Proceedings of the Second International Conference on Press-in Engineering 2021, Kochi, Japan – Matsumoto et al (eds)

Construction of retaining wall for river disaster restoration by Gyropress Method

K. Matsuzawa, T. Hayashi & K. Shirasaki
SATO JUKI Corporation, Niigata & Tokyo, Japan

ABSTRACT: A river improvement project has been conducted at the left bank of the Kinugawa River in Chikusei City. The project consisted of the works of levee heightening, construction and renovation of the riverbank and the sluiceway. The repair work of the Ezure water discharge channel was performed using a steel tubular pile wall as a main structure of the retaining wall of the sluiceway. Twenty-five tubular piles were installed at the point where the discharged water flows into the Kinugawa River. The wall was constructed in a hat-shape layout to protect both banks of the mainstream and the sluiceway. The Gyro Piler was set at the pile top level, 3.0m higher than the current bank crest, using a reaction base and reaction sheet piles (type 4). In a construction period of one-month, the tubular pile wall had been constructed steadily. Details of the piling work are reported in this paper.

1 OUTLINE OF THE PROJECT

1.1 *Place*

Chikusei City is located in the northwestern part of Ibaraki Prefecture and about 70km away from the center of Tokyo. Paddy cultivation is prosperous being blessed with the water supply from many rivers for many years. The cultivated area for rice field accounts for about 40 percent of the total area of the city. And the total agricultural field occupies more than half of the city.

1.2 *Background and objectives of the project*

The Kinugawa River is the first-grade river which flows through the eastern Kanto Plain from north to south, and confluents the Tonegawa. It is the longest tributary of the Tonegawa with the total length of 176.7km.

The Kinugawa has been called *the Abaregawa* in Japanese, which means a rampaging river, and the residents have suffered from the damage of the flooding frequently. By heavy rain which occurred in September, 2015, a flooding disaster occurred in the lower stream and the middle of the Kinugawa at 97 places including one bank collapse and seven floods.

The bureau, *Ministry of Land, Infrastructure, Transport and Tourism, Kanto Regional Development Bureau*, has promoted a large-scale countermeasure project for preventing a flooding disaster which will occur again from now on. Raising and extension of the riverbank was one of the major constructions for the project.

At the meeting point of Ezure discharge channel and the mainstream, a construction of a retaining wall which would supply a sluiceway for preventing flowback of the mainstream to the inland was done. Steel tubular piles were used as a main structure of this retaining wall. They were installed by means of the press-in method with gyration.

2 STRUCTURAL TYPE AND PILING METHOD

2.1 *Site condition*

Photo 1 shows the preparation of the construction yard for the piling. The piling work was performed on the left bank of the Kinugawa River. The high-water floor was used for the construction road, the working space for the crane and stock yard for the tubular pile materials. Because the pile top level was designed at 3.0m higher than the current levee crest, the reaction base for the Gyro Piler had to be set at that level using reaction sheet piles. Eighteen reaction piles,

DOI: 10.1201/9781003215226-47

Figure 1. Perspective view of the pile wall and raised levee.

Photo 1. Preparing construction yard.

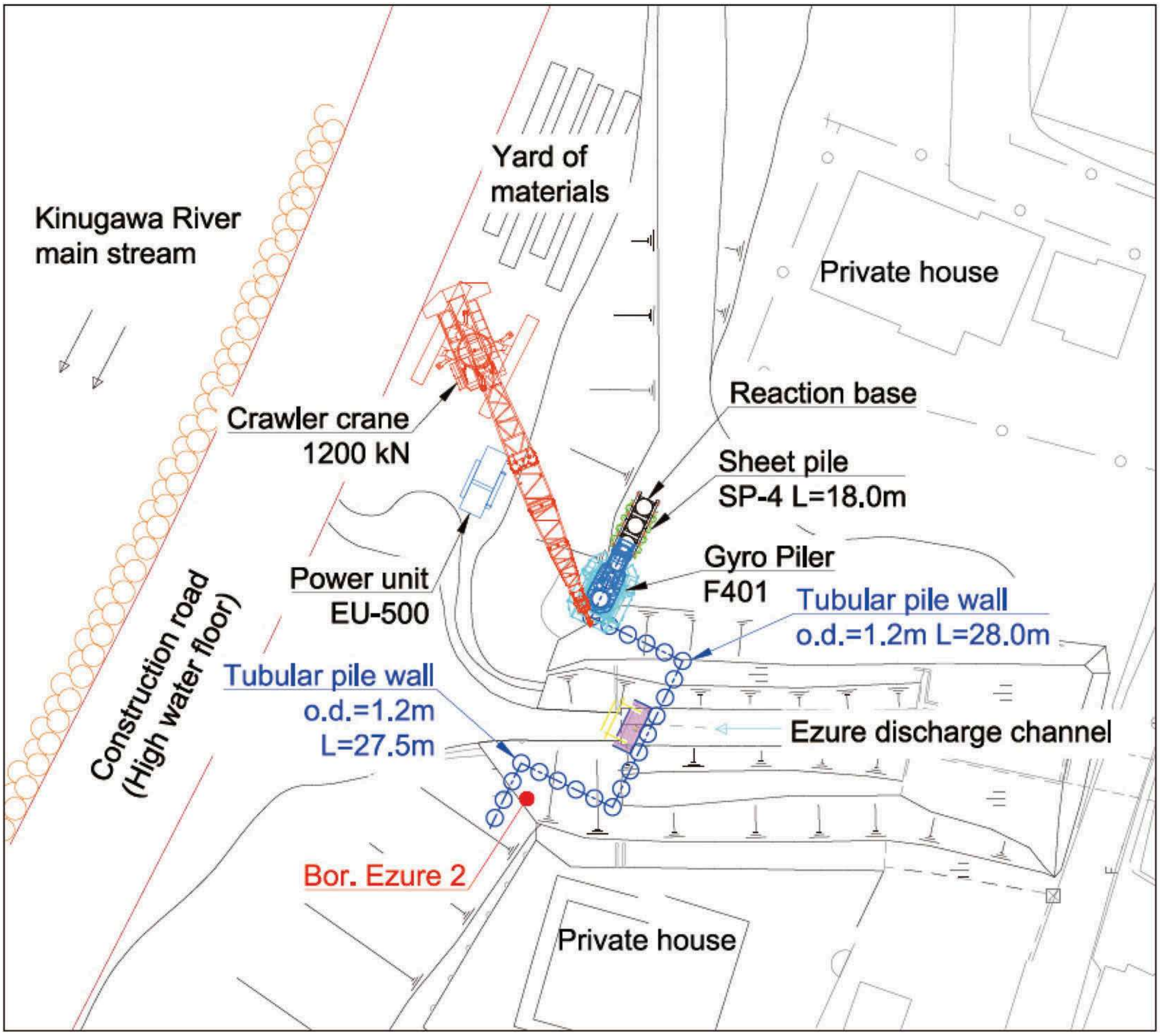

Figure 2. Layout of the piling site.

having length of 18m, were installed by a vibratory hammer before the procedure of press-in work.

2.2 *Ground condition*

Figure 3 shows soil profiles and SPT *N*-value at the nearest point of the pile wall. The condition of the ground is as follows.

Near the ground surface there was a refilled material with a thickness of 1m, overlying 7m thickness of clay and a silt layer with SPT *N*-values of 2 or 3. A fine sand layer having thickness of 8m and SPT *N*-value over 50 was laid at the depth of 10m to 17m from the ground level. Below the 17m was the silt layer with *N*-value of 20 to 30. At the depth of 20.8m, fine sand containing gravel, with *N*-value over 50, was laid for the bearing layer. The piles were penetrated 1.4m deep into the bearing layer.

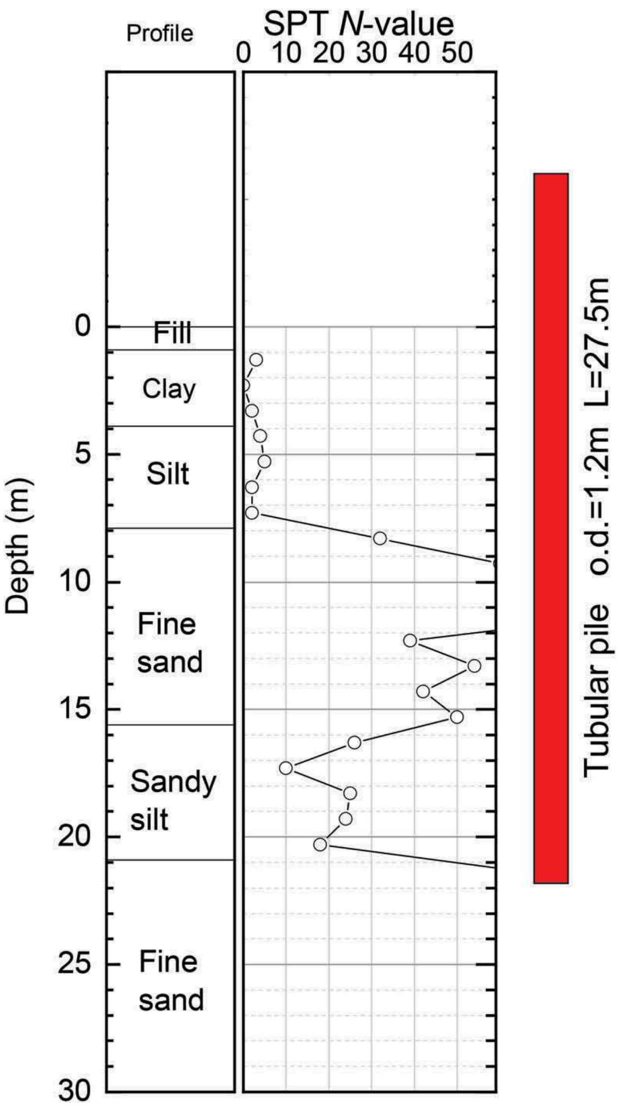

Figure 3. Soil profile with SPT *N*-value.

2.3 *Structural type*

Figure 4 shows a structural drawing of the retaining wall. The twelve piles installed to the upstream side had a diameter of 1200mm, a thickness of 12mm and a pile length of 28.0m. The rest, downstream side piles, had the same diameter, a thickness of 14mm and a length of 27.5m. They were installed with a spacing of 1,448mm from center to center. The datum line of piles formed a hat shape, or a crankshaft shape, in the plan view. The upper part of the central three piles were cut and removed at the bottom level of the discharge channel for the construction of the culvert and the flap gate.

2.4 *Piling method*

In order to install steel tube piles into a fine sand layer, with SPT *N*-value more than 50, the press-in method with gyration was adopted. It was also easy to cut the concrete blocks which covered the surface of both slopes of the discharge channel without pre-removal. As shown in Figure 4, 1200mm diameter steel tubular piles were used as the main structure of the wall. The pile materials were divided into two upper and lower members and spliced with circumference welds during gyration press-in.

As mentioned above, eighteen sheet piles were driven by the vibratory hammer as reaction piles as shown in Photo 2. The piling machine was supported steadily in the initial stage of piling.

Lubricating systems were used to reduce friction resistance by the surrounding soil and to prevent plugging of internal soil during gyration. A pair of pipelines supplied water at the pile toe. Pipes were protected by the covering angle, protector steel bar and internal cutting bit as shown in Photo 3.

A pair of equal angle steel were used as closure piles between two adjacent tubular piles. They were also pressed-in after each tube had been installed. The enclosed space by two piles and a pair of angle steel was filled with mortar afterward for the purpose of sealing. (see Figure 4)

2.5 *Piler machine*

The Gyro Piler, F401-G1200, was used for the installation of tubular piles in this site. Table 1 shows the specifications of the piler machine.

3 PRESS-IN PILING

In this section, the author reports the data of the press-in, the cycle time record, recorded by the G-pad.

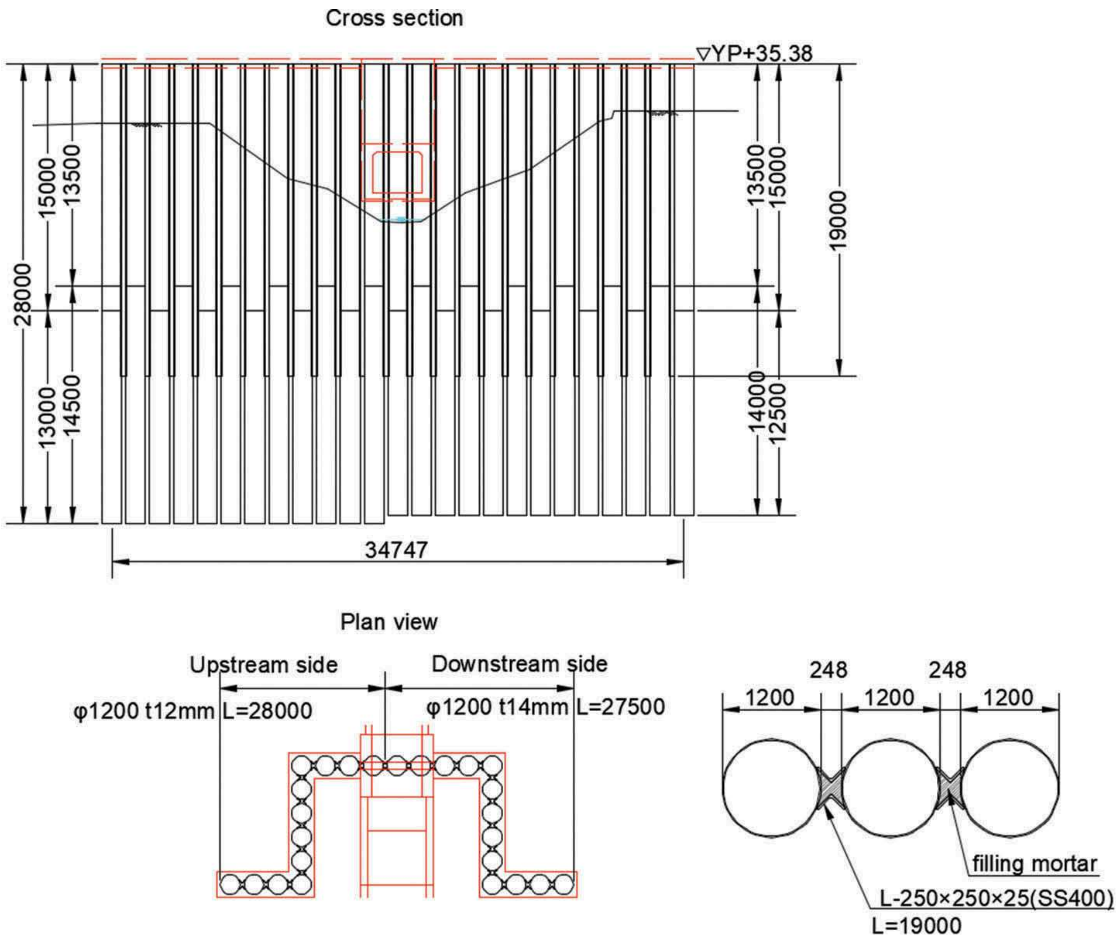

Figure 4. Structural drawing of the pile wall.

Photo 2. Reaction base supported by reaction sheet piles.

Photo 3. Internal pipeline for water supply.

The G-pad is a tablet PC which provides with the Press-in Assistance software. The operator of the piler can keep working while checking data such as press-in force, extraction force, gyration torque, and depth at the pile toe.

3.1 *Productivity*

Table 2 shows the typical duration of working procedure of piling. In this site, depth of press-in varied because the pile wall passed over the discharge channel as shown in Figure 4. The pile *Upstream No. 3* was the pile installed at the current levee surface, having the longest embedded length of 25m.

As shown in Table 2, it required about six hours of piling duration. In addition, extension of the scaffold was necessary according to the progress of each pile completion. In this site, we performed one pile per day steadily.

Table 1. Specifications of the Gyro Piler, F401-G1200.

Max. Press-in Force*	1500 kN
Max. Extraction Force*	1600 kN
Chuck Rotation Torque	900 kNm
Max. Chuck Rotation Velocity	11.0 rpm
Chuck Stroke	1000 mm
Press-in Speed	0.7 to 4.9 m/min
Extraction Speed	0.7 to 3.5 m/min

* for gyration use

Table 2. An example of durations of piling procedures.

Procedure (Depth m)	Duration (min.)	Elapsed time (min.)
Lower pile installation and center adjustment	27	27
Gyration press-in (6.0 m)	53	80
Pitching of Upper pile	20	100
Welding	35	135
Nondestructive inspection of welded joint	15	150
Gyration press-in (23.0m)	90	240
Setting of driving equipment	15	255
Successive Gyration Press-in (25.0m)	45	300
Angle steel press-in (both riverside and landside)	50	350
Total Gyropress duration	350	

3.2 *Encountered difficulties*

The concrete blocks for shore protection had been laid over the surface of the slope of the existing riverbank and the slopes of the discharge channel. At the initial gyration, we needed to take care that a tubular pile did not incline. It was better to reinstall the pile after the pile toe had passed over the thickness of concrete blocks. There was a tendency for the pile toe to be pushed out toward the downside of the slope. Piles were extracted and reinstalled after removal of concrete blocks with checking verticality and centering. Photo 4 shows the condition of the initial gyration.

After the pile installation, a pair of equal-angle steel was penetrated by pressing-in, in order to shut-up the interspace between the two piles. Because the length of the angle steel was 19m, it seemed difficult to install with no twisting and detaching from the surface of the pile. In order to overcome this problem, a few guide pieces were attached to the pile surface as shown in Photo 5. These were effective to support the angles during installation, which ensured the required quality for following sealing mortar injection.

During the piling procedure, the data concerning press-in were monitored and recorded by the G-pad.

Photo 4. Concrete blocks cut and removed.

Photo 5. Guide pieces attached on the pile surface to prevent deviation of angle steel.

The data sheet from Upstream No. 3 is shown in Figure 5. Press-in force, extraction force and gyration torque were recorded with respect to the level of the pile toe. YP(m) in this graph means Yedogawa Peil and it is 0.84m higher than T.P. (Tokyo Peil) which is used widely in the Greater Tokyo.

The graph shows that large press-in force is not necessary to penetrate tubular piles when using gyration. The maximum press-in force was about 300kN. In the graph, press-in force of 900kN were often recorded. But it was considered that it happened only when gyration stopped for release and re-chucking the pile tube. In fact, the weight of chucking equipment and the tubular pile itself should be considered for the correction of the values of press-in and extract force. About 200kN should be added to the press-in force and should be deducted from the extraction force.

It was also obvious from the graph that gyration torque in sandy soil layer, both at the middle depth and the bearing layer, seems greater than those in silt and clay layers. The graph shows consistency with respect to the soil profile.

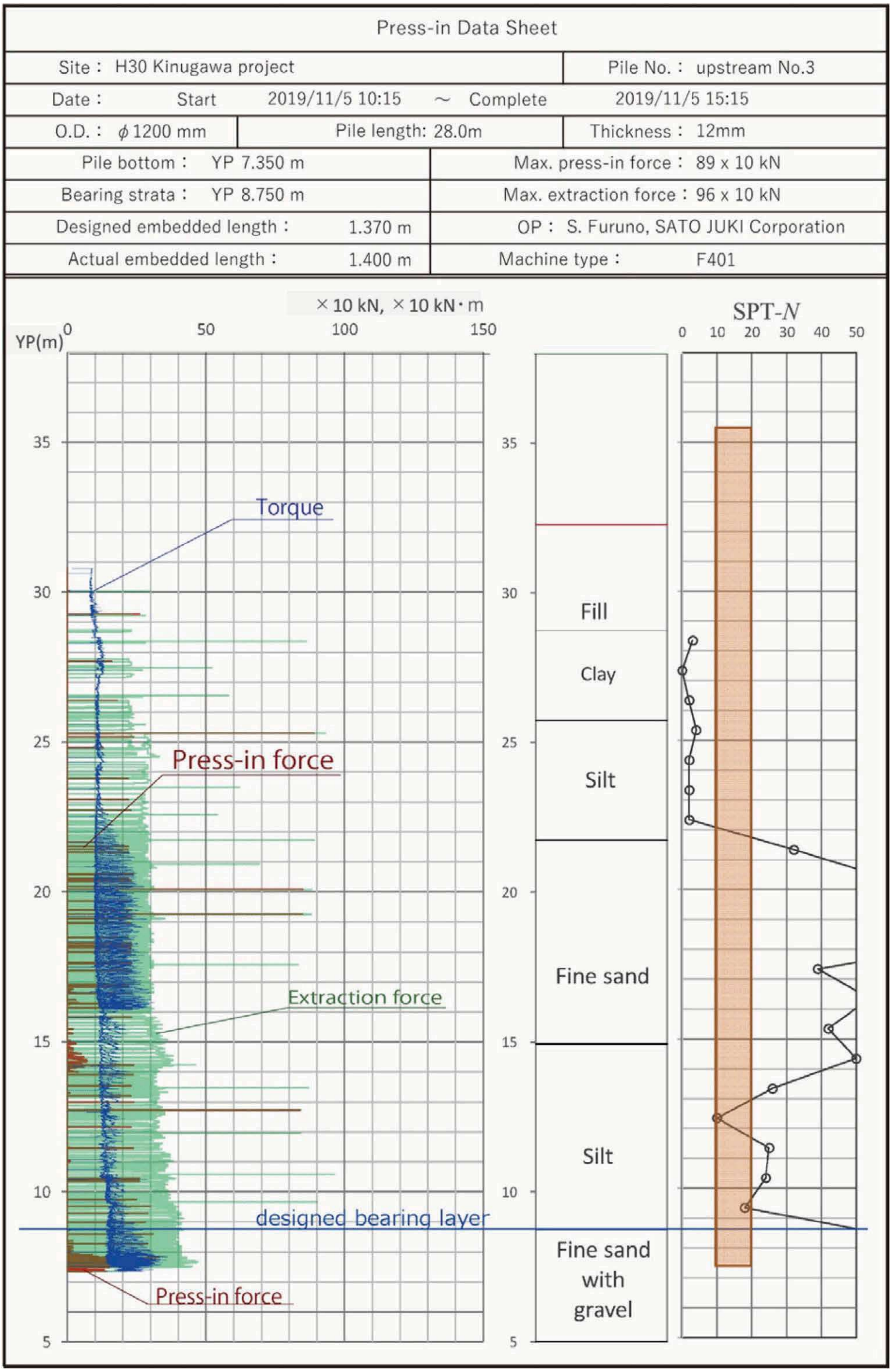

Figure 5. Press-in data sheet from *Upstream No. 3*.

3.3 *Quality control*

In order to secure the quality of piles, each piling procedure was carried out under strict quality control. Verticality and centricity of the pile and welding properties were inspected precisely.

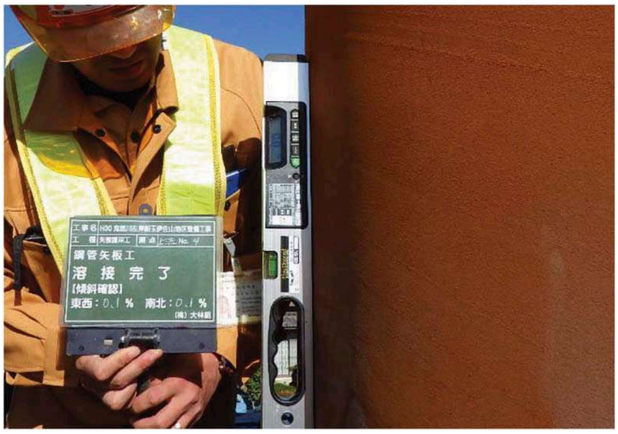

Photo 6. Measurement of verticality.

Photo 7. Checking root length and misalignment.

Photo 8. Verticality and centricity were surveyed during the piling procedure.

3.4 *Contribution to safety work*

Press-in work in this site was carried out at a high place, maximum 10m from the ground. It was necessary to build safe scaffolds coupled with the genuine

Photo 9. Piling work at high place.

Photo 10. Completion of the construction of the pile wall.

Photo 11. The Zero Piler used for sheet piling adjacent to the abutment structure.

Photo 12. Successive construction work for the sluiceway.

stages which were attached to the piler machine. These scaffolds have been used in successive works of the project after the series of pile work.

4 CONCLUDING REMARKS

Twenty-five steel tubular piles were installed by Gyropress method to construct the retaining wall for the Ezure discharge channel and the Kinugawa River.

The pile wall is still 3m higher than the current height of the riverbank, which would be raised in the near future.

Not only this pile wall, but many of sheet pile works and other tubular pile works were also used in this project as shown in Photo 11.

Press-in technology has been able to contribute widely to the countermeasure project and helped improve safety of the surrounding residents and their lives.

ACKNOWLEDGEMENTS

The authors express gratitude to people engaged in the Kinugawa left-bank countermeasure project, who recognized this paper contribution.

We also express gratitude to the persons concerned who cooperated with this construction work.

REFERENCES

K.S.S. Kinugawa Sagan Development Office, *http://kinugawa-sagan.com* (In Japanese)

Ministry of Land, Infrastructure, Transport and Tourism. Kanto Regional Development Bureau (M.L.I.T.), Kanto Regional Development Office. 2015. *About the flood damage in Kinugawa on H27.9 Kanto Tohoku torrential rain*. (In Japanese)

M.L.I.T., Shimodate River Office. 2019. *Aiming at reconstruction of consciousness for flood-defense*. (In Japanese)

Photo 13. Completion after providing with the flap gate at the center of the pile wall.