

Seismic Behavior of a Caisson Type Quay Wall on a Pile Foundation

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ABSTRACT

The dynamic behavior of a caisson-type quay wall resting on a pile foundation during the 1995 Hyogo-ken Nanbu Earthquake was evaluated numerically by liquefaction analysis, which was based on an effective stress model. The effective stress model used for liquefaction analysis during the earthquake ground motion was based on the strain space multiple mechanism theory. The effect of the application of a pile foundation to a caisson-type quay wall was studied by liquefaction analyses. The deformation during the earthquake ground motion was caused by an increase in the excess pore water pressure in the ground behind the caisson-type quay wall. The displacement of the caisson-type quay wall with a pile foundation was smaller than that of the caisson-type quay wall without a pile foundation. However, the deformation was mainly induced by the increase in the excess pore water pressure, regardless of the existence of the pile foundation under the caisson structure.

Key words: *Caisson-type quay wall, deformation, pile foundation, liquefaction*

INTRODUCTION

The investigation of the disaster damage from the 1995 Hyogo-ken Nanbu Earth-quake showed that the damage to the quay walls was mostly triggered by the strong acceleration force of the earthquake, which exceeded the maximum horizontal force of the waves allowed under the design of the facilities inside the harbor. The harbor facilities that lacked a structurally resistant design against severe waves were greatly damaged by the acceleration force of the strong earthquake. In addition to the direct damage from the acceleration force of the earthquake, many of the port and harbor structures suffered severe damage from liquefaction, which was induced by the increase in the excess pore water pressure. However, it is economically impractical to make all harbor facilities seismically resistant against strong earthquakes with low frequency.

Port and harbor structures such as the quay or the jetty are important for moving goods to/from overseas, and they also play a key role in the

restoration of disaster damage. Therefore, a concentrated investment in port and harbor structures is indispensable to the quick recovery of trade and the economy of the port region. In addition, an economical and practical seismic design for port and harbor structures is required. The structural forms that survived the Hyogo-ken Nambu Earthquake should be carefully investigated and assessed for their ability to withstand strong earthquakes. Most of the straight pile foundations suffered severe damage in the 1995 Hyogo-ken Nanbu Earthquake. However, some of the pile foundations, which had a short pile with an enlarged base, suffered little or no damage. These observations suggest that short pile foundations may be able to resist the motion of a strong earthquake. In order to minimize the deformation due to a strong earthquake, it is very important to investigate the economic feasibility and seismic resistance of a pile foundation for port and harbor structures.

In this paper, the feasibility of such a pile foundation to withstand a strong earthquake was investigated numerically by seismic response analysis of a caisson-type quay wall resting on a pile foundation. Using the acceleration wave records measured in the 1995 Hyogo-ken Nanbu Earthquake, the seismic response analysis was carried out by means of an elasto-plastic FEM analysis, which is usually used in the settlement prediction analysis of soft ground.

ANALYTICAL METHOD

Using the acceleration wave records measured in the 1995 Hyogo-ken Nanbu Earthquake, the seismic behavior of a caisson-type quay wall resting on a pile foundation was investigated numerically by liquefaction analysis, which was based on an effective stress model. The effective stress model used for the liquefaction analysis during the earthquake was based on the strain space multiple mechanism theory (Iai, et al., 1992). Figure 1 shows three analytical models, which takes into consideration the differences in the connection between the caisson structure and the pile foundation. In this paper, these models were investigated by measuring the resistance of the structure against liquefaction. Type A is a caisson