A Case Study of Design Change in the Press-in Method

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ABSTRACT

This paper describes a renovation work of the old Kaishin Bridge over a class-I Nishiyoke River in Kitanoda, Higashi-ku, Sakai, Osaka. The project was ordered by the Civil Engineering Office of Tondabayashi, Osaka. The site was near the station with a heavy traffic of vehicles and pedestrians, and the work had to be done adjacent to residential houses on both the sides of the river. Since steel sheet piles were used as a temporary earth retaining wall to remove an old weir and build a new abutment, the Press-in method with water jetting was selected at the design stage. However, the soil boring log showed the maximum SPT *N*-value is over 50, indicating that it might be impossible to press-in piles. Furthermore, there were possibilities that the sludge might flow into the river and the surrounding ground would be affected. Hence, the Hard Ground Press-in Method was selected instead, after the design change. The whole construction process including the pull-out works of steel sheet piles was completed by us, the prime contractor, Fujii Co., Ltd.

Key words: *Press-in Method with water jetting, Hard Ground Press-in Method, design change*

1. Outline of the project

1.1. Location

The construction work on the Kaishin Bridge over a class-I Nishiyoke River and in the river in Kitanoda, Higashi-ku, Sakai, Osaka. This was a renovation work for an old bridge and its abutment. We received this order for the lower structures as the prime contractor. The site was near the Kitanoda station of the Nankai Electric Railway with a heavy traffic of vehicles and pedestrians. Besides, it is adjacent to residential areas.

1.2. Background and objectives of the project

This was a renovation work of an old bridge. After building a temporary platform onto which the road is to be moved, the work should be continued while allowing traffic of vehicles and pedestrians. For this reason, the third-person disaster must not be allowed. In addition, since the site was adjacent to residential houses, it was necessary to minimize the environmental impacts such as ground displacement, noise and vibration.

2. Structural type and piling method

2.1. Site condition

The construction was carried out, moving the road onto the temporary platform on the downstream side, with vehicle and pedestrian roads close to each other. In addition, on both right and left river banks except on the road, this work was carried out in the construction yard adjacent to residential houses (**Fig. 1**).

2.2. Ground condition

According to the result of the standard penetration test (SPT *N*-value), both boreholes No. 7 and No. 8 were mainly in the sand and gravel layer, it was necessary to press-in piles in the ground with the maximum N-value over 50 (**Fig. 2**).

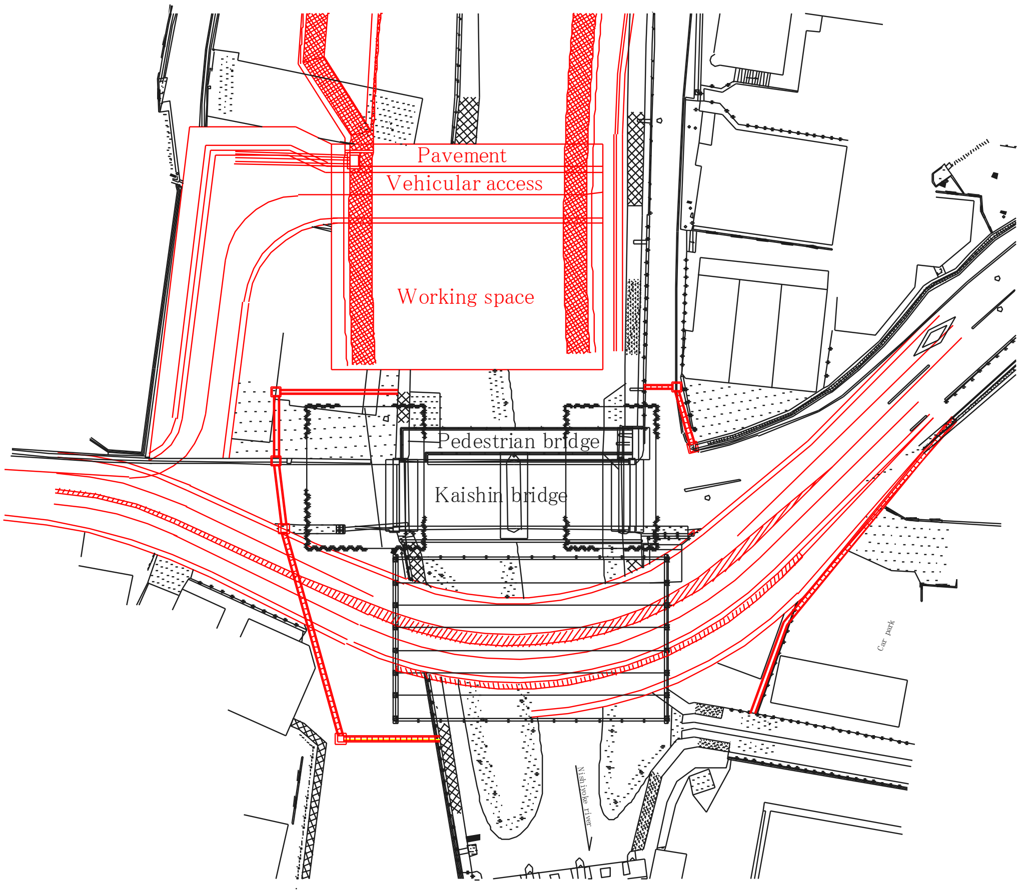

Fig. 1 Detour plan

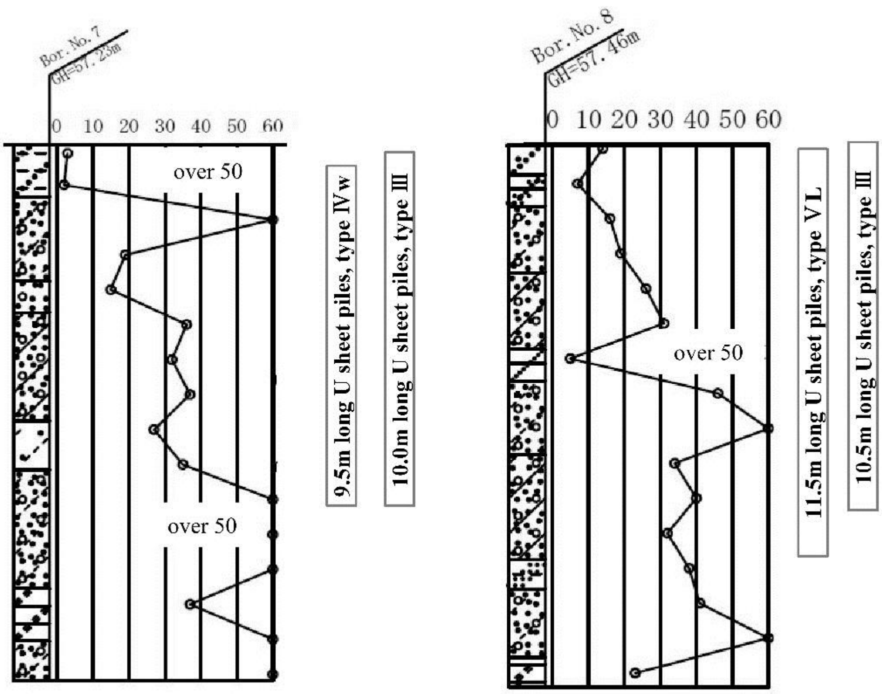

Fig. 2 Soil borehole logs

2.3. Structural type

1) Removal of the old weir

The steel sheet piles were pressed in as a temporary earth retaining structure on the right and left banks of the Nishiyoke River (**Figs 3** and **4**):

- Right bank:
  39 no. U-shaped steel sheet piles, type ⅤL, L=11.5m
- Left bank:
  26 no. U-shaped steel sheet piles, type IVw L-=9.5m

2) Construction of a new bridge abutment

The sheet piles were pressed in as a temporary cofferdam for the construction of a near bridge abutment (**Figs 5** and **6**):

- Abutment A1:
  98 no. U-shaped steel sheet piles, type III, L=10.00m
- Abutment A2:
  101 no. U-shaped steel sheet piles, type III, L=10.5m

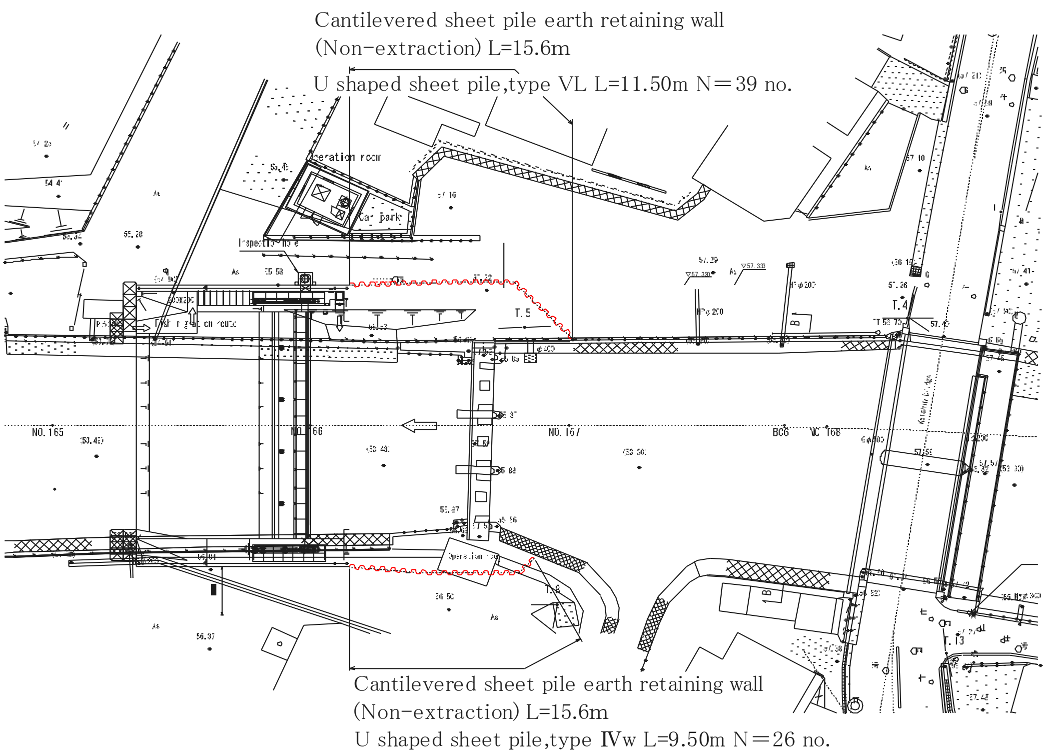

Fig. 3 Removal of old weir: Plan of temporary earth retaining structure

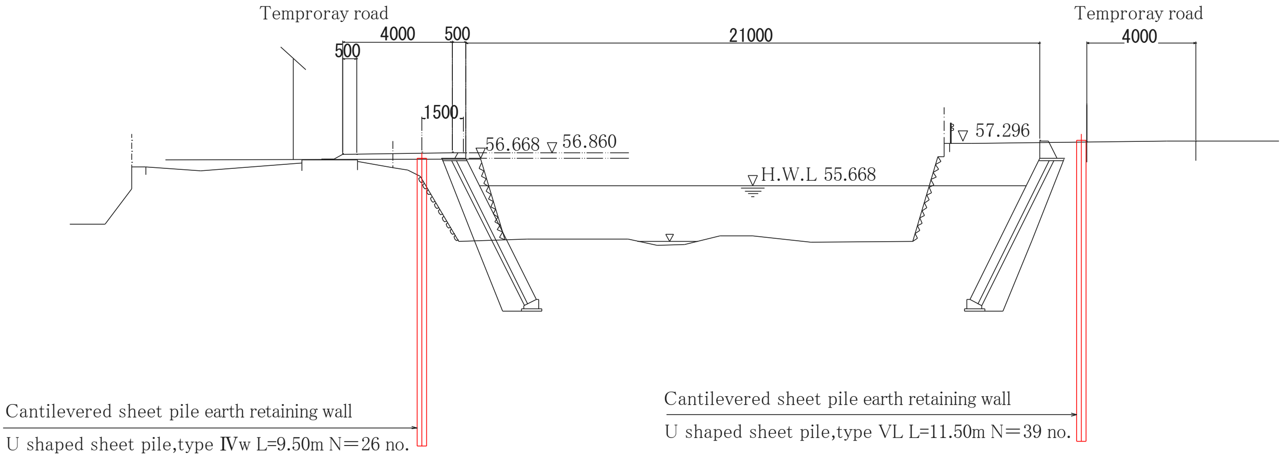

Fig. 4 Removal of old weir: Cross section of temporary earth retaining structure

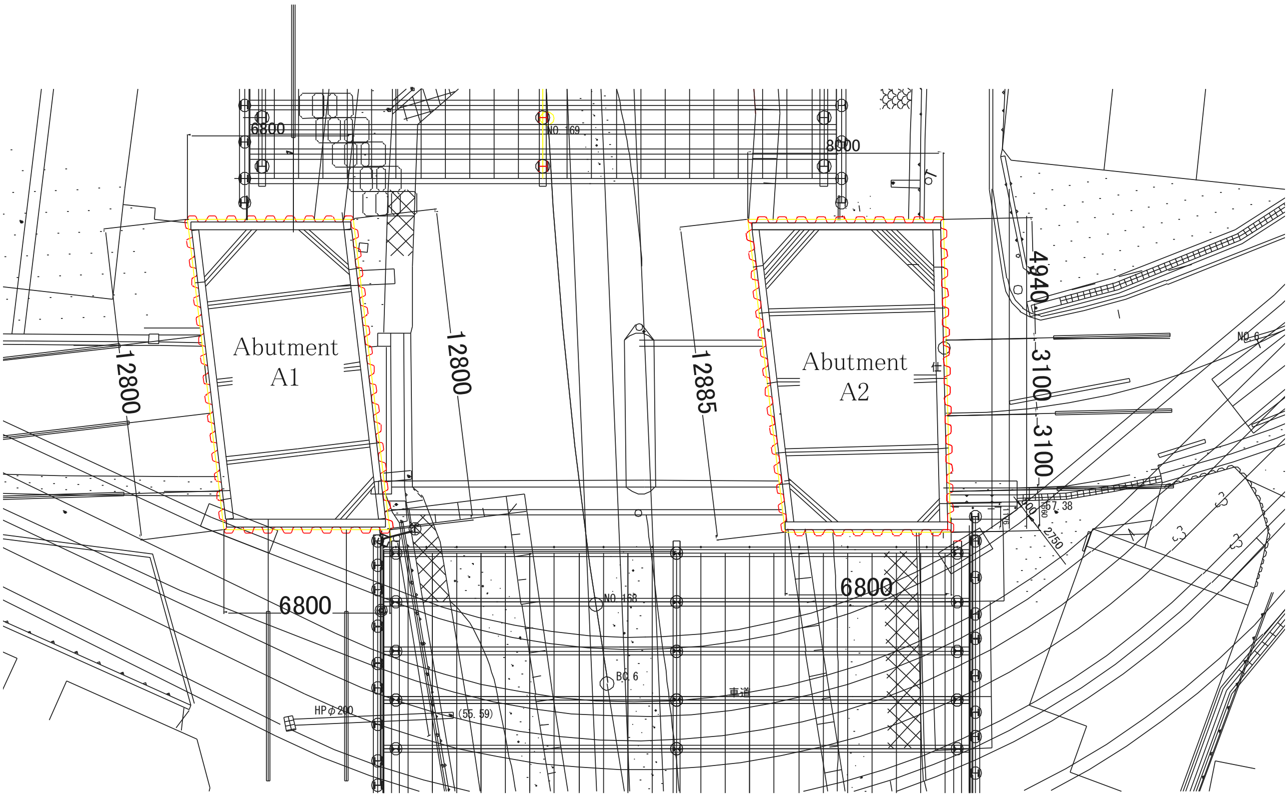

Fig. 5 New bridge abutment: Plan of temporary earth retaining structure

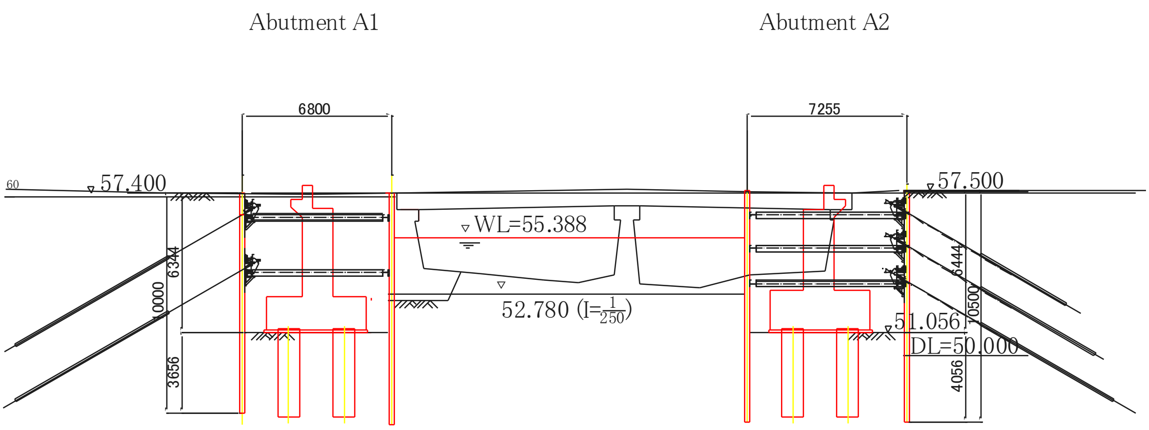

Fig. 6 New bridge abutment: Cross section of temporary earth retaining structure

2.4. Piling method

The Press-in Method with water jetting was selected for the original design. However, as shown in the soil boring log in **Fig. 2**, the maximum *N*-value exceeded 50 in some areas. According to Section 1) – 2: Selection of piling and appurtenant machines for hydraulic press-in/pull-out construction methods, Chapter 6: Temporary work in the estimation standard of civil engineering work by the Ministry of Land, Infrastructure and Transport (MLIT), a press-in machine capable of handling hard ground should be selected for the maximum N-value between 50 and 600 (MILT, 2017). Therefore, the original design was changed to the Hard Ground Press-in Method (**Table 1**).

Table 1. Selection of machine type and appurtenant machine

Type of work		Press-in operation		
Maximum N-value		$N_{max} \leqq 25$	$N_{max} \leqq 50$	$50 < N^{max} \leqq 600$
Type of steel sheet piles	Type Ⅱ, Ⅲ and Ⅳ	Engine type unit/emission control type (primary standard value) Press-in force 981 to 1,471kN Pull-out force 1,079 to 1,569kN		Engine type unit (for hard ground)/emission control type (2ndary standard value) Press-in force 800kN Pull-out force 900kN
	Type ⅤL and ⅥL	Engine type unit/emission control type (primary standard value) For wide steel sheet piles Press-in force 981 to 1,471kN Pull-out force 1,079 to 1,569kN		Engine type unit (for hard ground)/emission control type (2ndary standard value) For wide steel sheet piles Press-in force 800kN Pull-out force 900kN
	Types Ⅱw, Ⅲw and Ⅳw			
Appurtenant machine	For driving piles Water jetting	—	Engine type unit/emission control type (primary standard value) Pressure 14.7MPa Discharge 325ℓ/min	—

3. Press-in piling

3.1. Layout

1) Removal of the old weir

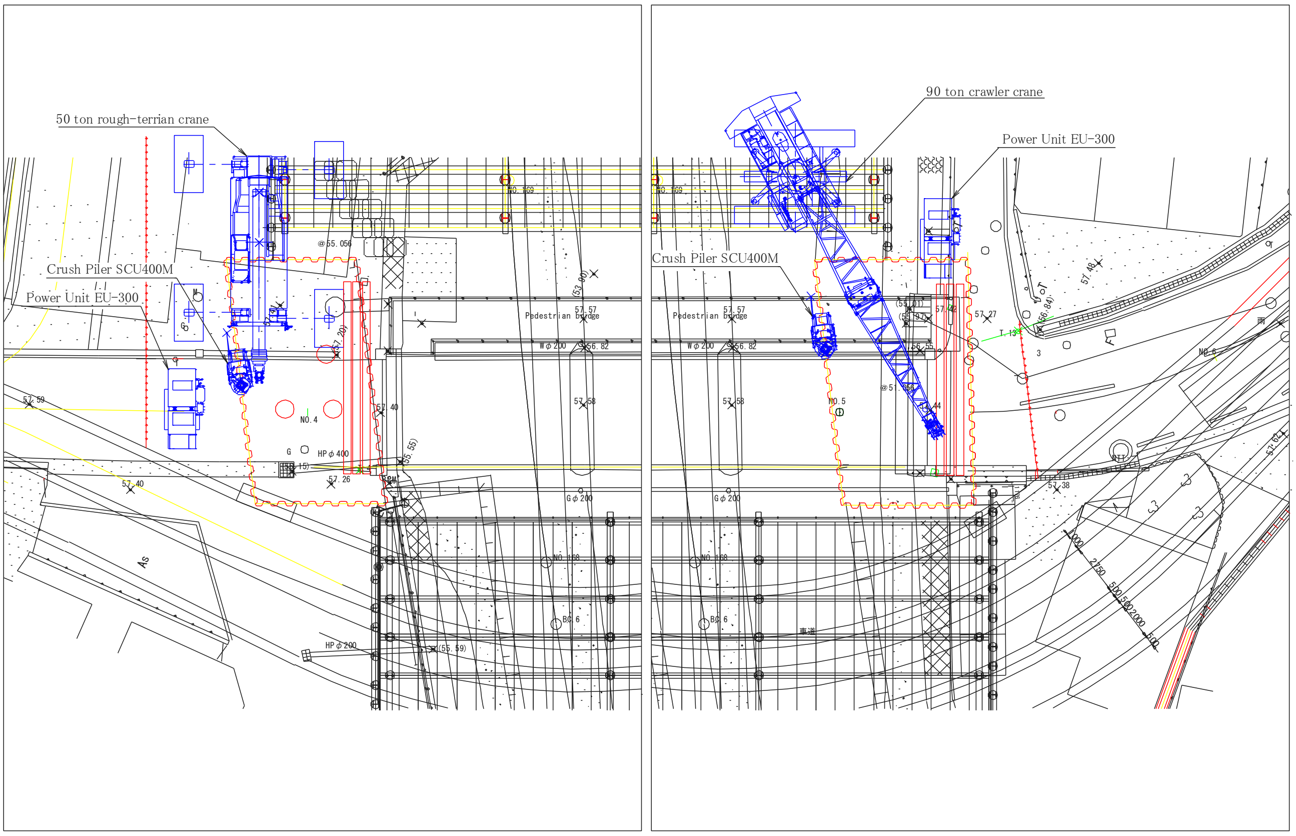

Fig. 7 Removal of historic spot: Plan of temporary earth retaining wall

2) Construction of a new bridge abutment

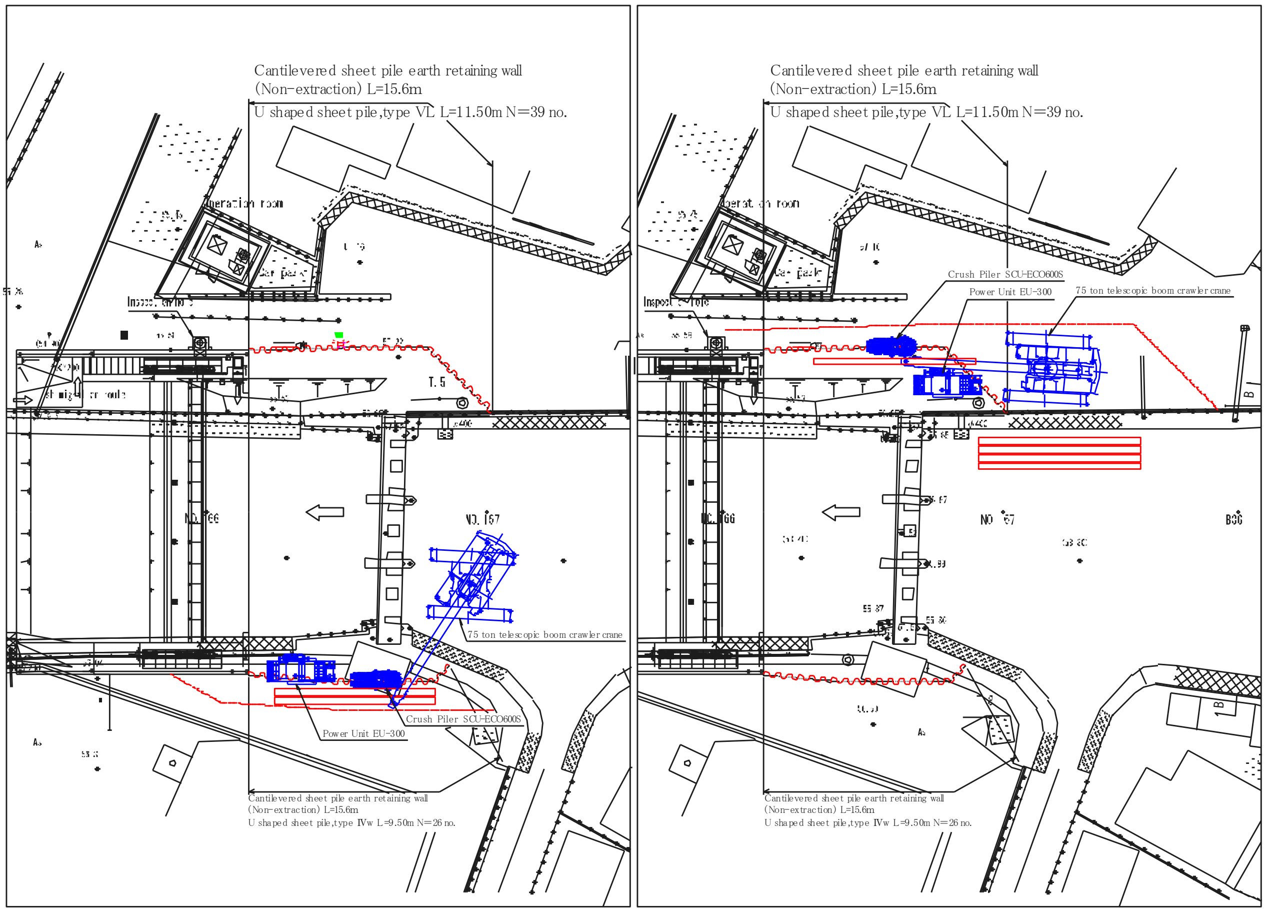

Fig. 8 New bridge abutment: Plan of temporary earth retaining structure

3.2. Piling data

1) Removal of the old weir

Compared with the assumed productivity per day in the estimation standard for the civil engineering work quoted in the material by MLIT, the actual productivity was lower than the estimated productivity. It was because the construction was implemented in a narrow site and the locations where the sheet piles could be pressed-in were limited, necessitating to have a set-up change on both right and left river banks.

2) Construction of a new bridge abutment

For Abutment A1, the actual productivity was larger than the estimated productivity. This was because the widest construction yard could be ensured in the site, and the construction condition was relatively in good environment. On the other hand, as for Abutment A2, the actual productivity per day was close to the estimation standard.

Table 2. Removal of old weir: Press-in construction data

	Specification/ number of sheets	Average number of installed sheets	Unit rate in the estimation standard※1	Remarks
Right Bank	39 no. U sheet piles, Pile length=11.5m Embedded length=10.5m type ⅤL	4.9 no./day	6.1no. /day (50＜Nmax≦100)	Narrow space With one set-up change
Left Bank	26 no. U sheet piles, Pile length=9.5m Embedded length=8.5m type Ⅳw	4.3 no./day	8.2no. /day (50＜Nmax≦100)	Narrow space, stepped section with one set-up change

Table 3. New bridge abutment: Press-in construction data

	Specification/ number of sheets	Average number of installed sheets	Unit rate in the estimation standard※1	Remarks
Abutment A1	98 no. U sheet piles, Pile length=10.0m Embedded length=9.0m type Ⅲ	12.3 no./day	9.2no. /day (50＜Nmax≦100)	Narrow space With one set-up change
Abutment A2	101 no. U sheet piles, Pile length=10.5m Embedded length=9.5m type Ⅲ	6.7 no./day	6.9no. /day (50＜Nmax≦100)	Narrow space, stepped section with one set-up change

3.3. Productivity

1) Removal of the weir

Table 4. Removal of old weir: Press-in construction data

	Specification/ number of sheets	Average number of installed sheets	Number of construction days	Remarks
Right Bank	39 no. U sheet piles, Pile length=11.5m Embedded length=10.5m type VL	4.9 no./day	11 days	Assembly/ disassembly with one set-up change
Left Bank	26 no. U sheet piles, Pile length=9.5m Embedded length=8.5m type IVw	4.3 no./day	9 days	Assembly/ disassembly with one set-up change

2) Construction of a new bridge abutment

Table 5. New bridge abutment: Press-in construction data

	Specification/ number of sheets	Average number of installed sheets	Number of construction days	Remarks
Abutment A1	98 no. U sheet piles, Pile length=10.0m Embedded length=9.0m type III	12.3 no./day	10 days	Two assembly /disassembly repetition
Abutment A2	101 no. U sheet piles, Pile length=10.5m Embedded length=9.5m type III	6.7 no./day	18 days	Assembly/ disassembly with one set-up change

3.4. Encountered difficulties

The Press-in Method with water jetting was selected for the original design. However, the design was changed due to the following challenges, according to the “Five Principles in Construction” (see **Photos 1** & **2**):

1) Treatment of sludge generated (contamination of the river)
2) Effect on the surrounding ground by water jetting
3) Effect on the existing levee
4) Difficulty in pressing in piles in the ground with N_{max} larger than 50
5) Scrapping ratio of pulled-out sheet piles

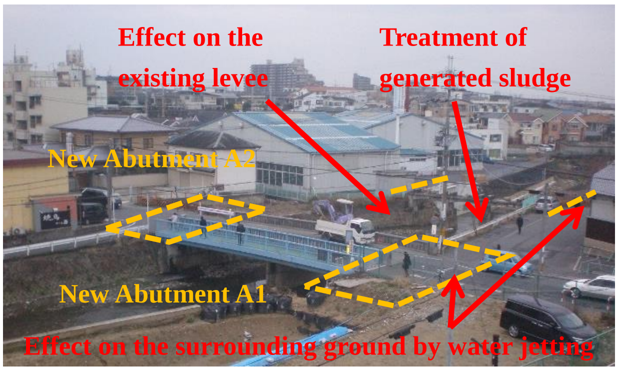

Photo 1. Construction site (before construction)

Photo 2. Construction site (during construction)

4. Concluding remarks

In this project, the Press-in Method with water jetting had been selected for the original design. However, since we had concerns about the difficulties described in the previous section, we talked with the client in advance, and it was agreed that the design be changed to the Hard Ground Press-in Method. In addition, our company was the prime contractor, and carried out the construction of the temporary earth retaining structure and temporary platform as the piling contractor at the same time. Usually the prime contractor makes the design change in consultation with the client, but in this case, we, as the specialty contractor, had an opportunity to take this role. So, this was one of the projects from which we could learn many things (**Fig. 9**).

It may appear that it was a simple design change from the Press-in Method with water jetting to the Hard Ground Press-in Method, but the same contractor did not only make a design change as both the prime and the specialty contractor in consultation with the client, but also carried out the construction as the subcontractor in a series of design change works. This unique situation gave us an opportunity to grow a great deal as a company. We believe that there must be other projects where a specialty contractor can act as the prime contractor, implementing the whole process from the supervision to the actual construction, and that there should be more projects to be implemented this way. From now on, even though we are a subcontractor as a piling contractor, we aim to be a company who can make suggestions without entirely depending on the prime contractor. (Kitamura, 2017) (GIKEN, 1967)

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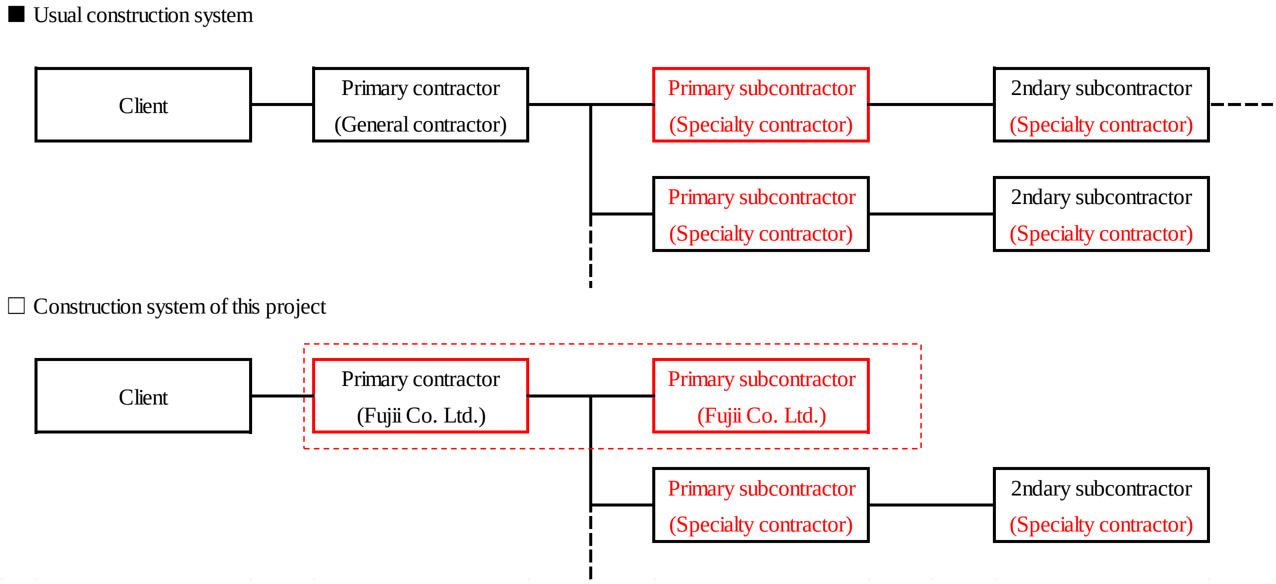

Fig. 9 Construction system diagram