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Experimental study on effect of wave set-up in storm surge

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Abstract

The storm surge height is usually determined as the surplus of height suctioned by atmospheric low pressure and that drifted by strong winds. These two models have been investigated for many years to resolve mechanisms of storm surges in inner bays. In the outer bay areas, some numerical models demonstrate the effect of wave set up cannot be neglected in the total deviation of storm surge. Almost all numerical models employ linear superposition of the original storm surge deviation and wave set up level. However, wave set-up itself is nonlinear phenomena and the mechanism is not clearly revealed. The paper describes an experiment employed in a newly developed Tsunami and Storm Sure Reproducing Channel (45m × 4m× 2m). The channel generates the following three types of wave and currents: 1) Soliton type tsunami and irregular waves by piston type wave generator; 2) Uni-directional and bi-directional current by current generator; 3) Tsunami generated by ice-break, volcano eruption etc. using overhead water tank. In the experiment, storm surge was reproduced by the current generator and the stormy wave was generated by the piston type wave maker. Spectra analysis and unit wave analysis are carried out and the nonlinear effect included in storm surge deviation in shore line is discussed.

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Keywords: experiment; storm surge; wave set-up; current generator; wave generator

1. Introduction

In March 11 2011, Tohoku off Pacific Ocean Earthquake Tsunami damaged the coastal area seriously. In addition, it is expected that number of typhoons in itself decreases, but the scale becomes larger. Recently, Typhoon No.26 in 2013 was a typhoon that had a very large force. Thus, it is possible that big scale sea waves occur, and the reevaluation of safety for costal structures is required. Evaluation for importance of costal structures is to be carried out not by only numerical computation but also by hydraulic experiment. Existing hydraulic experiments use mainly

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regular waves or solitary wave, and there are not so many experiments using random waves. In addition, there are few examples of experiments using waves and flow caused by pumps. This study investigates the variation of the water level in the case of using random waves and flow by pumps.

2. Change of water level by random waves

When waves approach to the coast from offshore, wave height is gradually increased by shoaling. When water depth becomes shallower than certain water depth, waveform becomes unstable and wave breaking occurs, and wave height decreases after wave breaking. After running up, waves as reflect ones go towards offshore again. But the energies of reflect waves are much smaller by wave breaking, and reflect waves are pushed back by waves from offshore to the coast and stay in breaker zone. Therefore, mean water level rises within breaker zone. The rise of mean water level is called “wave set-up”. In addition, mean water level in the outside of breaker zone decreases for the local increase of wave height by shoaling. The reduction of mean water level is called “wave set-down”.

Waves which flock along the shore have a property that low waves continue after high waves do. Such mean water level fluctuation happens in the period of a few minutes. The water level long period fluctuations are called “surf beat”.

3. Experimental condition

This study is experimented in a newly developed Tsunami and Storm Sure Reproducing Channel, Ujigawa Open Laboratory, Disaster Prevention Research Institute, Kyoto University (Fig. 1). The canal is 45 m in length, 4 m in width, 2 m in height. Wave generator is consisted of a piston type wave generator and a current generator. There is current generator outlet at 1.25 m forward from the center axis of piston type wave maker. 7m’s 1/10 slope is attached on the point distant 14 m from the center axis of piston type wave maker, and the behind becomes horizontal plane and is placed a model. Capacitance-type wave gages are employed in the measurement. The six gages are attached one by one in the points distant 9 m, 14 m, 15 m, 19 m, 20 m, 21 m from the center axis of piston type wave generator (Fig. 2). Current generator can make reverse flow by reverse rotation of pump, and can make oscillatory flow by periodic flow signals. This study made random waves in the situation of unidirectional flow from offshore to coast and oscillatory flow.

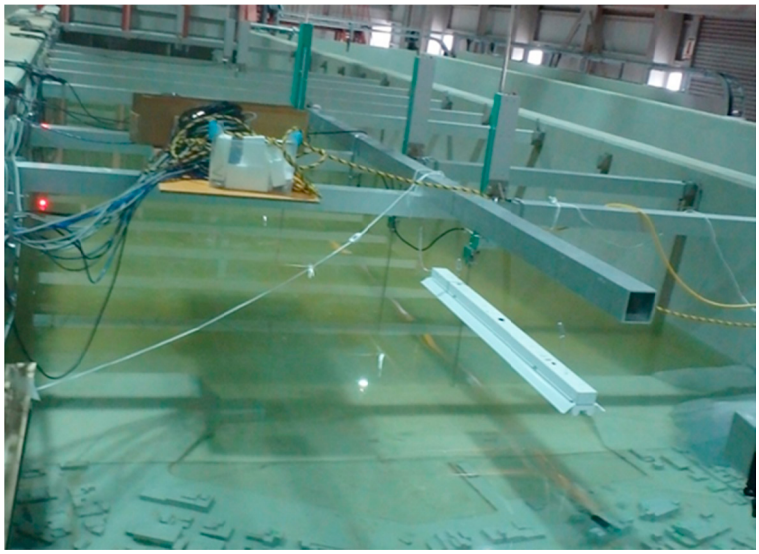

Fig.1. Experimental channel.