Advanced construction solutions in Thailand: The Pasak Riverbank Protection Project from a construction perspective

H. Kitamura
Civil Engineer, Construction Solutions Department, Giken Seisakusho Asia Pte., Ltd. Thailand Representative Office, Bangkok, Thailand
A. Wetvimon
Assistant Manager, Construction Solutions Department, Giken Seisakusho Asia Pte., Ltd. Thailand Representative Office, Bangkok, Thailand
C. Chanphisitsophon
Managing Director, Thai Fullmore Co., Ltd., Bangkok, Thailand

ABSTRACT

The Pasak River, originating from the northeast and flowing to the middle of Thailand, runs into the Chao Praya River and plays a critical role in the economic growth of Thailand from the perspective of transportation. However, the freight volume transported through the river by barges has a tendency to increase annually. The Pasak Riverbank Protection Project aims to increase the river transportation volume by excavating the riverbed to increase the depth of the water and thereby allow cargo vessels to navigate appropriately at all times. To protect the bank from collapse owing to the river channel excavation work and waves from the barges, hat-type steel sheet piles were installed using the SILENT PILER™ developed by GIKEN LTD. and a high-frequency vibratory hammer. In this paper, we discuss the outcomes of the project from the construction perspective and highlight the advantages of the press-in technology. The new revetments of the sheet pile double wall can successfully prevent further collapse and erosion, and the wall was constructed with minimal obstruction to neighboring houses and existing revetments using a press-in piling machine. The Press-in Method is expected to enhance the quality of life for residents and promote economic development in Thailand.

Key words: *Pasak River, Bank protection, SILENT PILER F301-900, Double sheet pile wall, Hat-type steel sheet pile*

1. Outline of the project

1.1. Location

The Pasak River flows from Loei Province in the northeast to Ayutthaya Province in the middle of Thailand. The total length of the river is 513 km. Currently, a section of the Pasak Riverbank Protection Project spans from the northern Ayutthaya area to the industrial area, and the targeted distance is approximately 52 km. This section is connected to the Chao Phraya River, which flows through Bangkok to the sea. The Chao Phraya River basin is a fertile area and is one of the most famous areas for rice production in Asia. In addition, there are many industrial areas in Ayutthaya because the region provides easy access to the rich industrial water from the Pasak River, and it is close to Bangkok, which is the city with the largest economy in Thailand. The annual freight volume transported through the Pasak River by barges is increasing annually, although there was a temporary decrease due to COVID-19 (Marine Department, 2023). The 52 km section is extremely important for economic growth from the perspective of transporting goods such as agricultural and industrial products. Hence, this section was selected for improvement work.

1.2. Background and objectives of the project

The objective of this project is to increase the river

transportation volume to approximately 64 million tons per year by 2051, which is approximately double the amount measured in 2017. To accomplish this, the riverbed must be excavated to increase the water depth so that cargo vessels can appropriately navigate on the Pasak River at all times. However, multiple sections were found to be at risk of either landslide or collapse due to river channel excavation and waves from barges. Hence, the riverbank needed to be protected by utilizing a hat-type steel sheet pile, which was installed using a press-in piling machine and high-frequency vibratory hammer. The project was divided into three phases, comprising a total of 25 parts collectively. The section referred to in this study is Phase 2, Part 1, which is the first project in Thailand to adopt the SILENT PILER F301-900 and hat-type steel sheet piles. As shown in **Figure 1**, Phase 2, Part 1 covered a distance of approximately 2 km out of the total targeted area of 52 km.

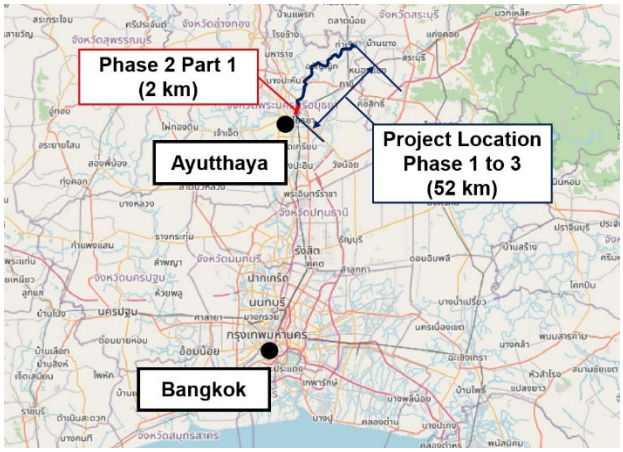

Figure 1. Project location in Ayutthaya

2. Structural type and piling method

2.1. Site conditions

As shown in **Figure 2**, Phase 2, Part 1 covered six sections. The total number of hat-type sheet piles was 4,238. As shown in **Figure 3**, some sections required high accuracy during the installation of the sheet piles because they were adjacent to residential and sensitive areas. Therefore, 2,782 of the 4,238 pieces were installed using the SILENT PILER F301-900 to ensure accuracy. In addition, the installation work for the sheet piles was conducted above the water. The water level tends to rise significantly, particularly during the rainy season from June to October, often surpassing the height of the hat-type sheet pile. Therefore, the installation of the hat-type sheet piles was paused for periods of time, for both the SILENT PILER and high-frequency vibratory hammer.

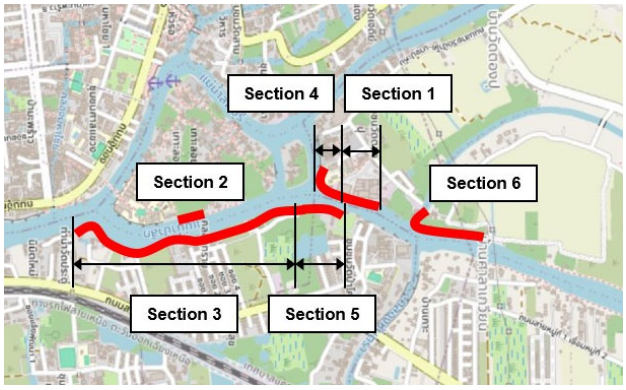

Figure 2. Sections for sheet piling work in Phase 2, Part 1

Figure 3. Construction carried out adjacent to a building

2.2. Ground conditions

A large amount of borehole data were collected, as Phase 2, Part 1 covered approximately 2 km. **Figures 4-1** and **4-2** show data from several representative locations. The ground conditions investigated in this project consist of soft to hard clay and dense sand. The maximum extrapolated SPT *N* value was 60–70.

2.3. Structural type

2.3.1 Structural details

Phase 2, Part 1 is the first project in Thailand to adopt hat-type steel sheet piles. In this project, the hat-type sheet piles 45H and 25H were designed for the riverside

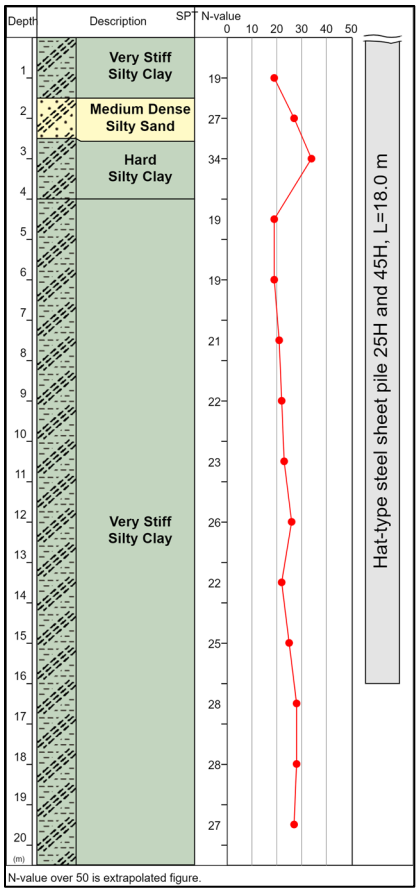

Figure 4-1. Typical borehole data

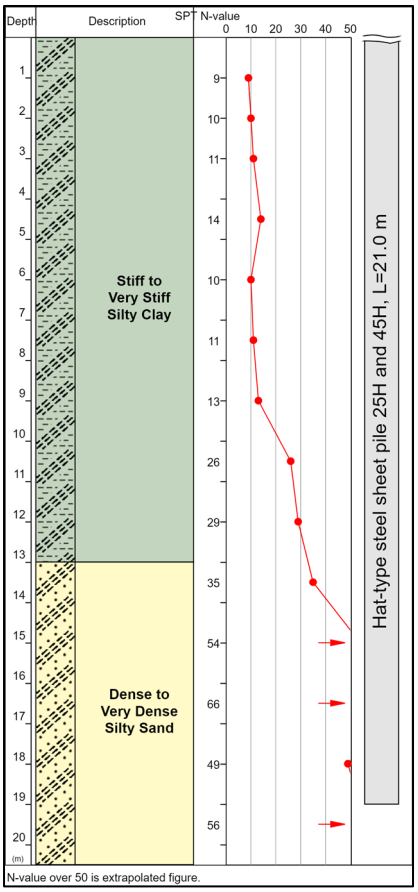

Figure 4-2. Typical borehole data

and landside, respectively, to create a double hat-type sheet pile wall as a revetment, as shown in **Figures 5** and **6**. In addition, to serve the community, a concrete slab was installed on top of the sheet pile to function as a pedestrian walkway. Moreover, stairs were constructed on the riverside to facilitate the locals to use their boats as a means of transportation to cross the river. The sheet pile wall, including its sidewalks and stairs, improved the living environment of the residents.

Figure 5. Double hat-type sheet pile wall

2.3.2 Advantages of hat-type steel sheet pile

Compared with U-shaped sheet piles, which are commonly used in Asia, hot-rolled hat-type sheet piles offer several advantages, the first being their superior construction productivity. The width of a hot-rolled hat-type sheet pile is 900 mm, which is 2.25 times wider than a U-shaped 400 mm sheet pile. Thus, the total number of sheet piles can be reduced, as shown in **Figure 7**. In other words, the construction period can be shortened, particularly in soft ground. The second advantage is their high structural reliability. For instance, for designing a U-shaped sheet pile in accordance with the Eurocode, reduction factors associated with sectional properties are required owing to the shape and interlock location of the sheet pile. However, a hat-type sheet pile does not require such considerations, as the interlocking position is located on the outermost side of the wall and the neutral axes of both the single hat-type sheet pile and the wall after construction are the same. Therefore, hat-type sheet piles ensure reliable structural performance even under different conditions (NIPPON STEEL CORPORATION,

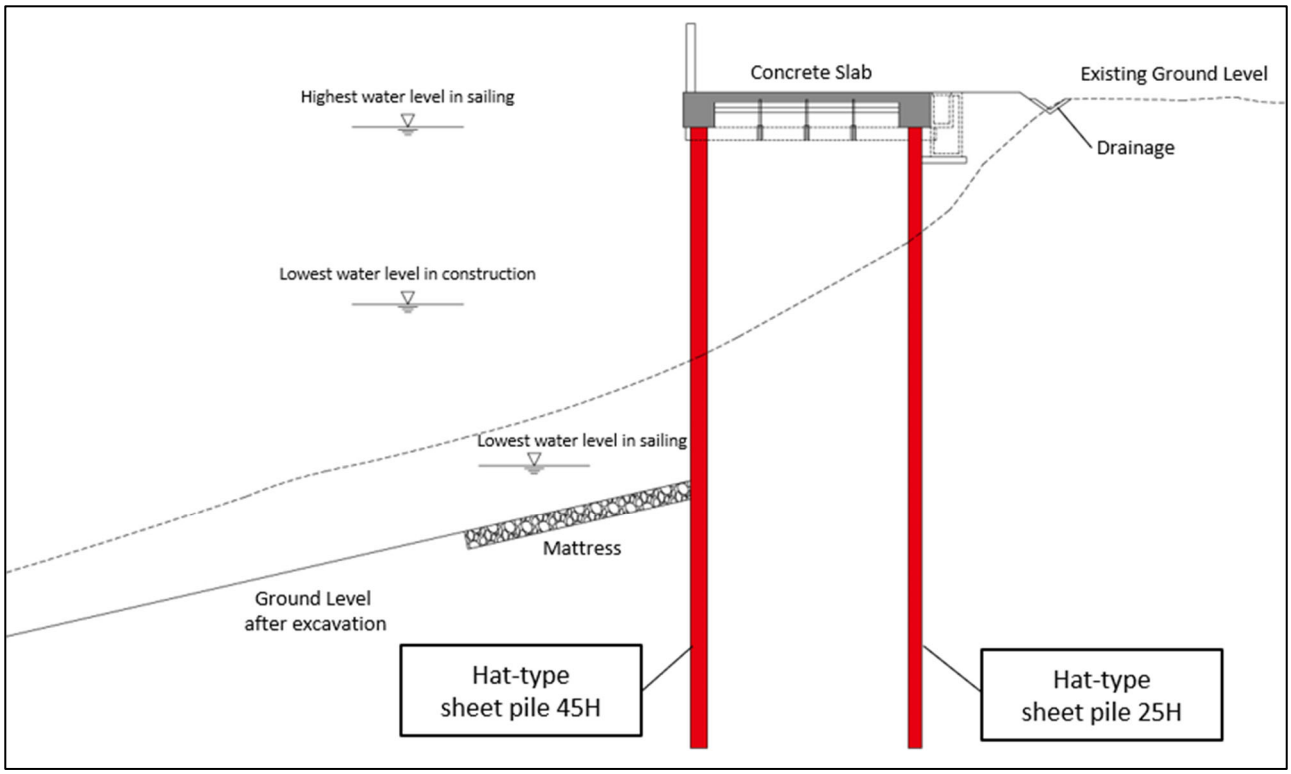

Figure 6. Cross-section of the double hat-type sheet pile wall

2019). Based on these characteristics, the double hat-type sheet pile wall was employed as a revetment in Phase 2, Part 1 in the Pasak River project.

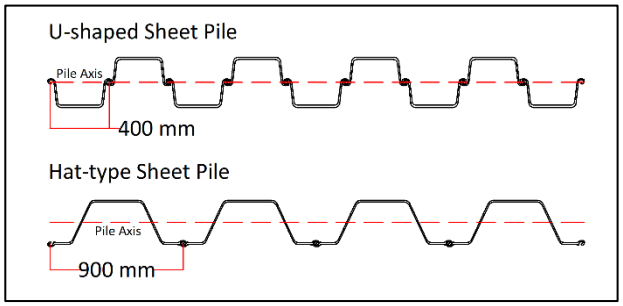

Figure 7. Comparison of the number of sheet piles

2.3.3 Obtaining the approval of Thailand Industrial Standards

Thailand Industrial Standards (TIS) are national standards established to promote and develop standardization in the industrial field. TIS is controlled and managed by the Thailand Industrial Standards Institute (TISI) under the Ministry of Industry (JETRO, 2018). TIS consists of two types of product certifications: voluntary certification mark and mandatory certification mark. Hot- rolled steel sheet piles are products that require a mandatory certification mark, which takes a few months to obtain. The application and approval of TIS are imperative for ensuring smooth import of materials and adherence to the construction schedule. The TISI has already approved TIS for hat-type steel sheet piles (TISI, 2024).

2.4. Piling method

2.4.1 Penetration techniques for sheet pile

As shown in **Figure 8**, three penetration techniques exist for sheet piling using SILENT PILER. The first one is the standard mode, which involves pressing-in sheet piles

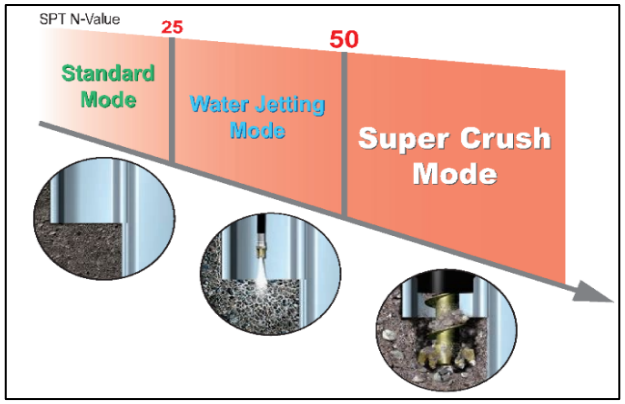

Figure 8. Penetration techniques for sheet piles (GIKEN LTD., 2022)

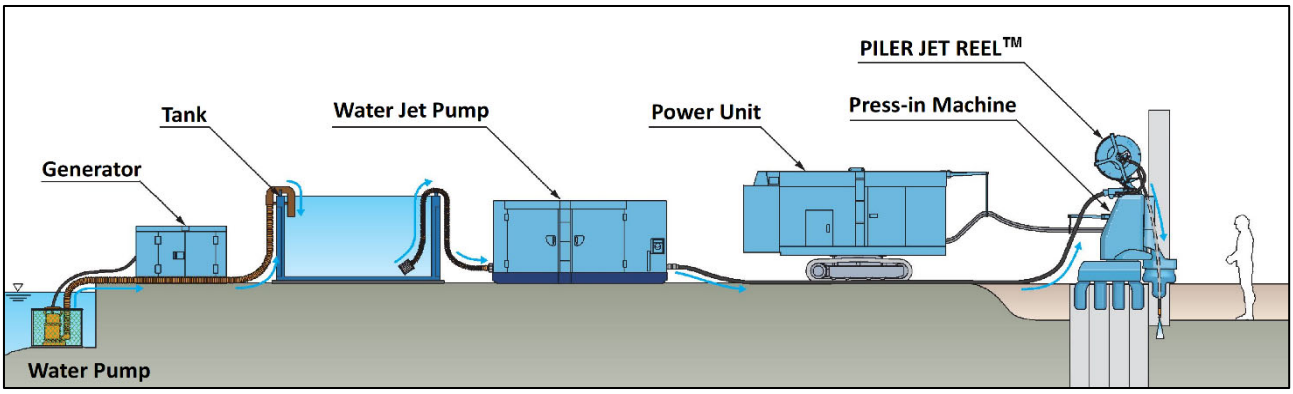

Figure 9. Main components of the water jetting mode

without driving assistance. Usually, it can be applied in soils with SPT *N* values of 25 or below. Second, the water jetting mode can be used to overcome medium-dense and stiff ground conditions with SPT *N* values more than 25 to 50 or less. Third, the super crush mode is applied when the piling work encounters hard ground, such as boulders or rock layers with SPT *N* values of greater than 50. A pile auger is used for driving assistance in this mode.

2.4.2 Selection of penetration techniques

In a few depths, the SPT *N* value exceeded 50 within the 2 km distance covered by Phase 2, Part 1. However, as the SPT *N* values were below 50 in most depths, the water jetting mode was adopted. Using a water jet to press-in the sheet piles can efficiently reduce the penetration resistance force. High-pressure water jetting can increase the porewater pressure between soil particles and temporarily make them easier to move. In addition, the water that is about to rise to the ground can reduce the shaft friction of the piles and the interlock resistance by removing the soil between the interlocks. As a result, the piles can be installed with minimal press-in force. Driving assistance, such as water jetting, is crucial to prevent damage to the piles.

2.4.3 Basic components of press-in with water jetting

Figure 9 illustrates the main components of the water jetting mode, namely a press-in piling machine with the PILER JET REEL™, power unit, water jet pump, water tank, generator, and water pump. **Figure 10** shows the standard details of the equipment for pile toe. Because the width of the hat-type sheet pile is 900 mm, two PILER ECO™ Hoses were used to promote efficiency, as shown in **Figure 11**.

2.4.4 Piling process of press-in with water jetting

Figure 12 shows the press-in process with water jetting. Compared with the standard press-in process, this process differs in steps 2 and 7, which mainly involve the PILER JET REEL and PILER ECO Hose. The reel is the device that winds the hose. Winding up and unreeling the hose are automatically carried out by the reel. In step 2, the jet nozzle is inserted into the JET LOCK™, which is welded on a pile and locked by a pin. In step 7, after the installation of the pile, the hose is extracted using the reel. Therefore, the PILER ECO Hose can be repeatedly used.

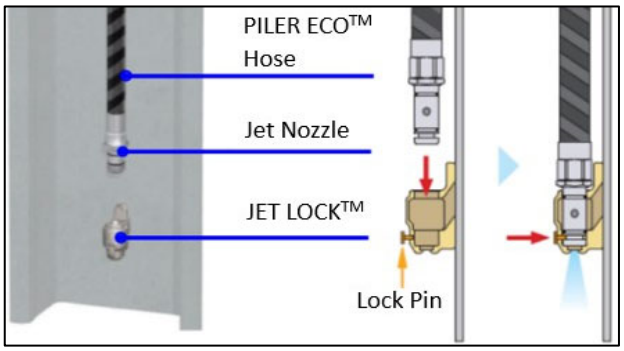

Figure 10. Water jetting equipment for a U-shaped sheet pile
(International Press-in Association, 2023, p. 15)

Figure 11. Water jetting equipment for a hat-type sheet pile

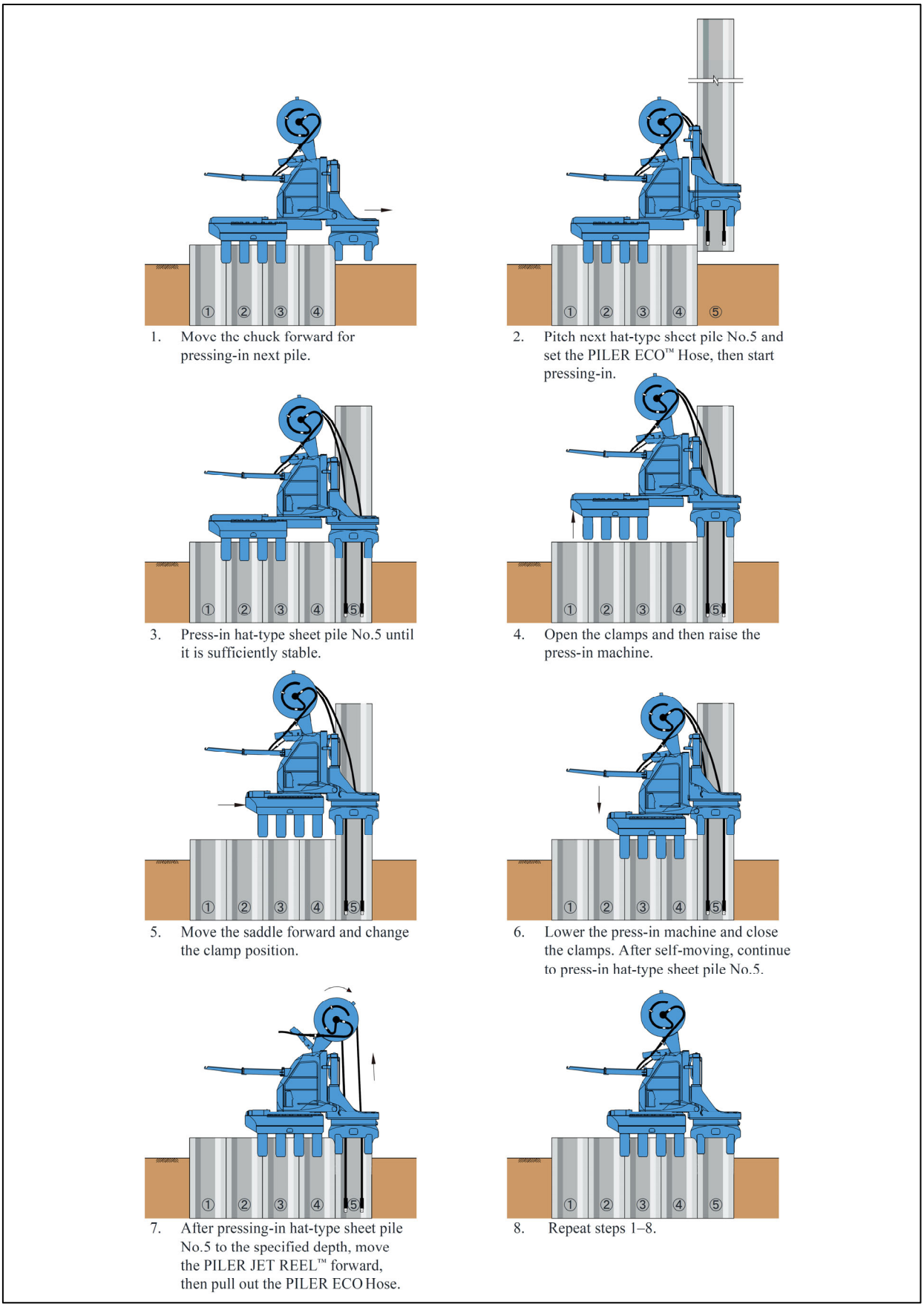

Figure 12. Piling process

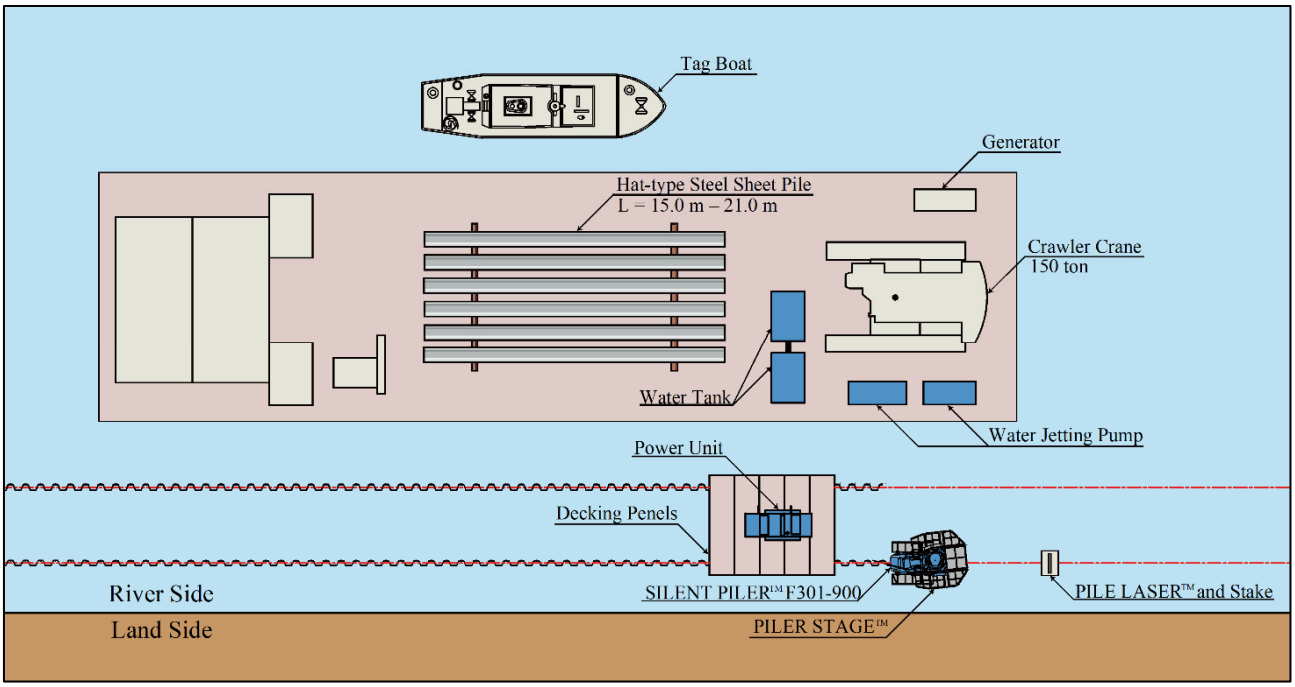

Figure 13. Plan view

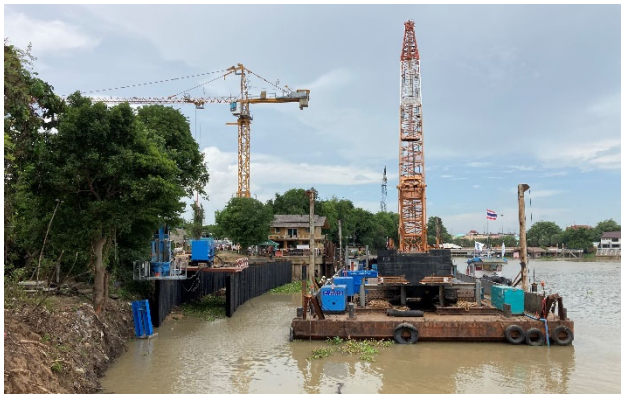

Figure 14. Construction site view

Figure 15. Power unit located on the decking panels

3. Press-in piling

3.1. Layout

The crane for pitching the sheet pile and other equipment were located on a barge, as depicted in **Figures 13** and **14**. The power unit was located on the decking panels, along with the SILENT PILER, as shown in **Figure 15**. Construction efficiency was improved by eliminating the need for re-arranging the power unit. In addition, the risk of hose damage due to the rapid movement of the barge caused by waves was eliminated.

3.2. Productivity

3.2.1 Daily productivity

Table 1 lists the number of hat-type sheet piles driven by the SILENT PILER and the high-frequency vibratory hammer. **Table 2** lists the daily productivities in terms of the actual working days and in-service days of the press-in piling machine. The term “actual working days” refers to the number of days the machine was operated, while “in-service days” refers to the number of days from the beginning to the end of sheet piling, including days when the work was halted owing to high water levels, days when materials were loaded onto barges, and holidays. Generally, the number of piles driven by the vibratory hammer per day surpasses that by the SILENT PILER; however, in this project, the daily productivity of the SILENT PILER was approximately twice as high as that of the vibratory hammer.

Table 1. Numbers of hat-type sheet piles

SILENT PILER

(Total: 2,782 pcs)

Pile Type \ Pile Length	15.0 m	18.0 m	21.0 m
Hat Pile 25H	92	705	558
Hat Pile 45H	87	774	566
Sub total	179	1,479	1,124

High-Frequency Vibratory Hammer

(Total: 1,456 pcs)

Pile Type \ Pile Length	15.0 m	18.0 m	21.0 m
Hat Pile 25H	306	410	53
Hat Pile 45H	294	336	57
Sub total	600	746	110

Table 2. Daily Productivity by SILENT PILER

SILENT PILER

(Total: 2,782 pcs)

Construction Duration

Actual working days	294 days
In-service days	403 days

Daily Productivities

Actual working days	9.46 pcs
In-service days	6.90 pcs

3.2.2 Reasons for the difference in daily productivity

There were two main reasons for the difference in the daily productivity, the first of which was preparation work. The vibratory hammer method uses a guide frame for ensuring the alignment of driven piles (Vibro-Hammer Method Technical Research Group, 2015). The guide frame was positioned above the water in this project, as shown in **Figure 16**. Therefore, it required more time for the H beam installation and welding works than for construction on the ground.

Figure 16. Guide frame for the vibratory hammer method

Conversely, the SILENT PILER uses the PILE LASER™ to confirm the alignment and verticality of piles, as shown in **Figure 17**. It is simple to set up, even when the pile alignment is above the water.

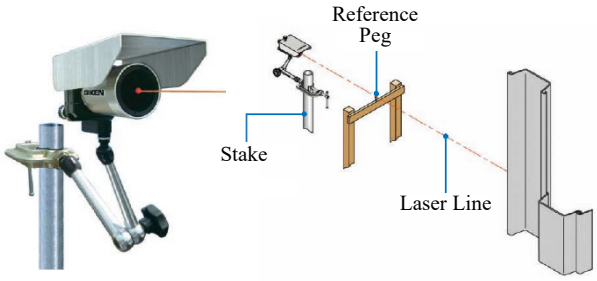

Figure 17. PILE LASER for the SILENT PILER (GIKEN LTD., 2023, Technical Brochure, p. 27)

The second reason for the difference in the daily productivity is the water level in the Pasak River. During the rainy season, the water level at the project location exceeded the top of the hat-type sheet pile for a specific period. Therefore, machine operation was temporarily suspended. However, the period of suspension for the SILENT PILER was shorter than that for the vibratory hammer owing to the PILER STAGE™ and clamp-gripping mechanism. **Figure 18** illustrates the stage, which is a component of the auxiliary equipment for the SILENT PILER. The vibratory hammer method utilized the horizontal H beams not only as a guide, but also as a platform in this project. Meanwhile, the PILER STAGE enables an operator of a press-in piling machine to work safely and efficiently, even if the platform is unstable atop water or on a high datum level.

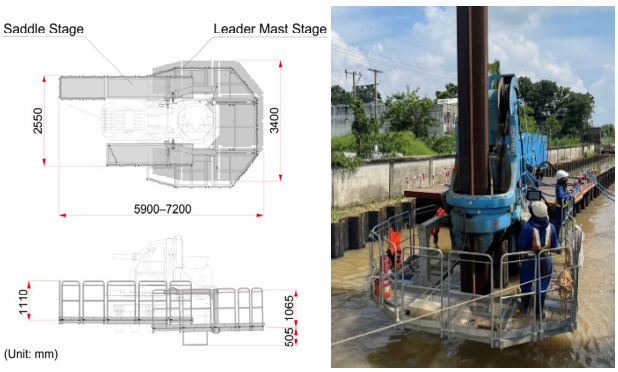

Figure 18. PILER STAGE (GIKEN LTD., 2023, Technical Brochure, p. 25)

Figure 19 shows press-in work when the water level was high. In this case, it was necessary to focus on the clamp gripping the reaction piles. The length of the clamp for F301-900 was 465 mm from the top of the sheet pile (GIKEN LTD., 2023, Machine Brochure). Although a margin of 550 mm is recommended for safety reasons, if the clamp is not submerged, the installation of the piles can be continued owing to the characteristics of the machine. Consequently, the use of the SILENT PILER allowed the installation work to continue for a longer period than what was possible with the vibratory hammer. Additionally, it enabled the work to be restarted promptly after the water level decreased. Hence, the usage of the SILENT PILER minimized the duration of work suspension owing to elevated water levels.

Figure 19. Press-in work with a high water level

4. Concluding remarks

Phase 2, Part 1 marks the first project in Thailand to utilize the SILENT PILER F301-900 and hat-type steel sheet piles. There were some problems such as a high water level during the construction period. However, owing to the low noise and vibration levels of the SILENT PILER, a hat-type sheet pile double wall was successfully built without affecting nearby houses and existing revetments. The sheet pile wall can protect revetments from the collapse and erosion resulting from river channel excavation, which is required to facilitate efficient navigation for cargo vessels, and the waves from barges. The same construction method and structure will be replicated for the remainder of the project. The Press-in Method is expected to enhance the quality of life for the residents and promote economic development in Thailand.

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