TSUNAMI-SEABED-STRUCTURE INTERACTION FROM GEOTECHNICAL AND HYDRODYNAMIC PERSPECTIVES: ROLE OF OVERFLOW/SEEPAGE COUPLING

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This paper presents some recent research advances in tsunami-seabed-structure interaction following the 2011 Tohoku Earthquake Tsunami, Japan. Role of overflow and seepage coupling is highlighted, based on the effect of tsunami-induced seepage on piping/boiling, erosion and bearing capacity decrease and failure of the rubble/seabed foundation (Takahashi et al., 2014; Sassa, 2014; Sassa et al., 2016).

A new tsunami overflow-seepage-coupled centrifuge experimental system was developed and applied such that the similitudes for tsunami overflow as well as turbulent seepage flows in the mounds were satisfied in addition to the mechanical similarity between the model and the prototype.

The concurrent processes of the instability involving the scour of the mound/sandy seabed, bearing capacity failure and flow of the foundation and the failure of caisson breakwaters under the overflow and seepage coupling are elucidated in the paper. The experimental results first demonstrated that the coupled overflow-seepage actions promoted the development of the mound scour significantly (Fig. 1), and caused bearing capacity failure of the mound, resulting in the total failure of the caisson breakwater, which otherwise remained stable without the coupling effect. The velocity vectors obtained from the high-resolution image analysis illustrated the series of such concurrent scour/bearing-capacity-failure/flow processes leading to the instability of the breakwater (Fig. 2). The stability of the breakwaters was significantly improved with decreasing hydraulic gradient manifested underneath the caissons due to the effect of embankments with varying thickness.

The paper also discusses the use of the geotechnical centrifuge and a large-scale hydro flume for the modelling of tsunami-seabed-structure interaction. Specifically, a comparison and discussion are made on the stability assessment for the design of tsunami-resistant structures on the basis of the results from both geo-centrifuge and large-scale hydrodynamic experiments.

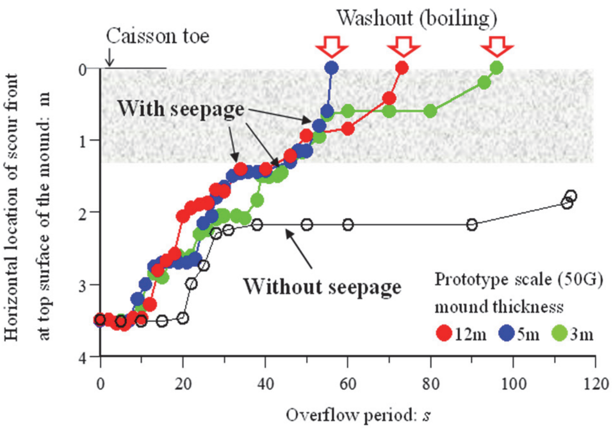

Figure 1 - Tsunami overflow and seepage coupling induced mound scour. The shaded zone indicates the region where the caisson became unstable.

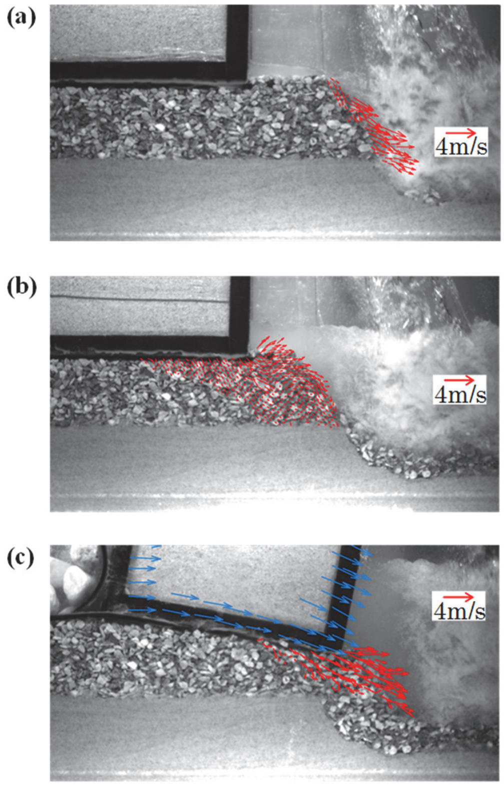

Figure 2 - Tsunami overflow and seepage coupling induced (a) scour of the mound/seabed ground, (b) bearing capacity failure, and (c) flow of the mound in the concurrent processes of the caisson instability, shown with velocity vectors.

Overall, these findings elucidate the crucial role of overflow/seepage coupling in tsunami-seabed-structure interaction, warranting an enhanced disaster resilience.

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