Construction example of a retaining wall by Combi-Gyro Method

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ABSTRACT

The steel sheet pile retaining wall can be constructed to have high water stopping capability, but when used as a retaining wall, it often lacks sufficient rigidity. In the Combi-Gyro Method™, Hat-type steel sheet piles are used as water-stopping walls, and steel tube piles are driven along with them to enhance the rigidity of the wall, making it suitable for use as a self-supporting retaining wall. One of the advantages of the Combi-Gyro Method is that it allows both the press-in of Hat-type sheet piles and the rotation driving of steel tube piles with a single press-in machine. This paper introduces construction examples of the retaining wall built using the Combi-Gyro Method. In this project, an integrated retaining wall was built at the newly established road intersection on the cut slope. The construction length of the sheet pile wall was 143 meters, with a total of 159 Hat-type steel sheet piles of type 10H, ranging in length from 7.0 to 9.5 meters. Eighty-two steel tube piles, each with a diameter of 800 mm, a thickness of 9 mm, and lengths varying from 13.5 to 16.0 meters, were installed. The completion of the sheet piles and steel tube piles required 45 working days.

Key words: *Retaining wall, Combi-Gyro Method, Hat-type sheet pile, Tubular pile, Water jetting*

1. Outline of the project

1.1. Place

Ikoma City is situated about 20 km east of Osaka and is a city at the northwestern edge of Nara Prefecture. Even in urban areas, there are scattered small hills and mountains, resulting in a complex terrain with many undulations. The Kiyotaki-Ikoma Road is a major highway that connects various areas, including Osaka City, eastern Osaka Prefecture, northern Nara Prefecture, and southern Kyoto Prefecture, along National Route 163. It is an 11-kilometer-long road running from Nakano, Shijonawate City, Osaka Prefecture, to Shikanohata-cho, Ikoma City, Nara Prefecture.

1.2. Background and objectives of the project

The development of the Kiyotaki-Ikoma Road has led to the formation of a network, playing a significant role in supporting regional revitalization. This includes facilitating the increase in the number of universities and private research facilities in the Kansai Cultural Academic Research City, as well as contributing to a substantial increase in population. The road aims to alleviate traffic congestion and ensure traffic safety due to the increasing traffic volume resulting from the development of the Kansai Culture and Academic Research City.

2. Structural type and piling method

2.1. Site condition

The newly constructed road will intersect with the old road after passing through the hilly area. The ramp to be installed here will be constructed by cutting the slope of the hill, necessitating the construction of a retaining wall on the hill side of the ramp. The plan considered a self-supporting retaining wall using steel sheet piles and

soldier piles. Although there are methods that use a vibratory hammer to install H-shaped steel piles alongside sheet piles, this cannot be used in this site due to the construction site being situated midway up a hill, with no barriers between the installation site and nearby residential houses, resulting in direct transmission of vibration and noise. Therefore, the Combi-Gyro Method, which allows for rotational cutting and press-in of steel pipe piles, was adopted. The piler, F301, enables the installation of both Hat-type sheet piles and steel pipe piles by simply changing the attachments on a single machine.

2.2. Ground condition

Fig. 1 shows the soil profiles together with the result of standard penetration test. The ground at the site consists of gravel-mixed clayey sand down to a depth of more than 20 meters. The top 2 meters of the surface have an SPT *N*-value of 5 or less, and the *N*-value is around 20 near the depth of 9 meters, but generally, it is a stratum having *N*-value of equal to or less than 10. Therefore, it was judged that the driving of steel sheet piles would be sufficient with a standard press-in method.

2.3. Structural type

Fig. 2 shows the structure diagram of the retaining wall. On the mountain side, 159 sheets of 10H Hat-type sheet piles with lengths of 7.0 to 9.5 meters were installed. For every other sheet pile, steel pipe piles with a diameter

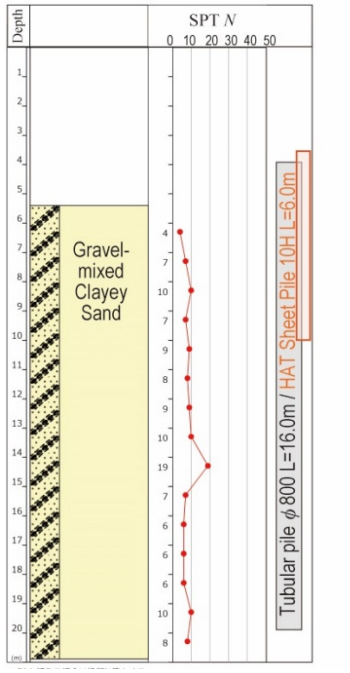

Fig. 1 Soil profiles

of 800 mm, thickness of 9 mm and lengths of 13.5 to 16.0 meters, totaling 82 piles, were installed on the road side. After the road side was excavated to the designed road level, the Combi-Gyro retaining wall was covered with decorative concrete.

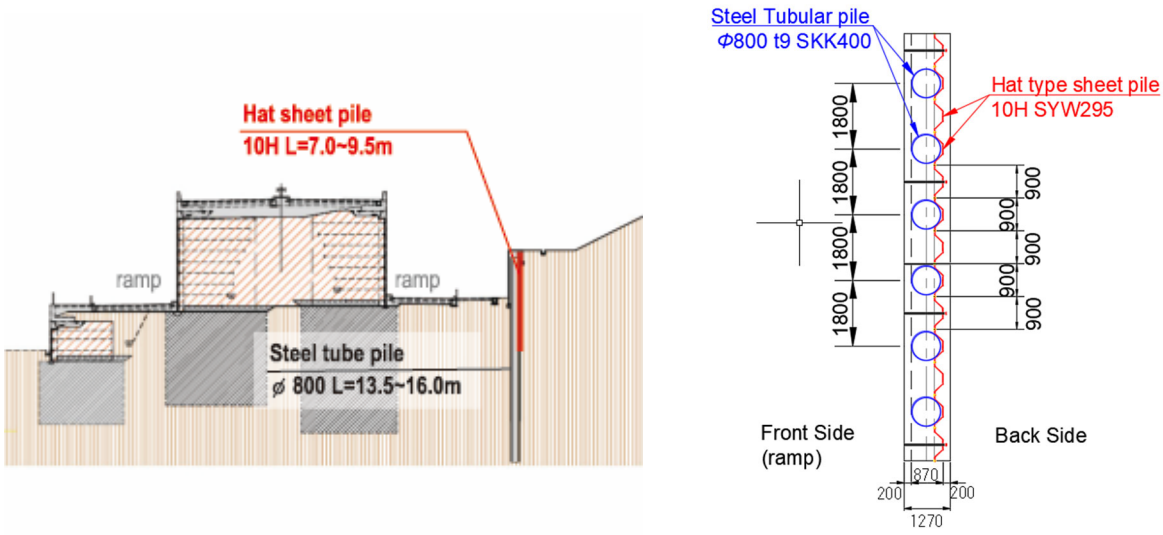

Fig. 2 Structure diagram of the retaining wall

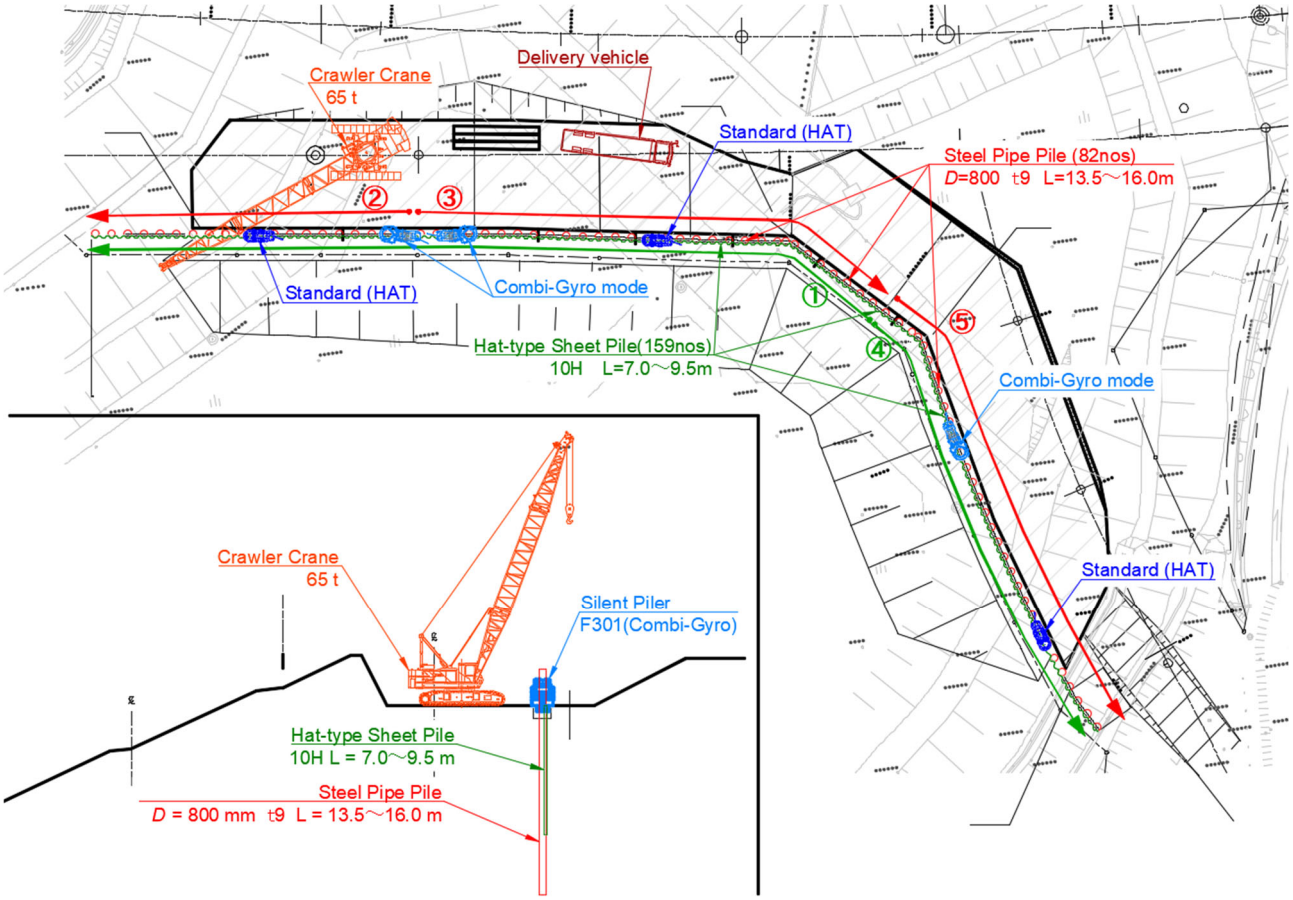

Fig. 3 The layout of the construction site

2.4. Piling method

From the soil profiles, it seemed that the Standard Press-in method would be sufficient for installing the Hat-type steel sheet piles. Since the steel pipes would be installed by Gyropress, a water jet system was prepared as an alternative to the water system for lubrication during the rotary cutting press-in procedure and brought to the site.

In reality, due to the adhesive force being stronger than anticipated and the press-in process taking longer than expected, water jetting was used for the Hat pile installation, instead of the standard pressing-in. This caused a reduction of piling duration.

3. Press-in piling

3.1. Layout

Fig. 3. shows the layout of the site. The planned Combi-Gyro retaining wall extends for a total length of 143 meters. It is structured with two inflection points along the middle of the hillside. Due to its location on a slope, the work yard could only secure a minimum width of 7 meters to a maximum of 12 meters, almost parallel to the retaining wall.

For the tandem crane operation, a 65-ton crawler crane was used, and the press-in machine was F301, which is compatible with the Combi-Gyro system. The specifications of F301 are as shown in **Table. 1**.

In the press-in work, Hat-type steel sheet piles were first driven into the ground. The piler was equipped with a chuck device that was replaced with a gyro chuck, and steel pipe piles were driven into the Hat pile from above, following along the Hat piles. The arrows and circled

Table 1. Silent Piler Specifications

F301 Combi-Gyro mode	
Applicable sheet piles	Hat-type: 10H, 25H, 45H, 50H
Applicable Tubular piles	ϕ800, 1000 mm
Max. Press-in Force	1000 kN (Standard/Water Jet mode) 800 kN (Combi-Gyro mode)
Max. Extraction Force	1200 kN (Standard/Water Jet mode) 850 kN (Combi-Gyro mode)
Gyration Torque	600 kNm
Stroke	850 mm
Press-in Speed	2.0 ~ 43.5 m/min
Extraction Speed	1.5 ~ 32.3 m/min
Control System	Radio Control
Movement	Self-Moving
Mass	12250 kg (Water Jet mode) 15500 kg (Combi-Gyro mode)

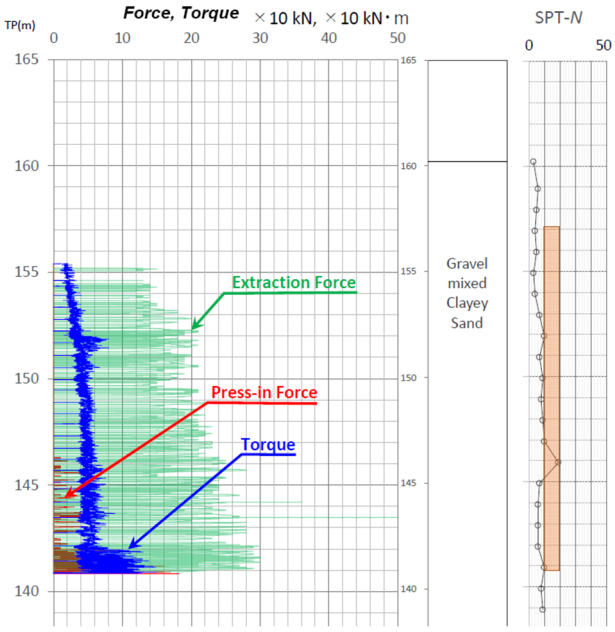

Fig. 4 Example data of Gyro press-in

numbers along the pile line in **Fig. 3** indicate the direction and order of pile construction. Numbers 1 and 4 represent the installation of Hat sheet piles, while numbers 2, 3, and 5 represent the installation of steel pipe piles.

3.2. Piling data

The first few sheet piles were installed by the standard press-in method. It took almost an hour to install an 8.5 m sheet pile. The maximum press-in force exceeded 300 kN. Considering productivity, water jetting was used to reduce the duration of pile installation. The average duration of pile installation with water jetting was decreased by a half hour. The maximum press-in force was also decreased to around 240 kN. The water jet undoubtedly contributed to shortening the construction period.

For tubular piles, the press-in data was as shown in **Fig. 4**. In the Gyropress Method™, almost no press-in force is required, so in the graph, the press-in force is nearly zero. Although an extraction force of about 200 kN is observed, considering the weight of the chuck device, 75 kN, it is thought to be effectively around 100 kN. Furthermore, the maximum rotational torque recorded near the final depth is approximately 150 kN. During the final 1 meter of penetration, the water supply was stopped, causing the press-in force and rotational torque to increase. The average duration of pile installation was around 40 minutes.

3.3. Productivity

The installation of steel sheet piles was generally at a construction rate of 10 sheet piles per day. Additionally, the steel pipe piles had a productivity rate of 3 or 4 piles per day. It required 45 working days to complete both 159 sheet piles and 82 pipe piles.

3.4. Encountered difficulties

In Japan, especially near residential areas, a two-day weekend system is often adopted, and this site was no exception. Therefore, there was always a demand for shortening the construction period. To address this issue, the time required for driving steel sheet piles was halved by utilizing water jets in conjunction with the driving process (**Fig. 5**).

In the Gyropress Method using steel pipe piles, it is common to install water piping inside the tubular pile to upply lubricating water. Installing piping in all the piles not only takes time but also incurs the cost of materials for the piping that will ultimately be buried and left in

Fig. 5 Press-in with water jetting for Hat pile

Fig. 6 Water jet pipe installed inside the tubular pile

Fig. 7 Pipe stopper equipment

Fig. 8 Pipe guard angles for jet pipe

place. Therefore, similar to the installation of sheet piles, by attaching a jet nozzle to the inner tip of the tubular pile and connecting a jet pipe to it, it is possible to pull out the jet pipe after the completion. This approach significantly reduces material costs and piping time, thereby greatly contributing to the shortening of the construction period. **Figs. 6, 7, 8** show the piping of the water jet system for the Gyropress Method.

4. Consideration for the environment

As seen in **Fig. 9**, the site is located midway up a hill, in an environment without any barriers to the surrounding houses. Therefore, construction using vibrating methods such as vibratory hammers or other relatively noisy machinery is challenging. To increase the strength of the sheet pile retaining walls, a structure combined with H-beams is sometimes used, but the installation of H-beams raises concerns about environmental impact. Considering the advantages of the Combi-Gyro Method, which allows for the combination of Hat-type sheet piles with steel pipe piles using the same machine, there is hope for the expansion of this construction method.

Fig. 9 Overview of the construction site

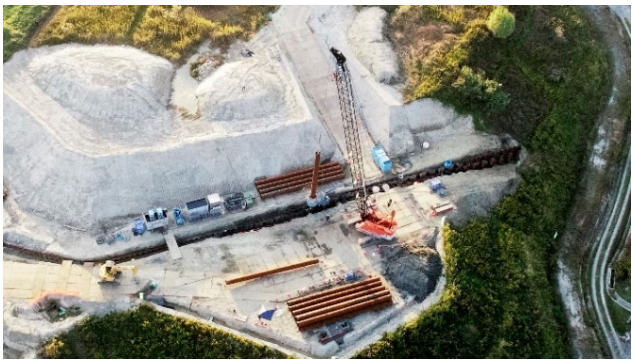

Fig. 10 Steel tube pile being installed

Fig. 11 Completion of Combi-gyro wall

Fig. 12 Completion of the architectural concrete wall

Fig. 13 Completion of the architectural concrete wall

5. Concluding remarks

For the retaining wall of the ramp for the Kiyotaki-Ikoma Road, a structure using sheet piles and steel pipe piles through the Combi-Gyro Method was adopted. A total of 159 Hat-type steel sheet piles and 82 steel pipe piles were completed within a 45-day construction period, with construction carried out in a way that minimized the impact on the surrounding environment. The use of water jets in conjunction with the construction was attempted, contributing significantly to the reduction of both the construction period and costs.

The Combi-Gyro Method is a construction technique that allows for the installation of both sheet piles and steel pipe piles using the one piler machine by changing attachments. It has been reconfirmed to be particularly useful in construction sites where vibration and noise are concerns for the surrounding environment.

6. Acknowledgements

The authors express gratitude to all individuals involved in this project, whose contributions have been invaluable to the completion of this paper.

We also extend our appreciation to all parties involved in the construction work for their cooperation and support.

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