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The effects of wave impacts on toe scouring and overtopping concurrently for permeable shingle foreshores

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Recent studies by the Intergovernmental Panel on Climate Change indicate that sea level will continue to rise in many low-lying areas due to the global climate change that would potentially cause the occurrence of more frequent extreme meteorological events and storm surges in future years. Concurrently, the damage to the critical infrastructures and surrounding properties from extreme climatic events such as wave overtopping, and scouring are expected to be exacerbated in future. Reliable prediction tools for wave overtopping and toe scouring characteristics at sea defences are therefore significantly important for climate resilience of coastal infrastructures. To date, however, most parametric studies regarding these aspects have tended to focus either only overtopping or scouring at sea defences, with investigations on the effects of wave impacts on both overtopping and scouring characteristics simultaneously, particularly for permeable shingle beaches in front of the structure being less well-studied. This limitation and research gap have driven the need to carry out a comprehensive suite of experimental investigations on the influence of wave impacts on toe scour and overtopping concurrently at sea defences with shingle foreshores.

Here we investigate the effects of wave impacts on overtopping and scouring characteristics on a seawall as well as on a smooth sloping (1V:2H) structure in a suite of laboratory tests performed in a 2D wave flume (22 m in length, 0.6 m in width, and 1.0 m in depth) at the University of Warwick, UK. Permeable shingle sloping (1V:20H) foreshores were constructed in front of the tested structures using the crushed filtered anthracite with a quoted specific gravity of 1.40 T/m^3. At a 1 in 50 scale, tested anthracite d_{50} values of 2.10 mm and 4.20 mm represented prototype shingles with d_{50} values of 13 mm and 24 mm, respectively. Overtopping volumes and scour depths were measured for each test comprised of around 1000 JONSWAP (gamma = 3.3) pseudo-random waves. Two nominal deep-water wave steepness values of 0.02 and 0.05 were tested to simulate both long and short wave conditions.

Results of this laboratory investigation showed that toe scouring and overtopping is principally caused by plunging or near plunging wave breakers for the tested both vertical and sloping structures on permeable slopes, which are in consistent with results that were previously reported for coastal structures on sandy beaches. The analysis of measured scour depths for vertical walls showed that overall greater scour depths were observed for the experiments under impulsive (violent wave impacting) conditions, when compared to those reported for the non-impulsive conditions. For both vertical and smooth sloping structures, it was found that there is no apparent relationship between toe scour depths and shape parameter of Weibull distribution function of wave-by-wave overtopping volumes in a test sequence. Measurements of this experimental study could be employed as a reference to further investigate the impacts of toe scouring on overtopping characteristics at coastal infrastructures.

Keywords: Coastal Resilience, Overtopping, Scouring, Wave impacts.

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