Design and Installation of a Permanent Sheet Pile basement for the Manly Twenty95 Development

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ABSTRACT

Manly Twenty95 project is a luxury 6 story (24 apartment) residential development currently under construction in Sydney Australia. J Steel Engineering had been constructed the permanent 4 level basement for an integral automated carpark storage facility for this development in March 2018 using the ECO600S Silent Piler. Approximately 100m of sheet pile wall was required for the basement structure. 21m long, 600mm wide hot rolled U piles were installed with the Super Crush system in dense to very dense sands to support excavation depths of up to 12.5m. The bottom-up technique with temporary propping was adopted by the builder. This paper identifies and discuss the design and construction challenges for the permanent sheet pile basement, including; supporting large vertical column loads on the sheet pile wall, durability aspects for providing a life beyond 50 years, and interfacing with temporary and permanent lateral supports. In addition, the paper emphasizes interesting aspects related to the installation of the sheet pile system, including use of the Super Crush for installing long sheet piles and problem solving of any other issues that arised during the works.

Key words: Giken ECO600S, Permanent Sheet Pile Basement, Design, Axial load

1. Outline of the project

1.1. Place

The project site is located on the corner of the busy intersection of Belgrave Street and Sydney Road in Manly, Sydney, NSW Australia – a 5min. walk from the surf beach and opposite to Manly Oval. Adjacent to the site is an existing telecommunications exchange and a heritage listed sandstone church **(Fig. 1).**

Fig. 1 Site location

1.2. Background and objectives of the project

The project site is a small congested site approximately 1000m^2 in area. Grocon are developing the site into 4 levels of 1, 2 & 3 bedroom luxury apartments in addition to some commercial and retail space. To service the building, a 4 level automated carpark within a permanent basement will be constructed. A maximum excavation depth of ~12.5m is required to construct the carpark.

2. Structural type and piling method

2.1. Site condition

The site is within the busy commercial/residential precinct of Manly and was formerly used as a park/carpark **(Photo 1)**.

Due to the restricted site space and concerns regarding noise within the retail area and vibration damaging heritage listed buildings, suitable retaining wall systems were carefully considered.

Photo 1. Site Image

2.2. Ground condition

The site is underlain by Quaternary sediments comprising medium to fine grained marine sands. In this part of Manly, the sediments typically overlie Hawkesbury Sandstone at depths of 36 m to 39 m **(Table 1** and **Fig. 2)**.

The groundwater table is high, about 4m below existing ground surface (+5.5m AHD).

A number of CPT's and sampled boreholes were completed on site indicating loose to medium dense sand becoming dense then very dense.

Table 1. Idealised geotechnical design profile

Top of unit (RL m AHD)	Material	Cone resistance q_c (MPa)	Consistency
5.50	Sand (Fill)	10	Variable
4.50	Sand	5	Loose
1.00	Sand	10	Medium Dense
-11.70	Sand	28	Dense to Very Dense

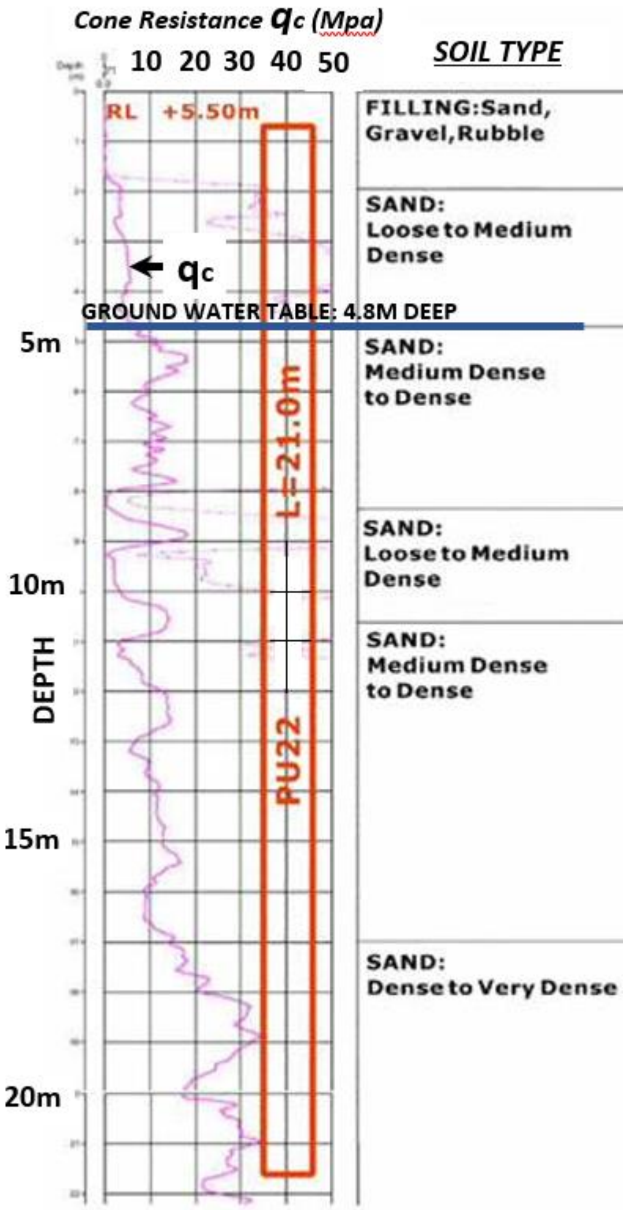


Fig. 2 Bore Hole Data

2.3. Structural type & design

The project required a permanent basement wall for a design life of 50 years. The basement would be constructed bottom up and required a maximum 12.5m excavation. In the temporary case, the walls would be supported by temporary anchoring and bracing, and by concrete slabs at each of the basement slab levels in the permanent scenario.

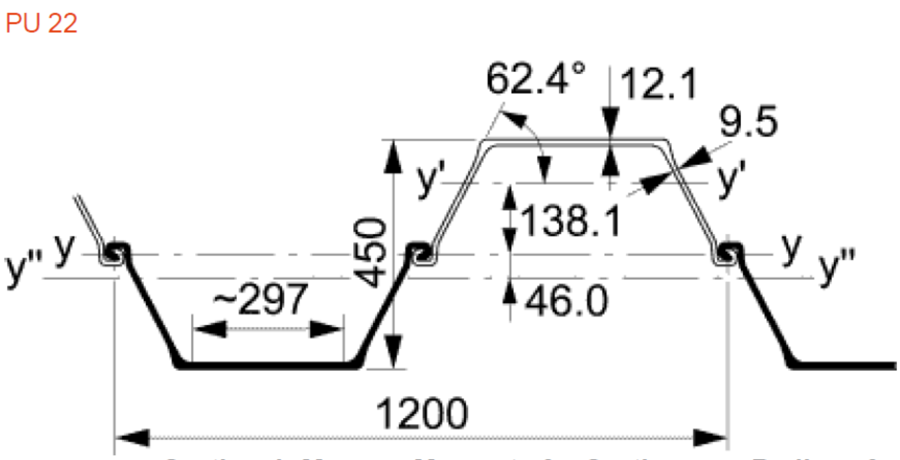
The initial Geotechnical report provided by the client suggested for the retaining wall system either of;

1) A secant pile wall comprising interlocking Continuous Flight Auger (CFA) piles or CFA piles with jet grouted columns between the piles.

2) Soil mixed wall systems constructed using specialised equipment to either blend cement with the in-situ soils to create a soil-cement mix.

The conventional sheet piles installation method using a vibration hammer was NOT recommended for the use on this site as there were movement sensitive structures adjacent to the excavation. We proposed the Press-in Piling method using our ECO600S with the design described below.

A PU22 pile section, supplied as 600mm wide U piles, was determined as the preferred section to support the earth and water pressures in the temporary and permanent case **(Fig. 3).**



	Sectional area cm^2	Mass per m kg/m	Moment of inertia cm^4	Section modulus cm^3	Radius of gyration cm	Coating area* m^2/m
Per S	109,7	86,1	8740	546	8,93	0,90
Per D	219,5	172,3	59360	2640	16,45	1,79
Per T	329,2	258,4	82060	3025	15,79	2,68
Per m of Wall	182,9	143,6	49460	2200	16,45	1,49

Imperial units

Fig. 3 PU22 pile properties

As per the client design requirement the walls also had to support permanent surcharge load from the adjacent pedestrian footpaths and roadways (up to 20kPa) as well as temporary construction load from the plant, equipment and materials (up to 50kPa).

Fig. 4 section view shows a typical design arrangement for the permanent case.

In addition to supporting earth and water pressures, the walls were required to support axial load from permanent columns supporting the superstructure above.

The maximum factored column loads of up to 2141kN were supported on 2, 3 or 4 U piles. **Fig. 5** shows column loading. Also the sheet pile/wall was required to provide cut-off to limit groundwater flow into the excavation.

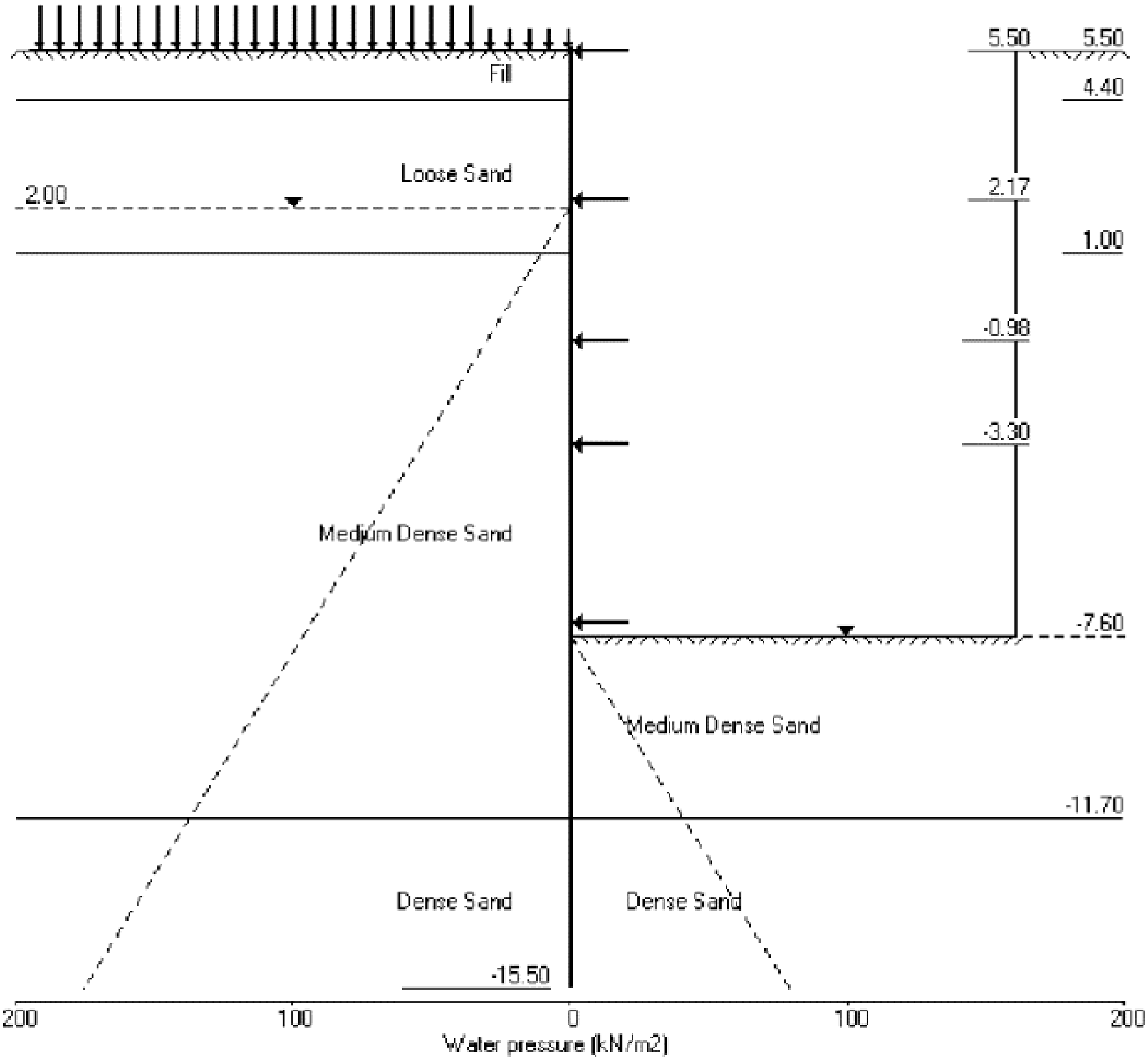


Fig. 4 PU22 pile properties

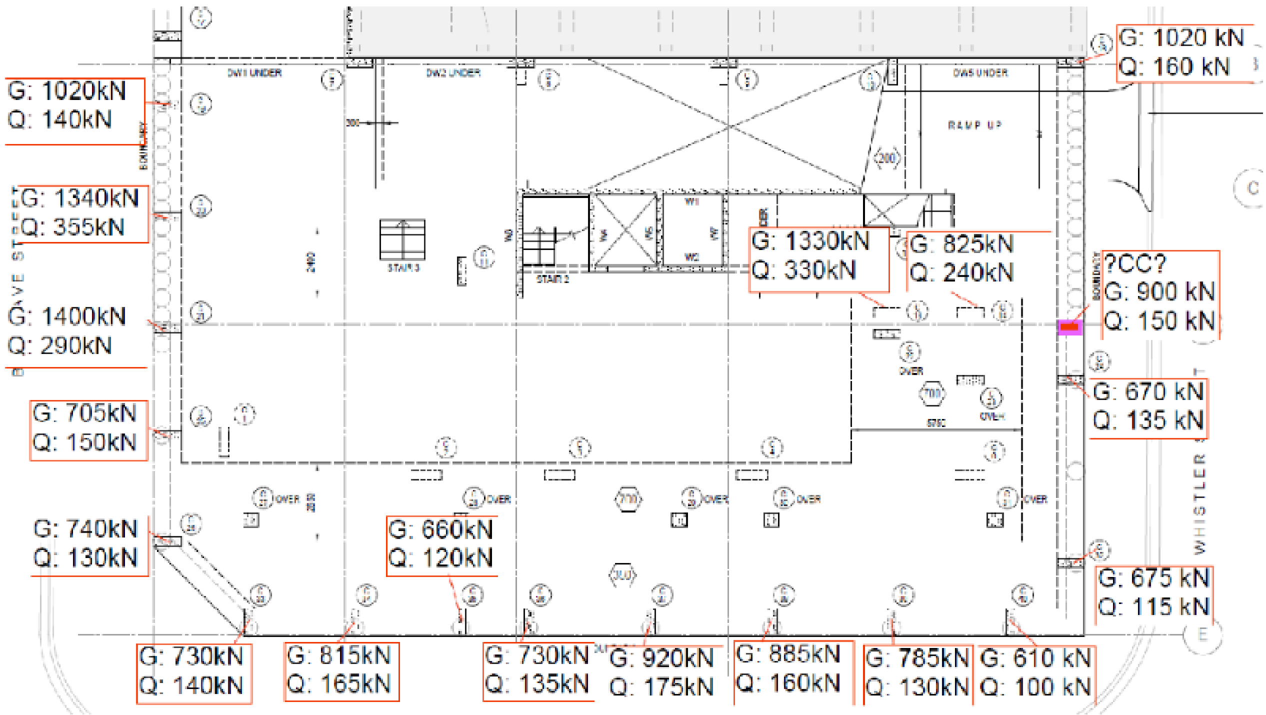


Fig. 5 Column Loadings

2.4. Durability

In accordance with the Australian Standard AS2159, the site was classified as non-aggressive to steel piling. A corrosion allowance of 0.025mm/yr was allowed on the front and back faces of the wall, reducing thickness by 1.25mm per side over 50 years (2.5mm overall). In addition, on the inside within the basement excavation, the sheet piles will be painted and maintained for a 25 year life.

The appropriate reductions in section modulus and moment of inertia were determined and applied in the design calculation to confirm satisfactory structural performance at end of life.

2.5. Piling method

The geotechnical report stipulated to conduct further testing to determine the appropriate disposal options of ground water as it detected hydrocarbons within the samples collected from the monitoring well.

Initially the press-in with water jetting was planned. However, considering the counter measure against possibly contaminated groundwater collected from the jetting operation, and a possible disturbance to nearby ground/ structure by high pressure jetting, J Steel proposed the press-in with augering with ECO 600S.

3. Press-in piling

3.1. Layout

The layout of the sheet piles can be seen in **Fig. 6.** The sheet pile length varies depending on the excavation depth.

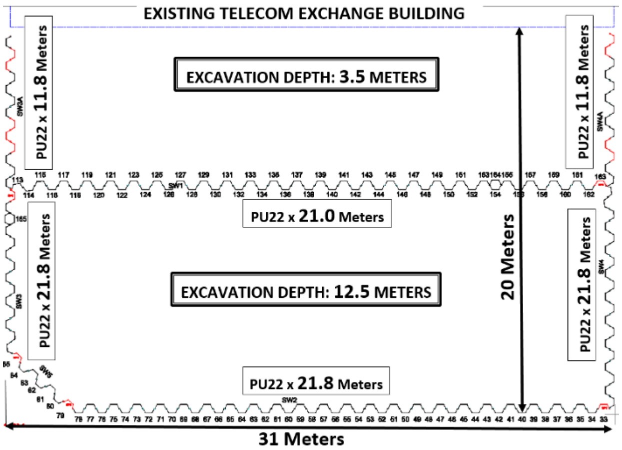


Fig. 6 Layout of Sheet Piles

3.2. Productivity

We used 1 no. x press-in machine (ECO 600S) for entire project. The outline of our program on the site is described in **Table 2**;

Table 2. Outline of Site Program

Piling Start Date:	18-Dec-17
Piling Finish Date:	16-Mar-18
Total Business days (include Saturday)	60 Days
Total Working Days (actual piled days):	34 Days
Total number of Installed Piles:	166 Nos
Total Length of Installed Piles:	3,377 m

Noticeably, the actual working (piling) day was 34 out of 60 business days we stayed on the site. The causes of the stand down of our resources will be explained in the next section.

The maximum length of sheet pile installed within a day was 9 Sheets x 21.0m = 189 m which was recorded on 17-January 2018.

3.3. Resources

3.3.1. Major plant and equipment

The major equipment use on site are listed below;

- 1 no. Press-in ECO 600S - Giken/ JSteel
- 1 no. 80 ton Crawler Crane - Keller/ WGC
- 1 no. 30 ton Crawler Crane - Keller/ WGC
- 1 no. 250 cfm Air Compressor - Keller/ Coates
- 1 no. 5 ton Excavator - Keller/ Coates
- 1 no. Welding Machine – Keller
- 1 no. Oxy Cut set – Keller

3.3.2. Site personnel

The site personnel to execute the works are listed below;

- T. Ito – Engineer (J Steel)
- T. Ueta – Operation of ECO 600S (Giken)
- M. Machida – Leading hand (Giken)
- K. Fukumori – Offsider (Giken)
- C. Carde – Supervisor (Keller)
- L. Copley – Welder (Keller)
- R. Coombes – Offsider (Keller)
- 80 Ton Crane Operator (Keller/ WGC)
- 30 Ton Crane Operator (Keller/ WGC)

3.4. Encountered difficulties

3.4.1. Delay of existing sub-station removal

We mobilised resources on 13/12/2017 based on the Sub-station located within the site would be removed in a week time. However this did not happen until 27/2/2018. This delay had resulted in significant low productivity and increase of work load. We were also forced to reduce our storage area and increased congestions on the site. The originally planned foot print was as per below **Fig. 7**. This was changed drastically due to the existence of the Sub-station. Cranes were needed to increase their capacity to enable to reach longer distance. Sheet piles were needed to store on top of the existing Telecom Building.

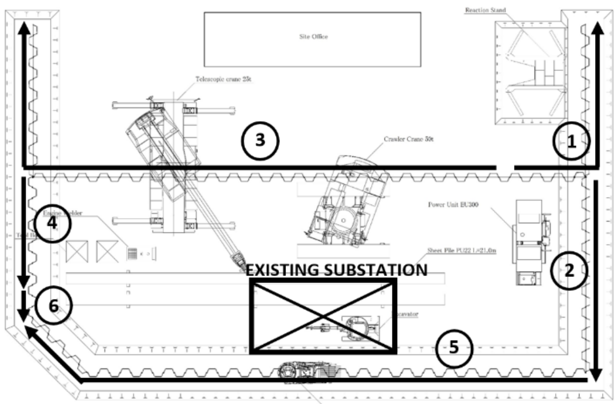


Fig. 7 Planned Foot Print

The existence of Sub-station also affected the sequence of our piling works. Closing the sheet pile wall as a “box” (clutched) required a careful planning. Closing at a 90 degree corner is a normal practice as it provides greater flexibility to absorb material and construction tolerance. However due to the existence of sub-station we needed to re-plan the piling sequence and compromised to close the wall at 45 degree (Number 6 at **Fig. 7)**, which eventually took us for a few days to close because of the the limited flexibility compare to a 90 degree corner and the deviation of the wall was more than what we anticipated.

Moving the Piler from one place to another took about half a day. The 27m casing auger was required to be removed and dismantled. Associated plant and equipment need to be re-organised.

Initially we anticipated only twice for moving the Piler. But after we changed the sequence we had to move 5 time which increased 3 movements from the original plan.

3.4.2. Piling platform level issue

1m deep x 2m wide trench was to be excavated along the perimeter line before we commence the piling works. However the client found an existing high voltage cables along the boundary line and could not create the trench **(Fig. 8)**.

The failure to excavate over the boundary resulted in extending piles for 1m and slower productivity while existing cables close to the site boundary had been identified and protected.

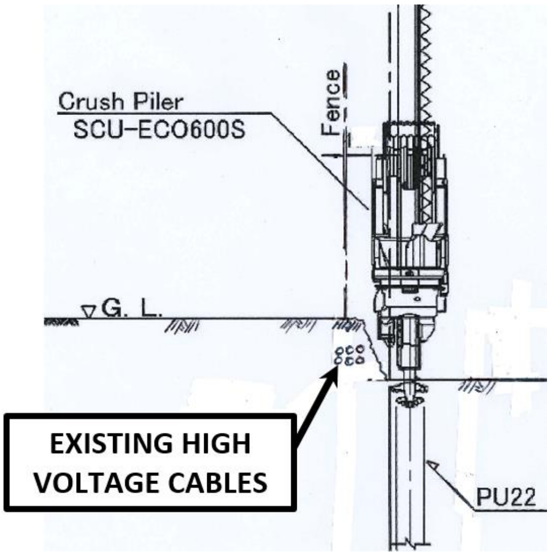


Fig. 8 Piling Platform Level

3.4.3. Tolerance of sheet pile material

The **Fig. 9** shows the comparison between the actual distance and the design distance of sheet pile walls. As can be seen approximately 270mm was lengthened due to extra 5-6mm width of each sheet pile.

These extra lengths were absorbed at the corner which had greater flexibility.

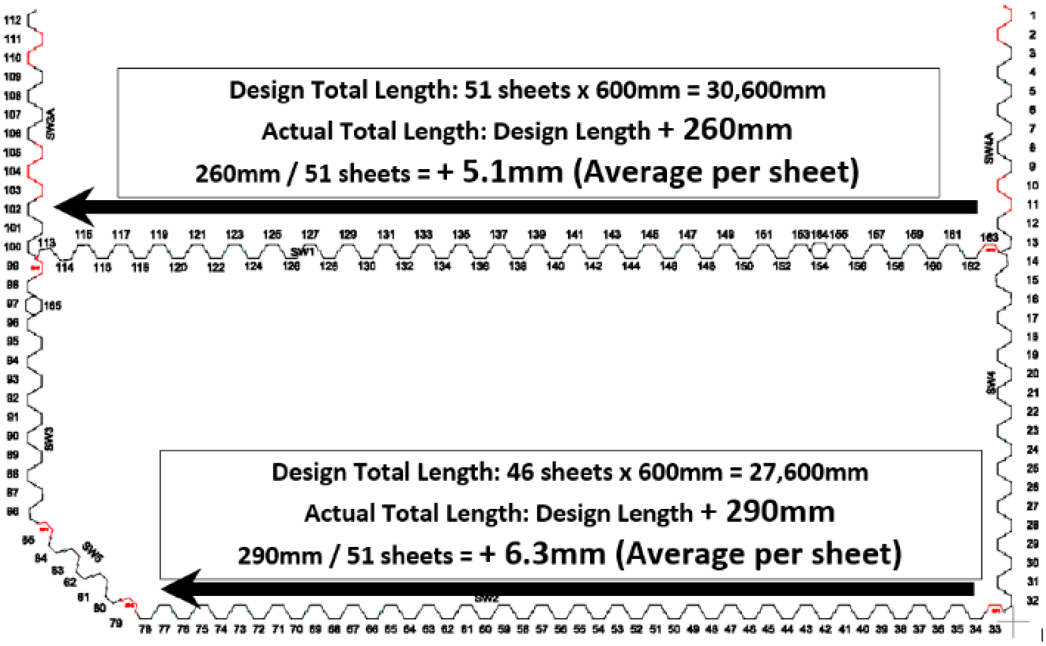


Fig. 9 Tolerance of Sheet Pile Material

3.4.4. Ground Movement due to Pre-Drilling

As can be seen in the **Photo 2** and **3**, we observed some crack and subsidence were caused, possibly by our augering works along the perimeter.

The client used plywood and fence posts and excavated the site about 1m before we commence our works (refer to **Photo 1**).

Patched repair of path was done by the client and fortunately no serious damaged been observed.

Photo 2. Pedestrian Path 1

Photo 3. Pedestrian Path 2

3.4.5. Execution team on site

Fig. 10 shows the contractual formation of the project. Although we had engaged with a well-known specialist contractor, Keller, they had no experience in press-in operation. Therefore, we had 3 members from Giken including an experienced operator during the course of the project to ensure we provide the best performance.

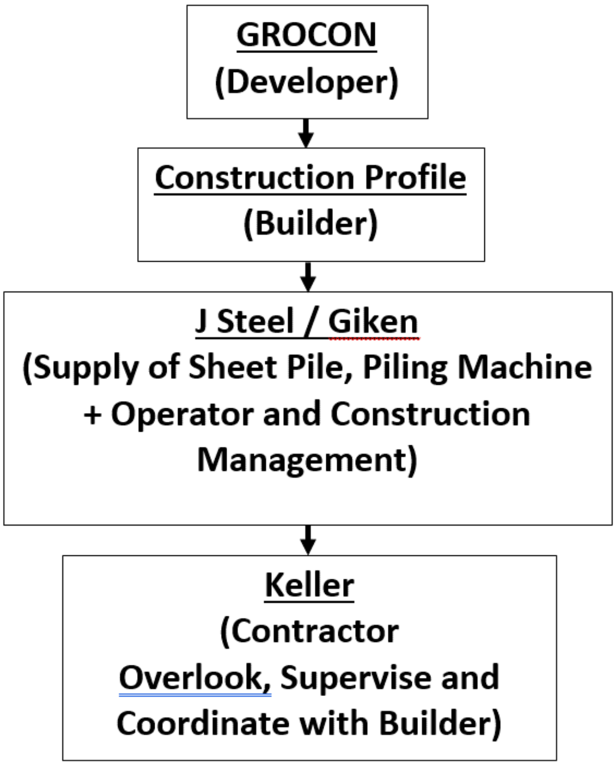


Fig. 10 Contractual Formation

4. Concluding remarks

This paper described the outline of the project including how we carried out the design for the basement as well as the construction works. We particularly spent a space for problems we encountered on site which we would like to share with other members for future use.

5. Acknowledgements

This project would not have been possible without full support from Giken's personnel from the tender stage to the completion of the site works. We would like to extend our sincere appreciation to all of Giken team.

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