Can the Landslide Induced Tsunami Be Reproduced by the Centrifuge Model Tests?

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Introduction

Submarine landslides can cause tsunamis which have a catastrophic impact on coastal areas. As of today, many catastrophic submarine landslide events that generating tsunami have been reported including the landslide-induced tsunami by the Great Japan earthquake on March 2011. A more recent example is the tsunami resulted by the 2018 Sulawesi earthquake with magnitude Mw 7.5. The huge earthquake and tsunami hit property and life with more than 2000 fatalities which surprised the researchers as it followed an earthquake with a strike-slip rupture mechanism unbelievable to generate catastrophic tsunamis (Omira et al. 2019).

The centrifuge model test is a realistic physical model to study on the submarine landslide. Several researchers such as Gue 2012, Takahasi et al. 2019, conducted centrifuge modelling for submarine landslide using beam-type and drum-type centrifuges. They observed the stability and the motion of submarine landslide. However, the phenomenal of earthquake induced submarine landslide causing tsunami was not fully studied in previous research. In this study, the submarine landslide of silica sand no. 7 was examined in the centrifuge modelling. The water-level fluctuation was observed during testing.

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 fine material (silica sand no. 7) was used, the properties of silica 7 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 1.40 g/cm^3. The relative density of 27% as loose sand. The water was filled from the bottom of container. The centrifuge model test and instruments are shown in Fig.1. One accelerometer was used to measure the input motion and three pore water pressure transducers were used to observed the excess pore water pressure during and after shaking.

Table 1 Properties of Silica sand No.7

Parameters	Value
Soil particle density, ρs	2.641 g/cm^3
Maximum void ratio, e_{max}	1.219
Minimum void ratio, e_{min}	0.675
Uniformity coefficient, U_c	1.875
Mean particle size, D_{50}	0.150 mm

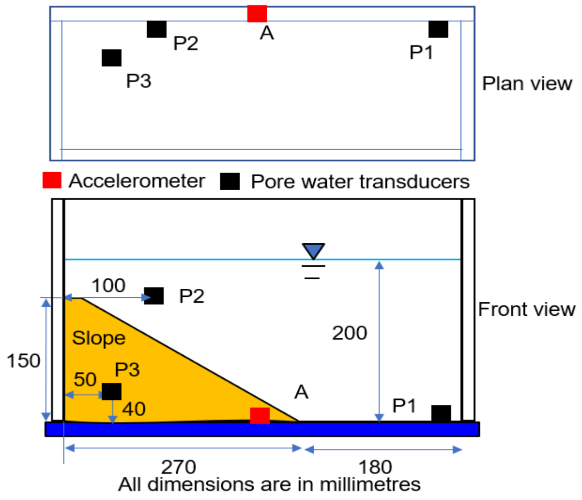

Fig.1 Schematic view of model test

After the centrifugal acceleration reached 50g, the model ground was shaken with a shaking incorporated 50 wave cycles, maximum acceleration of 2.2 m/s^2

and frequency of 2 Hz at the prototype scale (Fig.2).

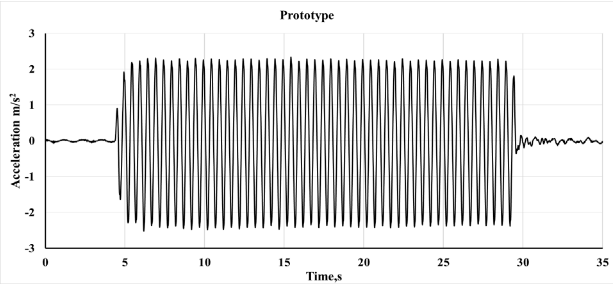

Fig.2 Input motion during shaking

Test results and Discussion

Fig.3 shows the time histories of excess pore-water pressure at three transducers P1, P2, P3. The pore water pressures have wave shade in response to seismic waves. After shaking, the excess pore-water pressure measured in the slope P3 reduced and reached the overburden pressure.

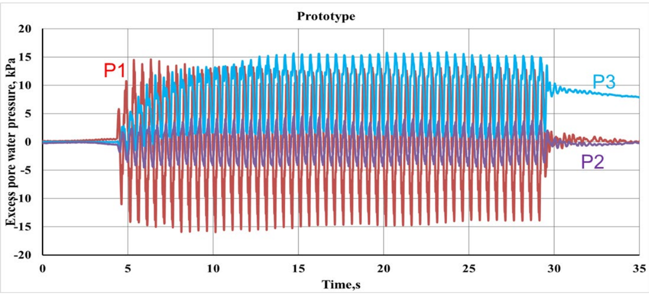

Fig.3 The time histories of excess pore-water pressure

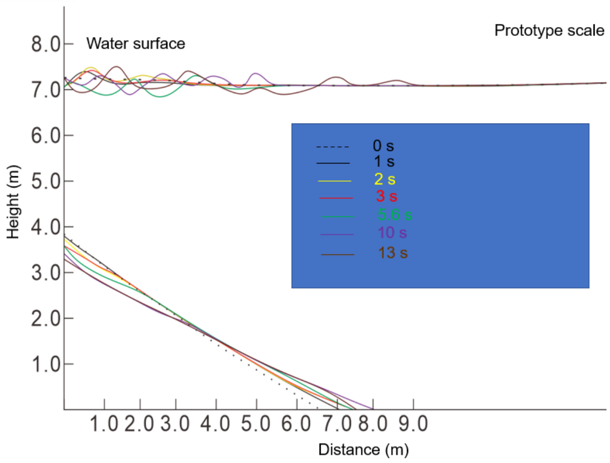

Fig.4 The change of water surface and ground surface

Due to landslide, the ground rapidly changes and the water level changes simultaneously. Fig.4 shows the successful test that the water level fluctuation was captured. It is clear to see the water surface changed in accordance with the change of ground surface. The maximum landslide depth of 0.5 m and the maximum of tsunami height of 0.3 m. The amount of landslide depth is larger than tsunami height.

This study examined the ability of centrifuge model to reproduce the submarine landslide induced tsunami. The first successful test of silica sand no.7 demonstrates that centrifuge model can satisfy the simulation of the full process from an unstable slope to the tsunami. In the future plan, the author will conduct the test with a bigger container and different material to understand the properties and landslide flow and water level change.

References

Gue CS (2012) Submarine Landslide Flows Simulation through Centrifuge Modelling. PhD thesis, University of Cambridge, Cambridge, UK.

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