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Study the Coastal Landslide Induced Tsunami by the Centrifuge Model Tests

○Loi Huy DOAN・Kyohei UEDA・ Ryosuke UZUOKA

Introduction

Tsunamis associated with landslides can occur in both onshore and offshore areas. Most landslides that generate tsunamis are caused by earthquakes. 30% of the World's population of lives within 60 km of the coast, and hazard assessment of tsunamigenic landslides become very important (Yamada et al., 2012). For hazard assessment, the maximum initial amplitude of landslide tsunami around the source region is an important parameter (Sabeti et al.,2021). There are three different methods to estimate the maximum initial amplitude: physical modelling, analytical calculations and numerical simulations. The centrifuge model test is a realistic physical model to study on the landslide tsunami. This study examined the coastal landslide of the Kashima River Sand no.5 which was collected near the river mouth in Choshi, Japan. The objectives of this research are to physically model tsunamis generated by a landslide which is caused by an earthquake and to determine maximum initial amplitude of landslide waves.

Centrifuge modelling and test program

The beam-type centrifuge equipment owned by the Disaster Prevention Research Institute; Kyoto University was used for this study. The maximum capacity and effective radius are 24 G-ton and 2.5 m. The maximum acceleration and displacement are 10g and 2.5 mm.

The Kashima River Sand no.5 was used, the properties of Kashima River Sand no.5 are shown in table 1. The soil with a water content of 10% was placed and compacted layer by layer with a hammer to make the ground with density of 1.71 g/cm^3. The relative density of 35% as loose sand. The water was filled from the bottom of container. The centrifuge model test and instruments are shown in Fig.1. Two accelerometers were used to measure the input motion and five pore water pressure transducers in the slope were used to observed the excess pore water pressure during and after shaking, and two water pressure transducers (P1, P2) were used to measure landslide waves.

Table 1 Properties of River Sand no.5

Parameters	Value
Soil particle density, ρs	2.63 g/cm^3
Maximum void ratio, e_{max}	0.764
Minimum void ratio, e_{min}	0.561
Uniformity coefficient, U_c	2.631
Mean particle size, D_{50}	0.430 mm

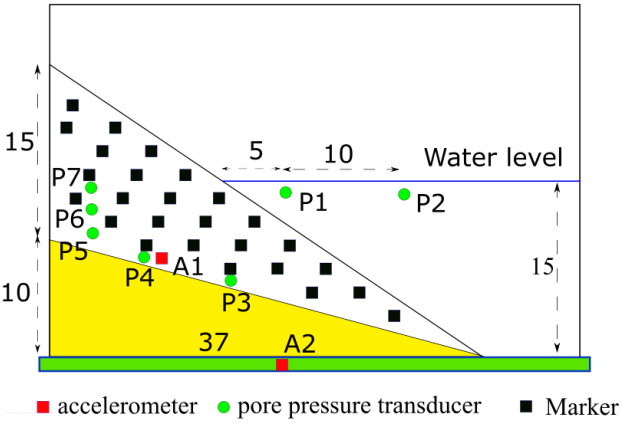

Fig.1 Schematic view of model test (unit:cm)

Three tests with water level of 12 cm, 15 cm and 18 cm were conducts to estimate the maximum initial amplitude of tsunamis. The test program was shown in Table 2. After the centrifugal acceleration reached 50g, the model ground was shaken with input motion from

2018 Palu earthquake (fig.2).

Table 2 Testing program

No	Relative density (%)	Slope angle (Degree)	Water level (cm)
1	35	30	15
2	35	30	18
3	35	30	12

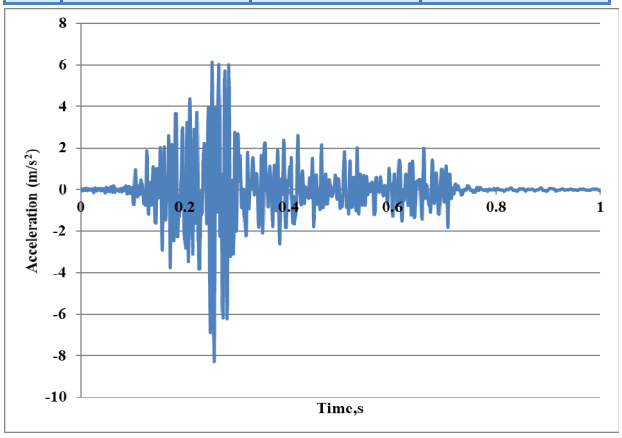

Fig.2 Input motion during shaking

Test results and Discussion

Low-frequency filtering was used to remove high-frequency noise mainly associated with waves generated input motion. Fig.3 presents the record data of case 1 at Pore water pressure transducer P1 (blue line) and low-pass filter data (red line).

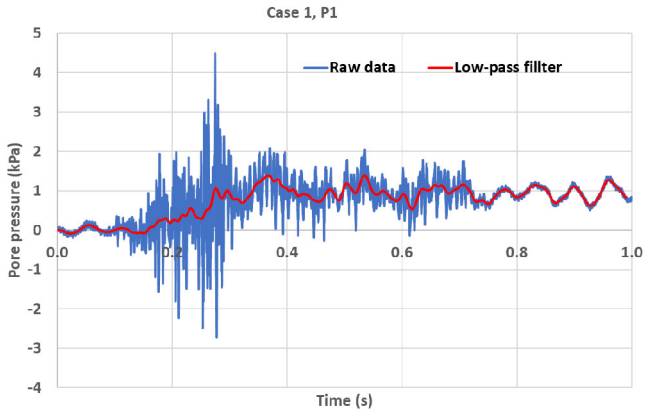

Fig.3 Low-pass filter pore water pressure record for case 1 at P1.

To study water level effects on the tsunami, we compare the test result of Case 1,2,3 (fig.4). In this figure, the maximum initial waves are about 12 cm, 5 cm, and 20cm for case 1, case 2 and case 3.

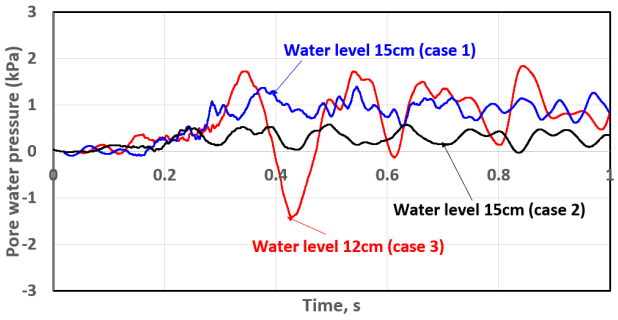

Fig.4 Tsunami wave at P1 with different water level

The primary conclusions of this study are as follows:

-Tsunamis generated by a landslide which is caused by an earthquake can be observed from the centrifuge test.

- Results of experiments show that the general pattern of wave is the same but the amplitude is different.

- When the water level increase, the maximum initial amplitude decrease.

References

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Sabeti, R., Heidarzadeh, M. A new empirical equation for predicting the maximum initial amplitude of submarine landslide-generated waves. Landslides (2021).