Case History

Seismic and Liquefaction Countermeasures in Kochi Coast, Japan

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Kochi Office of River and National Highway has mainly three objectives to conduct countermeasures for river, coast and road. The 'river' project includes River improvement and maintenance of Monobe and Niyodo Rivers, control of the landside water along Uji and Kusaka Rivers, survey of the hydrology and water quality, and making flood warning and flood forecast. In 'coast' project, we construct coast protection facilities and make flood warning in Kochi Coast. In 'road' project, we construct sidewalks in Tosa City.

Kochi Coast is about 30km long, from Konan City to Tosa City in the central part of Kochi Prefecture. Coast section under the jurisdiction of MLIT are 13.3 km long. It is sandy coasts, lying from Nankoku City to Tosa City. As Kochi Coast is shaped like a fan and is opened toward the south, it is susceptible to a typhoon, and regardless of the course of typhoon, waves tend to converge and their height increases. Sources of sand in the coasts are Monobe and Niyodo River, located in the east and west of the coast.

In the past, beautiful sand beaches spread in Kochi Coast. However, costal erosion has progressed due to a massive consumption of sea sand and gravels. Due to the disappearance of sand beach and the high waves, the frequency of occurrence of disaster has increased. Collapse of coastal levee and the closed traffic of the prefectural road have occurred frequently in recent years.

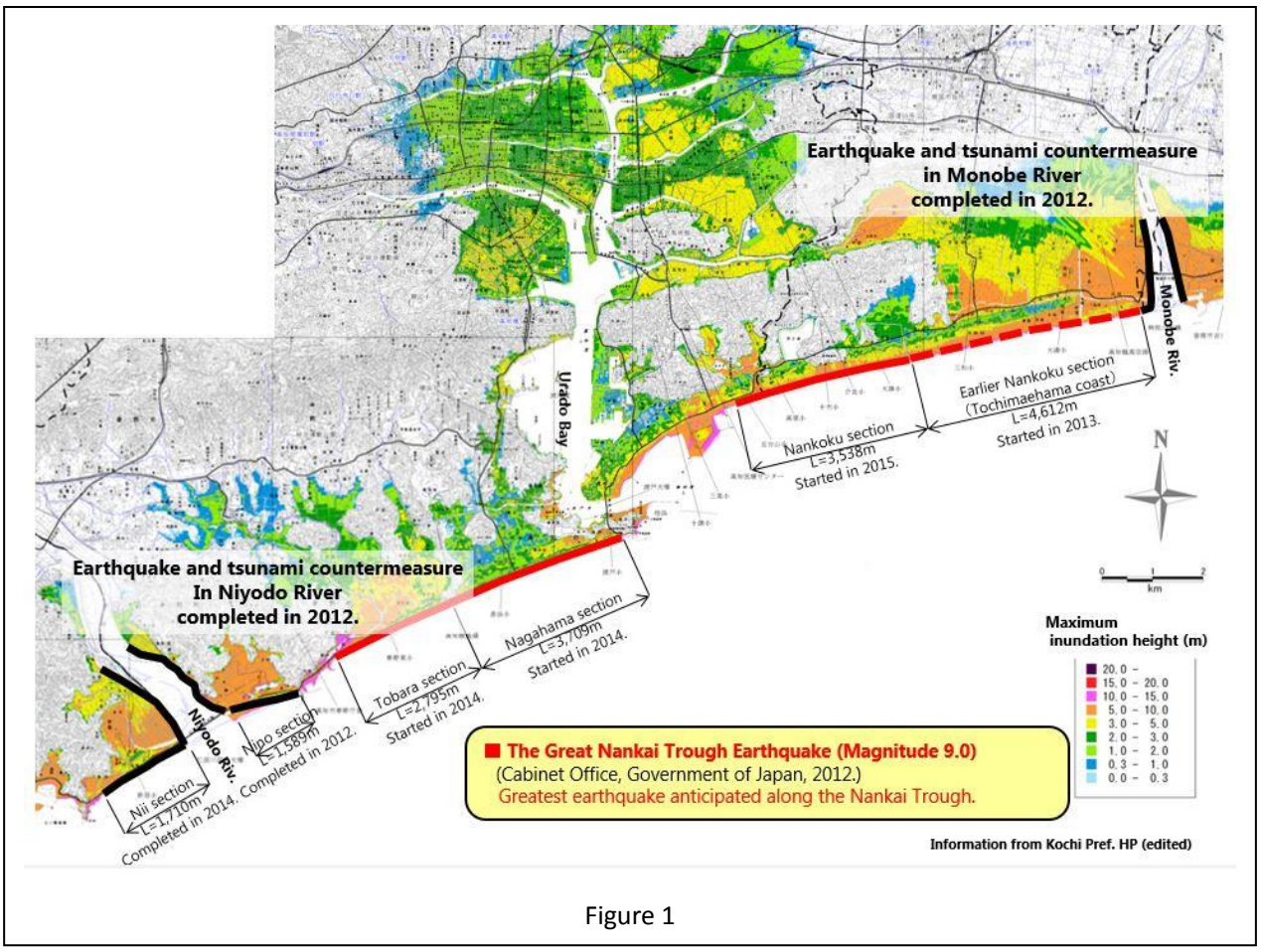

Figure 1

There are several types of countermeasures against storm surge and erosion in Kochi Coast: the offshore breakwater, the headland defense, the artificial reef and the artificial nourishment.

The estimation of damage due to tsunami in Kochi Prefecture, published by the Cabinet Office of the Government of Japan in 2012, is shown in Figure 1. The inundation areas are painted with colors. For examples, red means 15 to 20 meters height, orange 5 to 10, yellow 3 to 5 and green 2 to 3. Seismic and tsunami countermeasures in Niyodo River and Monobe River were completed in 2012 respectively. Along the coast, there are five sections, and two of them in Nii and Nino were completed in 2014 and 2012.

In designing the structures in Kochi Coast, the earthquake and tsunami are assumed to be the ones determined by 'Kochi Prefectural Committee of Earthquake and Tsunami Disaster Prevention Technologies'. The assumed earthquake is Tonankai and Nankai Earthquakes with the magnitude of 8.6. The planned height is determined as the highest of the heights assumed in each coastal region. It is 8.0m in Kochi Central Coast and in Nankoku Konan Coast. For tsunami with relatively high frequency of occurrence, the basic policy is to construct the coastal protection facilities such as coastal levees. For tsunami with largest scale, the basic policy is to integrate the structural and non-structural countermeasures, and the main option will be the evacuation.

The examples of seismic and tsunami countermeasures in Kochi Coast are shown in Figure 2. The construction methods were selected in terms of the workability and economic efficiency, taking into account the ground conditions in each area. In Nii section, tubular pile wall and double sheet pile walls were adopted, taking into consideration the shape of the levee and the ground conditions. In Nagahama and Tobara sections, a tubular pile wall was adopted, as the construction space was limited due to the adjacent houses. In Nankoku section, a tubular pile wall was adopted, as the construction space was limited due to the adjacent houses and plastic greenhouses.

There are two advantages in the tubular pile method. Firstly, the space required for construction is smaller, compared with other methods. Secondly, smaller construction space reduces the influence on adjacent structures and traffics. The construction procedure of the tubular pile method is as follows. Firstly, the construction of temporary works. Secondly, earthwork and construction of retaining wall. Thirdly, emplacement of materials. Fourthly, installation of tubular piles by the Gyropress Method.

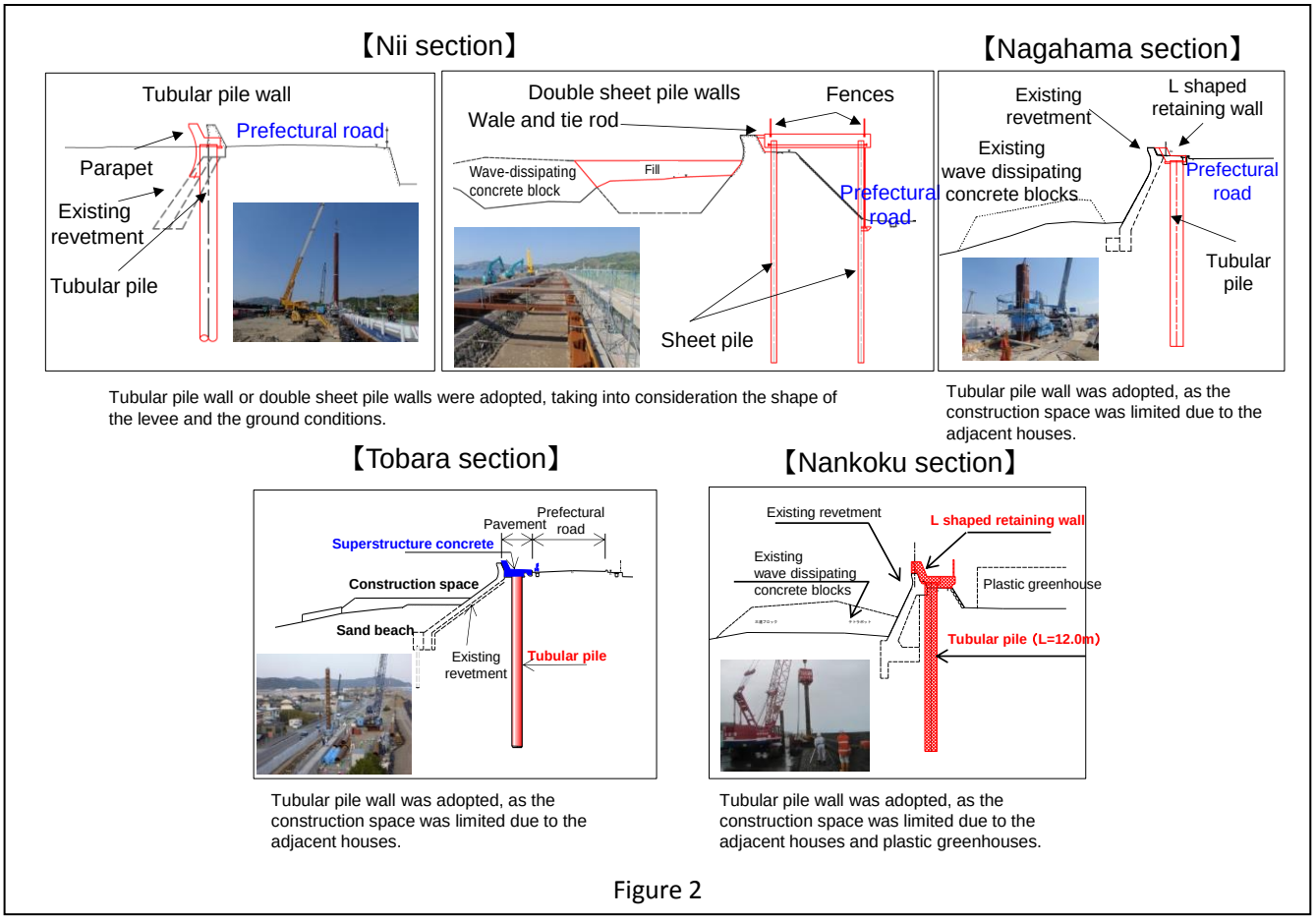

Figure 2

Finally, construction of superstructure. There were three difficulties in this construction. Firstly, consideration of safety of traffic was necessary because of the limited construction space. Secondly, it was necessary to cope with the obstacles such as the existing levees. Thirdly, it was a hard work to secure the press-in machines, as they were frequently occupied in other projects.

Picture 1

Picture 2

The situation after the completion of construction is shown in Picture 1. The left one is the double sheet pile wall method in Nii section. The right one is the tubular pile method in Tobara section.

The situation during the construction in Nagahama section is shown in Picture 2. The left one is the view of Nagahama section. The right one is GRB Non-staging Method.

Finally, the seismic and tsunami countermeasures in Kochi Port is based on the plans of 'triple protection' with three lines of protection, which has been shown by the country and the prefecture. The first protection line is the breakwaters which are expected to reduce the energy of tsunami and conserve the function of Kochi New Port. The second protection line is the outer edge and mouth of Urado Bay, which is expected to prevent or reduce the intrusion of tsunami. The third protection line is the revetments in Urado Bay, which is expected to prevent the collapse of revetments or the inundation of inland. We are going to push these plans forward in the future.

※ This case history is based on the presentation at "9th IPA press-in Engineering Seminar in Kochi 2016", which was held in July 2016.