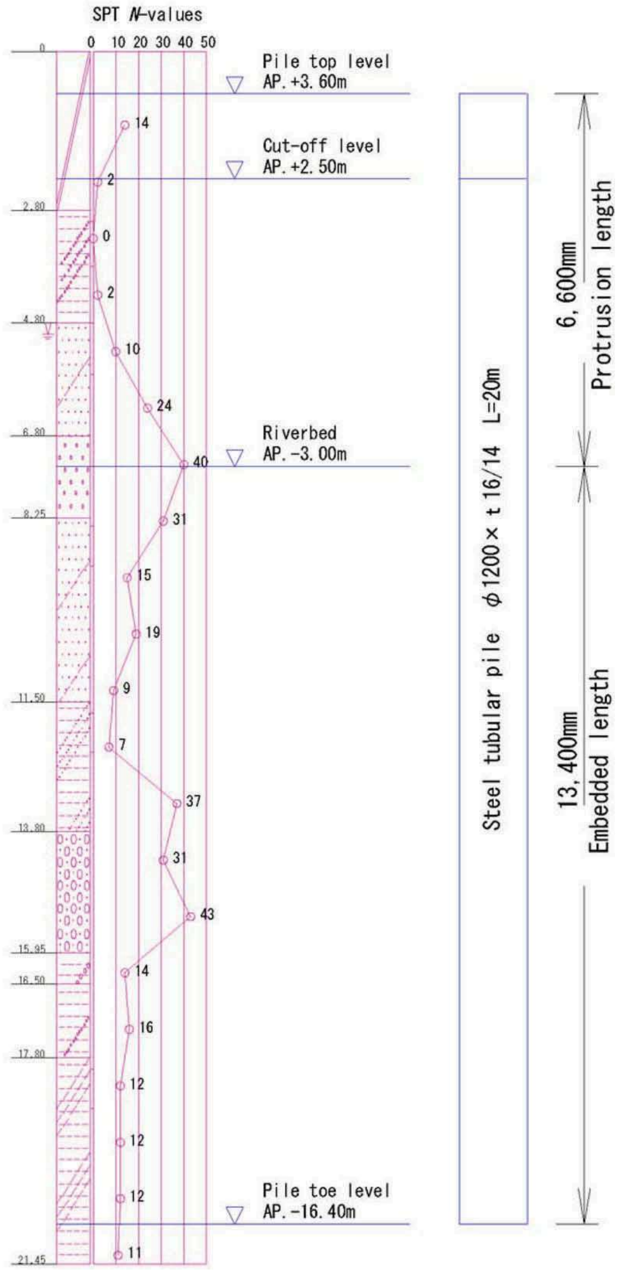

Figure 1. Borehole log with a tubular pile at the design stage.

riverbed consists of silty fine sand, sandy silt, gravel, gravelly clay, sandy silt, and silty clay. The gravel layer at a level stuff reading of 15m has the highest SPT *N*-value of 43. Below the gravel layer, there is a cohesive soil having SPT-*N* values of around 12 prevails. The pile toe of the tubular piles is at A.P. -16.4m, corresponding to a level stuff reading of 20.74m.

2.3 *Structural type*

The structural type of the wall is a steel tubular pile earth retaining wall. Figure 2 shows an overall plan view, and Figure 3 shows a typical cross-sectional view.

3 STEEL TUBULAR PILE PILING

3.1 *Piling method*

The piles were installed by the Gyropress Method which is also called "Rotary press-in piling". Within the construction site, having a total linear length of 60.4m, the first 11 tubular piles in the north-side river section (closer to the Benten Bridge) were installed by press-in piling with a GRB System (GIKEN, 2018), and the 12th to 42nd tubular piles (up to the southern end of the river section) were installed by a normal press-in piling (without the GRB System). In order to keep a working distance from the Benten Bridge in the north (downstream) side river section and from the JR Tokaido Freight Line subway on the south (upstream) side of the river section, the first Reaction Stand location was set to face the 13th tubular pile counted from the Benten Bridge side. 18 steel sheet piles (hereinafter called sheet piles) were installed by a vibratory hammer as reaction piles, setting up the Reaction Stand.

The reasons for adopting the Gyropress Method are as follows.

[1] It is a press-in piling method suited for reducing noise and vibration to neighboring residential areas.
[2] The press-in piling with a GRB System does not obstruct the navigation of general vessels.
[3] The press-in piling method does not affect the JR Tokaido Freight Line subway on the south (upstream) side of the river section.
[4] The piling method takes into account the neighboring work to the Benten Bridge on the north (downstream) side of the river section.

3.2 *Press-in piling data*

The length of the tubular pile is 20m, and its embedded length is 13.4m. As mentioned in the section 2-2., since the borehole log was obtained on the land side of the embankment, the planned riverbed height of A.P. -3.0m corresponds to a level stuff reading of 7.34m. The acquisition of press-in piling data (Figure 4) started at around 8.5m, and a graph showing a fairly good correlation between the rotation torque values and the SPT-*N* values was obtained. It was possible to press-in a pile by low force from 8.5m (after reaching the riverbed) to 16.0m. At depths of 17.0m and more, although the SPT *N*-values in the borehole log were low, press-in force increased gradually until reaching the highest value at the designed final depth. The pile was equipped with a toe ring with four outer bits and one water pipe allowing a water injection in the pile base.

3.3 *Productivity*

– Construction Period:
  From February 12 to April 1, 2020 (8 nonworking days in 4 weeks; 36 days of actual working)

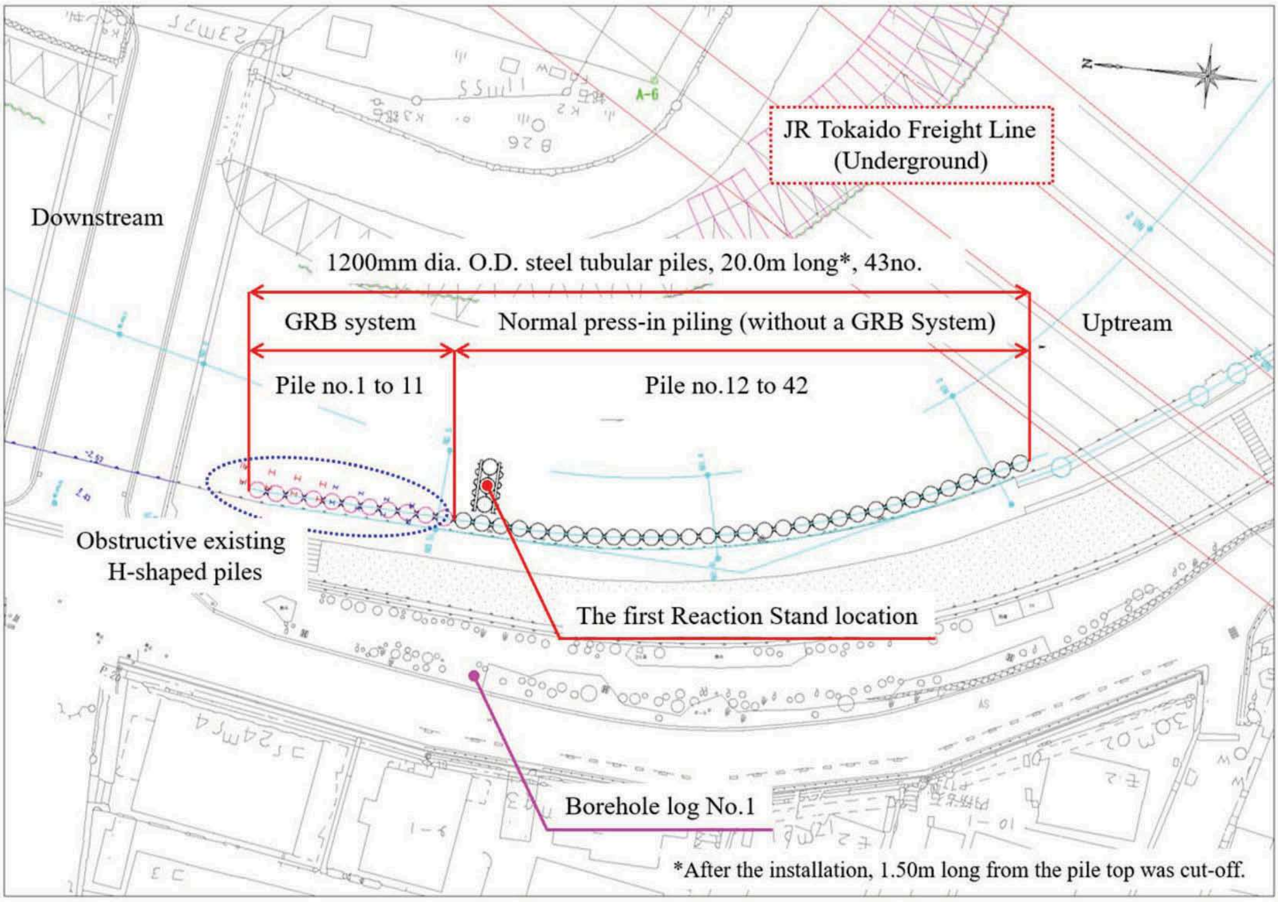

Figure 2. Overall plan view of the steel tubular pile earth retaining wall.

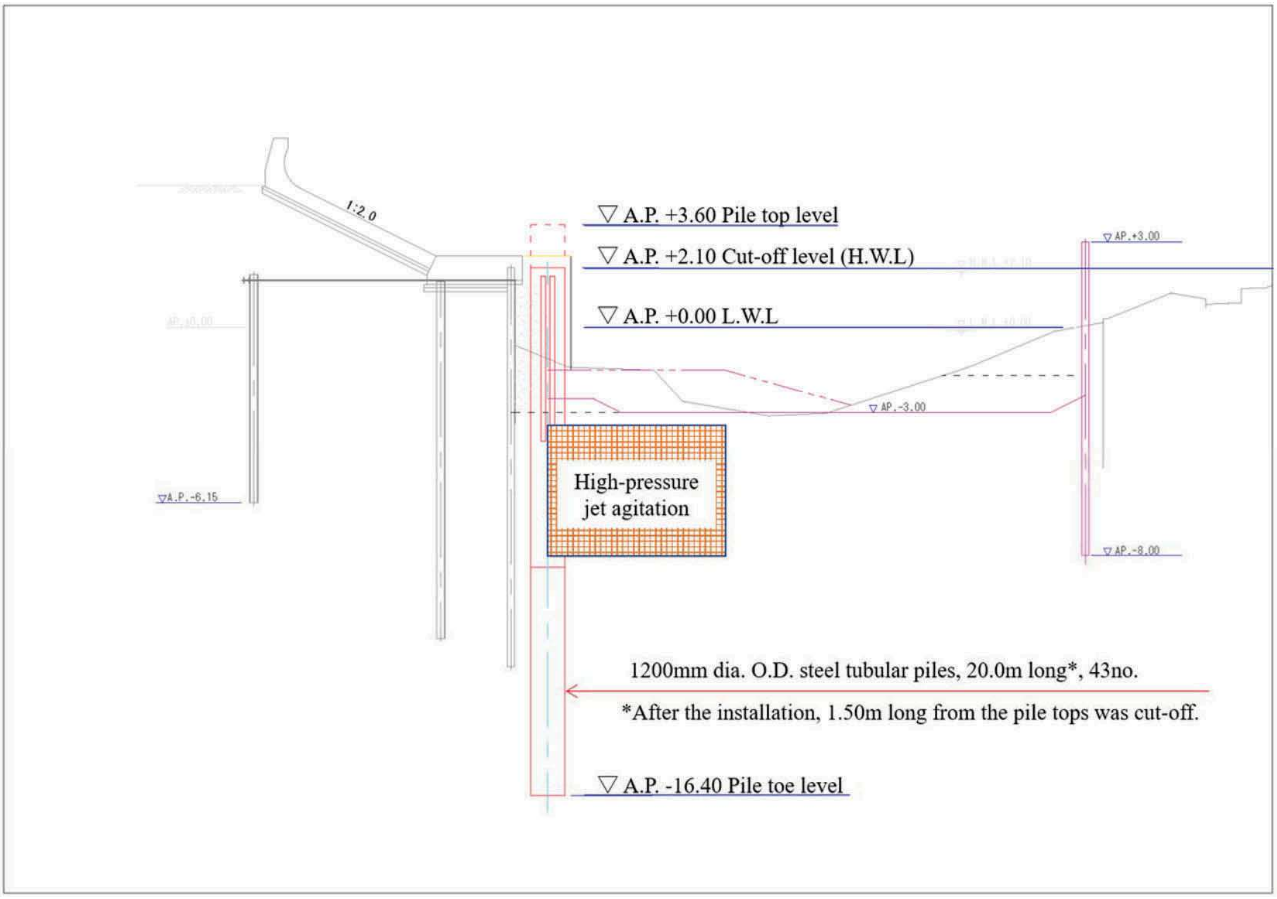

Figure 3. Typical cross-sectional view.

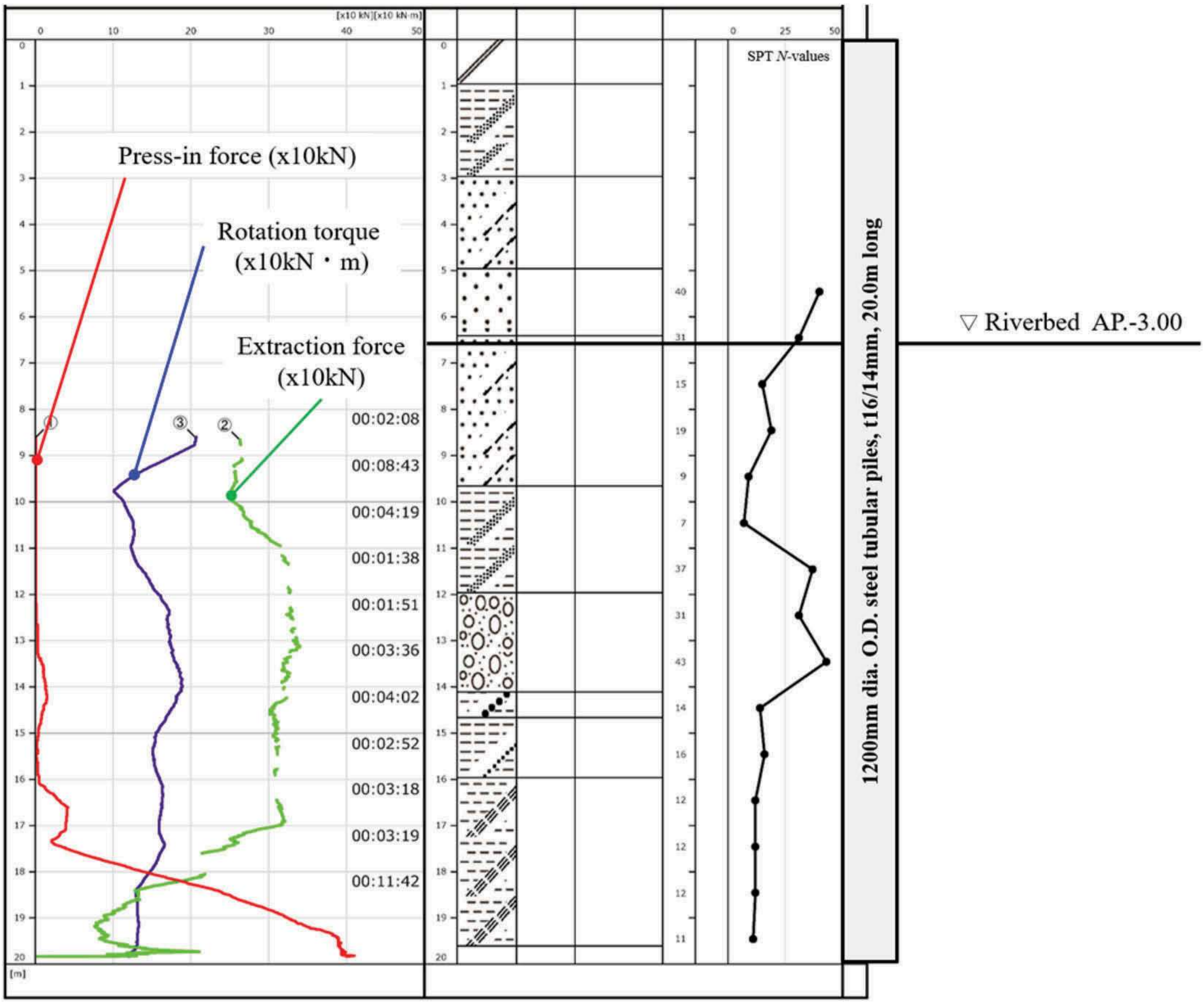

Figure 4. Press-in piling data.

– No. of pressed-in piles per day:
  5 piles/day for the normal press-in piling;
  2 piles/day for one with the GRB System

Among the 42 tubular piles installed at the site, 11 were installed by press-in piling with the GRB System, and 31 were installed by a normal press-in piling method. While the original design of construction was to carry out press-in piling from the Reaction Stand at one location, an additional round of press-in piling from the Reaction Stand and two more rounds of Gyro Piler assembling and disassembling were required for piling in the area of obstructive existing H-shaped piles (hereinafter called H piles). The required days of actual working increased due to the additional assembling and disassembling of the Clamp Crane.

4 STEEL TUBULAR PILING AT THE DEVIATED LOCATION

4.1 *Problem at the site*

Because of the knowledge of existing H piles in the GRB System section close to the Benten Bridge, an attempt was made to remove the existing piles by using a submersible vibratory hammer. It was possible to extract and remove the 300mm wide H piles, whereas it was not possible to extract and remove the 400mm wide ones as they broke at the joints situated at a depth of about 3m from the riverbed.

– Existing 300mm wide H piles, 8 no., 5.50 m long: The removal was completed
– Existing 400mm wide H piles, 8 no., 27.1 m long: They were unable to be extracted, meaning they became obstructions on the specified tubular pile line.

It was difficult to press-in tubular piles because the existing H piles were situated along the specified line of the tubular piles. After consultation with the client, it was decided to install the tubular piles deviated from their specified locations. Relevant concerns are described below.

[Concerns]

– There are three obstructive existing H piles (H400, L=27.1 m) on the specified installation locations of tubular piles.

- Although the height (A.P. -4.0 m) of the pile top of the existing H piles has been revealed by surveying, they may interfere with the new piles because of the unknown precision of verticality of the existing piles.
- The deviation of the tubular piles toward the river should be kept to a minimum because the pile tops might encroach the new structure formed by extending the embankment bottom slab and the width of the river.
- There is a limit to the amount of deviation of tubular piles toward the embankment (land) side because of the presence of sheet piles beneath the embankment bottom slab.
- Depending on the installation locations, the arrangement of tubular piles may not allow the Gyro Piler to self-walk.
- The construction plans should minimize any obstruction to the navigation of general vessels.

4.2 *Countermeasures*

Overcoming the problem occurred by the existing H piles, the following countermeasures were considered:

[1] Arrange the tubular piles to assure a verticality allowance of 1/100 (=200 mm), regardless of the verticality precision of the obstructive existing H piles.
[2] Arrange the tubular piles on condition that the embankment bottom slab is partially removed.
[3] Keep the distance between piles to allow installation of the Gyro Piler, and determine a piling procedure.
[4] Install some sheet piles, which were used as reaction piles for the initial piling, at the gap between tubular piles where the distance has been widened from the designed plan.
[5] Strengthen the operation and communication systems so as not to obstruct the navigation of general vessels during the installation and extraction of reaction piles using the vibratory hammer, installation and removal of the Reaction Stand, and assembly and disassembly of the Gyro Piler.

Figure 5 shows the arrangement of tubular piles in the area of obstructive existing H piles.

4.3 *Piling procedure*

The piling procedure of the tubular piles is described as below:

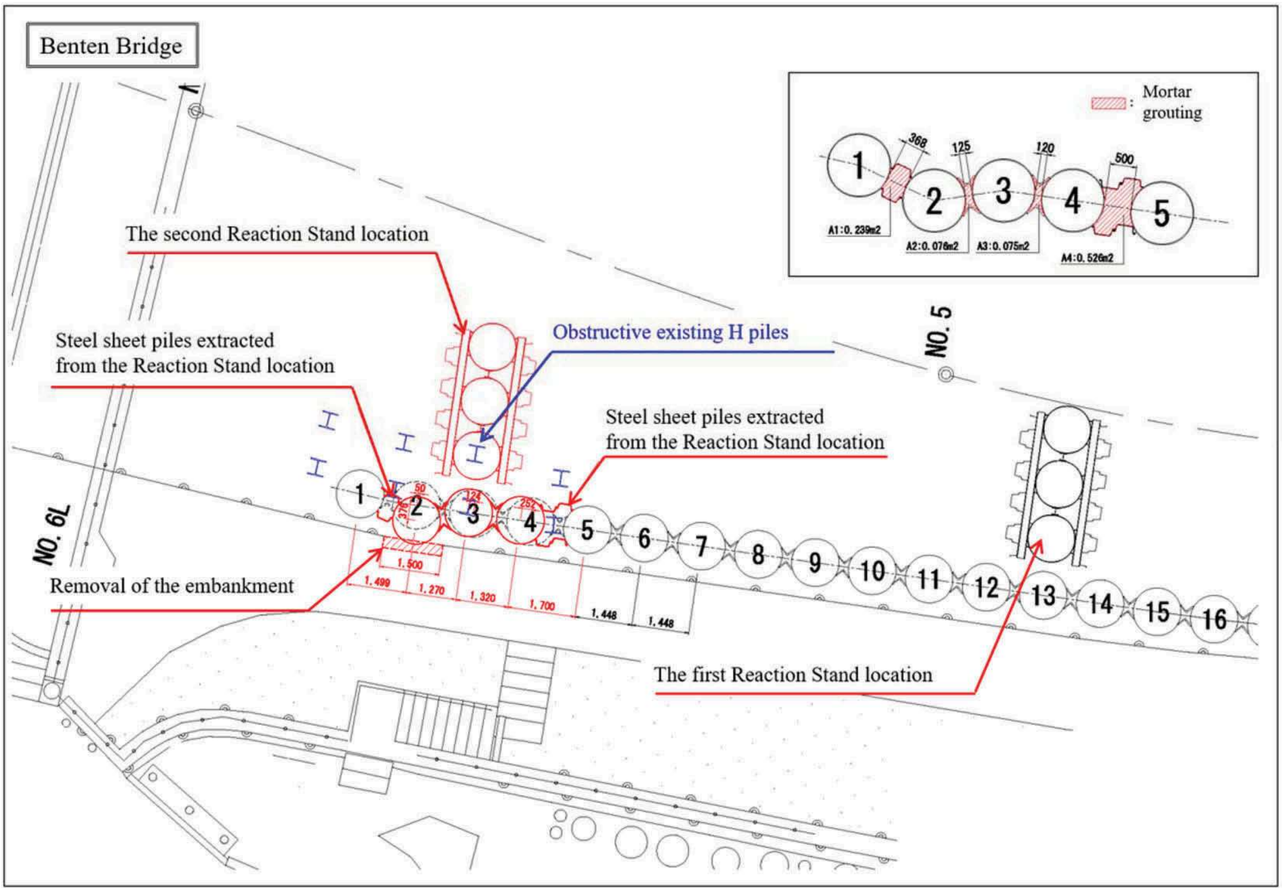

Figure 5. Tubular pile arrangement (area of obstructive existing H piles).

Step.1 From the first Reaction Stand location, Pile 12 to 26 are installed by the normal press-in piling.
Step.2 The Gyro Piler turns around and returns to the position of Pile 13 to 15.
Step.3 The Clamp Crane is assembled onto the position of Pile 17 to 19.
Step.4 Pile 6 to 11 are installed using the GRB system.
Step.5 The Reaction Stand is relocated from the position facing Pile 13 to the position facing Pile 3.
Step.6 The Gyro Piler is disassembled and then assembled at the second Reaction Stand location.
Step.7 From the second Reaction Stand location, Pile 2 to 4 are installed.
Step.8 From the second Reaction Stand location, the Gyro Piler self-walks to the position of Pile 2 and 3.
Step.9 Pile No.1 is installed.
Step.10 The Gyro Piler is disassembled and then assembled, and set up onto the position of Pile 6 to 8.
Step.11 Pile 5 is installed.
Step.12 The Clamp Crane is disassembled and removed.
Step.13 The Gyro Piler turns around and presses in Pile 27 to the 42 by the ordinary method until completion.

Note: Regarding the arrangement/numbers of tubular pile, refer to Figure 2 and 5.

Figure 6 to 10 below show the piling states.

Figure 6 shows the state of pile installation in which Step 1 to 6 have been completed.

Figure 7 shows the state of pile installation in which Step 7 is in progress. Pile 3 is being installed from the second Reaction Stand location.

Figure 8 shows the state of pile installation during Step 8 and 9. The Gyro Piler self-walks from the second Reaction Stand location onto already installed steel tubular piles to install the Pile 1.

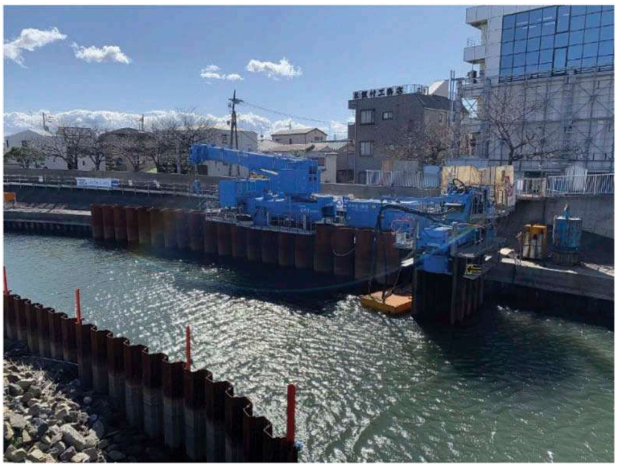

Figure 6. Piling state after Step 1 to 6.

Figure 7. Piling state at Step 7.

Figure 8. Piling state during Step 8 and 9.

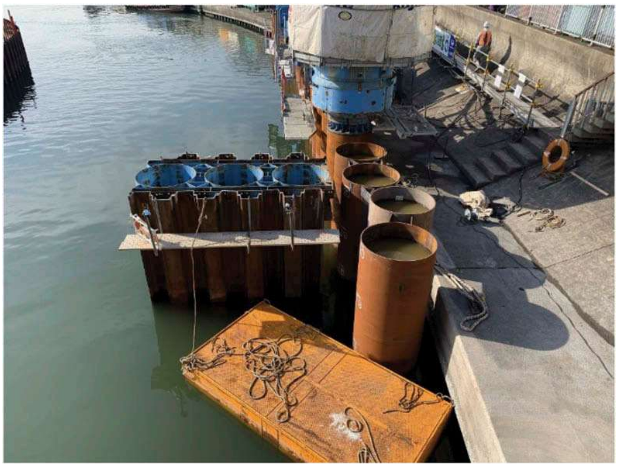

Figure 9. Piling state during Step 11 and 12.

Because the amount of pile deviation due to the obstructive existing H piles exceeds the clamp movable range of the Gyro Piler, Pile 5, which was supposed to be gripped by the third clamp, was pressed in at the final stage.

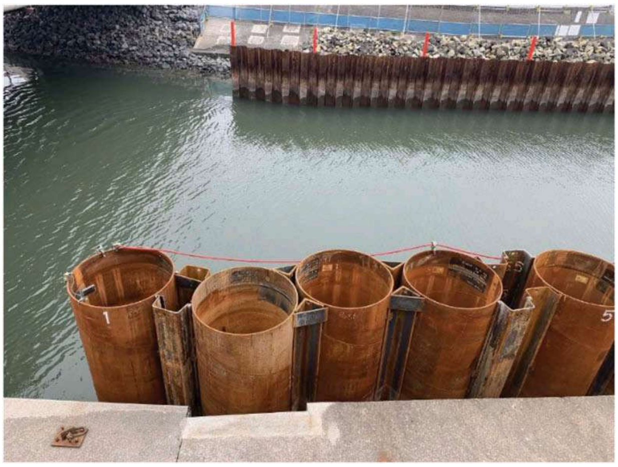

Figure 10. Completion of pile installation in the area of obstructive existing H piles.

Figure 9 shows the state of pile installation during Step 11 and 12. Because the tubular pile arrangement did not allow the third clamp of the Gyro Piler to grip a pile during installation of Pile 1, press-in piling was conducted after the installation of Pile 1 to 4.

Figure 10 shows the completed state of pile installation of Pile 1 to 5 in the area of obstructive existing H piles. Part of the embankment has been removed because of the deviation of Pile 2 toward the embankment side. Some sheet piles, which were used as reaction piles, were re-installed at the locations where the distance between tubular piles had been widened from the original plan.

5 CONCLUSION

It was possible to successfully complete pile installation in proximity to obstructive existing H piles. Although there was some metallic sound indicating contact with the obstructive piles during the pile installation, tubular piles managed to be pressed in without any problems. Thus, the project was completed without delay from the original plan.

ACKNOWLEDGMENT

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