A Case Study by the Gyropress Method in Consideration of Neighboring Residential Areas

Tsubasa TSUKANAKA
Technical officer, Piler division, Kajikawa Construction Co. Ltd., Aichi, Japan
Email: tsukanaka@kajikawa.co.jp

ABSTRACT

The objective of this project is to install steel tubular piles used as a temporary earth retaining wall as well as the main wall for an open-cut structure by the Gyropress Method, because the ground was stiff, and there were some areas where the ground surface was uneven, and the piling work had to be conducted adjacent to residential houses.
Among the technical challenges, the construction adjacent to residential houses was severe, only 1.5 m away at the closest location. One countermeasure was taken so as to prevent objects from being scattered over the residential houses, and the piling operation was carefully conducted within the allowable noise and vibration level. In spite of another countermeasure taken, slurry overflowed from the steel tubular pile, due to the stiff ground of shale layer that was prone to plugging. It was likely that the construction would be delayed, and dust would be scattered. As a measure, pre-cutting piles and a specially fabricated jig were used, and it was fortunately possible to solve the problem. In addition, vibration and noise never went over the maximum required value, and the construction was completed without any complaint. This paper introduces this construction case.

Key words: *Gyropress Method, Pre-cutting, Construction adjacent to residential houses*

1. OUTLINE OF THE PROJECT

1.1. Location

The site is located near the interchange of the planned expressway that about 70 % of the entire extension will be tunnels or semi-underground structures.

More than 200 steel tubular piles were installed by the Gyropress Method with some elevation differences. Among these, 20 piles were pressed in directly into concrete retaining wall at a high spot on the mountain side where the elevation difference was large and residential houses were densely populated.

1.2. Background and Objectives of the Project

As the project was conducted in a quiet residential area, the client had to select a construction method in which the environment was sufficiently taken into consideration. In addition, the ground was a stiff mudstone layer with a maximum SPT *N*-value of about 250, and some sections to install steel tubular piles were uneven. As a result, the Gyropress Method, the diaphragm wall method, and the boring hole (BH) method were compared. After an overall examination, the Gyropress Method was adopted for its advantageous features to the other methods, such as realization of construction sustainable to environment, capability to press-in piles into stiff ground and underground obstructions like concrete structures, and compact construction system.

The objective of the project was to build a temporary earth retaining wall which acts simultaneously as a main wall to construct an open-cut structure.

2. STRUCTURAL TYPE AND PILING METHOD

2.1. Site Condition

At the site, giving consideration to nearby residents, vibration and noise as well as working time were limited. Delivery of construction material and equipment were stopped on the weekends and on statutory holidays. A measure was taken for handling not to scatter sludge and slurry into nearby residential areas, together with a safety measure during the operation at a high spot.

2.2. Ground Condition

The soil borehole log is shown in **Fig. 1**. It may be seen that the ground consisted of yellowish grey weathered mudstone with sand at depths ranging from 1 to 10 m. At depths between 10 and 15 m, the ground was composed of dark grey and almost uniform mudstone with mica pieces, pumice and sand. At depths ranging from 15 to 32 m, the ground was dark grey sandy mudstone with pumice, shell and mica pieces, and with occasional mudstone. This suggests that the overall ground condition is hard mudstone, and that the ground would be heated up and become cohesive upon rotary cutting by the Gyropress Method.

The *N*-value increases from 70 to 150 in a section at depths between 3 and 19 m, while it increases from 150 to about 200 at depths ranging from 19 to 32 m.

The site was located on a hill, and the ground consisted of slopes with the elevation differences less than 200 m in a square kilometer. Liquefaction was judged to be unlikely. This project was divided into two sections which were conducted in order: the mountain side where elevation was high; and the valley side where elevation was low.

Currently there are no tall buildings or stations, just residential houses are built along the slope. Judging from the fact that the main transportation means of nearby residents is automobile or bus, it is recognized that this is a relatively calm and quiet area.

2.3. Structural Type

A plan view of a portion of the site adjacent to residential houses is shown in **Fig. 2**. The structure of the wall is cantilevered retaining wall built with steel tubular piles with a diameter of 800 mm. The typical cross-sections of the wall are shown in **Fig. 3-a** and **3-b**.

2.4. Piling Method

As the project was conducted in a quiet residential area, the client had to select a construction method in which the environment was sufficiently taken into consideration. The Gyropress Method (Press-in Method assisted with rotary cutting) was adopted, since it gives full attention to nearby residential houses, not spoiling the local cityscape. In addition, it was adopted since the Gyropress Method could cope with stiff ground assumed from the soil borehole log.

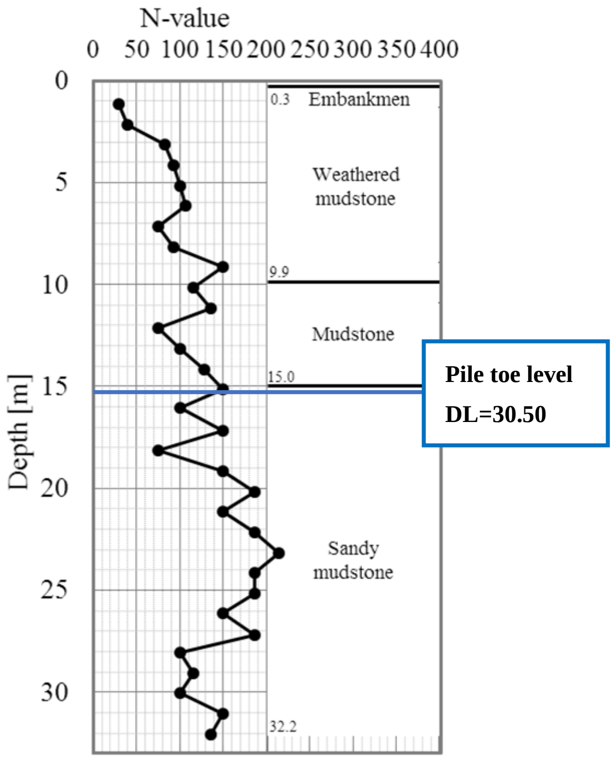

Fig. 1 Soil borehole log

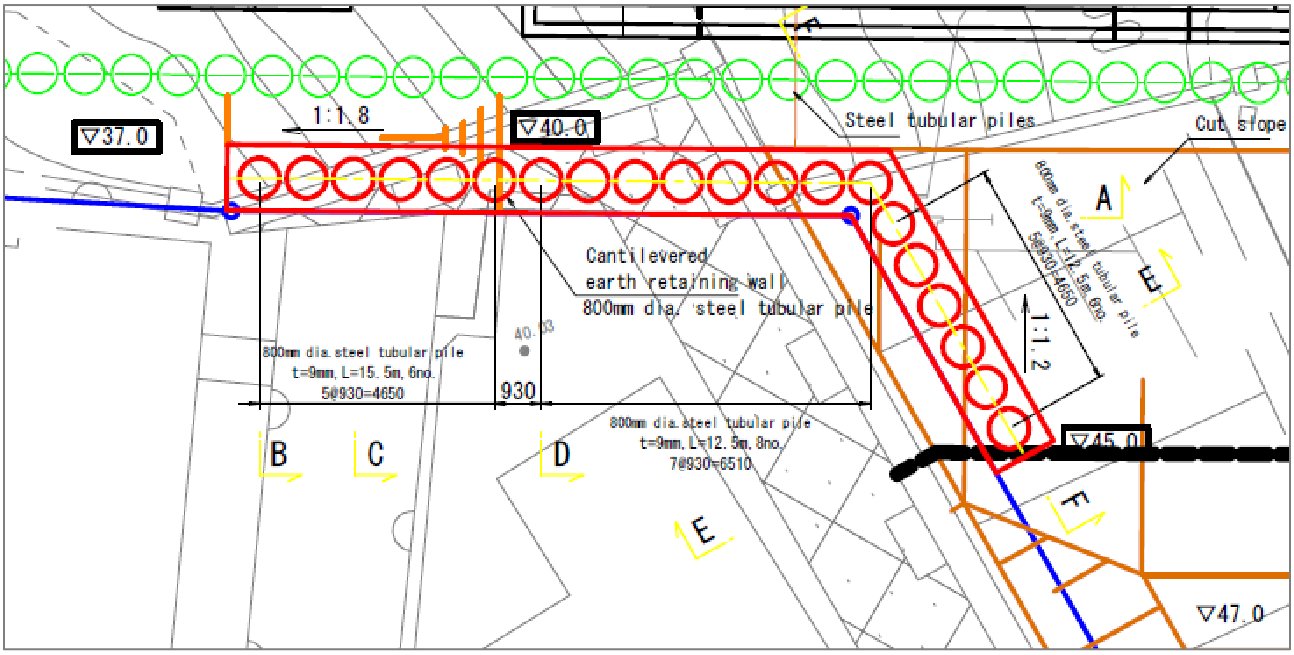

Fig. 2 Plan view of the site adjacent to residential houses

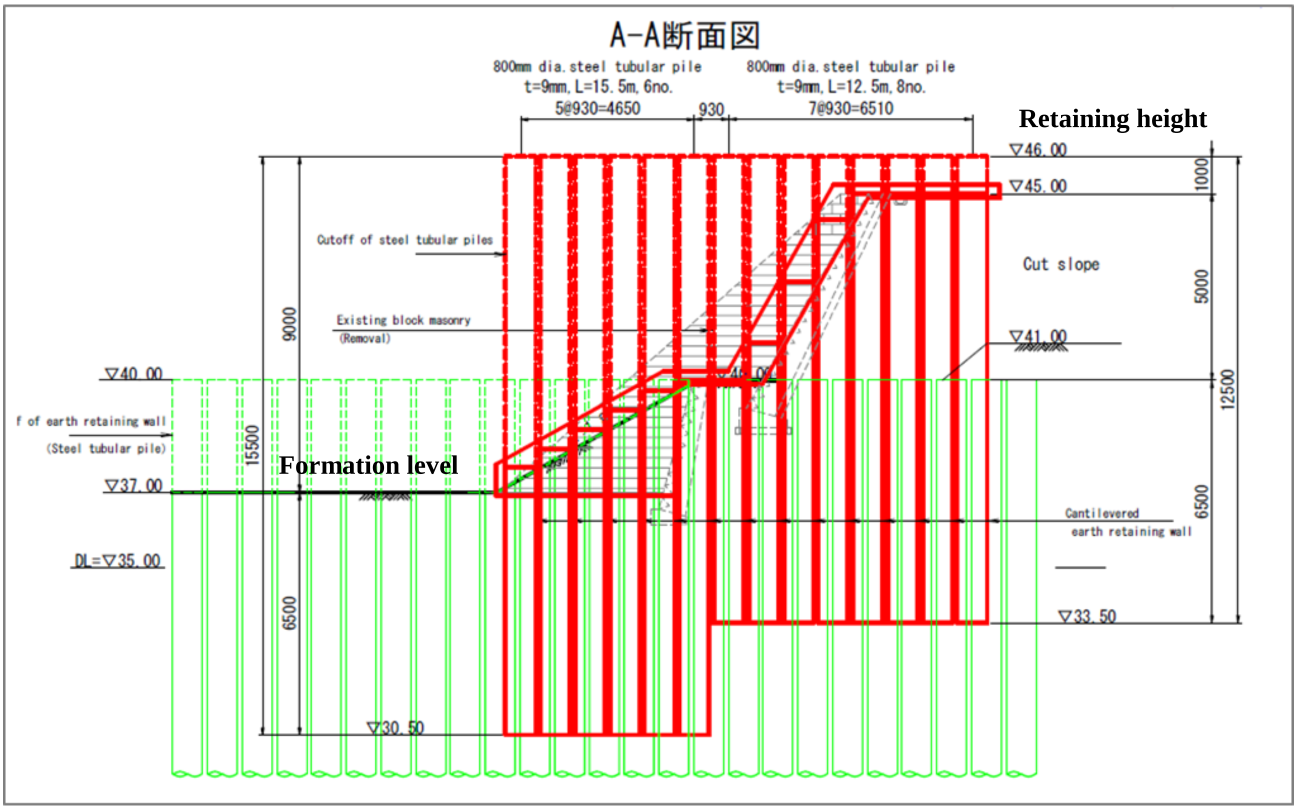

Fig. 3-a Typical cross-sections of the wall

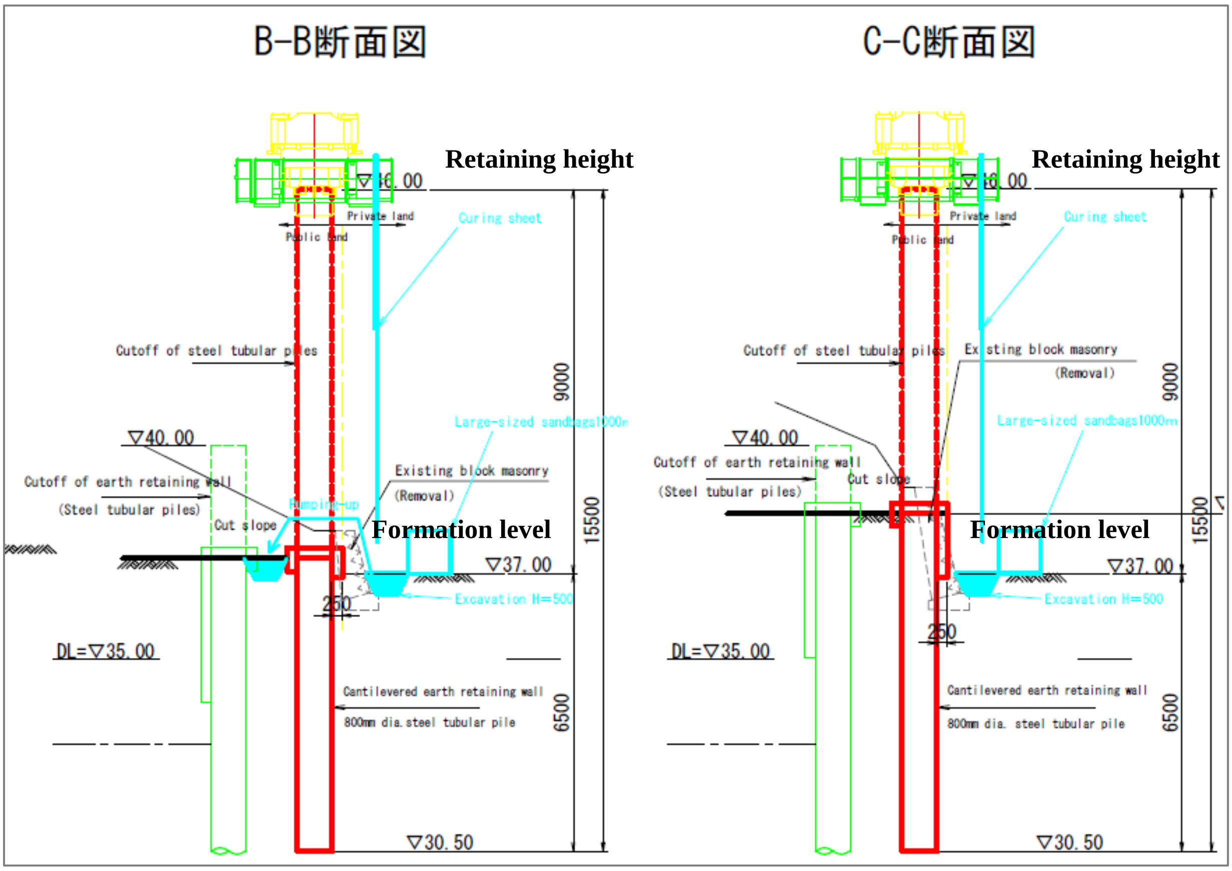

Fig. 3-b Typical cross-sections of the wall

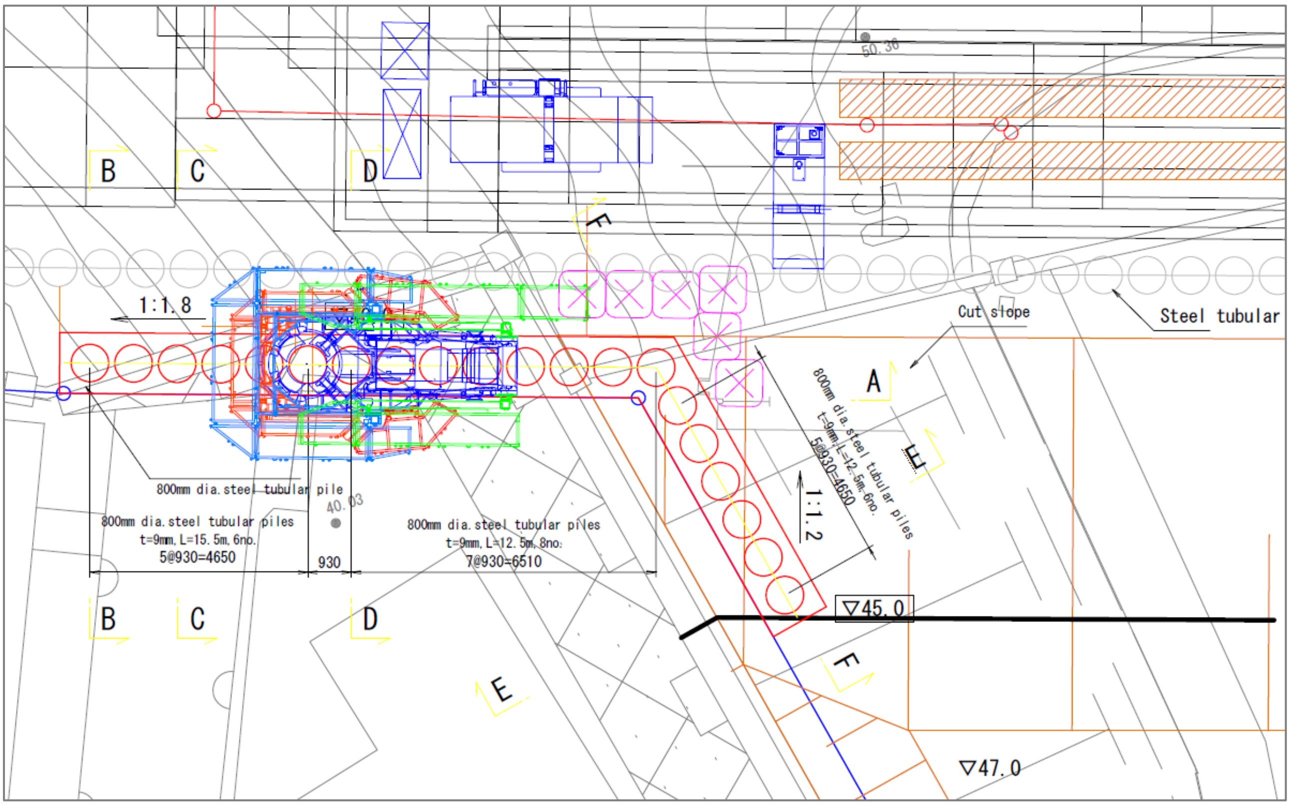

Fig. 4 Layout of the machine layout

3. PRESS-IN PILING

3.1. Layout

Fig. 4 shows a layout of the site in the press-in operation of steel tubular piles adjacent to residential houses. The construction was carried out at the height of about 8 m, and the lower part of the figure was facing the residential houses with a separation of mere 1.5 m at the closest point. The top part of the figure shows that a construction material and equipment are arranged on the platform. A 90ton crawler crane is set beside a steel tubular pile.

The construction advanced from the right to the left in the figure. The pressing-in machine self-walked backward, and pressed-in piles in the direction from the top to the bottom. In the operation at the corner, dummy piles were pressed-in to reset up the pressing-in machine.

The press-in operation is shown in **Fig. 5**, referring to section A-A. Piles were installed very close to the residential houses, without removing existing structures, directly into a concrete retaining wall (**Fig. 6** and **Photos 1**). Steel tubular piles were cut to the planned level and the ground was levelled after building a cut slope (**Fig. 7**).

Fig. 5 Press-in operation (refer to section A-A)

Fig. 6 Installation adjacent to residential houses

Photo 1. Installation of steel tubular piles directly into concrete retaining wall

Fig. 7 Cut steel tubular piles after the excavation

3.2. Piling Data

The press-in piling data regarding press-in and extraction forces are collected in **Fig. 8**.

The noise made by the heavy machinery was minimized by reducing the rotation speed of the steel tubular pile.

Note the amount of water flow supplied by the water lubrication system to the inside of the steel tubular pile was kept smaller than that to the outside, so that water inside the pile would not leak out.

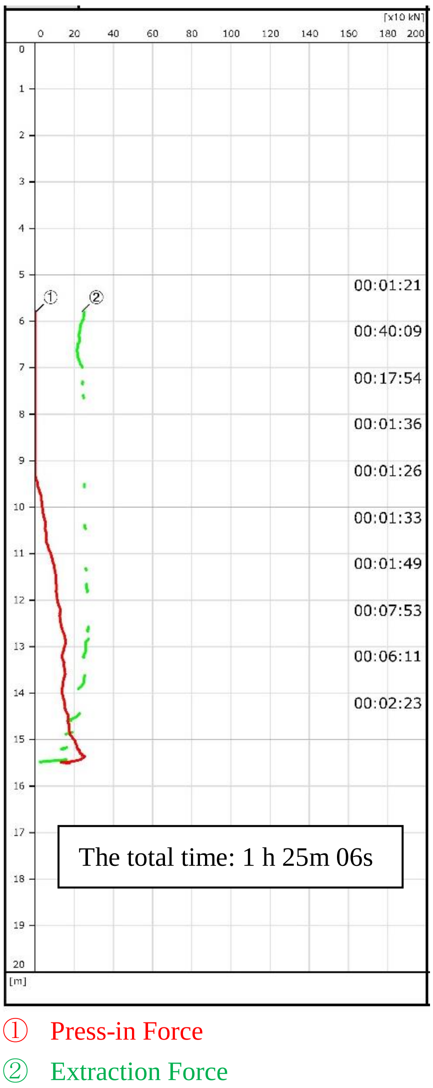

Fig. 8 Press-in monitoring data

3.3. Productivity

Construction of the retaining wall lasted for about 7 months between June 12, 2017 to January 18, 2018. The detail information of the installed steel tubular piles is shown in **Table 1.**

Table 1. Specification of the installed tubular piles

Specification	Qty
800mm dia. tubular piles, t=9, L=12.5m	14no.
800mm dia. tubular piles, t=9, L=15.5m	6no.
800mm dia. tubular piles, t=9, L=20.0m	41no.
800mm dia. tubular piles, t=9, L=24.0m	41no.
800mm dia. tubular piles, t=9, L=26.0m	28no.
800mm dia. tubular piles, t=9, L=32.5m	30no.
1,500mm dia. tubular piles, t=9, L=16.0m	24no.
1,500mm dia. tubular piles, t=9, L=18.0m	24no.

3.4. Encountered Difficulties and Measures Taken

3.4.1 Encountered difficulties

In the installation of steel tubular piles adjacent to residential houses about 1.5 m away at the closest point, it was likely that concrete pieces and injected water would scatter if piles were directly pressed into the concrete retaining wall at a high spot. In addition, to consider vibration and noise, the torque level had to be suppressed.

When pressing-in an 800 mm diameter steel tubular pile, sludge swelled out from the inside of the pile about 3 m and hindered the driving attachment[1] setting. Soil had to be removed manually. This took time, and daily progress of the construction became worse. Furthermore, water sludge as well as soil sludge was erupting from the pile top, it was likely for them to scatter over nearby houses. This might have happened by the following reason. Since the diameter of the steel tubular pile was small, when pressed into stiff ground that had been consolidated, the ground increased its volume. Swollen soil found way to the inside of the steel tubular pile, the only open space available, and might have erupted.

By rights, this is a problem that can be solved by the excavation before pressing-in the piles. However, the piles had to be installed adjacent to residential houses, and it was not possible to excavate a trench more than a certain amount.

[1] The special attachment used to drive pile until the pile top is completely buried in ground

3.4.2 Countermeasures taken

At the site, the countermeasure was taken against scattering objects. The pressing-in machine was covered with a 10 m x 10 m curing sheet to avoid visual sense of pressure and scattered objects. Where the retaining wall was likely to collapse, iron plates were set as a precaution. In addition, sprinkling water on the outside of the steel tubular pile, powders of the ground concrete were suppressed, and the pile was cooled down. At the lower part of the retaining wall, a supervisor was stationed. Monitoring the vibration and noise level measuring instrument, rotational speed of the pressing-in machine was controlled. When vibration level reached 65dB and/or noise level reached 75 dB that are restriction standard values of this project, a red light came on.

For the eruption of sludge and slurry from inside of the steel tubular pile, the following measures were taken. When the soil upheaval became more than 3 m, pre-cutting was applied. For the pre-cutting operation, the pre-cutting piles were fabricated using the dummy piles previously used at the site. The use of the pre-cutting pile was proposed and decided in consultation with the client and the prime contractor. Since the length of dummy pile was long, more than 10 m long, the piles were cut in such a way that they could be enough in the amount to control the erupting soil, and their lengths were safe to handle. A special jig was also fabricated to remove the soil inside the steel tubular piles. The jig was with a pointed H beam welded vertically onto the base iron plate (**Photo 2** and **3**). The soil stuck inside the steel tubular pile would not drop just by shaking it, so the protruded part of the H beam was inserted into the steel tubular pile, and the soil inside was scoured off by rotating the chuck of the pressing-in machine.

3.4.3 Results of Countermeasures

As for the countermeasure for scattering objects, vibration and noise were lower than usual since the rotational speed limit was kept, and the construction could be carried out without a complaint from the residents. In addition, construction was completed without scattering sludge and slurry over nearby houses.

For the soil eruption from inside of the steel tubular pile, though not in the design for the pre-augering pile, a toe bit was attached and used, soil removal time was shortened by about 60 minutes per pile, compared with manual soil removal.

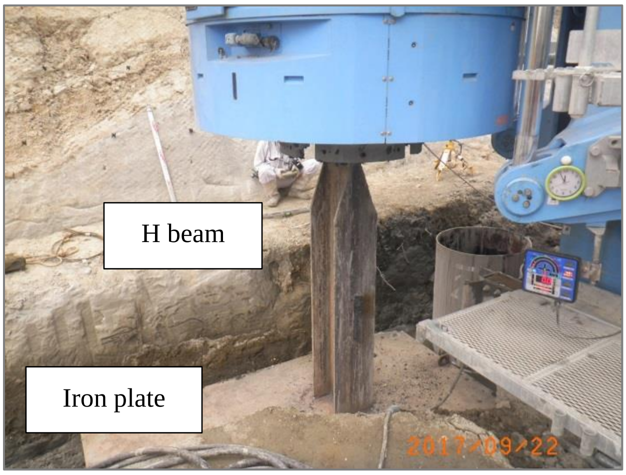

Photo 2. Jig for the removal of soil inside the steel tubular pile

Photo 3. Pre-cutting pile

4. ADDITIONAL DATA

Vibration and noise levels at the time of construction adjacent to residential houses are listed in **Table 2**. The restriction standards for vibration and noise levels of this project are 65dB and 75dB. **Table 2** shows average values for each hour for the working time between 8 AM to 5 PM and 1 hour before and after the working hours, including works by other companies at site. It may be seen that no data exceeded the restriction standard values. It may be said that the solid press-in operation with reduced rotational speed was successful. It may however be seen that the noise level was somewhat higher than the vibration level. It is therefore thought that paying more attention to the noise level will be more desirable in future, when carrying out construction with consideration to nearby residents.

In addition, as a means of conversation at site, the workers were equipped with wireless phones, which might have contributed a little to the favorable result of the project.

Table 2. Values of measured vibration and noise levels

2017/8/10

Time	Vibration level (dB)	Noise level (dB)
	Aveage	Aveage
7:00	27.6	57.3
8:00	30.8	59.1
9:00	46.6	66.8
10:00	54.2	67.2
11:00	49.2	65
12:00	37.1	59.5
13:00	49	63
14:00	54.5	63.2
15:00	37.6	61.8
16:00	36.7	63
17:00	33.1	58.5
18:00	35.6	55.2

2017/8/26

Time	Vibration level (dB)	Noise level (dB)
	Aveage	Aveage
7:00	33.3	51.5
8:00	33.9	49.8
9:00	40.2	65.8
10:00	42.3	63.7
11:00	42	67.8
12:00	36.2	52.8
13:00	42.6	68
14:00	43.2	65
15:00	41.3	62
16:00	40.8	58.1
17:00	33.5	54.1
18:00	33.3	53.6

5. CONCLUDING REMARKS

In such a site like this case where the neighborhood residents' living should be taken into consideration as the top priority, it is a decisive factor in adoption of a machine that enables environmentally friendly construction which can cope with stiff ground leaving the existing structures intact like the Gyropress Method. Its true value is demonstrated when installing piles adjacent to structures. Since it is possible to press-in piles into existing structures directly, construction could be conducted in a shorter period of time with less labor. It is really important for neighborhood residents that the construction was completed in a short period of time, for seeing a heavy machine in front of their houses may give them a sense of pressure. As in this site, to cope with the soil erupted from the inside of small-diameter steel tubular piles which were pressed into ground that was likely to plug up, although it might have been possible to press-in main piles, as specified in the design, the point was to accommodate pre-augering pile that was not specified in the design, judging from the effects on the construction progress and nearby residential houses.

It is expected that the Gyropress Method will be used more widely in future in constructions under similar ground conditions and status by making use of the data of vibration and noise as well as the press-in construction data and consequently by realizing constructions in harmony with the local environment