International Journal of Offshore and Polar Engineering (ISSN 1053-5381)

Vol. 29, No. 1, March 2019, pp. 53–61; https://doi.org/10.17736/ijope.2019.mk60

http://www.isope.org/publications/publications.htm

Response of RC Walls Subjected to Tsunami Debris Collision by Nonlinear Finite Element Analysis

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An experimental and analytical investigation of the response characteristics of reinforced concrete structures subjected to a tsunami wave pressure and debris collision force was performed, as well as verification of the applicability of numerical analysis. Even if the response of the material remained within the elastic range after a single collision, we found that plasticizing by receiving repeated collision forces was possible. In addition, the nonlinear finite element analysis generally provided the experimental results such as the strain, residual displacement, and crack pattern of the reinforced concrete structure subject to wave pressure and collision force.

INTRODUCTION

The damages of the gigantic tsunami that followed the 2011 Great East Japan Earthquake were confirmed on reinforced concrete (RC) structures (Nandasena et al., 2012). Moreover, the damages caused by the tsunami debris collision were confirmed in addition to the damages caused by only the tsunami. Therefore, it is important to clarify the response characteristics of the structure subjected to the tsunami wave force and collision force, and to establish a response evaluation method by numerical analysis. However, the response characteristics of RC structures subjected to two external forces with significantly different timings of actions—namely, wave pressure and collision forces—have not been clarified. Furthermore, to assess the responses of RC structures using numerical analysis, the two different types of superimposing external forces must be considered. However, the applicability of numerical analysis under such external force conditions has not been sufficiently verified.

In this research, a large-scale debris collision experiment was first conducted to experimentally investigate the response of an RC vertical wall subjected to the wave pressure and debris collision forces. Next, a reproducibility analysis of the experiment was performed with nonlinear finite element analysis to examine the adaptability of the finite element analysis.

EXPERIMENTAL PROGRAM

Test Channel

The experiment was conducted using a large-scale tsunami physical simulator at the Central Research Institute of the Electric Power Industry (Fig. 1) to investigate the response of the RC vertical wall that sustained the tsunami wave pressure and debris collision force (e.g., Kihara, Niida et al., 2015; Shibayama et al., 2015). The large-scale tsunami physical simulator is a large-scale experiment facility that includes a channel that is 4 m wide, 2.5 m high, and 20 m long. The large-scale tsunami physical simulator

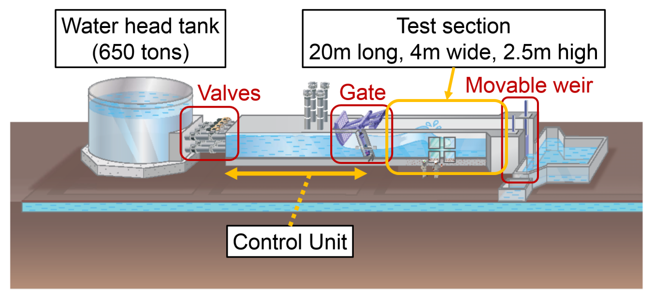

Fig. 1 Large-scale tsunami physical simulator

is capable of reproducing a tsunami that surges onto land with a greater scale and fidelity than conventional tsunami experimental facilities (Kihara, Ota et al., 2015).

The coordinate system for the channel plane-view diagram and the interior of the channel during the experiment are shown in Fig. 2. There are two RC wall specimens: one is a specimen for the wave pressure measurement test, and the other is for a debris collision test. The details of the wave pressure measurement experiments have been reported by Kaida et al. (2015). An RC vertical wall was installed on the bed of the test channel, and logs were loaded on the tsunami flood and collided on the wall. The experiment variables were input waveform, weight of logs, and their initial installation angles. As shown in Fig. 2, the angle of the log parallel to the RC wall specimen is defined as 0°.

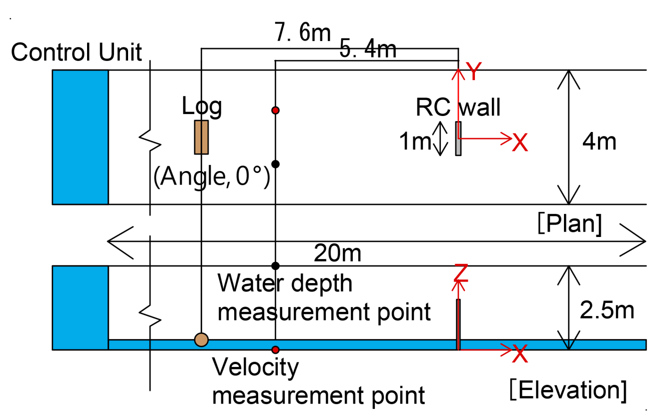

Fig. 2 Experimental setup and coordinate system

Received December 20, 2017; updated and further revised manuscript received by the editors May 3, 2018. The original version (prior to the final updated and revised manuscript) was presented at the Twenty-seventh International Ocean and Polar Engineering Conference (ISOPE-2017), San Francisco, California, June 25–30, 2017.

KEY WORDS: Tsunami, debris collision, RC sea wall, large-scale experiment, nonlinear finite element analysis.