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Extreme wave overtopping at ecologically modified sea defences

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Damage to coastal structures and surrounding properties from wave overtopping in extreme events is expected to be exacerbated in future years as global sea levels continue to rise and the frequency of extreme meteorological events and storm surges increases. Approaches for protecting our coastal areas have traditionally relied on the development and ongoing maintenance of 'hard' defences. However, the longer-term sustainability of coastal flood management that is underpinned by such defences is increasingly being questioned both in terms of dealing with climate change and in the environmental/ ecological consequences and associated losses of biodiversity that comes with these structural defence lines in coastal areas.

The term 'nature-based' has emerged in recent years to describe biomimicry-based engineered interventions in coastal defences. For example, the addition of artificial water-filled depressions on coastal structures e.g. 'vertipools' on seawalls and the use of 'drill-cored rock pools in intertidal breakwaters that enhance biodiversity and species richness on sea defence surfaces and in adjacent coastal zones. While the ecological benefits of such interventions are increasingly being investigated, the additional roughness they bring to sea defences and the role of this roughness in wave energy dissipation and in the mitigation of wave overtopping remains less well studied.

Here we investigate the wave overtopping characteristics of artificially roughened seawalls in a suite of laboratory experiments conducted in a two-dimensional wave flume at the University of Warwick, UK. An impermeable sloping foreshore with a uniform slope of 1 in 20 was constructed in front of a vertical seawall. The seawall was subsequently modified by including 10 no. different test combinations of surface protrusions of varying scale and surface density, replicating 'green' measures suitable for retrofitting to existing seawalls. Wave overtopping was measured for each test. All tests comprised approximately 1000 JONSWAP pseudo-random wave sequences. Both impulsive and non-impulsive wave conditions were considered in experiments with two constant deep-water wave steepness values of 2% and 5%.

Results from benchmark (plain seawalls) experiments showed an overall good agreement with predictions from new overtopping manual, EurOtop II, the European empirical design guidance for wave overtopping of sea defences and related structures. However, test results for the ecologically modified sea defences under impulsive (breaking) wave conditions showed significant reductions (up to factor 4) in overtopping compared to predictions from EurOtop codes. Reductions in overtopping for artificially roughened defences under non-impulsive wave

conditions were less conclusive. Overall, results indicate that there can be a dual benefit in retrofitting sea defences with ecological features, the first being enhanced biodiversity in the coastal zone and the second being reduced flood risk in coastal areas from reductions in overtopping, particularly for breaking wave conditions.

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