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Development of New Foundation Method Using Steel Pipe Sheet Pile with High Strength Pipe-Junction "Hyper-Well SP"†

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Abstract:

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In recent years, construction of the arterial highway system and access roads for airports and harbors has progressed throughout Japan. In these systems, bridges are frequently built on weak ground or in coastal areas, requiring large-scale foundations. There is also a strong desire for substantial cost reductions and shortening of the construction period in order to improve the effectiveness of investment in these projects.

To respond to the need for a significant reduction in the cost of large-scale foundations, JFE Steel developed the technology described in this paper as a method which improves economy by using an intrinsically high strength steel pipe-junction, while following the design and construction techniques used in conventional steel pipe sheet pile foundations[1–8].

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Hyper-Well SP incorporates improvements in the conventional steel pipe sheet pile foundation method. The new method consists of two types, the normal type and a type with cast-in-place concrete piles.

(a) Normal type (**g. 1**)
Type in which the steel pipe sheet piles are driven to the bearing layer and high strength pipe-junctions are used in the pipe-junctions for the piles.

(b) Type with cast-in-place concrete piles (**g. 2**)
Type used in cases where there is a hard intermediate layer which would make pile-driving difficult and this intermediate layer cannot be expected to serve as the bearing layer; in such cases, steel pipe sheet piles using high strength pipe-junctions are placed as far as the intermediate layer, and cast-in-place concrete piles are constructed under every other pipe sheet pile.

This method comprises composite piles, which consist of a steel-concrete composite structure and cast-in-place concrete piles, and high strength pipe-junctions which mutually connect the piles. When compared with the conventional technology, these component elements

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have the following features:

(1) High Strength Pipe-Junction

As shown in **Fig. 3** and **Table 1**, the high strength pipe-junction is based on the P-P junction[9] used in conventional steel pipe sheet pile foundations, but the shear strength of the junction is greatly increased by the following structure:

(a) Bond strength with the mortar is increased by providing ribs on the inside surface of the junction pipe.

(b) Bond strength is also increased by using high strength mortar.

(c) A larger bond area is secured by increasing the outer diameter of the junction pipe from 165.2 mm to 267.4 mm. This increase in the junction pipe diameter also improves workability in washing inside the junction pipe.

(2) Steel-Concrete Composite Structure

The steel-concrete composite structure is a structure consisting of a steel pipe filled with concrete. Effectiveness as a composite structure can be expected because ribs are provided on the inside surface of the pipe[10]

a small value in comparison with placement under an atmospheric condition or under water. Furthermore, these results also showed a good correspondence with the shear test results (in the case of field construction, considered to be close to placement under water). Thus, it was possible to confirm the appropriateness of this method of estimating shear strength based on bond strength.

In passing, it may be noted that, when the compressive strength test results of the samples (14 pieces) of high strength mortar (nominal strength: 60 N/mm^2; standard specification for high strength pipe-junction) sampled in the field construction test[4] were arranged in accordance with the conventional method[14], the average compressive strength of mortar with a nominal strength of 60 N/mm^2 was found to be 83 N/mm^2, and the lower limit of deviations was on the order of 40 N/mm^2.

Accordingly, assuming the lower limit value of 40 N/mm^2 as the specified concrete strength for the high strength mortar with a nominal strength of 60 Nmm^2,

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This technology was adopted for the first time in the Higashi-Kanjo-Ohashi (tentative name) which Tokushima Pref. is constructing at the mouth of the Yoshino River. Substructure construction of this bridge began in Dec. 2003, and construction has already been completed in one work section. For the bridge, a “standing style” foundation method was selected, as shown in **g. 12**[16]. Therefore, from the viewpoint of minimizing the river flow impediment ratio, a flattened oval plan-

Table 4 Eccentricity of steel pipe sheet pile

Pile	Junction form	Average eccentricity (mm)	
		Longitudinal direction	Transverse direction
a–c	High strength pipe-junction: 2 spots	23	15
d–i	High strength pipe-junction: 1 spot Normal pipe-junction: 2 spots	26	26
j–s	Normal pipe-junction: 2 spots	22	11

tions, the bridge longitudinal direction and transverse direction. The results are shown in **4**. In this regard as well, there was no large difference between the high strength pipe-junction and the conventional pipe-junction. The results of the above-mentioned measurements confirmed that the workability of the steel pipe sheet piles with the high strength pipe-junction is equal to that of steel pipe sheet piles with conventional pipe-junctions.

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JFE Steel developed a new construction method for steel pipe sheet pile foundations called “Hyper-Well SP,” which features a new high strength pipe-junction. By substantially increasing rigidity, the new method makes it possible to reduce the plane dimensions of foundations for large-scale bridges. As described in this paper, the structural performance and workability of the new method were studied, and a design evaluation method was established. Based on the results of this study, JFE Steel received certification for examination of construction technology from the Public Works Research Center in Aug. 2004 as a new foundation method for large-scale bridges. Study supporting further adoption, including case studies under various conditions, is planned for the future.

In closing, the authors wish note that this work was carried out as joint research with two construction companies, Shimizu Corp. and Obayashi Corp. We wish to express our deep appreciation to all concerned at both companies.

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