Press-in with Augering; an Installation of Steel Sheet Piles Connected Longitudinally (Hard Ground Press-in Method)

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ABSTRACT

The case described here is about the construction of the earth retaining wall in an aseismic reinforcement work of the Enoura Ohashi Bridge in Mie Prefecture, Japan. The site showed the maximum SPT *N*-value is 88, and a standard press-in was not applicable. In addition, the site was adjacent to residential areas, and a pressing machine that would emit as low vibration and noise as possible should be selected. Therefore, the press-in assisted with augering was adopted.
The construction site was limited under the existing bridge. Including the hoisting wire of a crane, the assembly length of the Pile auger for 8.0 m steel sheet piles became 17.88 m. Therefore, an auger hoisting system for the installation under overhead obstructions was selected at the design stage. However, segmenting the augers, casings and steel sheet piles, the normal press-in assisted with augering became possible by connecting the spliced piles vertically. When the site was narrow that a crane could not be set, the operation was carried out by the Silent Piler F111 (Hereafter, F111) only, without the crane support. This way, the construction method adopted for this work contributed to making the construction period shorter as well as saving the cost.

Key words: *Press-in Method assisted with augering, Hard Ground Press-in Method, Maximum N-value, Overhead clearance, Silent Piler*

1. OUTLINE OF THE PROJECT

1.1. Location

The project was an aseismic reinforcement work of the Enoura Ohashi Bridge in the Nagashima harbour, located at Nagashima, Kihokucho, Kitamuro, Mie Prefecture, Japan. The site consisted of sand and gravel with the maximum SPT *N*-value of 88. The site was adjacent to residential houses. In addition, the construction had to be carried out at a place where there was an overhead clearance of 12.3 m (**Fig. 1**).

1.2. Background and Objectives of the Project

The construction plan was to press-in 174 no. of 8.0 m long steel sheet piles of type III in a rectangular shape as a temporary earth retaining wall for an aseismic reinforcement with the concrete jacketing method. About 6.0 m below the ground surface, there was a sand and gravel layer with the maximum SPT *N*-value of 88. Judging from the hardness of the ground, it was possible to conduct the construction by using the three-point-supported type pile driving rig (Hereafter, three-point pile driver rig). However, there was an existing bridge girder as an overhead obstruction. In addition, the site was narrow, and a large machine could not be used. After consideration, it was judged and concluded that the construction would be possible, if the Press-in Method with augering (F111) was used, since the casing auger could cope with segmentation and connection of the steel sheet piles.

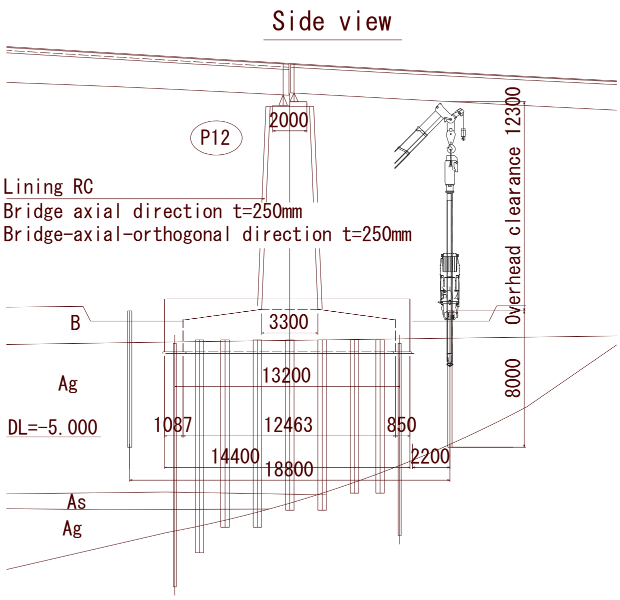

Fig. 1 Side view of the bridge

2. STRUCTURAL TYPE AND PILING METHOD

2.1. Site Condition

The site was in the vicinity of a river mouth area.

2.2. Ground Condition

As shown in **Fig. 2**, the site ground consists of sand and gravel layer with occasional boulders. Maximum SPT *N*-value was 88 in the sand and gravel layer, about 6 m below ground surface.

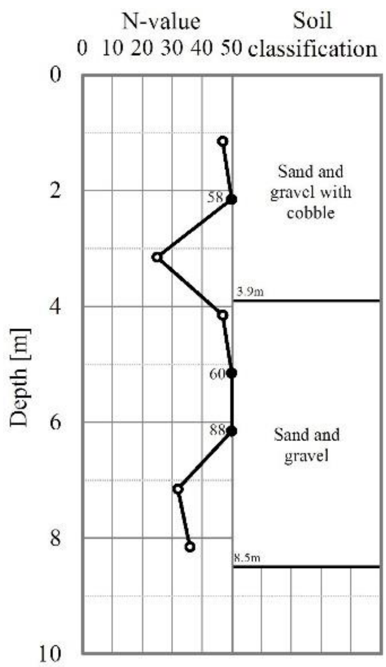

Fig. 2 Layout of the steel sheet piles

2.3. Structural Type

Fig.3 shows a plan view of the temporary structure. The steel sheet piles were to be installed in a rectangular shape of 16,000 mm x 18,800 mm. In total, 174 steel sheet piles of type III were pressed-in:

- 120 no. U-shaped steel sheet piles, type Ⅲ, L=8.0m
- 27 no. U-shaped steel sheet piles, type Ⅲ, L=8.0m (4.0mx2), one joint
- 27 no. U-shaped steel sheet piles, type Ⅲ, L=8.0m (3.5m+4.5m), one joint

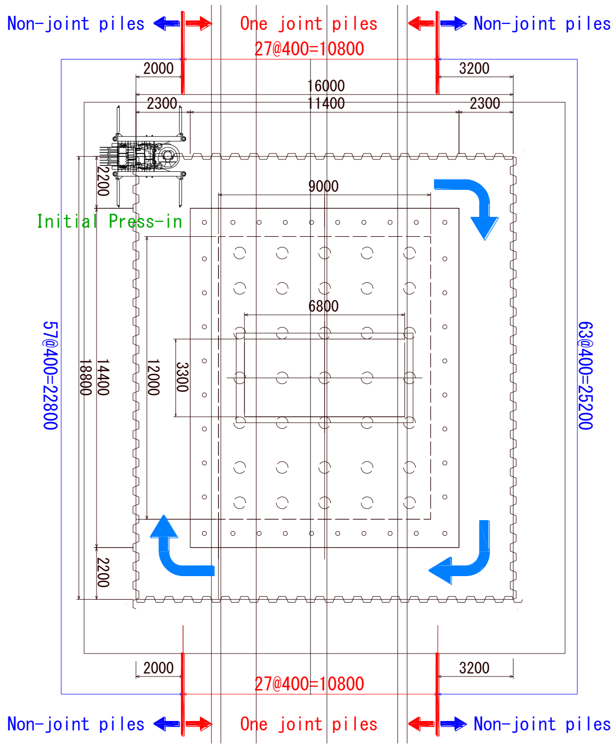

Fig. 3 Layout of the steel sheet piles

2.4. Piling Method

The Press-in Method with augering (Hard Ground Press-in Method) was adopted (**Fig. 4**). The construction was carried out in the following stages:

1) By using a 5.0 m long casing and auger, a lower spliced steel sheet pile is installed
2) Press-in the spliced steel sheet pile, disconnect the motor from the Pile auger and lay it on the ground
3) Connect the motor with a 4.5 m middle auger and casing and joint them with the already installed auger and casing after the crane lifts them up.

4) Pitch an upper steel sheet pile and connect it with the lower steel sheet pile by welding.
5) Press-in the jointed steel sheet pile, disconnect the motor from the Pile auger and lay it on the ground.
6) Connect the motor with a 2.0 m upper auger and casing and joint them with the already installed auger and casing after the crane lifts them up.
7) Press-in the jointed steel sheet pile.
8) Complete of the Press-in operation.
9) Extract the Pile auger including the disassembling of the augers and casings.
10) Repeat the procedure from 1) to 9)

Note that the type A piles (L=8.0m/4.0mx2) and the type B piles(L=8.0m/3.5m+4.5m) are alternately installed.

3. PRESS-IN PILING

3.1. Condition during Pressing-in Steel Sheet Piles

Though the maximum *N*-value was 88, the ground was not as hard as it required pre-augering. Therefore, the Press-in with simultaneous augering, which is "Coring press-in", was conducted. The construction was started with installing three no. 8 m-long steel sheet piles, then from the 4th sheet on, the steel sheet piles with a single joint were pressed-in.

Underneath the bridge, steel sheet piles were installed using a 4.9ton telescopic boom crawler crane (hereafter, telescopic crane) (**Photo 1**). In addition, the number of supervisors was increased to make sure the toe of the crane boom would not touch the bridge girder, and the construction was carried out cautiously, by restricting the boom angle and extension/contraction limits of the 50ton rough terrain crane (**Photo 2**).

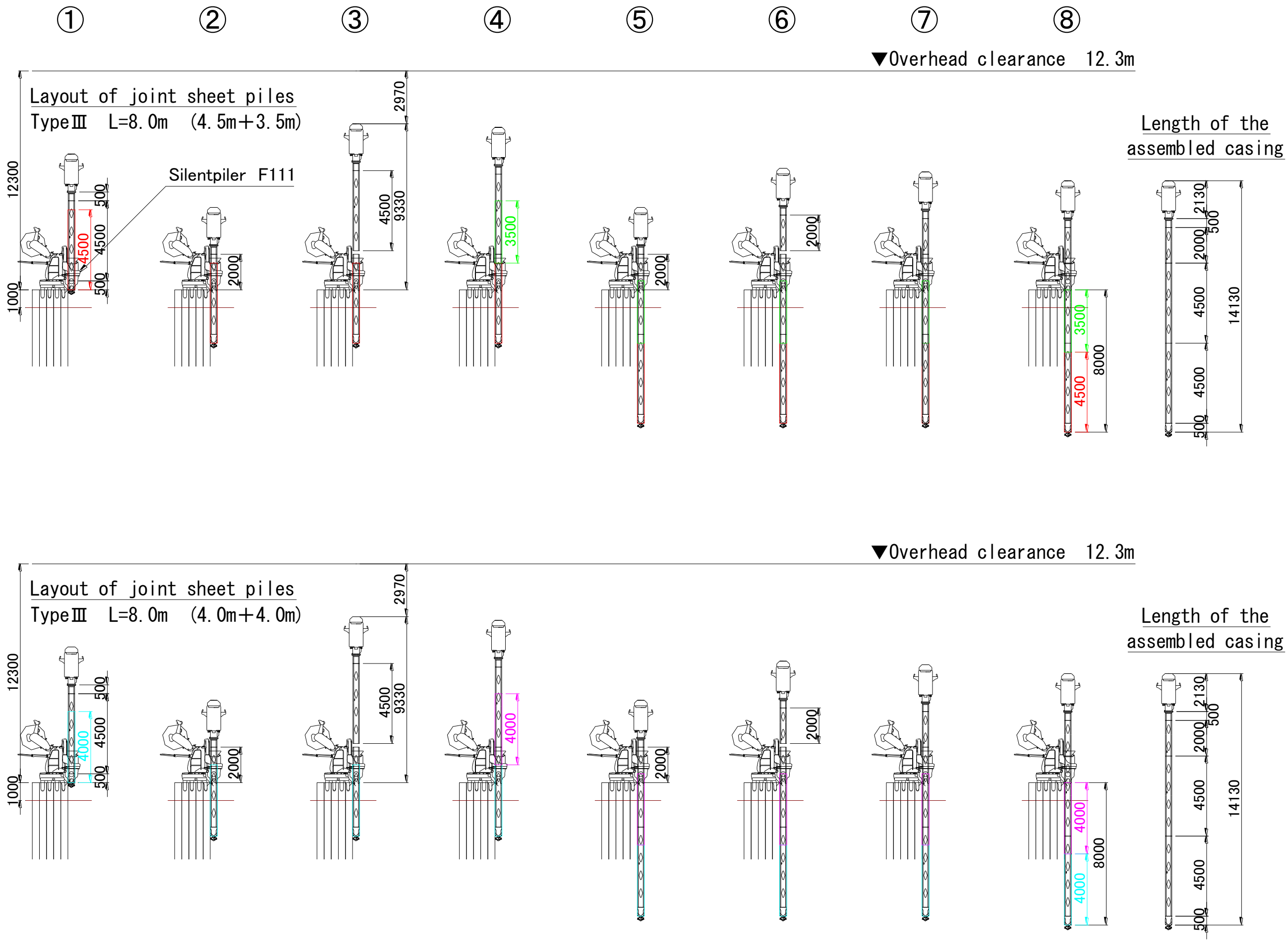

Fig. 4 Piling procedure of the Press-in Method with augering

When assembling and disassembling the augers and casings, the Pile auger should be once laid on the ground. The 50ton rough terrain crane hoisted the edge of the Pile auger whilst the 4.9ton telescopic crawler crane hoisted the other edge of it (**Photo 3**). When the Pile auger is hoisted after connecting the augers and casings, the same operation was conducted. There were some level differences on some narrow places of the ground where the rough terrain crane could not be set up (**Photo 4**).

In that case the press-in operation was continued only by the F111, and steel sheet piles were supplied by the 4.9ton telescopic crane (**Photo 1**). As the enclosure with closed corners approached, the inclination of the installed steel sheet piles and the distance between them were closely monitored, thus the press-in operation of 174 steel sheet piles was completed successfully.

Photo 1. Pitching of steel sheet piles using a 4.9ton telescopic crawler crane under a girder

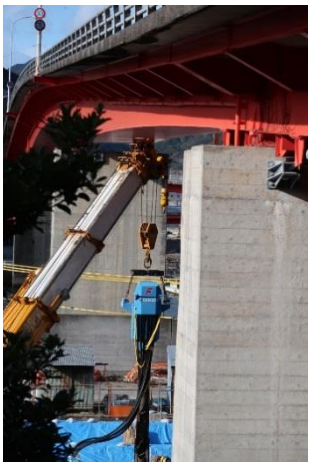

Photo 2. Planned augers and casings and an increase in the number of supervisors enabled the piling operation.

Photo 3. Mutual hoisting with the 4.9ton telescopic crawler and 50ton rough terrain crane, when the Pile auger is laid on the ground

Photo 4. For the enclose with closed corner, the piling operation was being conducted carefully after the installation under the bridge.

3.2. Productivity

The productivity of the construction is summarized in **Table 1**. As shown in the table, on average steel sheet piles without connection joints were installed at a rate of 15 piles/day, whereas those with one joint were installed at a rate of 6 piles/day on average. The press-in operation was completed in a period of 16 working days. The entire construction period of the aseismic reinforcement work of the Enoura Ohashi Bridge was from February 8, 2017 to November 30, 2017.

Table 1. Productivity

Pier "P-12" of the Enoura bridge	10-Mar Fri.	11-Mar Sat.	12-Mar Sun.	13-Mar Mon.	14-Mar Tue.	15-Mar Wed.	16-Mar Thu.	17-Mar Fri.	18-Mar Sat.	19-Mar Sun.
Sheet pile, type Ⅲ, L=8.0m 120 no.	Carrying in sheet piles	No work	Day off	Carrying in machinery and materials				Carrying in sheet piles		Day off
Sheet pile, type Ⅲ, L=8.0m (2@4.0m), 120 no.										
Sheet pile, type Ⅲ, L=8.0m (3.5m+4.5m), 120 no.										
Number of non-joint piles				Setting-up of Piler	Installation of no joint piles: 3no.	N/A	N/A			
Number of one joint piles					Installation of one joint piles: 3no.	5no.	6no.	6no.	7no.	
Numbers					6	11	17	23	30	

Pier "P-12" of the Enoura bridge	20-Mar Mon.	21-Mar Tue.	22-Mar Wed.	23-Mar Thu.	24-Mar Fri.	25-Mar Sat.	26-Mar Sun.	27-Mar Mon.	28-Mar Tue.	29-Mar Wed.	30-Mar Thu.
Sheet pile, type Ⅲ, L=8.0m 120 no.	Dummy piles L=5m,1 no. Corner installation		Dummy piles L=5m,1 no. Corner installation		AM 9:00 Nondestructive inspection		Day off	Dummy piles L=5m,1 no. Corner installation		Corner installation	Piler Dismantlement and Carrying out of Piler
Sheet pile, type Ⅲ, L=8.0m (2@4.0m), 120 no.					Color check						
Sheet pile, type Ⅲ, L=8.0m (3.5m+4.5m), 120 no.					Check by authority					Closing at the corner	Carrying out construction materials
Number of non-joint piles	Installation of no joint piles: 17no.	20no.	22no.	4no.				Installation of no joint piles: 7no.	24no.	23no.	
Number of one joint piles		Installation of one joint piles: N/A	N/A	7no.	5no.	7no.		Installation: 8no.			Sitekeeping
Numbers	47	67	89	100	105	112		127	151	174	Completion

3.3. Encountered Difficulties

In the original design, a construction method using the GIKEN auger hoisting system was planned. It was however judged that the construction by means of the Hard Ground Press-in Method could be possible by conducting the assembling/disassembling of the augers and casings. However, had it been possible to conclude that the Hard Ground Press-in Method could be applied to the site when the bridge overhead clearance was known to be 12.3 m, the construction planning would have been made smoother. For a smooth planning, we feel that a kind of table for the combination of auger and casings should be organized so that it can be referred to as a guideline for considering the construction under overhead obstructions.

The minimum overhead clearance in the construction method with the GIKEN auger hoisting system is up to 7.0 m (applicable for 400mm-wide U-shaped steel sheet piles). On the other hand, the minimum overhead clearance in the Hard Ground Press-in Method we adopt is 10.0 m. Therefore, we concluded that the GIKEN auger hoisting system be used for the overhead clearance smaller than 10.0 m, and that the Hard Ground Press-in Method with spliced steel sheet piles be used for the overhead clearance larger than 10.0 m.

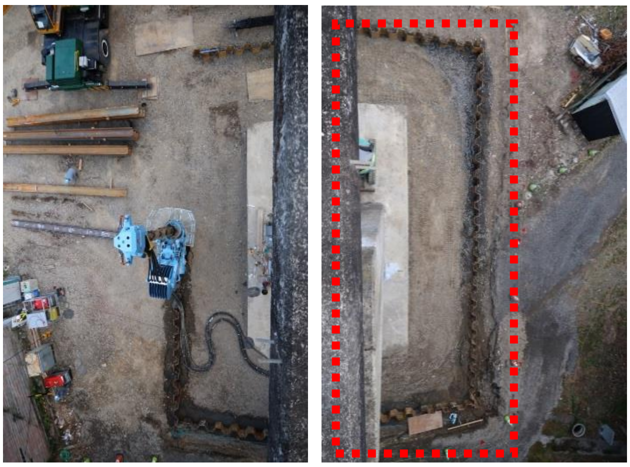

Photo 5. Setting up the 50ton terrain crane could not be set at the location inside the dashed line, where the ground was narrow and possessed differential elevations. Press-in operation was carried out by the F111 only, without the crane support to lift the Pile auger.

4. CONCLUDING REMARKS

In the Press-in Method assisted by augering (Hard Ground Press-in Method) using steel sheet piles with joints, the ground condition was pretty good as it was a not-too-hard sand and gravel layer so that the press-in operation with the F111 could be conducted in quite stable condition. In addition, due to good teamwork and communication among the workers, segmentation and connection work of the casings and augers was gradually improved, which helped the work to be done speedily, and thus the construction was completed safely and successfully.

In the case of construction with the Press-in Method assisted by augering, there is no work that can be done under the same site condition. We came to a conclusion that we can achieve the best and safest possible construction by having close and in-depth discussions with the prime contractor day by day under the condition at each time, and by building good teamwork among the workers to exchange good ideas and then implement them. (**Photo 6**).

Photo 6. Completion of the aseismic reinforcement work

5. ACKNOWLEDGEMENTS

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