NUMERICAL MODELLING OF BREAKWATER IN TSUNAMIS: TROUGH-LEAD WAVE & SEEPAGE EFFECT

Zulaika Nur Jannah, University College London, zulaika.jannah.22@ucl.ac.uk
Tiziana Rossetto, University College London, t.rossetto@ucl.ac.uk
Susana Lopez-Querol, University College London, s.lopez-querol@ucl.ac.uk

ABSTRACT
Tsunamis are long and large ocean waves triggered by earthquakes or landslides, causing severe damage to coastal areas. To tackle this threat, several prevention methods have been developed to mitigate the effect of tsunamis, including the design of coastal structures such as breakwaters. Among these structures, caisson composite-type breakwaters have emerged as a popular choice for tsunami-resisting measures. This structure has demonstrated its crucial role in mitigating the impact of tsunami waves and safeguarding coastal areas. Extensive research has shown that this breakwater type, along with similar structures, plays a vital role in reducing the tsunami impact. Regrettably, the full understanding of the behaviour of this protection breakwater, and similar structures, during tsunami events is still not fully known. Past studies mainly focused on tsunamis with crest-only waves, neglecting the trough-lead waves and related phenomena like seepage forces. This seepage can affect breakwater stability. This report uses 3D models in MIDAS GTS NX software to analyze breakwaters under tsunami waves both trough-lead and crest-only. The analysis encompasses seepage-stress coupling and is validated against experimental data provided by the MAKEWAVE team using a tsunami simulator in HR Wallingford. The validation procedure demonstrates the model's accuracy, yielding results with disparities of less than 5%. The results indicate two potential failure types: global and local. However, the breakwater shows small movement and the stress is low. The lowest safety factor recorded is 2.33, signifying a secure value. Furthermore, the critical velocity analysis indicates no probability of scour. These outcomes match the experiments, which found no signs of failure. The safety factor analysis, using the strength reduction method (SRM), shows a critical factor at the crest part and indicates the influence of wave properties on breakwater stability. The safety factors decrease with bigger wave amplitude and longer periods. The analysis also explores the impact of layer thickness, it shows a higher safety factor for thicker layers during the trough. Two modified breakwater designs were also analyzed to enhance landside strength. The overall analysis highlights that accounting for both wave profiles is crucial in breakwater analysis. Structure behaviour greatly differs between trough-lead and crest-only waves, particularly decreasing safety factors for the trough-lead wave.

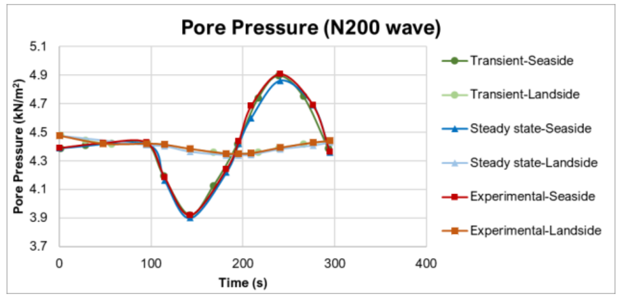

Figure 1 - Model validation with pore pressure comparison

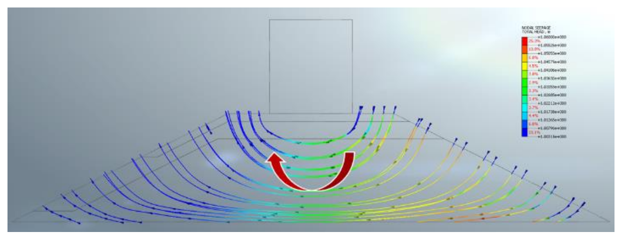

Figure 2 - Seepage flow inside rubble mound breakwater

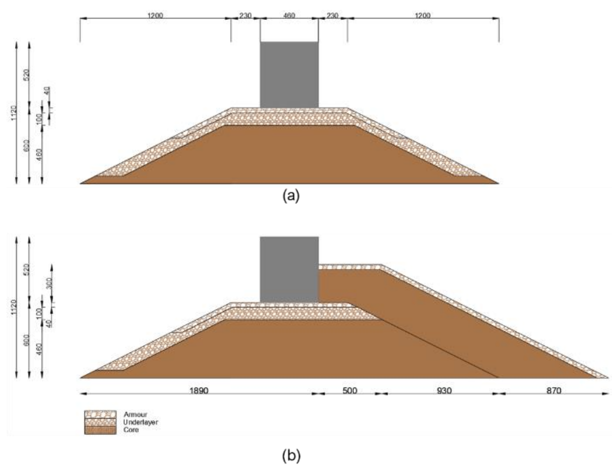

Figure 3 - Geometry modification (a) Extended Armor and Underlayer and (b) Additional Embankment in Landside