Case Studies: Use of the Gyropress Method in Tubular Pile Earth Retaining Walls for Foundation Works in Urban Area

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ABSTRACT

Earth retaining walls for foundation works in urban area are often constructed under conditions where there are buildings and underground structures in the neighbouring areas. These items will become the key factors in a selection of proper construction method. Due to these backgrounds, cases have lately been seen where the earth retaining walls constructed of steel tubular piles installed by the Gyropress Method are adopted in urban area. The method can penetrate not only stiff grounds, but also underground obstructions. It is possible to largely reduce construction period, since the earth retaining walls can be constructed only by press-in operation without removing underground obstructions in advance. In addition, it is possible to construct walls even in narrow sites where enough working space cannot be secured, since the press-in operation is conducted with self-walking on top of the already installed piles. The constructions can be implemented with low vibration and low noise, keeping the effect on the surrounding environment to a minimum. In this paper, with such advantages of the Gyropress Method as described above, introduced are the cases where steel tubular earth retaining walls for foundation works constructed by the Gyropress Method are adopted in urban area.

Key words: *the Gyropress Method, earth retaining wall*

1. Introduction

Earth retaining walls for foundation works in urban area are often constructed under conditions where there are buildings and underground structures in neighbouring areas. **Photo 1** shows the construction of adjacent earth retaining wall in urban area. It is very scarce for the structure to be built in an open place free from existing structures or underground obstructions. For this reason, careful consideration should be given to, at the design stage of earth retaining walls, the area of excavation, locations and status of adjacent buildings, ground conditions, buried structures, which will become issues in a method selection (Motoi, Y., 2015). Under such circumstances like these, in earth retaining wall constructions in urban area, it is essential to conduct design and construction, considering not only safety and economy, but also effects on the surrounding structures

Photo 1. Construction of earth retaining wall in urban area

and adaptability to environments (Katsura, Y., 2015). That is the reason why cases have lately been seen where earth retaining walls constructed of steel tubular piles installed by the Gyropress Method are adopted in urban area. In this paper, introduced are the cases where earth retaining walls constructed of steel tubular piles installed by Gyropress Method were adopted in urban area.

2. Overview of earth retaining walls

2.1. Different types and features of earth retaining walls

Fig. 1 shows different types of earth retaining walls used in construction works and their classification (Architectural Institute of Japan, 2002). Depending on whether water shielding is required they are divided into water pervious wall and water cut-off wall. Water pervious wall may include soldier piles and a lagging wall. Construction of this type of walls is relatively easy and the construction cost is low. Therefore, they are often used as earth retaining walls. Water cut-off wall may be divided into steel sheet pile wall, steel tubular sheet pile wall, soil cement continuous wall, and cast-in-place reinforced concrete wall. Among the earth retaining walls, soil cement wall and cast-in-place reinforced concrete wall can be used as the permanent structure. Earth retaining walls are usually used for temporary purposes. However, the cases are increasing where the earth retaining walls are used as permanent structures in order to reduce construction period or temporary work cost.

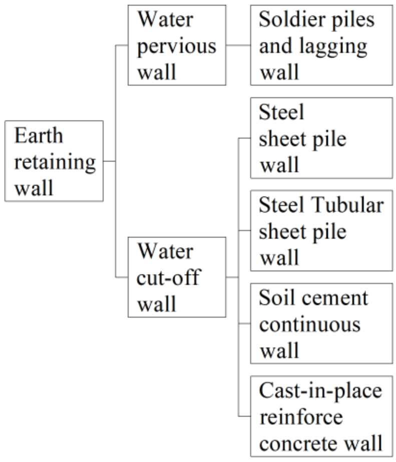

Fig. 1 Different earth retaining walls and their classification

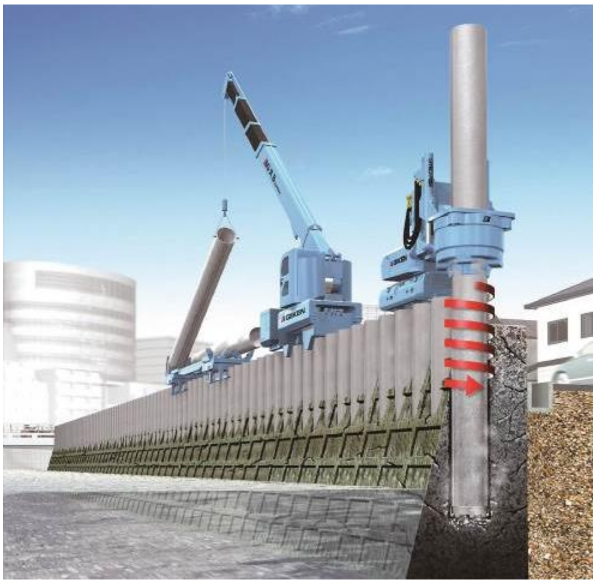

Fig. 2 Gyropress Method

Photo 2. Cutting bits

2.2. Advantages in the construction of earth retaining walls by the gyropress method

The Gyropress Method (**Fig. 2**) is a construction method where a steel tubular pile with cutting bits (**Photo 2**) at the toe is rotated and pressed-in. It can penetrate not only stiff ground such as boulder and rock, but also underground obstructions such as existing reinforced concrete structures. It is possible to largely reduce construction period, since the earth retaining walls can be constructed only by press-in operation without being affected by underground obstructions or stiff grounds. In addition, it is possible to construct walls even in narrow sites where enough working space cannot be secured since the press-in operation is conducted with self-walking on top of the already installed piles. In addition, an earth retaining wall constructed by the Gyropress Method is a continuous steel tubular pile wall. Therefore, it is possible to make it a cantilever wall structure, even when the wall is high. Due to the increase in different types of pressing-in machines, it is now possible to install steel tubular piles with diameters ranging from 600 to 2,500 mm. Since constructions with large-diameter steel tubular piles are now available, cases are increasing where the Gyropress Method is adopted not only for road retaining walls in civil engineering projects, but also for earth retaining walls in architectural projects.

3. Construction cases

3.1. Case study 1: extension work in an existing structure site

3.1.1. Construction overview

In this section, a case study is introduced where the Gyropress Method was adopted to construct an earth retaining wall in the extension work at an existing structure site. The site is shown in **Photo 3**. The main purpose of the project was to construct a new building in the exiting property. The plan view is shown in **Fig. 3**. An earth retaining wall was required between the new and existing buildings for the construction work. Existing buildings were supported by a pile foundation. Due to restricted access to the working space in the residential area, heavy construction machinery to install a cast-in-place reinforced concrete wall was unsuitable. During the initial stage, soldier piles and a lagging wall with struts and ground anchors were considered. However, from the point of view avoiding ground anchors striking the pile foundation of existing buildings, a steel tubular sheet pile wall, which enables the building of a cantilevered structure, was adopted.

3.1.2. The initial plan - soldier piles and a lagging wall with struts and ground anchors

At the initial stage, soldier piles and a lagging wall with struts and ground anchors were considered. The typical cross section is shown in **Fig. 4**. As the planned wall was adjacent to an existing building, the reduction of ground displacement was essential to prevent ground from being deformed. For this reason, the plan required struts and ground anchors as a support for the main wall.

Photo 3. Photo taken at the construction site

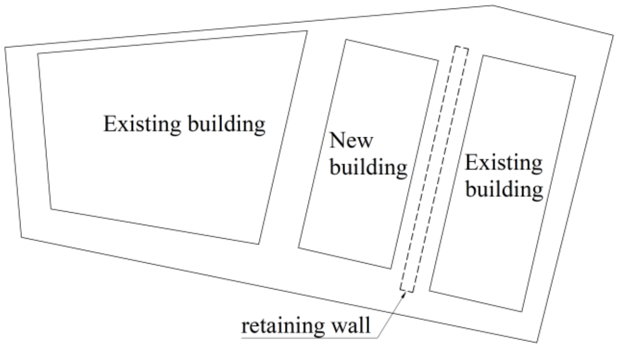

Fig. 3 Plan view

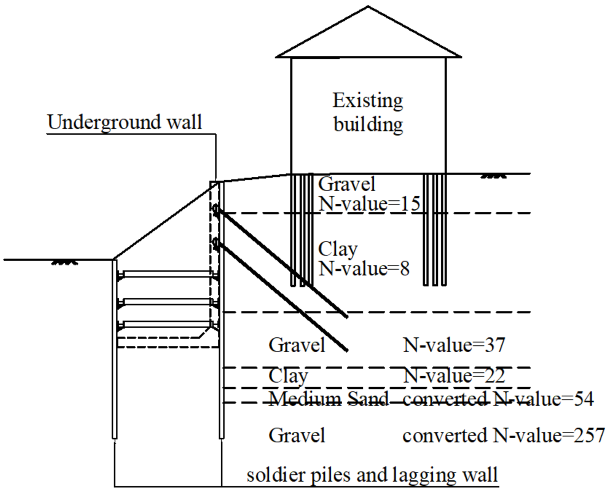

Fig. 4 Typical cross-section of the initial plan

However, two levels of ground anchors were required by this plan and the upper ground anchor had to be installed between the existing piles, which made the construction project very challenging.

3.1.3. The accepted plan – a cantilevered steel tubular sheet pile wall

A cantilevered steel tubular wall installed by the Gyropress Method was adopted as an earth retaining wall due to lack of interference with foundation. A typical cross-section of the construction is shown in **Fig. 5**. The soil layer from the ground surface to a depth of about 10 m consisted of sand and gravel and sandy clay with SPT *N*-values of about 10. At a depth of the pile toe, the ground consisted of sand and gravel, with a converted *N*-value of about 250. Steel tubular piles used at the site had an outer diameter of 1,500 mm with a thickness of 25 mm. Pile length was 27.6 m, and 36 piles were installed. It was possible to build an 8m high cantilever structure without ground anchors or ground improvement. The site was very close to the existing buildings (**Photo 4**), but there was no damage on the neighboring houses, and the installation of the steel tubular piles was safely completed without any accidents.

3.2. Case study 2: renovation work of a kindergarten and a public school

3.2.1. Construction overview

In this section, a case study in renovation work of a kindergarten/public school is introduced, where the Gyropress Method was adopted to build an earth retaining wall. The site is shown in **Photo 5**. The work included dismantling old structures, constructing a new building, partial preservation, and aseismic renovation work. The plan view of it is shown in **Fig. 6**. Constructing the basement of the new building, an earth retaining wall had to be installed between the new and adjacent existing buildings.It was impossible to use ground anchors, since they would have had to be installed under private properties of the neighboring houses. Although a soil cement continuous wall with struts was planned at first, a steel tubular pile wall was adopted through the deign change to reduce the construction duration.

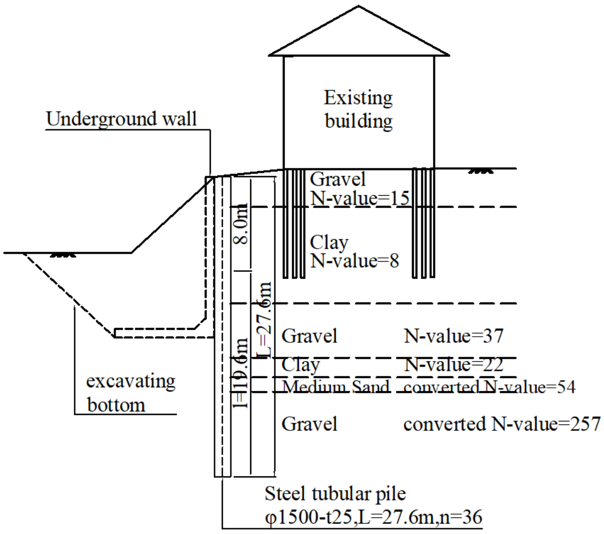

Fig. 5 Typical cross-section of the construction

Photo 4. Construction adjacent to the existing building

Photo 5. Photo taken at the construction site

3.2.2. The initial plan – a soil cement continuous wall with struts

At the initial stage, a soil cement continuous wall with struts was considered. A typical cross-section of the wall in the original design is shown in **Fig. 7**. In the design, it was necessary to use shore struts in four layers, in addition to a diagonal shore strut. Also, a working space for heavy machinery to install a soil cement continuous wall was required, while a construction of an earth retaining wall to prevent slope failure on the private side was necessary. This way, the original design required a long construction time and labour, and was a factor to prolong the construction period.

3.2.3. The accepted plan – a steel tubular sheet pile wall with struts

A typical cross-section of the earth retaining wall by the Gyropress Method is shown in **Fig. 8**. The soil layer from the ground surface to a depth of 10 m consisted of fill and clay with *N*-value of about 5. At the depth near the pile toe, the soil consisted of fine sand, with a converted *N*-value of about 140. Steel tubular piles used at the site had an outer diameter of 1,500 mm with a thickness of 25 mm. Pile length was 31.0 m, and 27 piles were installed. In the design with the Gyropress Method, earth retaining walls are constructed of steel tubular piles. Therefore, it was not necessary to build a soil cement continuous wall, or to prepare a construction space for heavy machinery to build the wall. In addition, since there was no excavation involved in the installation of steel tubular piles, the earth retaining wall to prevent slope failure on the private property side was not necessary. Furthermore, using large-diameter steel tubular piles with high stiffness, the diagonal shore strut and another shore strut were omitted. Consequently, the work to build the earth retaining wall was largely reduced, and the construction period was shortened by 4 months, compared with that in the original design which took 3 years. The fact that the construction period was shortened and that the effect on the neighboring residential houses was minimized by a low vibration and low noise construction was highly evaluated, and an agreement was formed with the client for selecting the Gyropress Method to construct the earth retaining walls.

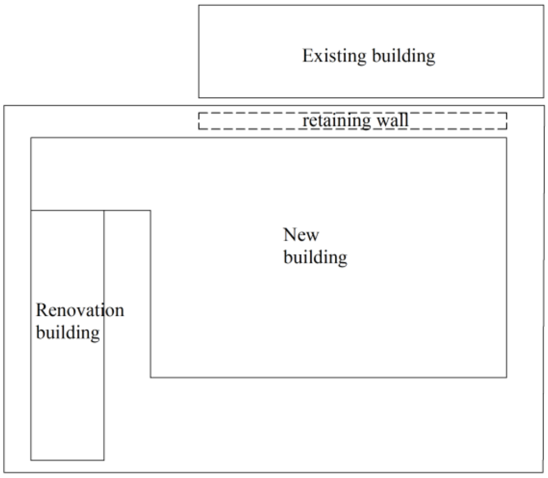

Fig. 6 Plan view

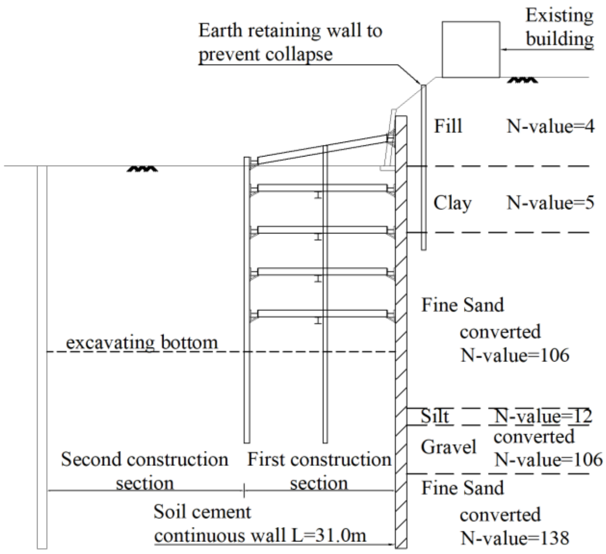

Fig. 7 Typical cross-section of the initial plan

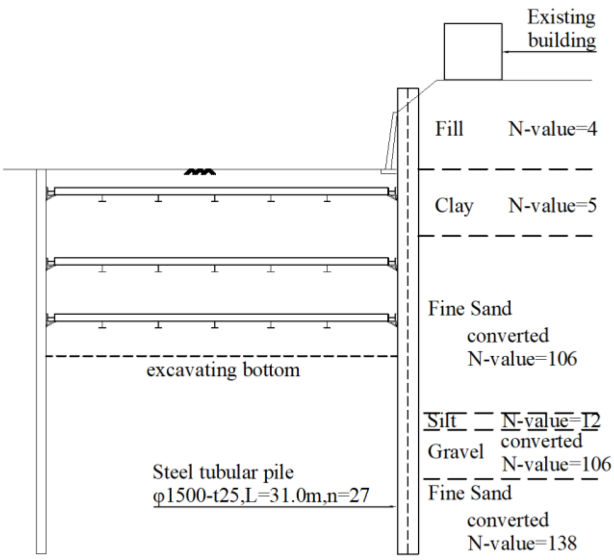

Fig. 8 Typical cross-section by the Gyropress Method

Photo 6. Construction adjacent to the existing building

The site was very close to the existing buildings (**Photo 6**), but there was no damage on the neighboring houses, and the installation of the steel tubular piles was safely completed without any accidents.

4. Concluding remarks

In this paper, two construction cases were introduced, where the steel tubular earth retaining walls by the Gyropress Method were adopted in urban area.

In Case study 1, the great stiffness and cantilevered steel tubular pile wall solved the issue of the construction site where ground anchors were unable to be installed between the existing piles. In Case study 2, taking the best use of the Press-in procedure in which a wall can be constructed, temporary works (i.e. construction to install a temporary earth retaining wall for a working space for heavy machinery or to prevent a slope beside the existing building from collapsing) were not necessary and the construction duration could be reduced.

In the process of method selection, a steel tubular sheet pile wall constructed by the Gyropress method might be regarded as a dominant structure. As in the cases introduced, it is expected that foundation works in urban area under strict construction conditions will increase in future. It would be very grateful, if this paper will be referred to in a selection of construction methods, or if it can be of some help in promoting the steel tubular pile earth retaining walls and the Gyropress Method.

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