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Infrastructure Development Institute—JAPAN

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21st Infrastructure Technology Development Award 2019

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21st Infrastructure Technology Development Award 2019

Japan Institute of Country-ology and Engineering (JICE) was established as a public interest corporation to promote construction engineering in Japan by conducting cutting-edge research and development activities.

As more incentives should be provided for construction technology researchers and research institutes to enhance the level of construction engineering more effectively, JICE commenced Infrastructure Technology Development Award with Coastal Development Institute of Technology (CDIT) under the auspices of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

Seventeen technologies competed for the 21st Infrastructure Technology Development Award. In principle, the applicants' technologies should have been developed within the past five years and applied to the real sites already.

As a result of examination, institutes and researchers with the following technologies were awarded 21st prizes.

The grand prize is "Practical use of monitoring technology in track maintenance and its application to maintenance management".
And the two excellence prizes are "The Automatic Placement System of Dam Concrete", and "Rapid Removal Technology for Replacing Reinforced Concrete Decks of Composite Girder Bridges".

The one of the two excellence prizes is introduced below.

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Rapid Removal Technology for Replacing Reinforced Concrete Decks of Composite Girder Bridges

Subtitle: Hydro Jet Demolition Technique for Replacing Decks (Hydro-Jet RD Method)

1. Background and reason for development of this technology

Many expressway bridges built during Japan's period of rapid economic growth are now suffering from remarkable aging and deterioration. Their renewal is one of the country's key social infrastructure tasks. In the case of the Hanshin Expressway, more than 50 years have passed since it was opened in 1964, and its aging structures are deteriorating. Large-scale renewal and repair project, which began in 2015, covered 62km of the total length of 250.4km. Reducing adverse effects on the traffic by shortening the process has been an important issue in this work, along with reducing costs by utilizing improved construction methods. We have developed a rapid removal technology while focusing on replacing reinforced concrete decks of composite girder bridges.

2. Technical details

Replacing the decks of composite girder bridges includes the problem of dense configuration of studs on the steel girders which makes it difficult to remove joints between steel girders and concrete decks. To deal with this, water jets (WJ) are used to remove concrete from joints. Namely, WJ are used for the bottom side of decks of bridges open for traffic, to chip the joints (Photo-1) and to expose studs for lengths of about 50 mm over the entire length (Photo-2). Steel

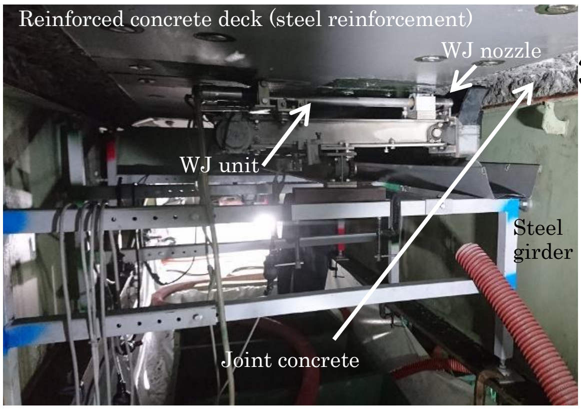

Photo-1 WJ application state

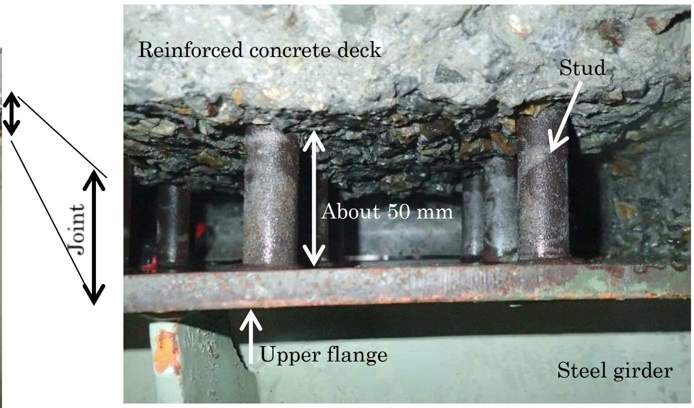

Photo-2 Joint removal state

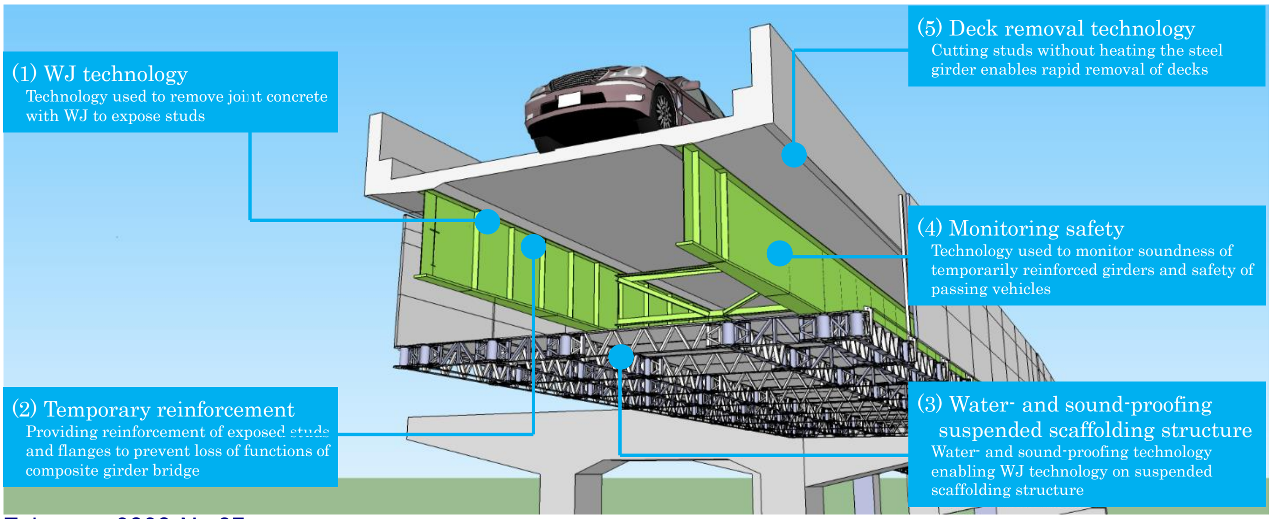

Figure-1 Overview of the developed technology reinforcements (Figure-2) and temporary reinforcements made from special mortar are fixed to the exposed studs to maintain the design performance of the composite girder bridge and to ensure the availability of bridge for traffic. With the traffic being regulated, the temporary reinforcements are removed, and the studs are cut (Photo-3), for rapid separation and removal of the concrete decks and steel girders.

3. Scope of use of this technology

The technology is used for the renewal of reinforced concrete decks of composite girder bridges, while reusing steel girders. Currently the studs are limited to headed studs.

4. Effect of technology

・ By exposing the studs on steel girders over the entire length, decks can be removed rapidly and simply by cutting the studs after closing the bridge to traffic (Photo-4). The decks can be cut without regard to the location of the steel girders (Photo-5), which means that the number of blocks to be removed can be minimized. In consequence, the period of closing the bridge to traffic during the removal of the decks of composite girder bridges can be reduced to half of the usual time, or even to one-third as far as the process of removing deck blocks is concerned.

・The conventional method requires manual chipping of concrete on the girders, and the estimated period required for deck removal on a bridge with two main girders, one span, and a span length of 20 meters is 18 days; the bridge will be closed for that length of time. The period when the bridge must be closed can be reduced

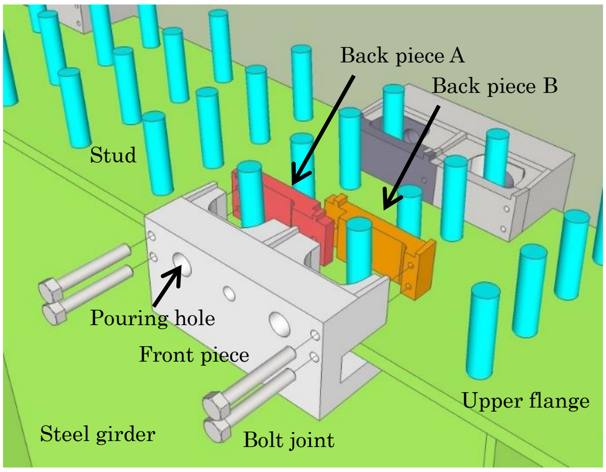

Figure-2　Composition of steel reinforcement

Photo-3　Cutting the stud

Photo-4　Deck removal state

Photo-5　Cutting with concrete cutter

Table-1 Estimated shortening of the process

Normal reinforced-concrete deck removal process			Deck removal using preliminary treatment with WJ	
Type of work	No. of days		Type of work	No. of days
Work before closing	None	Before closing	Chipping with WJ, temporary reinforcement	About 17 days
Deck cutting	About 6 days	After closing	Removal of temporary reinforcement, deck cutting	About 6 days
Removing deck block	About 6 days	After closing	Deck block removal	About 3 days
Blasting above the girder	About 4 days	After closing	Blasting above the girder	None
Stud removal	About 2 days	After closing	Stud removal	Included in previous work
Total days closed	18 days		Total days closed	9 days

to 9 days when the Rapid Removal Method is used (Table-1). This newly developed method enables complete deck removal in 20 days for a bridge with a span length of 22 meters, two main girders, and three spans (work executed in daytime only, with work periods of 7 days per span). Deck block removal was completed in one day for one span (as compared with the standard estimate of three days).

・ For urban expressways, loss of toll revenue can be minimized by shortening the period when the bridge must be closed for deck removal.

5. Social significance and further development of technology

The period of closing expressway bridges can be shortened, and the social burden reduced. In the future, reviewing the overall process of renewal projects, including deck installation, will enable meeting the need to keep bridges open to traffic during daytime, by closing one lane for traffic regulation, and by partial reconstruction, etc. The Large-scale renewal and repair project we currently are engaged in, is a pioneering challenge for us as well as neighboring countries. The technological achievements and improvements will be propagated to these countries.

6. Applicable record of technology

Study of cutting studs between steel girders and reinforced concrete decks (2) November 2017 to January 2019 ,1 other case.

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Introduction of Fukabari-Method

Subtitle: Easy Reinforcement of Pier by Pile Connection

1. Introduction

Japan's social capital stock was intensively developed during the period of high economic growth from the 1950s to the 1970s, and there is serious concern that the number of aging facilities will increase rapidly in the near future, and it is required to strategically maintain, manage, reuse and renew infrastructure. In port berths, in addition to the aging of existing facilities, in recent years they have been required to adapt the increase of the size of ships (especially cruise ships) and to strengthen earthquake resistance in preparation for large-scale earthquakes. As a result, the number of cases where specified performance cannot be satisfied has increased, and reinforcement measures for existing berths have been required. According to a survey conducted by the Ministry of Land, Infrastructure, Transport and Tourism, the ratio of key port berths exceeding 50 years of service will reach 35% in 2024 and reached 60% in 2044. Conventionally, measures such as the addition of piles have been taken in piled pier as a method of reinforcement, but large-scale construction such as the removal of superstructures (Fig. 1) is required. It causes a problem that the construction period of the site becomes long and the use of the pier is restricted. In order to solve these problems, "Fukabari-Method" which is a simple pier reinforcing method was developed. Fukabari-Method is a construction method for installing Fukabari (steel box beams) between existing piles. It is possible to make the maximum use of existing members such as piles and superstructures, and extend the life of the piers while adding functions to cope with the enlargement of ships and to strengthen the earthquake resistance. Furthermore, the construction period can be greatly shortened and the construction can be carried out while the pier is being operated. This paper introduces the outline of Fukabari-Method and its effects.

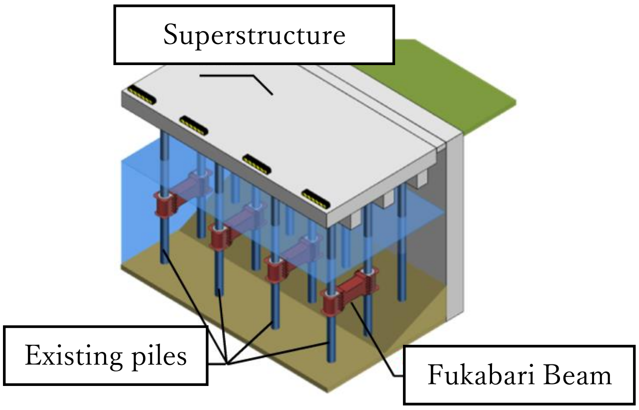

Figure-1 Pier Perth of Fukabari-Method

2. Summary of Fukabari– Method

As shown in Fig. 2, Fukabari-Method has a merit by installing Fukabari in the middle of existing piles. The pier becomes a multi-layer moment frame, which can distribute the bending moment generated in the pile head during the load action to the middle of the pile (Fukabari joint part). Thus, the pier can be reinforced while making maximum use of existing members such as superstructure.

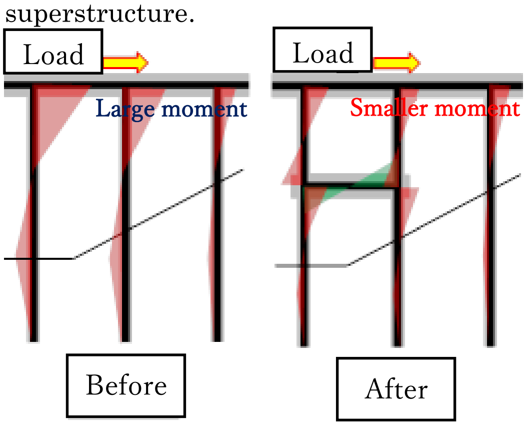

Figure-2 Reinforcement Effect Image

As shown in Fig. 3, Fukabari is consisted of "steel box beam part" and "steel u-shaped connection part". Studs are placed on the inside of the u-shaped connection part and on the existing piles. Fukabari is installed in line with the existing piles, and a grout material is placed as a filler after closing the connection part.

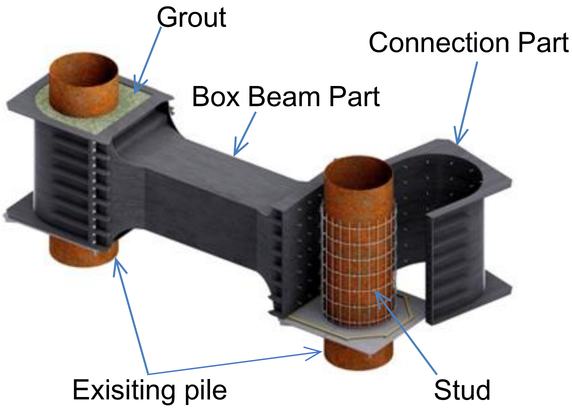

Figure-3 Structure drawing of Fukabari

3. Construction flow of Fukabari–Method

The construction flow of Fukabari-Method is shown in Fig. 4. In order to remove marine organisms adhered to existing piles, surface treatment is carried out. Then stads are placed in the sea (Flow ①). Rebar is wound around the stud (flow ②). By using a crane, Fukabari is immersed in the sea from the superstructure (flow ③). The diver places Fukabari at a predetermined position in the sea(flow ④). In order to integrate the existing pile and Fukabari, a grout is casted in the gap between Fukabari u-shaped connection part and the pile (flow ⑤), and the installation is completed (flow ⑥). In order to simplify the installation of Fukabari, the center part is made of a box beam, so that it is possible to transporte to a predetermined position as a floating body, and to sink in the sea by pouring the water into the box beam. In addition, since the U-shaped connection part is attached to both ends of the box beam via the opening/closing rotary hinges, it is easy to cover the piles with the connection part structure, and to integrate with the pile.

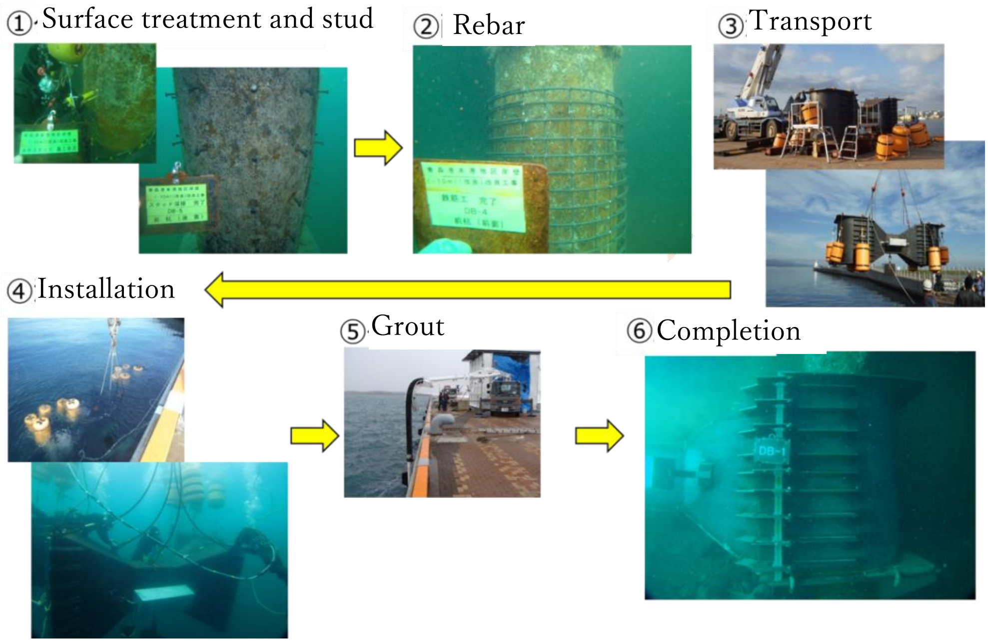

Figure-4 Construction Flow

4. Effect of using Fukabari

Fig. 5 compares Fukabari-Method with the conventional additional piles method. Fukabari-Method can shorten the site construction period by 60% and the shutdown period by 90%, and reduce the construction cost by 20%, compared to the additional piles method. In addition, a spillover effects, such as the reduction of economic loss by shortening the period of service shutdown and the reduction of environmental impact since a large heavy machinery is not required, can be expected.

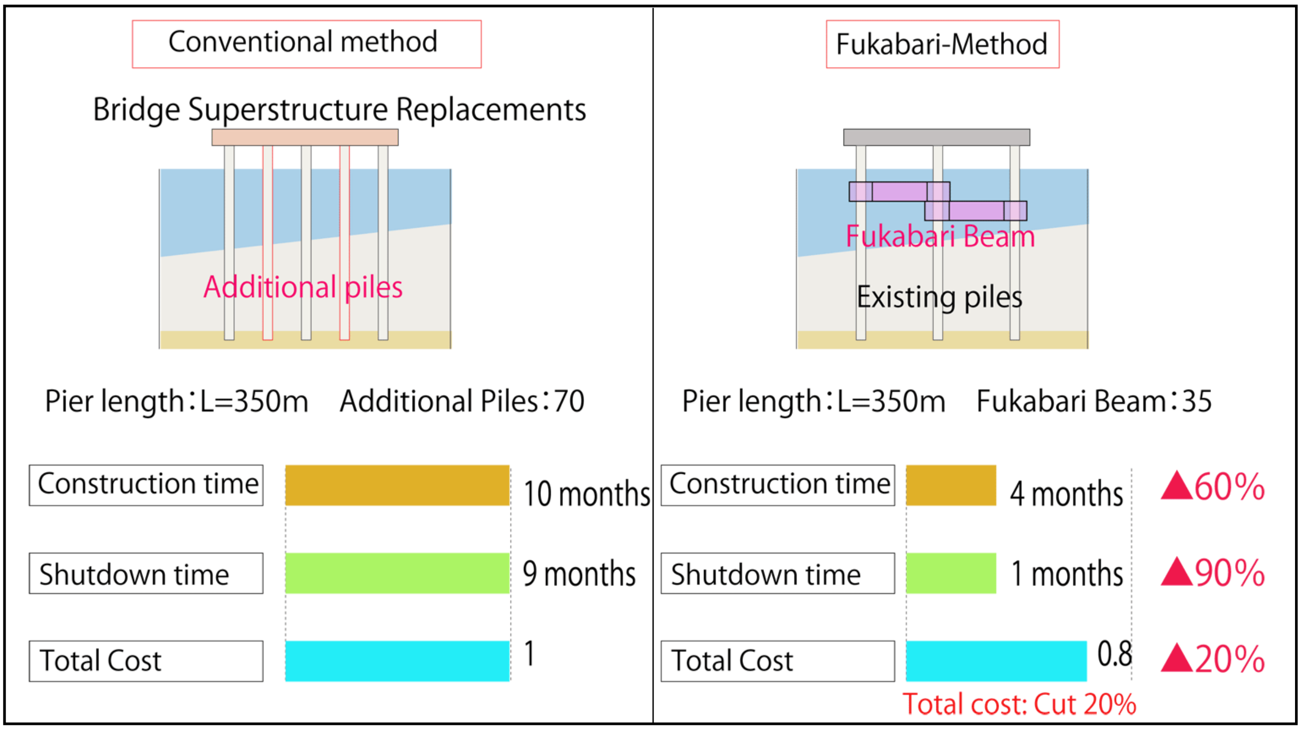

Figure 5 Comparison of methods

5. Construction results

Records and photographs of Fukabari are shown below.

① Aomori Port Honkou Area Berth

Number: 35 blocks

Construction Period: Oct. 2014 – Feb. 2015

Pic. 1 Aomori Port

② Osaka Nanko Ferry Terminal

(No.1 Pier, No.2 Pier)

Number: (No.1 Pier) 64 blocks

(No.2 Pier) 52 blocks

Construction Period:

(No.1 Pier) May 2015 – Aug. 2015

(No.2 Pier) May 2017 – Jul. 2017

Pic. 2 Osaka Nanko Ferry Terminal

③ Fukushima Matsukawaura Fishery Port

Number: 5 blocks

Construction Period: Sep. 2019

Pic. 3 Fukushima Matsukawaura Fishery Port

④ Shimizu Port Hinode Berth

Number : (Works 1) 47 blocks

(Works 2) 10 Blocks

Construction Period:

(Works 1) Mar. 2019 – Jul. 2019

(Works 2) Sep. 2019 – Nov. 2019 (planned)

Pic. 4 Shimizu Port

6. In return

In this paper, Fukabari-Method is introduced as an effective method to solve the various problems regarding the reinforcement of existing pier. The method realizes the reinforcement while making the maximum use of the existing members and short service down time. As aging infrastructures are rapidly increasing, it is expected that the starategic maintenance, reuse and renewal of the infrastructures by using Fukabari-Method will contribute to the reduction of maintenance and management costs in social capital stocks.

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IDI provides consulting services to facilitate International Assistance to developing countries, to promote international exchange of information and human resources, and to support globalization of project implementation systems targeting both developed and developing countries in the field of infrastructure.

IDI has been publishing the free quarterly journal called "IDI Quarterly" since1996 to introduce information related to public works and construction technologies developed in Japan to foreign countries. We have distributed the journal to administration officials in more than 90 countries around the world by e-mail.

It is highly appreciated if you would send us your opinions, impressions, etc. on the articles.
We also welcome your specific requests for the following Quarterly issues.