

Application of Pile with Expanding Base to Foundation of Caisson Structure

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ABSTRACT

The dynamic response of a caisson-type structure resting on pile foundation loaded by waves was numerically evaluated by FEM analysis in order to investigate the feasibility of a pile with an expanding end to support such offshore structure foundations. The caisson-type structure, e.g. caisson breakwater, caisson-type seawall, dike, dolphin, quaywall or jetty, was assumed to be a linear and elastic solid and the soil was assumed to be a linear, elastic and permeable medium to simulate a normally consolidated soil. The displacement and the pore water pressure around the piles were numerically estimated from the viewpoints of the number of piles under the caisson, the distance between piles and the connection between the caisson and piles. This type of pile foundation prevents the generation of excess pore water pressure beneath the caisson. The connection between the caisson and piles is considerable with uneven sinking and rocking.

KEY WORDS : *Caisson-pile-seabed interaction, pre-cast concrete pile, pile foundation, regular wave, pore water pressure, FEM analysis*

INTRODUCTION

Port structures such as quays and jetties are important for goods movement from/to overseas. The importance of port structures increases especially after disastrous earthquakes. A severe shock of earthquake crushes infrastructures such as transportation, telecommunication, lifelines and buildings. The disaster rehabilitation works need the infrastructures described above to supply (1) foods and water; (2) emergency goods; (3) construction materials; (4) workers; (5) accommodations and so on. It takes a long time more than several years to complete the restoration of such infrastructures. Even their emergency rehabilitation takes considerable time too before they will be available to use. The mass transportation by the shipping becomes the principal means to supply a large amount of relief goods and commodities. According to circumstances, the shipping is utilized as accommodations or an emergency department for the area stricken by earthquake. And the shipping is also available for the emergency evacuation. Thus, the reasonable seismic design method is required for port structures e.g. quay and jetty. On the other hand, new construction method has to be considered to reduce the cost of execution and the restoration expenditure or to increase the structural resistance against wave action or ground motion by earthquakes.

Takatani et al.(1996) have evaluated the dynamic response of a

caisson with suction. And Takatani et al.(1997) investigated the applicability the steel caisson with skirt, which takes suction effect into its stability against wave. In this paper, the resistance of a caisson on pile foundation against earthquakes is investigated by examining that against waves.

The investigation of damages caused by the Hyogo-ken Nanbu Earthquake (the Kobe Earthquake), which occurred in 1995, shows that most of the quays were damaged. The damage was triggered by the large acceleration, which produced seismic forces approximately equal to the mass of structure times the earthquake-induced horizontal acceleration, which exceeded the horizontal force against propagating waves inside the harbor for which the quays had been designed.

Because of the costs of construction, the port and harbor structures were not designed to resist either waves in the open sea or earthquake accelerations beyond 250 gal. It is necessary to increase the structural resistance against earthquakes within reasonable costs of construction. Some pile supported jetties survived the severe horizontal acceleration caused by the Kobe Earthquake. This fact implies that piles provide positive effects to increase the resistance against earthquakes. Thus, bearing pre-cast concrete piles with expanding bases were proposed as foundations for retrofitted caisson-type structures.

In order to investigate the feasibility of a pile with expanding base to serve as foundations of port and harbor structures such as caisson breakwaters, caisson-type jetties, dolphins, dikes, quaywalls and seawalls, the response of a caisson breakwater, as a typical port structure resting on a pile foundation, against incoming waves from offshore is numerically evaluated by FEM analysis in this paper. In this numerical analysis the caisson-type structure is assumed to be a linear elastic solid, and the seabed soil is assumed to be a linear elastic, permeable medium under normal consolidation. Sinusoidal waves are employed for the waves acting on the front surface of a caisson.

For the caisson-pile-seabed interaction analysis, the displacement and the pore water pressure around the pile foundation are numerically estimated from the viewpoints of the number of piles, the distance between piles and the connection between a caisson and its piles.

OUTLINE OF CAISSON-PILE-SEABED INTERACTION ANALYSIS

The proposed caisson structure-pile-seabed interaction analysis assumes the following: the caisson-type structure is installed on the pile foundation, which is composed of many piles in a soft seabed