PRESSURE DISTRIBUTION ACTING ON BREAKWATER CAISSON UNDER TSUNAMI OVERFLOW

by

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ABSTRACT

Many caissons of breakwaters were slid or overturned due to tsunami overflow pressure caused by 2011 Tohoku earthquake. To prevent this sliding failure, the pressure estimation method under tsunami overflow was introduced in the new Tsunami-Resistant Design Guideline for Breakwater in 2015. In this guideline, the uplift and the overburden pressure are not considered, instead only static buoyancy acting on the caisson is considered. However, under tsunami overflow, the pressure difference between the bottom and the top of breakwater caisson, especially the caisson having a large parapet, can be extremely larger than the buoyancy force. In order to examine this excess uplift force, a series of hydraulic experiments and numerical simulations were conducted. The experiment was conducted in an experimental flume in which the large pump was installed to produce tsunami overflow. Through the experiments and numerical simulations, it was clarified that the large uplift pressure and the small overburden pressure cause the dynamic buoyancy larger than the quasi-static buoyancy estimated by the design guideline. This upward force reduces the stability of caisson, especially the caisson having the large parapet.

1. HYDRAULIC EXPERIMENT

As the experimental result, it was clarified that the pressure distribution in front and behind the caisson is almost static and triangle shape. In contrast, the pressure on top of the caisson is smaller than the pressure distribution estimated from the water surface elevation. This decrease of pressure is supposed to be caused by the increase of velocity, the significant downward acceleration of the water particle around the curving flow and the occurrence of eddy. Fig. 1 shows the relationship between the velocity (V1) and the pressure decrease, Δp at the top of the caisson. The pressure is nondimensionalized by the water depth, η at P10. Pressure decreases as the velocity increases. The pressure decrease is supposed to be caused by the increase of velocity and the significant downward acceleration of the water particle around the curving flow

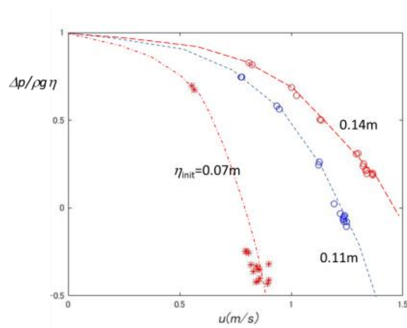

Figure 1: Relationship between velocity and pressure decrease at the top of the caisson

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2. **NUMERICAL ANALYSIS**

Tsunami overflow reproduced in the hydraulic experiment was simulated by the VOF method implemented in the CADMAS-SURF-2D CFD model (CDIT, 2001). Fig.2 shows the snapshot of the CS1. Fig.3 shows the ratio of dynamic buoyancy ($B_{dynamic}$) and static buoyancy (B_{static}) with different water surface elevation ($\eta_{front}/h_{caisson}$) when the height of weir (h_{weir}) is 0.2m. Here, η_{front} is defined as water surface elevation in front of caisson during tsunami overflow and $h_{caisson}$ is the caisson height. In the case of CS1 and CS2 (Caisson with large parapet), the dynamic buoyancy ($B_{dynamic}$) is 5% larger than the static buoyancy (B_{static}).

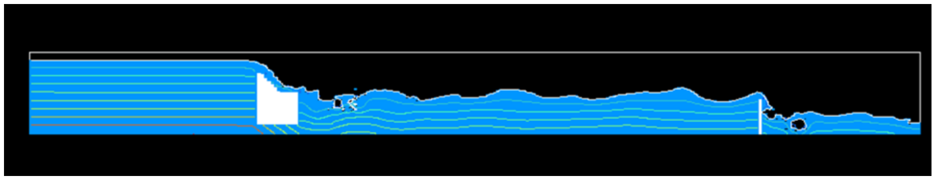

Figure 2: Snapshot of CS1 (h_{front}=0.45m, h_{weir}=0.2m)

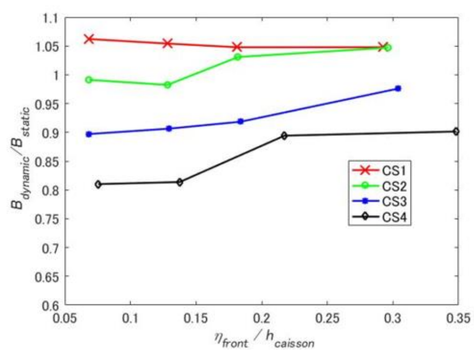

Figure 3: Ratio of dynamic and static buoyancy (h_{weir}=0.2m)

3. **CONCLUSIONS**

A hydraulic experiment and a numerical simulation of tsunami overflowing on the caisson type breakwater was conducted and the following clarified.

1) The pressure on the caisson under tsunami overflow condition is smaller than the static water pressure corresponding to the water level. The significant downward acceleration of the water particle around the curving flow appears to be the main reasons of the observed pressure drop at the front end of the caisson.
2) The large uplift pressure and the small overburden pressure during tsunami overflow cause the large dynamic buoyancy. The dynamic buoyancy acting on the caisson with large parapet is 5% larger than the static buoyancy estimated by the design guideline (2015).

References

Coastal development institute of technology (CDIT) (2001). CADMAS-SURF, CDIT library No. 12, 68p.

Ministry of Land, Infrastructre, Transport and Tourism (MLIT) (2015). Tsunami-Resistant Design Guideline for Breakwater, website; http://www.mlit.go.jp/kowan/kowan_tk5_000018.html.