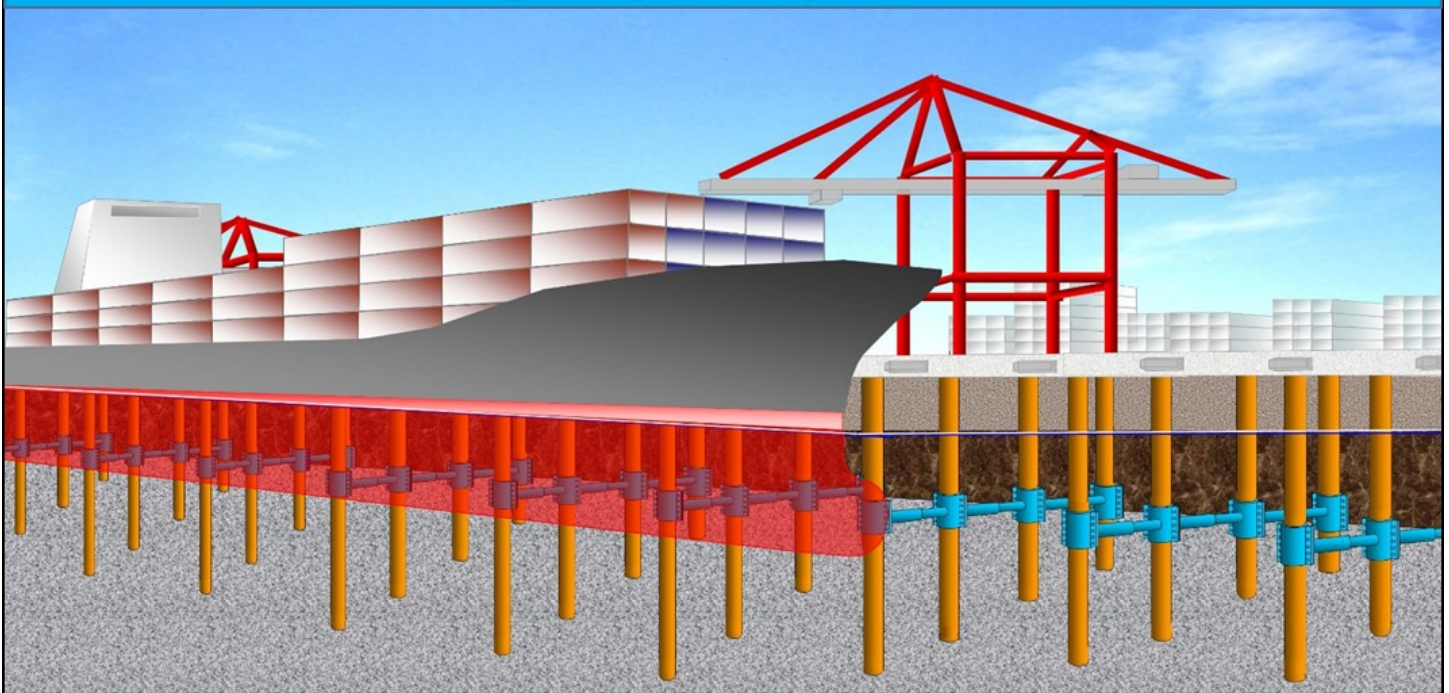




“Re-pier method” for efficient seismic retrofitting of piled piers in service



CONTENTS

The 19th Infrastructure Technology Development Award 2017

“Re-pier method” for efficient seismic retrofitting of piled piers in service	2
Restoration for Preservation of Himeji Castle Main Keep, National Treasure of the Heisei Era	5

Infrastructure Development Institute – Japan (IDI)

Suido-cho Bldg, 3-1, Suido-cho, Shinjuku-ku, Tokyo, 162-0811, JAPAN

Tel: +81-3-5227-4107 Fax: +81-3-5227-4109 E-Mail: idi17@idi.or.jp Website: <http://www.idi.or.jp/english/00index.htm>

The 19th Infrastructure Technology Development Award 2017

The 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).

Thirty-six technologies competed for the 19th Infrastructure Technology Development Award.

In principle, the applicants' technologies should have been developed within the past five years and applied to the real sites within the past three years.

As a result of examination, institutes and researchers with the following technologies were awarded 19th prizes.

The grand prize is “Next-generation construction production system centered on automation of construction machinery A⁴CSEL” .

And the three excellence prizes were awarded to “RE-PIER METHOD for efficient seismic retrofitting of piled piers in service”, “Restoration for Preservation of Himeji Castle Main Keep, National Treasure of the Heisei Era”, and “Network Compatible Unmanned Construction System”.

The grand prize and one of the three excellence prizes are introduced below.

For any inquiries/ comments please contact JICE :

Homepage: <http://www.jice.or.jp/>

(Japanese version only)

E-Mail: webmaster@jice.or.jp

“Re-pier method” for efficient seismic retrofitting of piled piers in service

1. Background of Technology Development

The Ministry of Land, Infrastructure, Transport and Tourism of Japan formulated the “Emergency Program for Development of High Earthquake-Resistance Mooring Facilities” in 2006, and is making efforts to attain the objectives. In this context, the ministry has to extend service lives and implement seismic retrofitting of existing structures with a limited budget for social capital development in order to enhance the earthquake resistance of structures. Many private companies that own mooring facilities for exclusive use do not have any other facilities that they can use when the service lives of their mooring facilities have expired, so they have a need to extend the service lives of their mooring facilities at low cost without suspending their services. Therefore, there has been a demand for a

cost-efficient method enabling the seismic retrofitting of mooring facilities without reducing their existing physical distribution function or while minimizing the effect of the retrofitting work on the use of the mooring facilities.

2. Detailed Description of the Technology

This technology was developed for the seismic retrofitting, extension of the service life and deepening of existing piled pier structures. It is a method to reinforce an entire pier structure by connecting steel pipe piles with stiffening members (Fig.-1).

The stiffening member has a nested structure consisting of two steel pipes with different diameters. This structure makes the length of the member adjustable (Photo-1, Fig.-2).

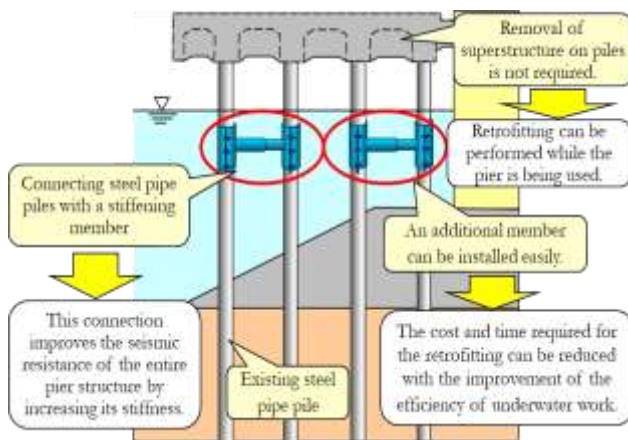


Fig-1. Conceptual diagram of pier retrofitting

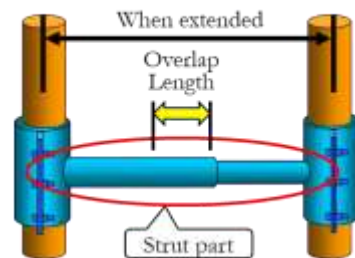
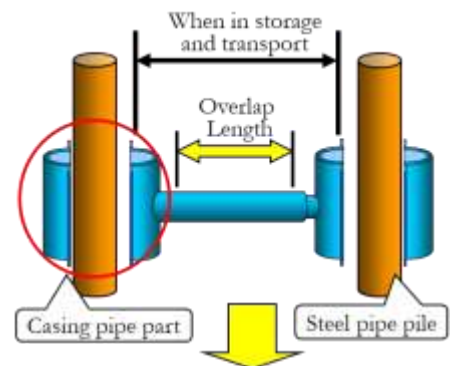


Fig-2. Mechanism for the length adjustment of the stiffening member

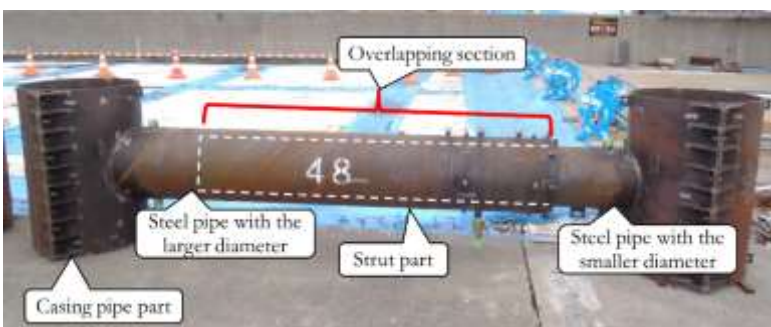


Photo-1. Stiffening member (strut member)

The members are transported to a retrofitting site in the shortest form with the inner pipe fully inserted in the outer pipe. They are extended to required lengths at the site and installed between two existing piles.

The stiffening member has a casing-pipe part which consists of two parts manufactured by splitting a steel pipe in half at either end. These two parts are joined at their flanges after the member has been installed between two piles. Then, the spaces between the existing piles and casing parts and between the inner

and outer pipes of the member are filled with mortar (Fig.-3) to form rigid joints between the stiffening member and the existing structure. While a superstructure on piles has to be removed before stiffening members are to be placed by inserting piles into the casing parts from pile top ends in the conventional seismic retrofitting technology, this technology allows the installation of additional stiffening members without removing the superstructure.

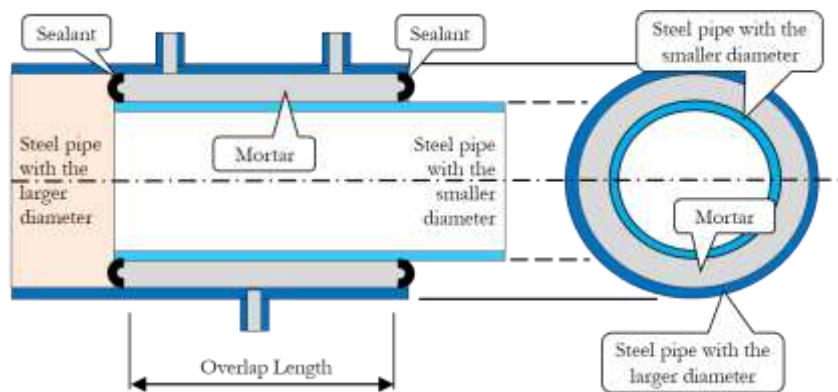


Fig-3. Section drawings of the overlapping part

The characteristics of this technology are summarized in the following:

- The nested structure consisting of two steel pipes with different diameters allows the length of the stiffening member to be changed in a wide range. When in storage and transport, the length of the member will be shortened than the gap between two existing piles, and it can be placed between the piles easily in its shortest form. Then, it is extended to connect the two existing piles in order to integrate the member in the pile structure.

There is no need to remove a superstructure on piles for the installation of additional stiffening members. This characteristic significantly reduces not only the impact of the retrofitting work on the operation of the pier (Photo-2) but the cost and time required for executing it.



Photo-2. Retrofitting while using a piled pier

3. Scope of Application

Pier structures in general (including vertical pile structures, coupled/battered pile structures and dolphin structures)

4. Advantage of the Technology

This technology significantly reduces the cost and time required for the retrofitting (by 43 % and 61 %, respectively), compared with the conventional technology that requires the removal of a superstructure on piles before applying stiffening members between the piles. (The time required at a retrofitting site is compared. The time to manufacture the stiffening member in a plant is however required when the new technology is to be used.)

5. Installation Record

Approximately 10 % of the mooring facilities in Japan had been in service for at least 50 years as of 2014. This percentage will increase to approx. 35 % in ten years and approx. 60 % in twenty years. The application of this technology will reduce the maintenance cost of social overhead capital. It will also contribute to building national resilience with the extension of the service life of infrastructure and improvement of seismic resistance of existing structures.

6. Record of the Application of the Technology

This technology has been used in five projects.

Technology Developer:

Aomi Construction Co., Ltd.

Contact:

Tohru Yoshihara, Aomi Construction Co., Ltd.

E-Mail: netis@aomi.co.jp

TEL: +81-3-5439-1001

• Even if the distances between pairs of piles of an existing pier structure vary because of construction errors, the same length-adjustable stiffening members mass-produced in a plant (standardized members) can be used to connect them. (Fig.-4)

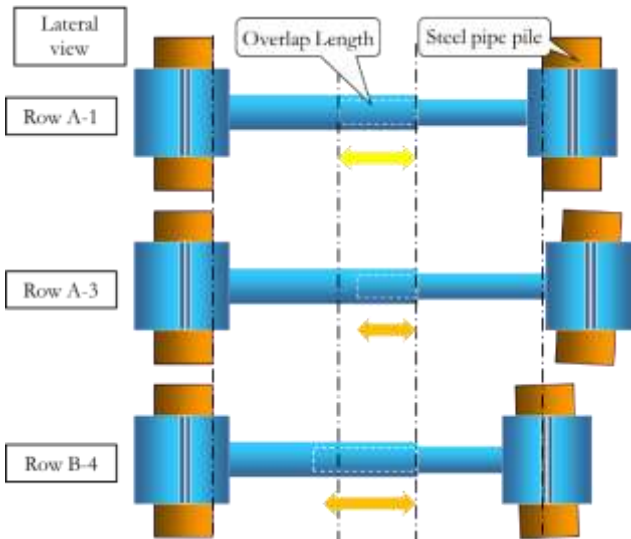


Fig-4. Stiffening members installed on pairs of steel pipe piles at different distances

• The stiffening members can be installed manually by divers because the member can be kept at neutral buoyancy with the use of a float specifically designed to give buoyancy to the member (Photo-3). Therefore, work vessels will not occupy the water in front of the pier during the retrofitting because they are not required in this technology.



Photo-3. Float specifically designed for the stiffening members

Restoration for Preservation of Himeji Castle Main Keep, National Treasure of the Heisei Era (Reborn of Himeji Castle by Melding Traditional and Contemporary Technologies)

1. Background of Technology Development

Under many constrained conditions restoration for preservation of Himeji Castle, a National Treasure and a World Cultural Heritage, posed issues of “accurate and appropriate restoration for preservation” and “higher durability and improved seismic resistance”, but we successfully did solve the issues by melding traditional artificer’s skills and contemporary technologies, and then implemented the restoration work. Before the commencement of the restoration work for preservation, a protective roof scaffolding covering the structure from the weather and a huge gantry used for transportation and lifting of the building materials were constructed.

After completion of the restoration for preservation, dismantling of the protective roof scaffolding was carefully implemented without any delay, accident, or damaging Himeji Castle Main Keep, which was reborn as a shining white castle.



Photo1 Full view of Himeji Castle Main Keep

2. Detailed Description of the Technology

By unitizing the steel frames of the protective roof scaffolding for the steep rafter roof, some of risky construction processes were eliminated and the work was simplified (Photo2, 3).



Photo2 Dismantling Process of the Protective Roof Scaffolding



Photo3 Unitization of the Truss Beam for the Steep Rafter Roof

The interval between eyelet holes in mesh sheets (with a 30 % effective perforation rate) was reduced to half (from 300 mm to 150 mm) against gale winds. Risky work of re-covering mesh sheets was eliminated through the idea. (Photo4)



Photo4 Flameproof Mesh Sheet Rafter Roof

According to the traditional construction method, roofing soil and batten cleats preventing roof tiles from sliding were partially nailed and fastened with copper wire. This time, wood batten cleats were assembled on the roof tile base and roofing soil was applied in strips, and all roof tiles were fastened using nails and copper wire as fall-preventive measures. (Photo5)



Photo5 Combination Method of Roofing Soil and Wood

Because it was impossible to change the shape of the roof tiles to stop the water leak, we obtained permission to use copper plates as substrate roofing material under roof tiles. (Photo6)



Photo6 Copper plates under roof tiles

Inorganic water absorption inhibitor whose effect had been verified in the outdoor exposure test was sprayed to prevent deterioration of the carbon coating on roof tiles, cracking by freezing in the wintertime and suppress the growth of mold to delay blackening and deterioration. (Photo7)



Photo7 Spraying Water Absorption Inhibitor

As seismic reinforcements of columns, flat bar frames were fixed using wooden wedges in order to react to the possible slackening and ensure breathability of wood parts in the future. (Photo8, Figure1)



Photo8 Seismic Retrofitting for wood parts

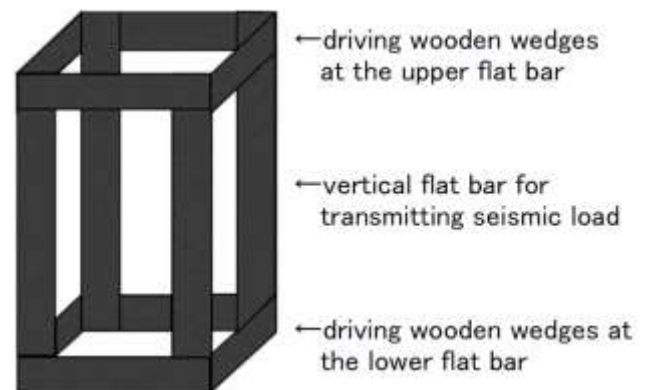


Figure1 Structure of a Flat Bar Frame Set

3. Scope of Application of the Technology

Concerning the steel frames for protective roof scaffolding, unitization of the truss beam for the steep rafter roof and integration of the suspended scaffolding are effective in assembling and dismantling of protective roof scaffolding on complex terrain. This unitization eliminates some of risky construction procedures. In addition, reinforcement of flameproof mesh sheet against strong winds, which was done for the mesh sheet around the steel frames for the protective roof scaffolding, is effective in windy regions as well as in the case of constructions that may cause internal damage by removing mesh sheet.

4. Effect of Technology

As the protective roof scaffolding was gradually dismantled and the current state of Himeji Castle was uncovered, it became an evident that the restoration work for preservation was proceeding safely. Many mass media requested coverages of the dismantling, and it was aired on TV. Consequently, people became more interested in Himeji Castle as well as restoration work of cultural heritages.

5. Social Significance and Possibility for Further Development of the Technology

Protective roof scaffoldings are indispensable in cultural heritage preservation work. Because Himeji Castle was built as a fortress to keep away enemies, there is not sufficient construction ground around it.

The construction method used for Himeji Castle is efficient when it is in a complicated situation like this. Moreover, the technology to increase durability and seismic resistance appropriately investigated from a viewpoint of cultural heritage preservation will contribute to achievement of long-term preservation of historic buildings and their beautiful appearances that continue to give strong impressions on people. In addition, melding of the traditional and contemporary technologies can contribute to the succession of the traditional technology as well as ancient cultures and buildings to future generations.

6. Achievement of the Technology Application

The technology was applied to restoration work for preservation of Himeji Castle Main Keep for the first time. (November 2009 - March 2015)

Technology Developer : Kajima Corporation
Contact:
Kajima Corporation Public Relations Office
E-mail: h-takeda@kajima.com
FAX: +81-3-6438-2733

About IDI and IDI-Quarterly

Infrastructure Development Institute (IDI)-Japan is a general incorporated association operating under the guidance of Ministry of Land, Infrastructure, Transport and Tourism of Japanese Government.

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

IDI has been publishing the free quarterly journal “IDI Quarterly” since 1996 for the purpose of introducing information relating 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 are also welcoming your specific requests on articles to pickup for the following Quarterly issues.