EXPERIMENTAL INVESTIGATION OF DENSITY EFFECT ON TSUNAMI BORE FORCES ON VERTICAL WALLS

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INTRODUCTION

In the tsunami generated by the 2011 Great East Japan Earthquake, black tsunamis were identified in many locations. According to Kise and Arikawa (2020), in the areas where samples were obtained, the seawater was found to be mixed with silt components by about 10%. They also reported that a large impulsive wave pressure might be generated when the silt-mixed seawater acted on a vertical wall as a bore. Although there have been many studies on the mechanism of impulsive wave pressure in bore-shaped tsunamis (e.g., Co and Yeh, 2018), the effects of sand and silt mixing have rarely been investigated. Therefore, in this research, bore-shaped tsunami pressure experiments with sand and silt in various states of density were conducted to clarify the mechanism of impulsive pressure on a vertical wall and to verify the effect of density on impulsive pressures.

EXPERIMENTAL METHODOLOGY

Figure 1 shows a schematic of the experimental setup. Following Matsutomi et al. (2018), water stored in the tank was released to create a pseudo-bore-like tsunami that acted on a vertical wall, while blowing up the sand at the bottom of the flume. Experimental cases were conducted by changing the tank water levels to 10 cm, 12 cm, 15 cm, 20 cm, and 30 cm, and three types of bottom of the flume: freshwater, sand, and silt. To verify the reproducibility, each case was performed 15 times. Figure 2 shows a snapshot of silt-mixed water in action. Before conducting the wave pressure experiments, wave tests without a wall were performed to measure density. The range of densities was from 1.03 to 1.1.

RESULTS

Figure 3 shows an example of a time series of waveforms obtained from a wave pressure experiment. Both impulsive wave pressure and quasi-static wave pressure were measured. Figure 4 shows a comparison of the mean values of impulsive wave pressure in silt and freshwater. The silt mixed water is larger than the fresh water at the same Froude number. The relationship between the water surface angle and the wave pressure at each impact was examined. The water surface angle was determined by checking the images before and after the vertical wall impact from the high-speed camera. Figure 5 shows relation between water surface angle and impulsive pressure in these experiments, where θ is the water surface angle. There is a large variation for each experiment. The water surface angle tends to increase with the amount of water in the experiment. The water surface angle is also larger in the case of Si15(15cm with silt) and Si20, which have higher densities than Si10.

CONCLUSION

The effects of sand and silt mixing on the bore-like tsunami wave force acting on a vertical wall were investigated by hydraulic model experiments. The results showed that the effect of sand was not apparent. However, silt might increase the impulsive wave pressure compared to the same condition in freshwater due to increased water surface angle during impact.

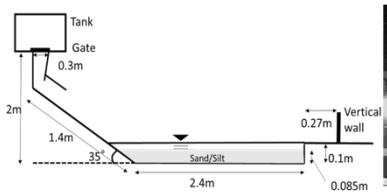

Figure 1 – Schematic of the experimental setup

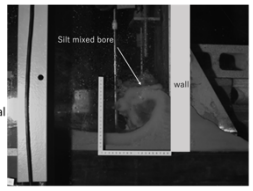

Figure 2 – Snapshot of silt-mixed water in action

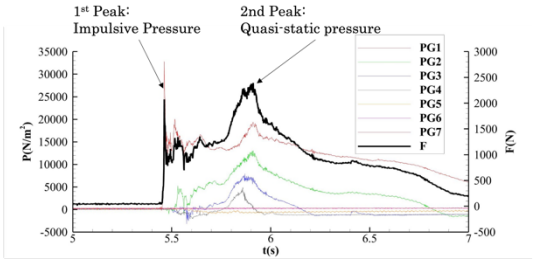

Figure 3 – Time series of waveforms of pressure

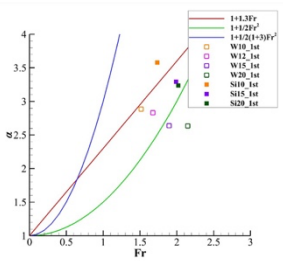

Figure 4 – Comparison of the mean values of impulsive wave pressure in silt and freshwater

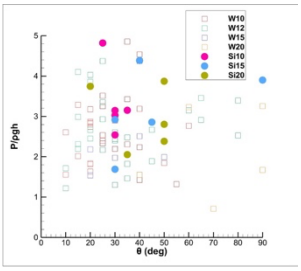

Figure 5 – Relation between water surface angle and impulsive pressure

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