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Case-History

Usa Coast Seawall Upgrade Project, Kochi, Japan - Disaster Mitigation Projects at Coastlines in Kochi, Japan -

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INTRODUCTION

Every 100-150 years, Nankaido in Southwest Japan is periodically struck by a large earthquake which is known as the “Nankai Earthquake”. Its most recent occurrence was on the 21st of December 1946, known as the “Showa Nankai Earthquake”. The earthquake measured between 8.1 and 8.4 on the moment magnitude scale and resulted in at least 1362 dead, 2600 injured and 100 missing. During the earthquake, serious damage to levee embankments occurred in Kochi Prefecture (Fig. 1) due to the tremors, liquefaction and tsunamis, resulting in widespread Inundation in the region.

Fig. 1. The epicenter of the Earthquake (Depth of 30km)

Fig. 2. Pacific Ring of Fire

Japan is located on what is called the Ring of Fire (Fig. 2). This is a giant circle around the Pacific Ocean where edges of tectonic plates are slowly moving. This can result in sudden displacement of the ocean floor, which causes earthquakes and tsunamis. Beneath the Pacific Ocean along the Southwest coast of Japan, the Philippine Sea Plate is slowly being pushed under the Eurasian Plate. It is said that within the next 30 years, there is a 70% chance of the next Nankai mega earthquake (Fig. 3).

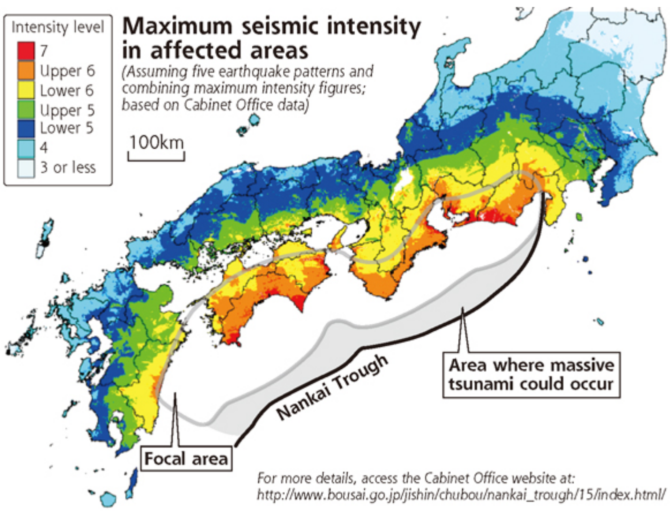


Fig. 3. Distribution of Maximum Seismic Intensity (Shindo)
in the event of maximum possible Nankai Mega Earthquake

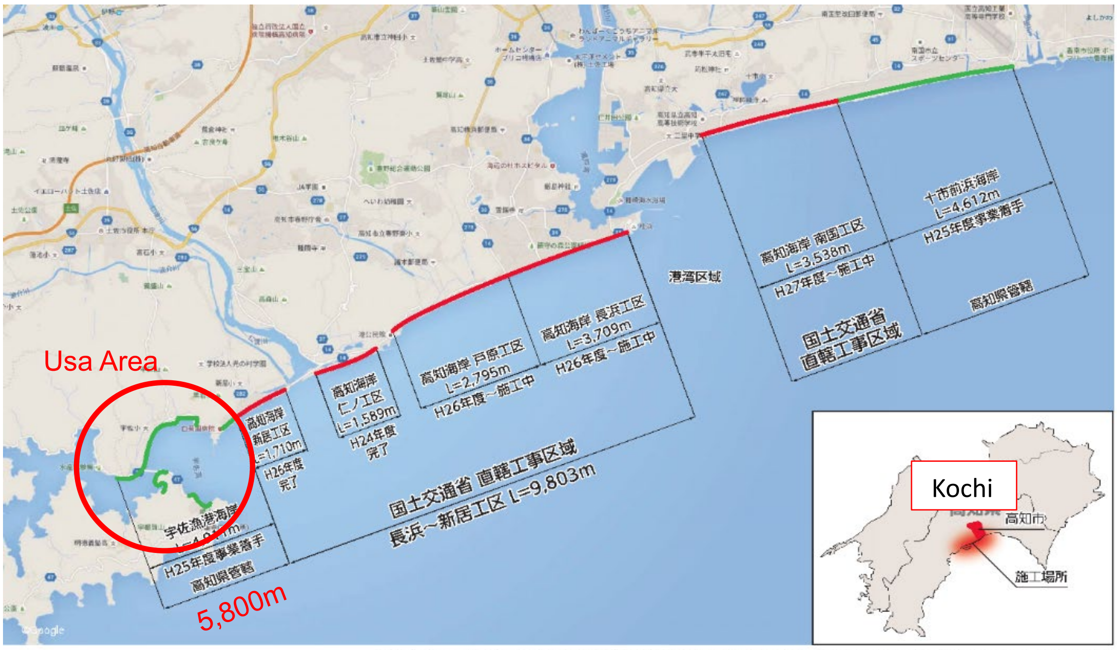
PROJECT'S SCOPE OF WORK AND SELECTION OF PRESSED-IN PILE WALLS

The Usa area is located approximately 10km west of Kochi city and at the mouth of the 12km deep Uranouchi Bay, which is surrounded by the mainland of Shikoku Island and the Yokonami Peninsula. The Usa area is blessed with warm climate, a ria coast and the Kuroshio Current. It is a thriving distribution hub and is rich in fisheries resources. Nowadays, the area is famous for fish farming, leisure fishing and marine sports and recreation. Due to its calm water, the area is also used as an important refuge harbor. In the narrow hinterland of the Usa coast, there is an emergency transportation route and there are approximately 600 households with a population of approximately 4,000. The area was one of the hardest hit by the previous "Showa Nankai Earthquake" in 1946. Therefore, in order to minimize damage, it is preparing itself for the next Nankai mega earthquake.

PROJECT'S SCOPE OF WORK AND SELECTION OF PRESSED-IN PILE WALLS

In order to protect the coastlines from the Nankai mega earthquake, coastal infrastructures are being upgraded with high resiliency. This is in line with the National Resilience Plan, which is one of Japan's national policies. In the Usa area, coastal protection projects and levee reinforcement projects were carried out to increase resiliency against earthquakes, tsunamis and storm surges. This document specifically features these coastal and levee seismic reinforcement projects, which utilize Implant Structures.
*Implant Structure^{TM}: Embedded piled foundation installed by the press-in piling method.

The Usa coast seawall upgrade project stretches approximately 5,800m (Fig. 4). The following seismic design criteria were applied on the project.



出典：国土交通省 四国地方整備局 高知河川国道事務所「直轄高知海岸南国工区堤防耐震・液状化対策事業」、水産庁「平成24年度公共事業の事前評価書」

Fig. 4. Coastal Protection Scheme in Kochi Prefecture

1. Seismic movement level
   1) Level 1 earthquake ground motions
      Moment magnitude scale of earthquake: 8.6
      Acceleration of earthquake: 250gal
      Horizontal seismic coefficient: Kh=0.19
      *Level 1 earthquake ground motions: Earthquake ground motions which have a high possibility of occurrence, during the service life of proposed structures (every tens or hundreds of years).
   2) Level 2 earthquake ground motions
      Acceleration of earthquake: 400gal
      Horizontal seismic coefficient: Kh=Not specified (Analyzed by utilizing a deformation dynamic analysis software)
      *Level 2 earthquake ground motions: Earthquake ground motions which have an intensity of the maximum scale, among those expected to occur on proposed structures. Although it has an extremely low possibility

of occurrence, it would have a cause catastrophic impact on the area.

2. Required aseismatic performance of seawalls
   1) As for Level 1 earthquake ground motions
      Structures maintain their serviceability during and after earthquakes.
   2) As for Level 2 earthquake ground motions
      Structure damage caused by earthquakes is not critical, but minor and local, and can be repaired in a short period of time without additional reinforcement works.
3. Wave impact (Impact of tsunamis)
   130kN/m (Impact load by floating objects is not considered.)
4. Required height of seawalls
   2.2-2.4m above the existing seawalls
5. Service life of proposed structures
   50 years

The proposed seawalls were installed right in front of the existing seawalls. Behind the proposed seawalls, there was a road and dense residential area. In addition to this, there was only a restricted narrow working space available alongside the proposed seawalls. Therefore, the Implant Structure (embedded steel tubular pile wall installed by the press-in piling method) was chosen for the seawall upgrade work, to satisfy the following criteria.

1) High resiliency and toughness of seawalls against earthquakes and tsunamis, with the above mentioned aseismatic performance
2) Minimum footprint of proposed seawalls
3) No interference to the adjacent road traffic and daily activities in the community during construction
4) Construction works within a restricted working space
5) Low noise and vibration
6) Economy
7) Minimize construction time

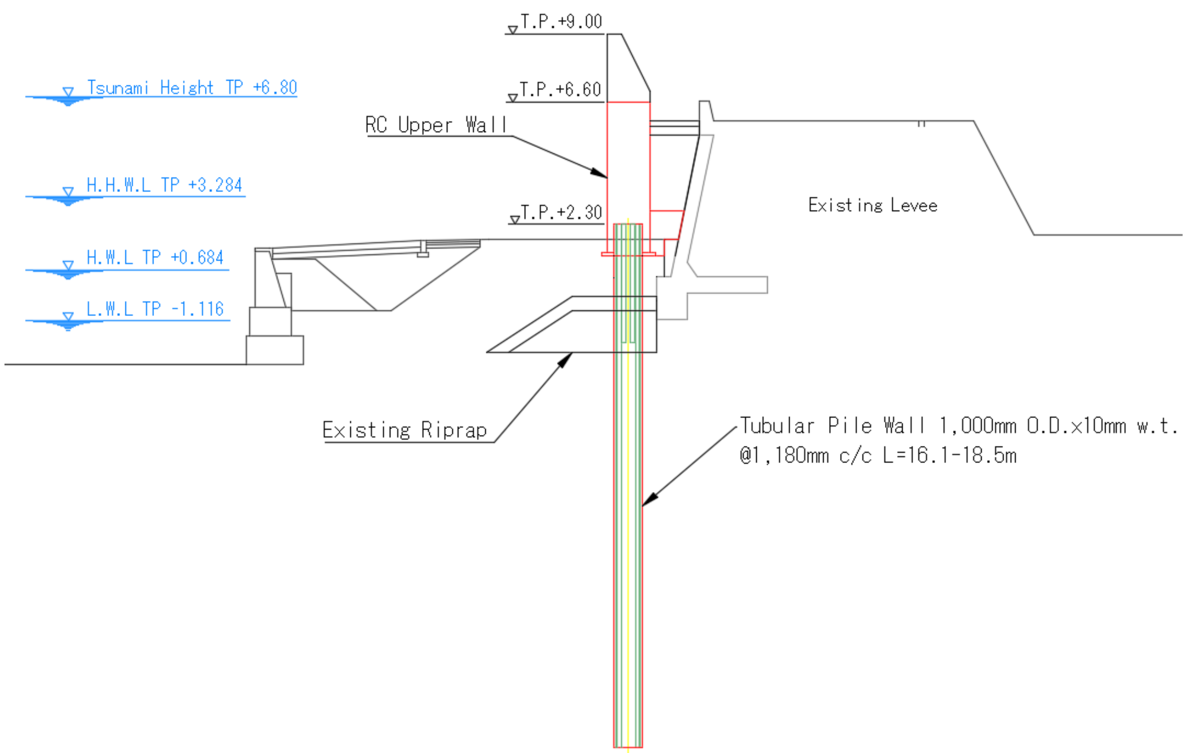


Fig. 5. Typical Cross Section of Proposed Seawall

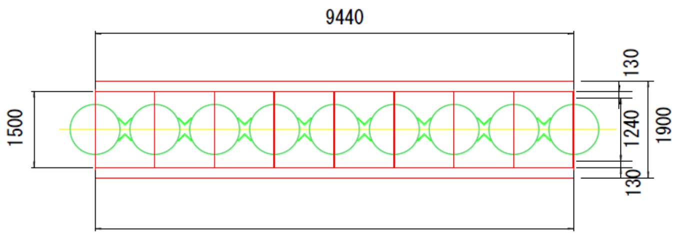


Fig. 6. Detail of Seawall (Plan)

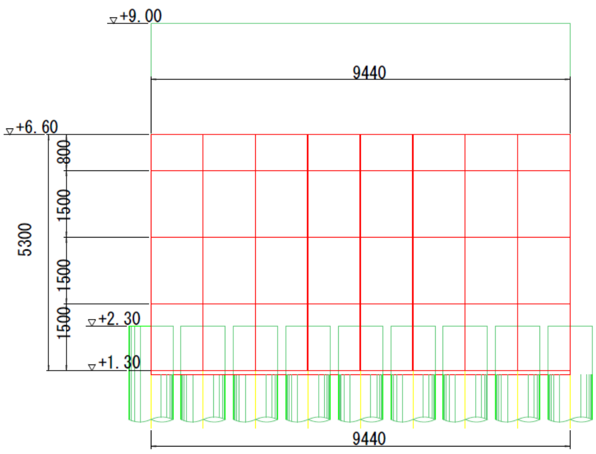


Fig. 7. Detail of Seawall (Longitudinal Section)

GROUND CONDITION

In the project areas, there are liquefiable soil layers (loose sand and silty sand layers) beneath the existing levees, which are broadly located. 1,000mm diameter steel tubular piles were installed into the non-liquefiable soil layer (silt layer) underlying the liquefiable layer, to minimize the horizontal deflection of the levee in the event of earthquakes (Fig. 8).

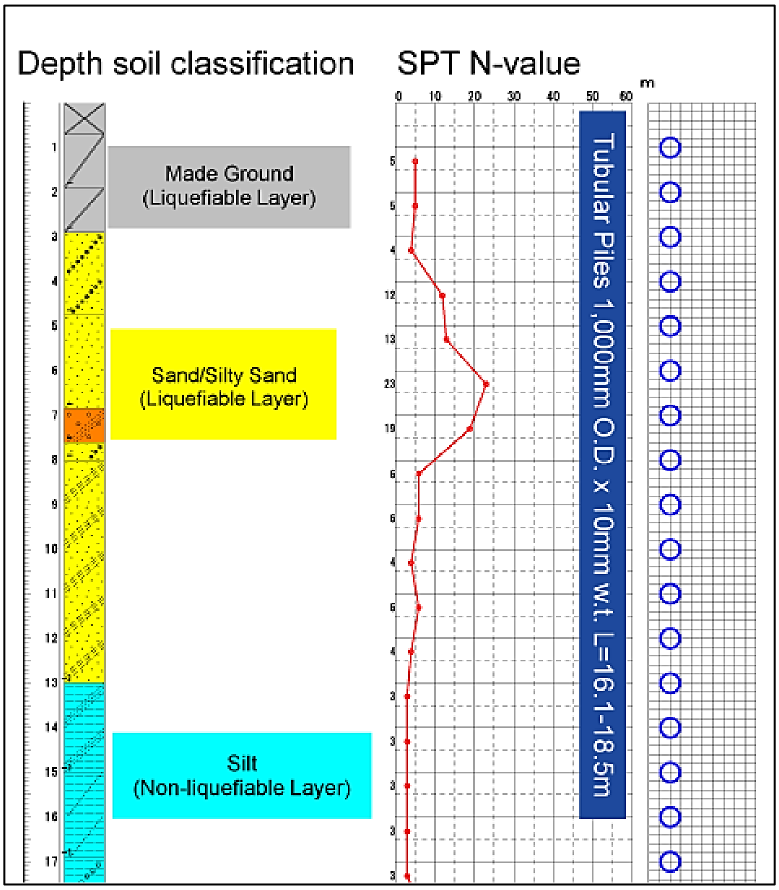


Fig. 8. Soil boring log

CONSTRUCTION METHOD

The Gyropress Method ™ (rotary press-in piling method) was utilized to install tubular piles efficiently in the restricted working space, with less noise and vibration. In order to overcome local rock and unforeseen obstructions, sacrificial drilling bits were attached on the pile tip. When encountering major obstacles, a core barrel (reusable steel tubular pies with larger number of non-sacrificial drilling bits) was utilized to penetrate through the obstacles prior to the pile installation.

Where there is enough access available for a normal service crane, the standard Gyropress Method was utilized to install tubular piles (Photo 1). In contrast, in some areas of the project site, the access for construction machines in front of the existing sea walls was only a few meters wide. In order to overcome the extremely difficult working conditions, the Gyropress method with the GRB™ Non-staging system was utilized (Photo 2).

*GRB Non-staging System: A footprint-free pile installation method, which comprises 1) Silent Piler, 2) Clamp Crane and 3) Pile Runner. With the GRB Non-staging System, all the steps including transportation, pitching and installing the piles, are completed on the piles since each mechanical device travels on top of previously installed piles.

Photo 1. Pile Installation (Standard Gyropress Method)

Photo 2. Pile Installation (Gyropress Method) with GRB Non-staging System)

CONCLUSION

The Implant Structures comprises high modulus pile materials and they are firmly installed into the ground using the press-in piling method. Being embedded into the ground, the structure is extremely resilient despite its narrow footprint. When liquefaction is a concern, in the case of earthquakes, Implant Structures do not normally require solidifying surrounding ground. On the other hand, gravity structures normally require ground improvement, when being constructed above a liquefiable soil layer. Also, Implant Structures can be constructed within restricted working space, since the press-in piling method enables prefabricated piles to be installed using a minimum working space.

Coastal infrastructures are critical in the protection of human life and as defenses for other infrastructures in their hinterland. Urban coastlines are a priority in the importance of protection works. In such places, generally only narrow spaces are available for construction works. Therefore, gravity structures are not often considered on urban coastlines due to their need for considerable space. In contrast, the combination of narrow and resilient Implant Structures and the press-in piling method is a perfect fit for construction on or the rehabilitation of coastlines. Implant Structures can also be installed rapidly and economically. Therefore, construction costs and time are less compared to large gravity structures.