JFE TECHNICAL REPORT
No. 19 (Mar. 2014)

# Construction Technology of Artificial Ground for Huge Tsunamis†

## 1. Introduction

Learning from the Great East Japan Earthquake and Tsunami, which caused catastrophic damage to Japan's northeastern coast in March 2011, it is essential to be able to evacuate to safe high locations immediately after an earthquake occurs. For this, nearby high ground or high structures which are not overtopped or destroyed by a tsunami are necessary. Fishing ports are particularly vulnerable areas with a high concentration of human life and property, as many people work and enjoy leisure in areas directly fronting the sea. Therefore, structures which function as both production/everyday life facilities under normal conditions and as evacuation facilities in case of disaster are required.

One solution to this problem is construction of artificial ground with spacing between columns to secure working areas at the existing coastline. In other words, the lower level under the structure is used as an area for handling marine products and processing facilities, while the upper level provides an evacuation area. In case of disaster, forklifts and other equipment/materials that are normally used in handling products can be moved to the upper level, enabling use in recovery work. Moreover, if the upper level and high ground are connected by a bridge, speedy evacuation is possible, and if the upper level is normally used as a car parking area, greater mobility will be possible in an evacuation.

Various concepts for effective utilization of artificial ground under normal conditions are possible. For example, conceivable ideas include construction of commercial facilities such as shopping centers, etc. which have a combined function of storing emergency provisions, construction of amenity facilities such as sports centers that can be used as indoor shelter in a disaster, and the like. However, compatibility with the disaster prevention/disaster mitigation plans of the region as a whole is necessary.

Although various modes of using artificial ground are conceivable, it is necessary to increase the spacing between the columns in order to use the lower level effectively. Steel structures are effective for realizing this type of design. As structures in which the upper level is used as artificial ground or a roadway, JFE Group companies have constructed steel structures such as the jacket type quay shown in **Photo 1** and the Metal Road[1)] in **Photo 2**. This report introduces these construction technologies, which can be used in artificial ground and elevated roads for evacuation as countermeasures against huge tsunamis.

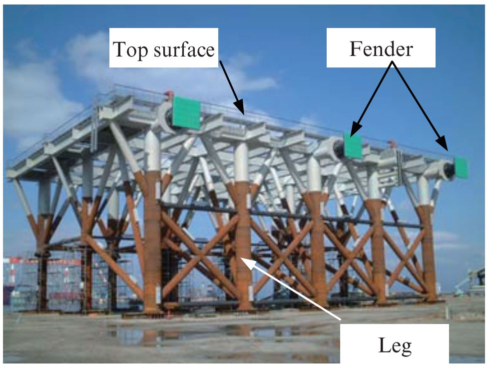


Photo 1 Jacket type quay

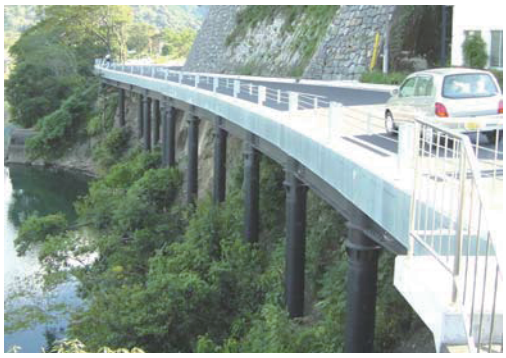

Photo 2 Metal Road

## 2. Example of Artificial Ground for Fishing Ports

### 2.1 Concept of Artificial Ground

**Figure 1** shows a conceptual drawing of artificial ground for a fishing port. Assuming a huge tsunami with a height of 15 m or more, the lower level is used as a space for handling marine products, and under normal

† Originally published in *JFE GIHO* No. 31 (Jan. 2013), p. 32–33

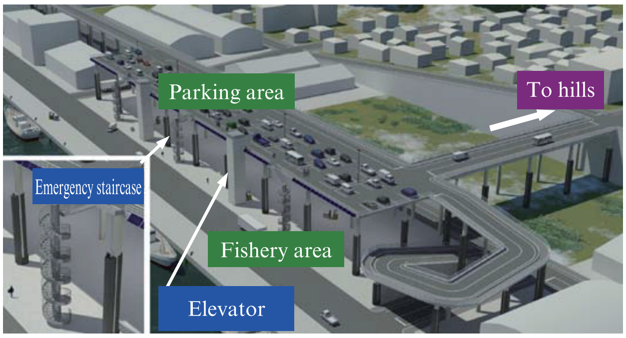


Fig. 1 Concept of artificial ground for fishing port

Photo 3 Jacket of taxiing way of the D-Runway construction at Tokyo International Airport (Haneda)


Photo 4 Artificial ground in Saitama Prefecture

conditions, the upper level, that is, the artificial ground, serves as a parking lot for employees. If a huge tsunami is expected, it is also possible to evacuate to high ground via the elevated access bridge.

### 2.2 Work Height and Column Height of the Lower Level

If the lower level is to be used as a space for handling marine products, a height clearance of at least 4.5 m is necessary, considering travel by transportation vehicles. Including the height of the artificial ground structure (deck, cross beams, etc.), the height of the upper level is 5 m or more, and thus can secure safety against a disaster-level tsunami (1–2 times in 100-year event). If the height is on this order, it is possible to use a rigid frame structure consisting of steel-pipe columns and cross beams, like that of the Metal Road shown in Photo 2.

A height of more than 15 m is necessary to secure safety in a once in several 100- to 1 000-year tsunami, such as that following the Great East Japan Earthquake on March 11, 2011. However, because structural members connecting pairs of columns, etc. can be added in the space above the construction gauge for work vehicles, a panel length on the order of 5 m can be secured between the columns. As this structural member between columns, it is also considered to be possible to use the truss jacket structure which was adopted for the taxiway in the D-Runway construction at Tokyo International Airport (Haneda), as shown in **Photo 3**.

### 2.3 Lower Level Column Spacing

Although the column spacing will vary depending on the needs of product handling and processing plants, a high degree of freedom is possible if steel-pipe columns are used. If the artificial ground is to be used as a parking facility or roadway, Metal Road can be considered, and in this case, the standard column spacing is 6 m. If a wider spacing is necessary, it is possible to respond by increasing the diameter of the steel-pipe columns and the dimensions of beams.

On the other hand, "Saitama Prefecture South Wholesale Complex"[2] (**Photo 4**) is an example in which artificial ground was erected over a retarding basin, and a commercial facility was constructed on that ground. Although there were no restrictions on the column spacing in this example, the columns of the warehouse were directly joined with the piles, and the column spacing was approximately 6 m, which is the same as that of Metal Road.

### 2.4 Protection of Columns, Etc.

If steel pipes are used as columns, the acting force of tsunami waves and debris is reduced. However, in order to prevent damage by impact, protection by placing filled concrete in the columns is advisable. Also considering the possibility that washed-away ships may collide with the artificial ground, it is considered advisable to install fenders, like those provided on the quay in Photo 1, on the sides of the deck.

### 2.5 Construction Methods

The proposed artificial ground with a steel structure can be constructed by transporting members to the site, erecting the floor system from the pile drivers, and then performing the deck construction at the site. However, rapid construction is also possible by assembling the floor system in blocks in the factory or an assembly yard in parallel with the column construction work at the site,

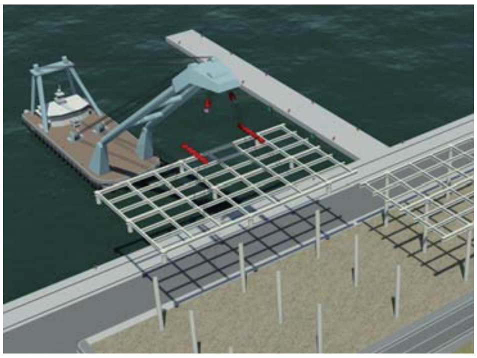

Fig. 2 Large block erection by floating crane

and then installing large blocks by a large-scale floating crane, as illustrated in **Fig. 2**.

## 3. Conclusion

Examples of artificial ground for use as a countermeasure against huge tsunamis were presented. Although a wide variety of scales and modes of use are conceivable, the threat of natural disaster is also incalculable. The artificial ground using steel structures presented here is capable of responding to those diverse needs. JFE Group companies hope that this technology will be useful in preserving precious human life.

### References


1) Metal Road. JFE Civil. http://www.jfe-civil.com/.
2) Dohi, Koichiro et al. 47th JSCE Annual Meeting Proceedings. 1992-09, VI-187.


### For Further Information, Please Contact:


Planning Dept., Steel Structure Engineering Sector,
JFE Engineering
Phone : (81) 45-505-7512 Fax : (81) 45-505-6558