Simulation of Armor Blocks in front of Caisson Breakwater by DEM-MPS Hybrid Model

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ABSTRACT

At a low crown caisson seawall with a large-size wave overtopping drainage, the pick-up of blocks on a caisson mound is one of the important issues in the design of seawall. Therefore, in this study, a simulation by the DEM-MPS hybrid model is carried out. In this model, fluid is calculated based on the MPS method and blocks are tracked by the DEM. In a calculated result, blocks around the top of mound slope are picked up. This fact agrees with the hydraulic experiment.

KEY WORDS: Particle method; DEM-MPS hybrid model; armor block; wave overtopping; caisson breakwater.

INTRODUCTION

One of the significant design issues of a low crown caisson seawall with a large-size wave overtopping drainage is the pick-up of blocks on a caisson mound due to high wave impact. In the process of wave overtopping in this kind of seawall section, a part of water which flows over the caisson falls down in front of the caisson. The investigation of a velocity field around armor blocks is needed to examine a mechanism of the pick-up of blocks, however, it is difficult to measure a velocity field in a hydraulic experiment due to bubbles generated by falling water in front of the caisson, and the current meter can be damaged by picked-up blocks. Hence, the application of the numerical analysis must be key of the examination of the pick-up of blocks. Gotoh et al.(2007 and 2008) carried out the simulation of wave overtopping in this kind of seawall by the particle method and examined the reproducibility of this numerical model. Moreover, the pick-up of armor blocks was predicted on the basis of the CERC formula with using simulation results by the particle method. However, for more accurate prediction, it is unavoidable to track blocks. Therefore, in this study, the simulation of the pick-up of armor block is executed by using the particle method which is suitable for treatment of a moving object.

HYDRAULIC EXPERIMENT

A hydraulic experiment is executed in a two-dimensional wave flume. In the 33m long wave flume, 1/60 scale model of caisson wall is set, as shown in Fig.1. From the offshore end of the flume, the wave maker, the 20.45 m long flat bottom section, the 9.0 m long 1/50 slope, the 1.75 m long 1/8 slope and the model of caisson are set up. The initial water depth is 0.65 m in the flat bottom section. Wave height is measured at 6 points. Wave height at the measuring point (H1-3) from the caisson is defined as an offshore wave height. The velocity is measured at 6 points, where the distances from the bottom are 20.0 mm, 60.0 mm, 100.0 mm, 140.0 mm, 180.0 mm and 220.0 mm, in the same section as H5-1. These velocity measurement points are named VD-1~6. In Fig.2, the seawall section is shown. A mound is set in front of the 0.25 m height caisson. The 0.25 m wide wave overtopping drainage is arranged at 0.333 m onshore side from the front wall of the caisson. The wall heights of the drainage are EL+12.5 m in offshore side and EL+13.0 m in onshore side, which are 0.158 m and 0.167 m in a model scale. Regular waves, which have $T=1.9$ s in wave period and $H=0.15$ m in wave height, are generated.

Figure 1. Experimental wave flume