MODELLING THE WOLF ROCK LIGHTHOUSE

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SUMMARY

Wolf Rock lighthouse (1870) is an isolated offshore rock tower off the Southwest tip of England, built on a steep pinnacle. It is surrounded by relatively deep water, i.e. 60-70m. The lighthouse is battered by Atlantic winter storms, which result in dramatic wave impacts and exceptional runup, even reaching to its 41m high lantern level. New experimental and numerical modelling campaigns are carried out to understand the structural response of this engineering marvel. This paper will present the main results of the hydrodynamic investigations, highlighting the main issues and achievements of the first-ever attempted model of a rock lighthouse with the ambitious scale of 1:40.

BACKGROUND

Victorian lighthouses have survived more than 150 years without requiring major repair work. However, during the last two decades, some supporting structures have showed minor damage (Figure 1), even though the main rock towers show little signs of deterioration. Over the last century, Mean Sea Level has increased at 1.8mm/year (Wadey et al., 2014). In 2067, extreme design water level will be more than 1.5m higher than what it was at the time of the lighthouses' design. This will change the wave impact location and its intensity, putting the stability of these masonry structures at risk. In order to assess lighthouse behaviour under extreme wave loading, the UK and Irish General Lighthouse Authorities and three UK universities instigated the "STORMLAMP" research project. Among the seven investigated lighthouses, Wolf Rock was chosen for extensive study for its exposed location.

Figure 1 Boat Landing platform at Wolf Rock Lighthouse

EXPERIMENTAL INVESTIGATIONS

Accurate description of the surrounding rock bathymetry and the Wolf Rock lighthouse structure have been achieved through bathymetric and airborne topographic surveys, creating the basis for the physical model layout. Raby et al. (2019) investigated the historical evolution of the Wolf Rock lighthouse structure by means of combined Discrete and Finite Element models, with wave loading described empirically. However, a site specific description of the measured hydrodynamic loading will undoubtedly improve the accuracy of the results. Hence, the presented laboratory tests aim to completely describe the breaking wave loading affecting Wolf Rock lighthouse. Furthermore, in order to extend the physically investigated parameters, a CFD wave tank model of the Wolf Rock lighthouse is developed and validated from the experimental results. Experiments were carried out in the Ocean Basin (35 m long x 15.5 m wide x 3m high) of the COAST Laboratory at the University of Plymouth (Figure 2a). Irregular, regular and focused wave conditions are modelled according to the identified risk level proposed in Raby et al. (2019). Focused waves are based on the NewWave theory (Whittaker et al. 2016), with spectral width and focusing location the investigated parameters. Total force acting on the lighthouse is measured using 6 DOF load cell. Pressure field is measured through 12 pressure transducers. Structural response of the model for separating unwanted model vibrations from desired data is captured using optical motion tracking system and three accelerometers fixed inside the model. Hydrodynamics at the vicinity of the structure and wave runup were captured using a high-speed camera (125 fps). Surface elevation, at 15 positions around rock and also in front of the lighthouse is recorded.

(a) Wolf Rock Lighthouse Model(1:40 scale) (b) Wolf Rock Lighthouse in 2012

Figure 2 Tests in the Ocean Basin, University of Plymouth

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