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Technical Report

Proposal of Steel Pipe Pile Structure to Realize Labor Saving and Safety Improvement of Temporary Construction Work on Site

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Abstract

The need for temporary gantries is increasing in response to the demand for replacement of aging bridges and the construction of roads in mountainous areas to eliminate missing links. H-shaped steel is mainly used for the supporting columns and supporting piles of temporary gantries, but the construction volume is large and the construction involves work at elevation. In addition, there are concerns about a decrease in construction efficiency, safety, and quality due to a decrease in the number of skilled workers, etc., and further improvement in the safety and efficiency of on-site work is an urgent issue. In this report, we introduce the "SOKKETSU KANBEE™" and "KANTORII™ construction method" as labor-saving solution technologies using steel pipe piles that improve the safety and shorten the construction period of temporary gantry construction sites. Compared to conventional H-beam steel, the weight of steel materials, the amount of construction work, and the amount of work at elevation can be reduced by lengthening the span and installing the substructure all at once.

1. Introduction

In order to meet the construction demand for replacing aging infrastructures such as the rebuilding or repair of bridges, and the construction of roads in mountainous areas to eliminate missing links, the need for temporary gantries used as roads or working space for construction vehicles and construction machinery is also increasing. Temporary gantries consist of a substructure composed of such components as supporting piles, supporting columns, bracing members, and lateral stiffeners which connect columns, and a superstructure composed of such components as main beams, beam seats, and covering plates. Since a temporary gantry is a temporary structure, steel structures have been employed for supporting piles and supporting columns, and conventionally, H-shaped steel has been mainly used (**Photo 1** (a)). The temporary gantries constructed with H-shaped steel require a large volume of construction work, and scaffolding construction work on-site ground and work using a gondola high above, accompanying work at elevation. In addition, the decrease in skilled workers and expert workers, and the deteriorations of construction work efficiency, safety, and quality are causes for concern, and it is a matter of urgency to further improve the safety and efficiency in site construction work. This article reports the labor-saving solution technologies developed to meet these needs for the construction of temporary gantries by using pipe piles.

2. Collective Temporary Gantry Construction Method "KANTORII™ Construction Method"[1–4] for Temporary Construction Using Mechanical Joint "SOKKETSU KANBEE™"

2.1 Advantage of employing steel pipes for temporary gantries

Since a pipe has a circular section, it has a common cross-sectional performance in any direction, and in addition, since it has a closed-sectional hollow shape, a pipe features high cross-sectional performance towards bending, torsion, buckling, and so forth. In addition, when a pipe is used as a foundation pile, as compared with

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(a) Example using H-shaped steel　　(b) Example using steel pipe piles

Photo 1　Example of temporary gantry

H-shaped steel, a variety of construction methods are applicable, and a large supporting force can be exerted. By taking advantage of these features competently, lengthening the span between columns (supporting columns) and the reduction of bracing members and/or lateral stiffeners are realized. As a result, by employing pipes to replace H-shaped steel for temporary gantries, shortening of the construction period and reduction of cost are expected. In order to fully enjoy the merits of adopting pipes, elimination of the on-site welding work for joining a supporting pile and a supporting column, and absorption of construction errors of a supporting pile are essential. The solution technology which realizes these issues is introduced.

2.2 Overview and features of KANTORII™ construction method

In the "KANTORII construction method," a substructure consisting of supporting columns, bracing members, and lateral stiffeners is assembled into a gate form unit on the ground in advance, which is pulled up by a crane, and collectively erected onto supporting piles (**Photo 2**). The construction flow of the KANTORII construction method is shown in **Fig. 1** (for more details, refer to the video[4] on the Nippon Steel Corporation Home Page[1, 3]). By assembling the substructure on the ground, and by collective erection, higher work efficiency and the reduction of work at elevation are possible, and therefore, enhancement of safety, and additionally, shortening of the construction time period are enabled by the parallel work of pile installation.

2.3 Overview and features of SOKKETSU KANBEE™

The substructure unitized by the KANTORII construction method is joined to the supporting piles not with the conventional on-site welding but with the mechanical joint "SOKKETSU KANBEE" for temporary usage (**Fig. 2**). Herein, SOKKETSU KANBEE means the joint installed at the bottom edge of the aforementioned supporting column in the unit, and it has a simple structure consisting of an upper socket tube and a bottom socket tube, a diaphragm, and fastening bolts (Fig. 2). The clearance between the upper socket tube and the supporting column (column side) is smaller (about 10 mm on one side), and considering the working conditions of the slope and/or hard ground, the clearance between the lower socket tube and the supporting pile (pile side) is increased in size (30 mm on one side). With this structure, the absorption of construction errors in the horizontal direction of the supporting pile is possible, with which welding is unable to comply. Since the work of installing the supporting piles and assembling of the substructure can be promoted in parallel, in addition to the labor saving in on-site joining work, shortening of the construction period is realized.

Photo 2　Example of unit structure of "KANTORII™ construction method"

3. Verification of Construction Performance

3.1 Installation test of SOKKETSU KANBEE™

In order to verify the on-site construction performance of SOKKETSU KANBEE, an installation test simulating the actual construction flow was conducted by using a φ500 mm pipe pile. The installation process of SOKKETSU KANBEE followed the actual installation process shown in Fig. 1. As the first step, SOKKETSU KANBEE was installed in the laid supporting column (a simulated material), and laterally spliced with bolts (**Photo 3** (a), (b)). Next, the supporting column installed with this SOKKETSU KANBEE was pulled up by a crane, and the supporting column was installed on the supporting pile head as if the SOKKETSU KANBEE were capping the pile head, and vertically spliced with bolts (Photo 3 (c)). Thus, the installation work of SOKKETSU KANBEE is simple both in terms of lateral splicing and vertical splicing, and since the work was conducted smoothly and in a stable manner, it was confirmed that the on-site workability is free of any problems and the construction method is applicable. Furthermore, by using the test sample after the installation test, axis-bending tests were carried out under various axial force ratio conditions, and the strength perfor-

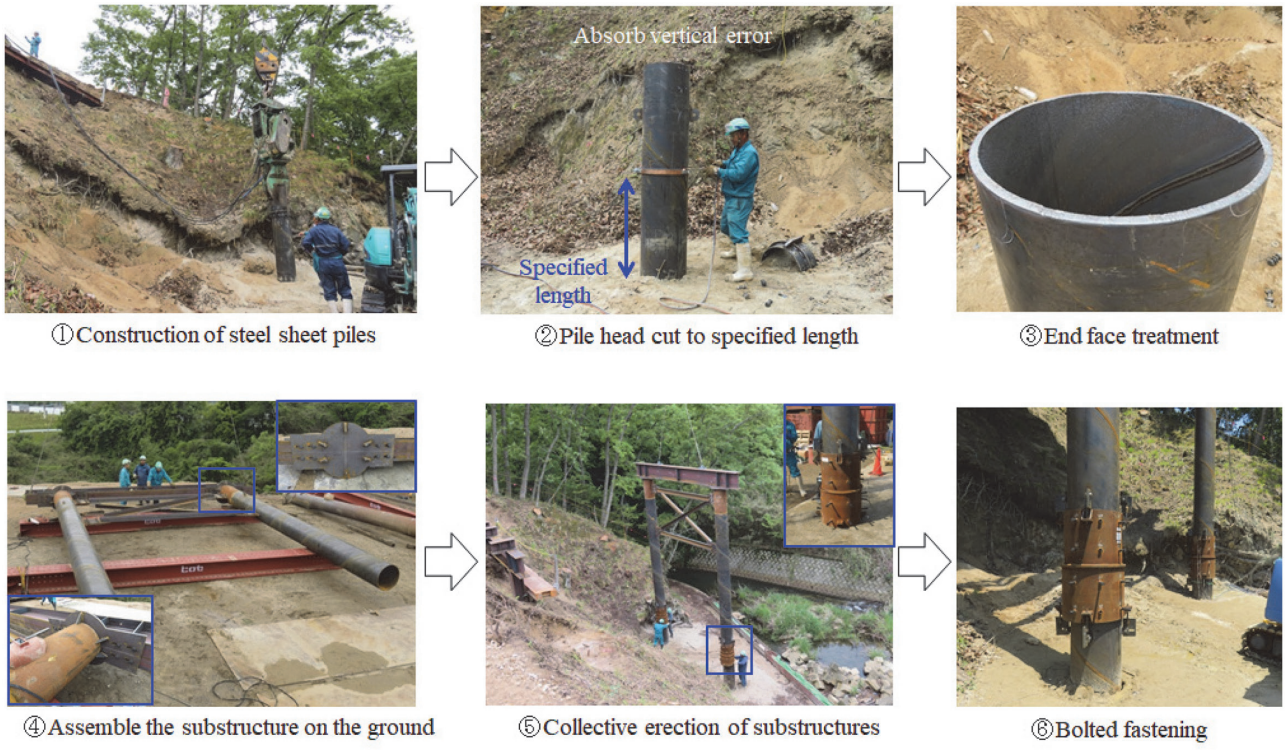

Fig. 1 Construction flow of "KANTORII™ construction method"

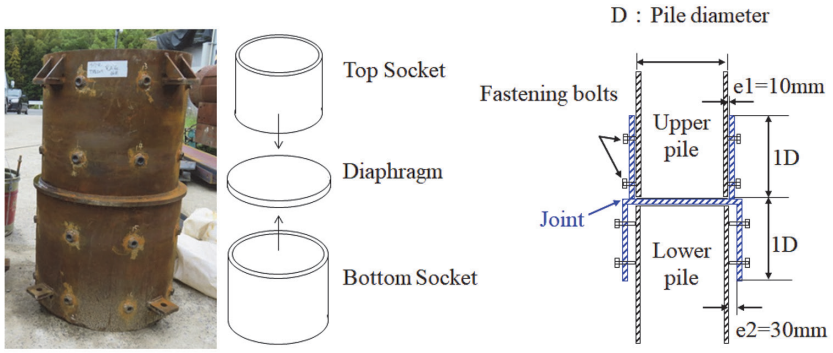

Fig. 2 Overview of "SOKKETSU KANBEE™"

(a) Lateral connection of supporting columns and joints

(b) Joint of support column and joint

(c) Longitudinal splicing of joints and supporting piles

Photo 3 Overview of installation test of "SOKKETSU KANBEE™"

Photo 4 Overview of full-scale structural test of "SOKKETSU KANBEE™"

mance of the joint section was confirmed (**Photo 4**).

3.2 Actual construction test of KANTORII™ construction method

As indicated in the preceding section, since the workability with respect to the installation of SOKKETSU KANBEE was confirmed, the workability test of the KANTORII construction method on the real ground was conducted. A pipe pile of φ500 × t12 mm was used for the test. The supporting columns, bracing members, lateral stiffeners, SOKKETSU KANBEE, and so forth were assembled on the ground in a single unit, and collectively erected on the supporting piles installed in the real ground. Through the actual construction test of the substructure about eight meters high up to the girder, problem-free construction was confirmed in the actual size and on the real ground.

3.3 Examples of construction

The examples of the actual construction cases of the KANTORII construction method employing SOKKETSU KANBEE are shown in **Table 1**. Herein, in the bridge construction to build a bypass for the National Highway 289 in Yamagata Pre., this construction method was applied to the temporary construction work for the construction of the bridge. The temporary gantry was 20 m in height, and steel pipes of φ500 mm were used, and despite the geographical features of the inclined site and under severe snowy weather construction conditions, assembling of the substructure on the ground and collective erection onto supporting piles were conducted without problems (Photo 1 (b)). Based on these actual construction achievements, the effects of utilization of the KANTORII construction method over the conventional H-shaped steel construction method were recorded, and, in June 2022, the KANTORII construction method was registered with the New Technology Information System (NETIS) of the Ministry of Land, Infrastructure, Transport, and Tourism.[2)]

Table 1 Construction example

Project	Client
Ordinary national road Shirataki Miyajuku Line, Temporary bridge construction	Murayama General Office, Yamagata Pref.
Kanmuriyamatouge road #5 bridge substructure construction	Kinki Regional Development Bureau, Fukui Office of Rivers and National Highways

4. Conclusion

This report introduced the labor-saving solution technologies for the construction of temporary gantries by using steel pipe piles that realize enhancement of safety and shortening of the construction period in on-site construction work. Different from H-shaped steel conventionally and mainly used for the supporting columns and supporting piles of temporary gantries, by using steel pipes excellent in cross-sectional performance, elongation of span, reduction of bracing members, and so forth are possible. Furthermore, by combining with application technologies like the "KANTORII construction method" which employs "SOKKETSU KANBEE", and by the collective erection of substructure, elimination of on-site welding, reduction of steel material weight, amount of construction work, and work at elevation has become possible, thereby realizing the enhancement of safety and shortening of the construction period.

In recent years, earthquake and heavy rain disasters have frequently occurred, and the needs for temporary gantries for subsequent restoration works and/or emergency works are increasing. These solution technologies are considered to assist in early restoration. We are determined to contribute to construction needs such as building a resilient country, enhancing productivity, and reducing environmental load through the development and proposal of highly value-added solution technologies utilizing steel materials.

Acknowledgment

We hereby wish to express our utmost appreciation to Messrs. HIROSE & Co., Ltd., the associate developer of "SOKKETSU KANBEE™" and the "KANTORII™ construction method," for their great contributions and advice given to the development and establishment of the construction method, especially from the construction viewpoint.

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2) New Technology Information System (NETIS) of the Ministry of Land, Infrastructure, Transport and Tourism: KANTORII construction method (KK-220022-A), June 6th, 2022
3) Nippon Steel Corporation: "ProStruct™" brand web site
https://www.nipponsteel.com/product/prostruct/
4) Nippon Steel Corporation: "SOKKETSU KANBEE, error-absorbing type mechanical joint for temporary construction" video
https://www.youtube.com/watch?v=v-cP-yBWlXI/

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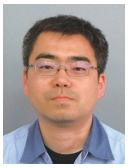

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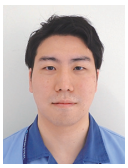

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