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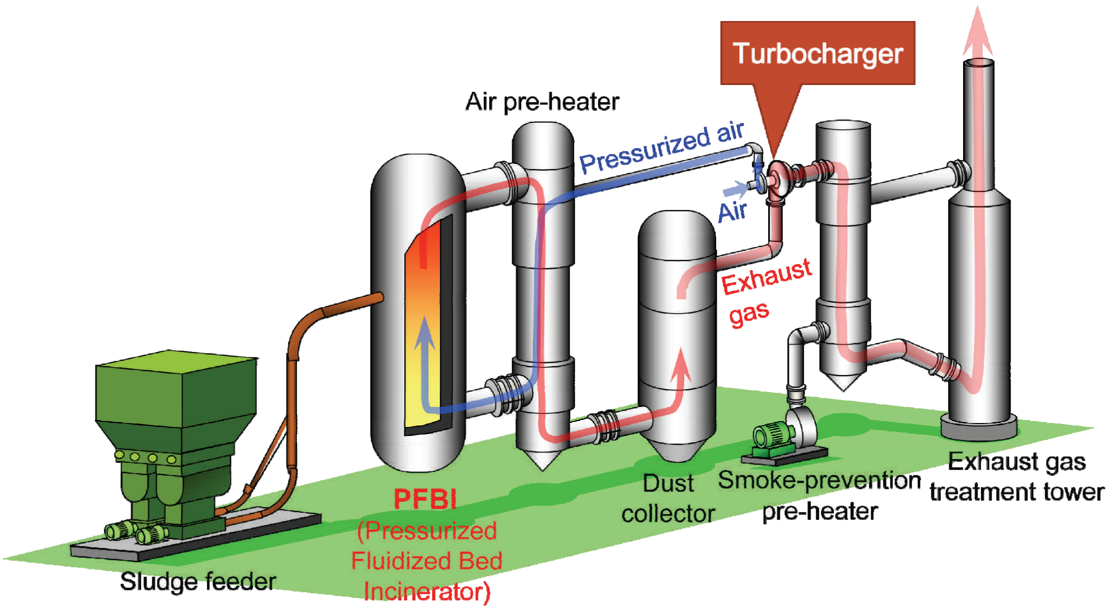
IDI

Infrastructure Development Institute—JAPAN

Fluidized Bed Incinerator with Turbocharger

Energy-saving and low environmental load incinerator for sewage sludge



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The 17th Infrastructure Technology Development Award 2015

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.

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

Twenty-five technologies competed for the 17th Infrastructure Technology Development Award. In principle, the technologies had to have been developed within the past five years and applied to the real construction sites in the last three years.

This year, two grand prizes were awarded for the following technologies as a result of examination: "Fluidized Bed Incinerator with Turbocharger (Energy-saving and low environmental load incinerator for sewage sludge)" and "High Durable Concrete with Seawater (Environment-Friendly Concrete with Seawater, Byproducts, and Special Additives)".

The three excellence prizes were awarded to "Tunnel Enlargement Method for Shield Tunneling with Segments (WJ Segment Method)", "Hybrid tsunami protection wall to enable 'ultra' rapid construction (Minimization of site works and nearby producing materials due to divide wall into pre-casted blocks)", and "Countermeasure against liquefaction and mitigation of global warming by log piling (Log Piling method for Liquefaction mitigation and Carbon stock (LP-LiC))".

One of the grand prizes and two of the excellence prizes are introduced below, and the other two technologies will be introduced in the next issue of IDI Quarterly.

For any inquiries/ comments regarding the prizes please contact JICE:
Website: http://www.jice.or.jp/
(Japanese version only)
E-Mail: webmaster@jice.or.jp

Fluidized Bed Incinerator with Turbocharger

(Energy-saving and low environmental load incinerator for sewage sludge)

1. Background of Technology Development

Around seventy percent of sewage sludge generated through municipal wastewater treatment in Japan is incinerated to reduce its volume, which causes two problems related to global warming. Firstly, huge amount of fossil fuel and electricity are consumed with Conventional Fluidized Bed Incinerators (CFBI), which are often adopted for sludge incineration. Although exhaust gases from CFBI have high energy potential, they remain almost unutilized. Secondly, a large amount of nitrous oxide, one of the greenhouse gases with highest warming potential, is emitted from sewage sludge incinerators.

To address these problems, a new technology for sewage sludge incineration was developed by the National Research and Development Agency Public Works Research Institute (PWRI), National Institute of Advanced Industrial Science and Technology (AIST), Tsukishima Kikai Co., Ltd., Sanki Engineering Co., Ltd., and Bureau of Sewerage, Tokyo Metropolitan Government.

2. Detailed Description of the Technology

The new technology, Fluidized Bed Incinerator with Turbocharger (FBIT), consists of a pressurized fluidized bed incinerator and turbocharger as shown in Fig. 1. FBIT enhances combustion efficiency by pressurized incineration of 120-140kPaG. Gas exhausted from FBIT enters through the air preheater and hot gas filter, and turns the turbine blade in the turbocharger as shown in Figs. 2 and 3. The air compressor in the turbocharger driven by the energy of the exhaust gas from FBIT generates pressurized air for combustion. When sewage sludge is supplied to FBIT continuously, combustion air is supplied to FBIT without consuming electricity for driving the air blower.

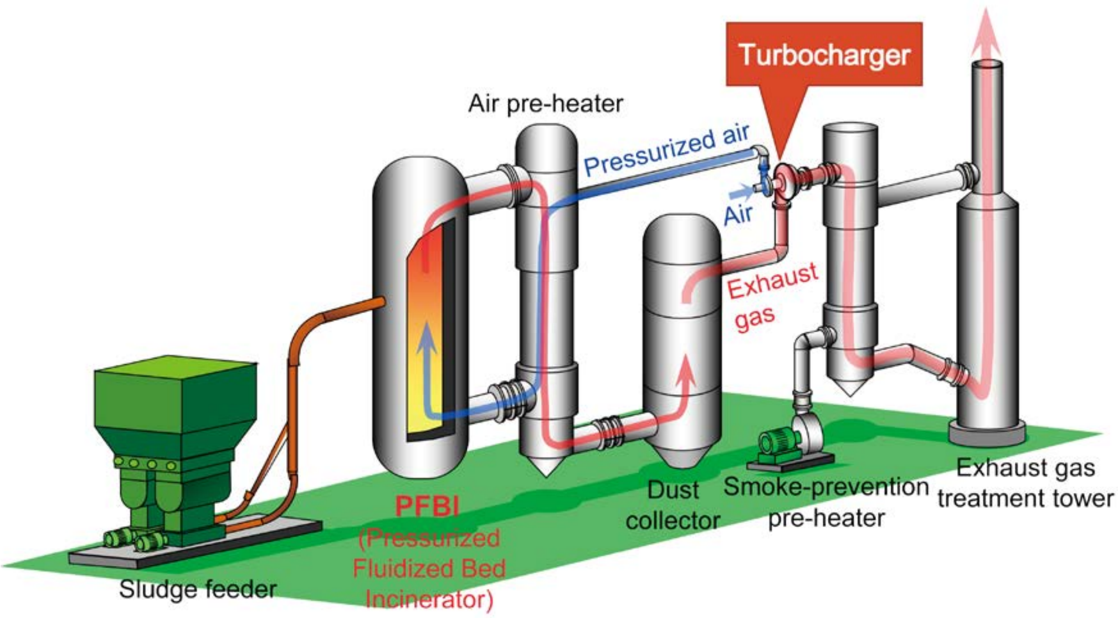

Figure-1 Schematic illustration of the Fluidized Bed Incinerator with Turbocharger

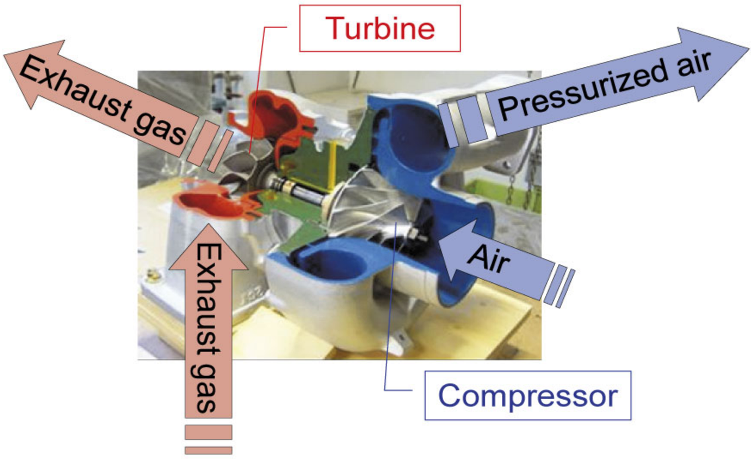

Figure-2 Cut model of turbocharger and flow of air

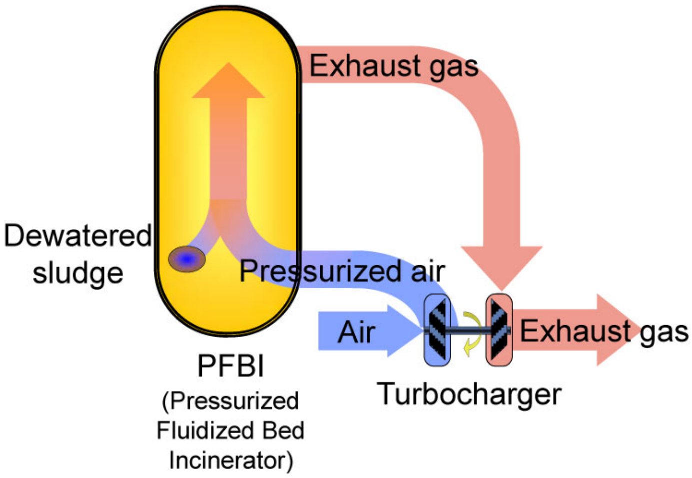

Figure-3 Flow of air in PFBI and Turbocharger

3. Advantages of the Technology

FBIT has great advantages in terms of energy and fuel consumption, and reduced greenhouse gases in comparison with the CFBI.

[Reduced Electric power consumption]

FBIT can save around 40% of power consumption, since it enables combustion of sewage sludge under the pressure of 120-140kPaG and generates combustion air without consuming electricity by using the turbocharger.

[Reduced fuel consumption]

FBIT can reduce around 10% of supplemental fuel consumption, because the pressurized incineration enables a smaller-sized incinerator, which leads to a reduction in radiation heat loss from the incinerator.

[Reduced nitrous oxide emission]

FBIT can reduce around 50% of nitrous oxide emission, as FBIT generates a high - temperature combustion area (870-890 Celsius degrees), enhancing the decomposition of nitrous oxide.

4. Applicability

FBIT is applicable to sewage sludge incineration.

There are around three hundred incinerators in Japan as of March, 2011. Installation of FBIT is expected when the aging incinerators are renewed.

5. Installation Record

FBITs are in operation at four wastewater treatment plants, and under construction at three wastewater treatment plants as of April, 2015.

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Tunnel Enlargement Method for Shield Tunneling with Segments (WJ Segment Method)

1. Background of Technology Development

Construction of expressways in metropolitan areas is accompanied by various difficulties as the number of instances in which a tunnel structure is used has increased for the purpose of preserving the environment. One of the greatest technical challenges in this respect is constructing branches or junctions for routes where there is a change in the sectional shape. Conventionally, the cut and cover method is used for such work. However, since this method has a large impact on the surrounding environment and on the road traffic, the development and commercialization of a tunnel enlargement method has been called for as a solution to the problems in the conventional methods.

The work for the Ohashi Ramp, in which a diverging/merging section is being constructed for the Central Circular Shinagawa Route of the Metropolitan Expressway and the Ohashi Junction, needed to be conducted under severe restrictions. For example, the road under which the Ramp was to be constructed is a trunk road with a daily traffic volume of around 40,000 vehicles, tall buildings are concentrated along the road, and various overpasses, rivers, and major structures exist in the area surrounding it. The adoption of cut and cover method was therefore judged as too problematic. As a solution, a new tunnel enlargement method (Wing Joint Segment Method) that joins two shield tunnels with arch-type segments (hereinafter, "enlarged-segments") (Figs. 1 and 2) was developed and commercialized.

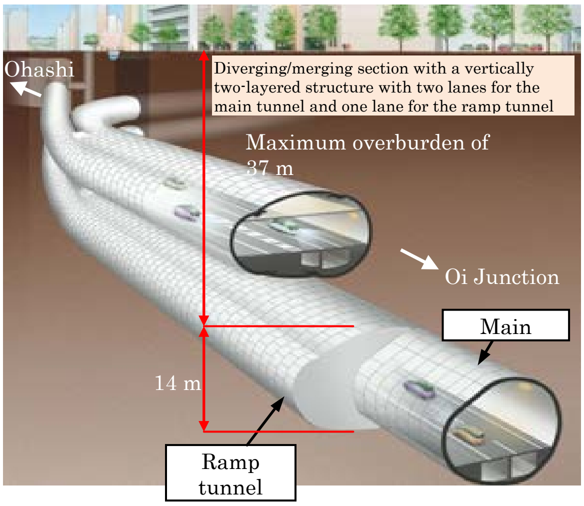


Fig. 1 Outline of Ohashi Ramp Construction for the Central Circular Shinagawa Route

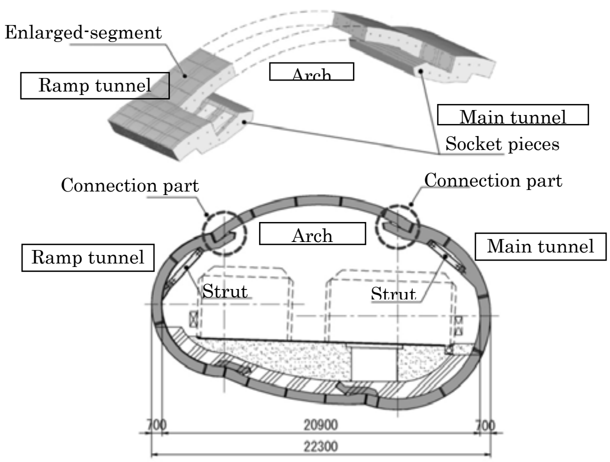
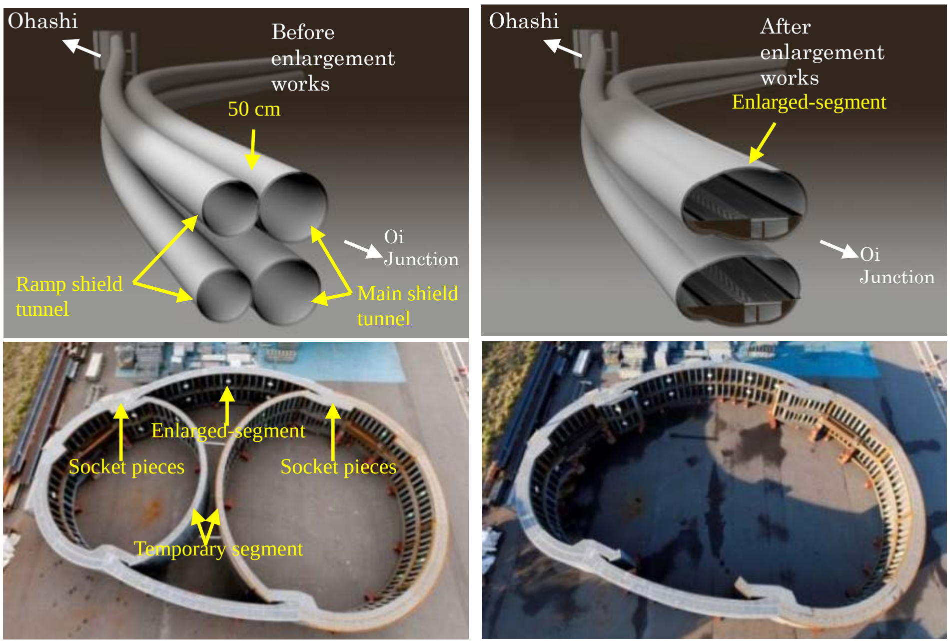


Fig. 2 WJ (wing joint) Segment Method

2. Detailed Description of the Technology

The newly-developed technique involves the construction of one large shield tunnel by enlarging two shield tunnels underground. As there is no need to control traffic on the ground, this technique allows the construction of a diverging/merging section without affecting road traffic. The use of steel segments with excellent strength and toughness to constitute the lining structure, enabling a large shield tunnel built at great depth, has reduced the weight of the structure and improved its water-tightness and durability. Furthermore, the construction period has been greatly reduced by introducing on-site assembly of shop-fabricated segments for lining work for the internal surfaces of the enlarged section. Also, specially-shaped socket pieces designed to be bolt-jointed to enlarged-segments are placed in advance of the shield tunneling work, and temporary segments between tunnels are removed after the enlarged-segments are assembled. This work sequence requires minimal excavation of the original ground, ultimately minimizing as a result the impact of ground anomalies, such as surface settlement, on the surrounding environment (Photo 1).



Construction procedure

(1) A main shield tunnel and a ramp shield tunnel are constructed in parallel with each other with an interval of 50cm between them.

(2) Enlarged-segments are assembled both above and below the tunnel (to ensure structural stability thereof).

(3) Temporary segments, placed between the tunnels are removed to enlarge the two tunnels into a single tunnel.

Photo 1 Construction procedure for the WJ Segment Method

3. Advantages of the Technology

Showing the benefits of the new technique on the basis of the construction work of the Ohashi Ramp for the Central Circular Shinagawa Route:

(1)Realizing a large shield tunnel built at great depth by adopting the tunnel enlargement method:

- A vertically two-layered large shield tunnel of about 200m in length, 22.3m in width and 14m in height was constructed at great depth with a maximum overburden of 37m and a maximum water pressure of 0.45MPa.
- A comparison of the design with the monitoring results verified the validity of the design, thus establishing the design technique for this method.

(2)Shortening work period: The tunnel enlargement work after the completion of the shield tunnel took one year and 10 months.

(3)Controlling impact on the surrounding environment: The maximum ground surface settlement due to the construction of the large shield tunnel described above was kept within 8mm.

4. Applicability

This technology has no specific limitations to its application. Nevertheless it is necessary to keep the following five points in mind: 1) a certain land width is necessary for the entire length of the section to be enlarged; 2) delays in the shield work causes a delay of the entire tunnel enlargement work schedule; 3) an auxiliary method is necessary in the case of unconsolidated ground; 4) coordination is necessary to make work space or work routes for the shield work and enlargement work; and 5) specially shaped segments require appropriate segment erectors in the shield tunneling work.

5. Installation Record

Ohashi Ramp for the Central Circular Shinagawa Route: May 2007 to Nov. 2014 (Photos 2, 3)

Photo 2　Completed tunnel

(showing the diverging section toward Ohashi)

Photo 3　Completed tunnel

(showing the merging section in the Oi direction)

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Hybrid Tsunami Protection Wall to enable "ultra" rapid construction

(Minimization of site works and nearby producing materials due to divide wall into precast blocks)

1. Background of Technology Development

The Government of Japan had designated the five-year period until FY2015 as one for intensive restoration work from the Great East Japan Earthquake in 2011. However, manpower and supply of locally produced material such as ready-mixed concrete and formwork have still been insufficient because a number of reconstruction works are being carried out in parallel. Therefore, various problems have occurred such as prolonged work term and delays in start of construction.

Under these situations, shortening the work period, reducing the number of local workers employed, and mitigating the impact of supply and demand trends of locally produced material are required with regards to the tsunami protection walls. As shown in Fig.1, "Hybrid Tsunami Protection Wall" has been newly developed to respond to the above needs.

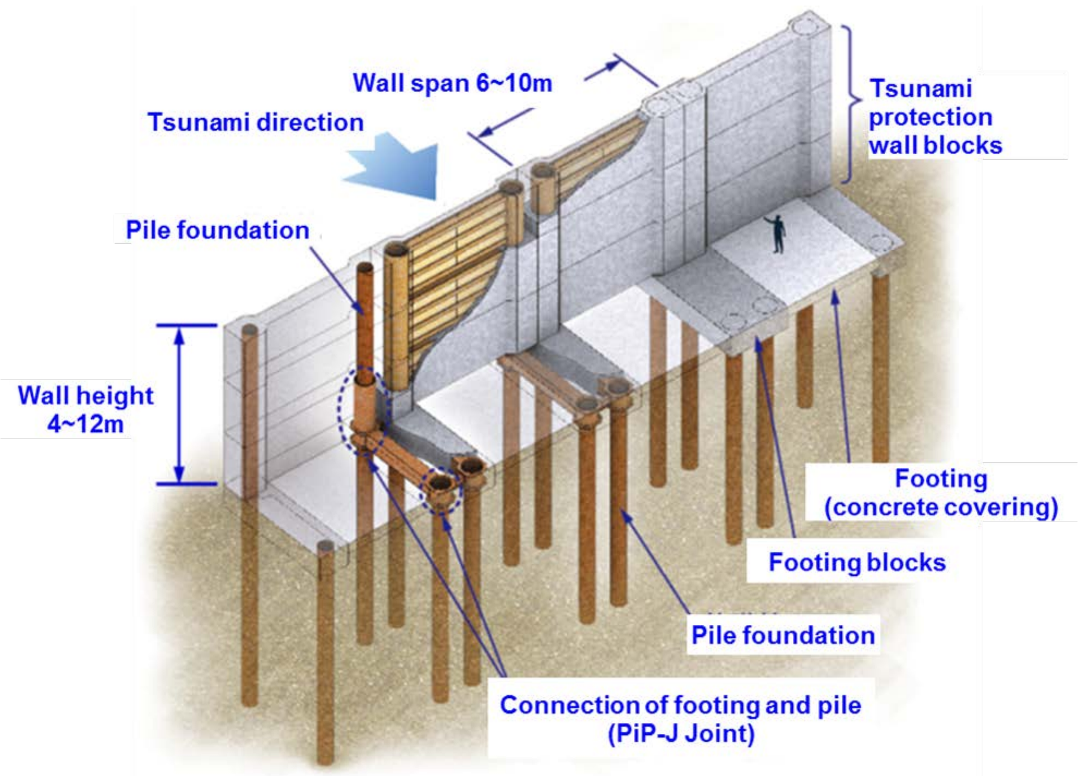

Fig.1 Schematic view of "Hybrid Tsunami Protection Wall"

2. Detailed Description of the Technology

The hybrid wall is supported by pile foundations from both the sea side and land side, as shown in Fig.1. The wall consists of tsunami protection wall blocks and footing blocks. Fig.2 and Fig.3 show work flow at construction site and transport flow of prefabricated and precast blocks, respectively. These blocks are hybrid structure members as shown in Fig.4, in which steel members are covered and integrated with concrete.

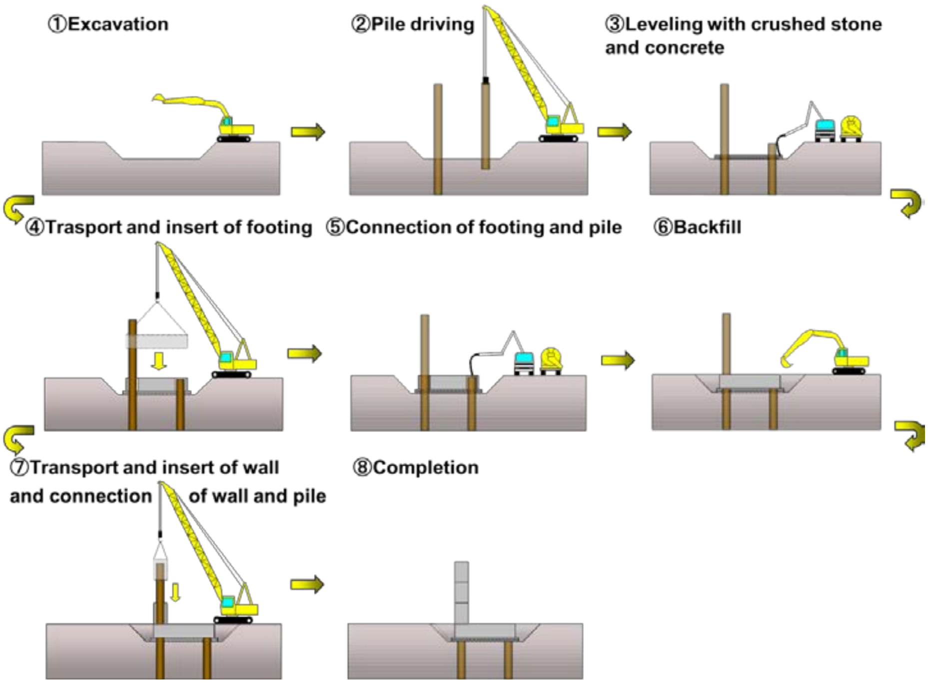

Fig.2 Work flow at construction site

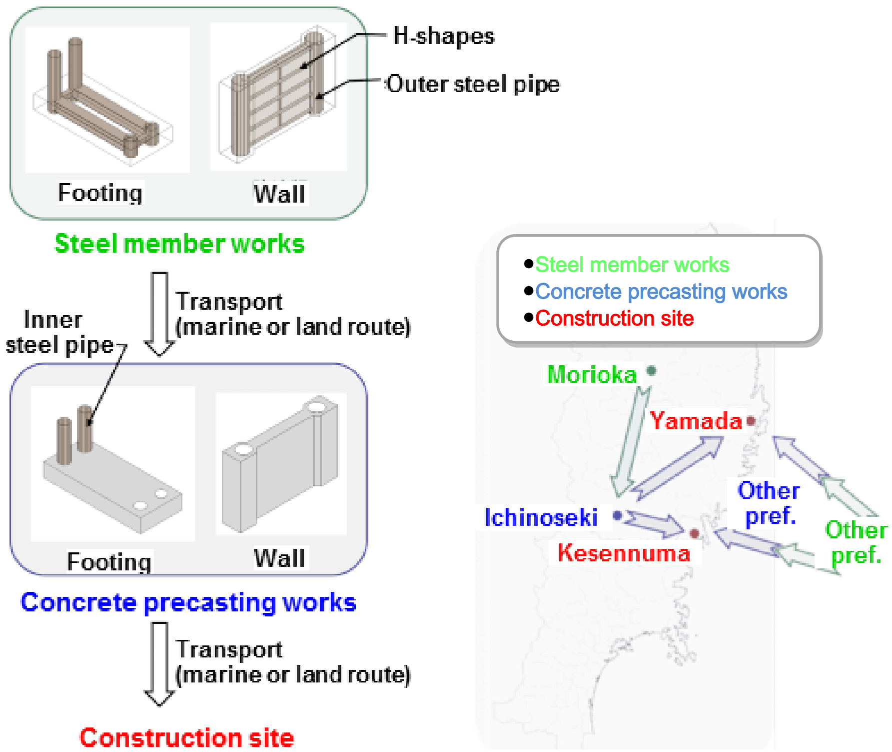

Fig.3 Transport flow of prefabricated precast blocks

Fig.4 Layout of reinforcement and transport of wall blocks (upper) and footing blocks (lower) for the 1st disaster restoration construction at Yamada fishery port

Tsunami loads generate large bending moment around the base of the hybrid wall. To endure the large bending moment with only pile foundations for support, extremely-thick piles are required. Those piles are relatively expensive and it will take longer to procure them. Therefore a double steel pipe structure, called “PiP-J Joint”, has been designed: Footing block is inserted into previously driven piles as shown in left of Fig.5, so that “Inner steel pipe” projected from footing block and the steel pipe pile easily become double steel pipes structure, which have necessary thickness to endure the large bending moment.

Fig.5 Insert a footing block (left) and a wall block (right) to pre-driven piles for the 1st disaster restoration construction at Yamada fishery port

3. Advantages of the Technology

Comparing the hybrid wall to a conventional concrete wall in projects similar in scale to the tsunami protection wall at Yamada fishing port:

[Work term and volume of site works]

Work term and work load are roughly estimated on the basis of standard production rates of each work item, adding idle period due to lack of ready-mixed concrete. As a result, the hybrid wall can reduce 60% for work term, and 80% for work load in comparison with a conventional wall.

[Locally produced materials]

The hybrid wall can reduce 80% of ready mixed concrete, and 95% of area for formwork in comparison with a conventional wall.

4. Applicability

- Grounds where pile driving is possible
- Pitch of piles in extension direction: within 10m

  Height of walls: within 12m

5. Installation Record

- The first disaster restoration construction at Yamada fishing port, March 2013 to January 2014 (extension of completion period to August 2015; Fig.6 shows completion view)
- 8 other installation records

Fig.6 Distant view of completion for the 1st disaster restoration construction at Yamada fishery port

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IDI has been publishing the free quarterly journal “IDI Quarterly” since1996 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.

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