SITE MANAGEMENT FOR LONG STEEL PIPE SHEET PILE WITH SILENT PILER AND HYDRO HAMMER

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1. INTRODUCTION

Steel pipe sheet piles (SPSP) are being commonly used in various applications in Japan. This time, the utilization of SPSP as a cofferdam for a bridge foundation is presented. The bridge (1075 m long) will be supported by 23 piers. The construction of the first pier (P1) is succinctly explained by emphasizing on the adjoint existing bridge foundation displacement and combined application of a silent piler and a hydro hammer. This paper is expected to become a reference for similar construction projects.

2. SOIL PROFILE, DESIGN AND CONSTRUCTION WORKS

Soil profile, elevations and SPT N values are shown in Fig. 1. The subsurface conditions can be generally described as saturated loose to medium dense silty sand with shell and coquina fragments to elevation -33 m, underlain by a layer of soft to stiff silty clay extending to elevation -50 m where 7 m fine dense sand underline, and lastly supportive sandy gravel layer was encountered to the termination of the boring at elevation -70 m.

The P1 was supported by 63.5 m long 24 SPSP which constructed with five parts (下杭, 中 1, 中 2, 中 3, and 上杭). Except the last one (上杭), all the parts were installed with silent piler. The 上杭 (roughly 11.5 m) was driven with the hydro hammer. The silent piler is chosen for its environmentally friendly feature (limited noise pollution). However, the hydro hammer is selected to increase skin friction. Moreover, the combine method was utilized not only for supporting the pier but also preventing the extreme settlement of the existing bridge which is only 3.2 m far away.

Allowable bearing capacity of SPSP was calculated according to the Japan Road Association (2012). The skin resistance of pile which driven with the silent piler inputted as 8% of the inner excavation value in the specification (pp. 395). The 8% of the inner excavation value was determined according to field pile impact test results. The general (R_a) and dynamic allowable bearing capacities (R_{ae}) were calculated as 960 and 1440 kN, respectively. The project was basically completed within eight steps shown in Fig. 2. Step 1: Site preparation for the construction. Step 2: Temporary dock construction. Step 3: SPSP installation with silent piler and hydraulic hammer. Step 4: Well excavation and supporting, and containment sheet piling. Step 5: Construction of pier body (in-situ reinforcement and concrete casting). Step 6: Arrangement of pile upper code (pile cutting). Step 7: Filling the foundation until the river code and removing the supports. Step 8: Clean up and finishing.

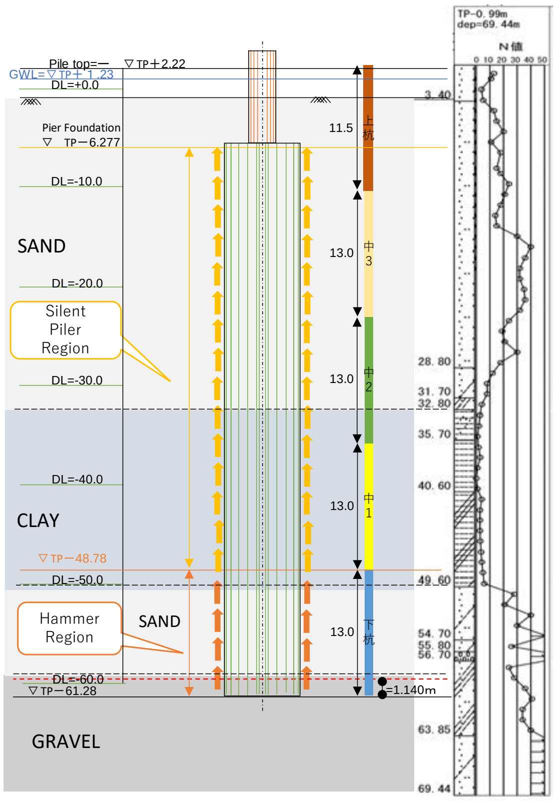

Fig. 1 General information of foundation

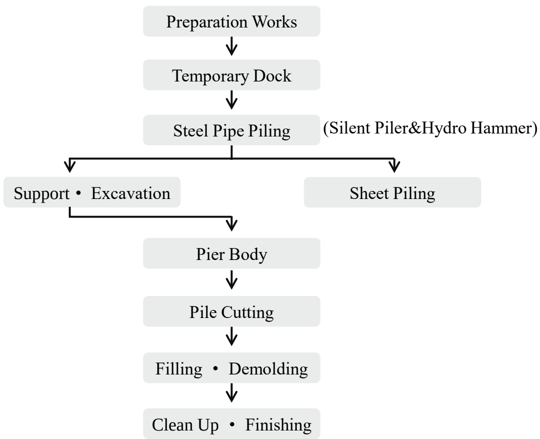

Fig. 2 Works steps

3. DYNAMIC PILE LOAD TESTS AND DEFORMATION CONTROL ON THE ADJACENT BRIDGE FOUNDATION

The R_a, and R_{ae} were checked with in-situ dynamic pile load test (DLT). During the installation of the top pile parts (上杭) with hammer, the numbers of blows, permanent pile set, drop height, elastic penetration and other necessary parameters were noted, and the vertical in-situ pile resistances were calculated according to the formulae which suggested by Japan Road Association pp. 555 (2012). With respect to the results, the average pile resistance obtained as 3762 kN which is

Keywords: Steel Pipe Sheet Pile, Cofferdam, Deep Foundation
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roughly 2.6 times of the R_{ae} (1440 kN) shown in Fig. 3. The difference between the estimated and in-situ pile resistances might be related to the pile joint, which is not taken into account during the R_a and R_{ae} calculations. Moreover, Randolph (2003) mentioned that the pile capacity may never be estimated by formulations in many soils more accurately than about 30%. We therefore need to rely on pile tests conducted in the construction phase.

Protective and preventive actions are required during the construction. The project should not affect the normal functions of the existing bridge shown in Fig. 4. As well, the displacement must remain within the allowable limit (γ_{all}=10 mm). Thus, deformations on the adjoint bridge were recorded to evaluate the impact of piling. A real time measurement was conducted with a total station (receiver) and a reflector (prism) set up. The simultaneous displacements were checked not only by engineers but also by the workers in the field. The control values were informed to the workers before they came to the site. These control values are: ①Primary value (3 mm) which is equal to the 30% of the $\gamma_{all.}$ If the deformation reaches this value, workers give notice to the field engineer. ②Secondary value (5 mm) is the 50% of the γ_{all}. At that point, the workers need to stop the operations and report to the engineer. ③Critical value is equal to the γ_{all}. If γ_{all} is observed, the workers must quickly stop all the works, inform the chief engineer, and directly apply countermeasures.

Fig. 5 illustrates the changing of deformation on the x, y, and z directions with respect to construction date. The deformations started to increase when the silent piler operation began close to the bridge. During the construction, they remained in allowable range and reached the maximum values as -2.9, 2.6 and -1.9 mm in x, y, and z direction, respectively. The fluctuation in x deformation is considered to be affected by the traffics on the bridge. Hence, the x displacement is higher than the y and z directions. Although, there is doubt about the actual x deformations, the recorded displacements did not reach 3 mm (the primary control value) on the adjacent bridge foundation during the construction period.

4. CONCLUSIONS

This paper summarizes the utilization of a steel pipe sheet pile as a cofferdam with two different construction methods: ① the silent piler and ②hydro hammer. With the presence of structure in the vicinity, a careful method selection and construction management was inevitable. Therefore, the silent piler is chosen for limited noise and vibration characteristic, however hydro hammer is selected for high skin resistance (friction) and low displacement feature. In conclusion, with rigid management and ingenuity in the process, such long piles were successfully installed in difficult surrounding. We hope that this case study will serve as a reference for similar future projects.

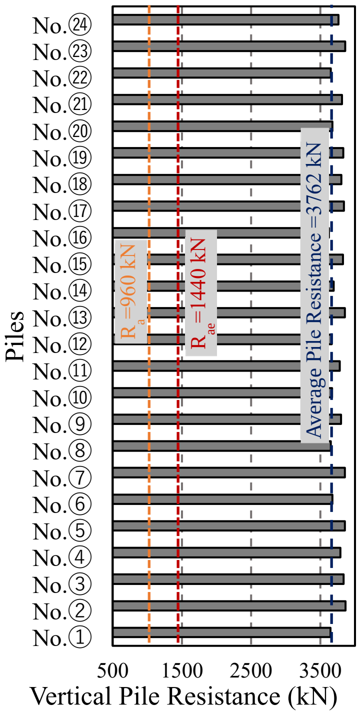

Fig. 3 In-situ Pile Resistances

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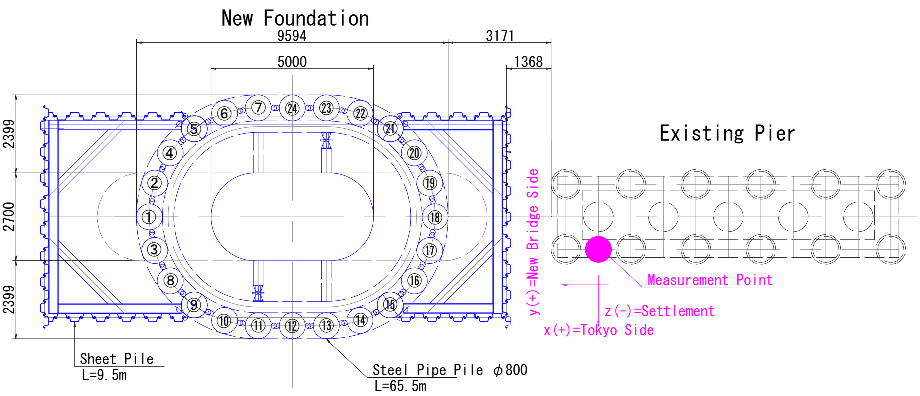

Fig. 4 Plan View of the Foundation and Deformation Measurement Point

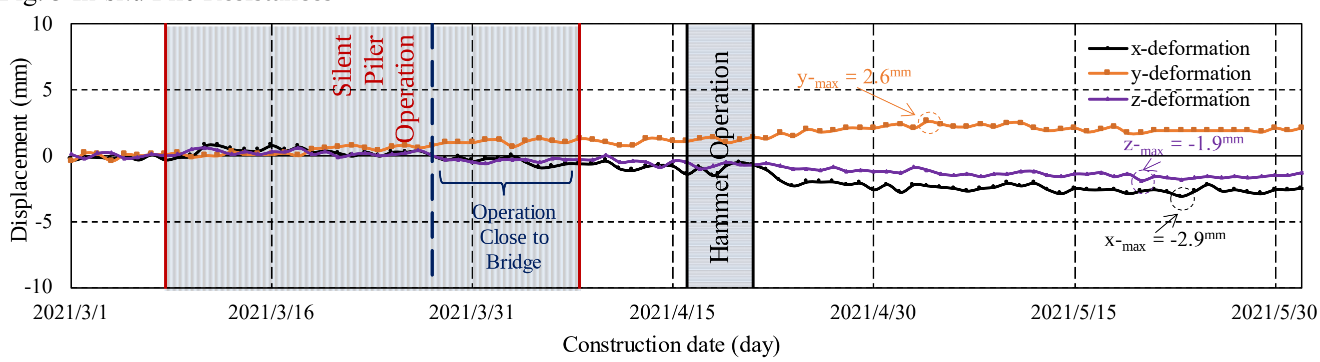

Fig. 5 Deformation on the Adjacent Bridge Foundation