FAILURE OF SEAWALLS DUE TO TSUNAMI-INDUCED SCOUR

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INTRODUCTION

The Indian Ocean tsunami in 2004 and the Tohoku tsunami in 2011 have shown that tsunami-induced scour is one of the primary reasons for the failure of coastal defence structures (Bricker et al., 2012; Jayaratne et al., 2016). In a coastal structure, scour can occur when the plunging jet impacts the landward toe of the structure, resulting in digging a hole around the foundation which eventually may destabilize the structure (Fig. 1a,b). This can be exacerbated by rapid drawdown induced liquefaction during the receding wave, and can lead to the failure of the structure. Therefore, accurate prediction of local and plunging scour is very vital in order to ensure the safety of the coastal structures under such conditions.

Figure 1 – Tsunami-induced scour failure of seawalls in (a) Watari North and (b) Ishinomaki, Japan (Jayaratne et al., 2016).

Data we have at present are based on final or equilibrium scour depths, not the maximum scour depths. Survey teams measure scour profile once the extreme event is over. However, the trough or scour hole made can be partly filled by sediment transport from upstream (in the live bed case) or from sediment suspended within the scour hole that settles after the flow slows down. Thus, the scour depth survey teams measure are less than the actual maximum depths. Therefore, a novel experimental and numerical study is proposed to tackle this problem with the funding of the Royal Society, UK.

PROPOSED METHODOLOGY

To predict maximum scour depth expected near vertical seawalls, laboratory experiments that measure time-varying scour depths are necessary, scalable to field conditions by ensuring the experiments on which they are based have Reynolds, Froude and Shields numbers in the correct range. The proposed research will investigate both plunging scour during incident tsunami overflow, and combined plunging scour and rapid-drawdown-induced scour during tsunami return flow. For this purpose, the University of East London's (UEL) and University of Michigan's wave flumes with dam-break tsunami gates will be used, each with a soil box holding a seawall model (Fig. 2). Three sets of experiments will be proposed, varying tsunami heights with soil scaled in different ways, including use of plastic or glass beads.

In the first set of experiments, the soil grain size and density will be scaled by Shields number, representing initiation of motion of soil grains. The second set of experiments will be scaled by Froude number, to represent behaviour of soil settling back into the scour hole after initiation of motion. The third set of experiments will be scaled such that the porous flow speed in the sediment bed is representative of the prototype scale. This will allow recreation of rapid drawdown induced scour. Maximum scour will be measured by high speed digital video camera, echo sounder and electrical conductivity probe. Also novel is that our experiments will investigate failure of the structure as well as scour depth.

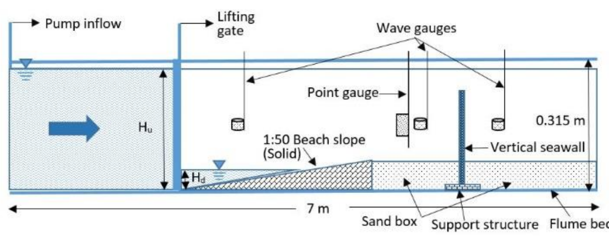

Figure 2 – Proposed experimental set-up at UEL.

CONCLUSIONS

Based on the three experimental datasets, the accuracy and performance of plunging-jet scour predictive formulae of Bricker et al. (2012), Jayaratne et al. (2016), and ASCE7-16 will be verified. Combining experimental results in terms of physical variables will be accomplished using an artificial neural network. The resulting final relationship will find utility for prediction of maximum scour depth through development of new sets of tsunami wave height vs failure duration curves. Major laboratory works for the proposed study are scheduled to be done during autumn/winter 2022 and the findings from those studies will be presented at the 37th ICCE conference in December 2022.

REFERENCES

Bricker, Francis, and Nakayama (2012): Scour depth near coastal structures due to the 2011 Tohoku tsunami, Journal of Hydraulic Research, TAYLOR & FRANCIS, vol. 50(6), pp. 637-641.
Jayaratne, Premaratne, Abimbola, Mikami, Matsuba, Shibayama, Esteban, and Nistor (2016): Failure mechanisms and local scour at coastal structures induced by tsunamis, Coastal Engineering Journal, TAYLOR & FRANCIS, vol. 58(4), 1640017.