PHYSICAL MODELLING OF THE WOLF ROCK LIGHTHOUSE

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INTRODUCTION

The EPSRC-funded STORMLAMP brought together a range of engineering disciplines to investigate the structural response of rock lighthouses under wave loading. Here we present hydrodynamic scale modelling of the Wolf Rock lighthouse. This lighthouse is the most exposed of Trinity House's towers. It is perched on the top of a wave-washed reef, surrounded by water depths of ~ 50 m, and subjected to Atlantic waves. Preliminary STORMLAMP experiments had approximated lighthouse geometries to cylinders on the top of a plane slope in a 2D flume or on top of a conical frustum. All experiments were conducted in the University of Plymouth's COAST Laboratory.

WOLF ROCK BATHYMETRY AND TOPOGRAPHY

For the final hydrodynamic tests, an accurate 1:40 scale model was designed and constructed in the Ocean basin. This facility can have a range of water depths, courtesy of a movable floor. But as a result of having a moving floor, and the requirement to keep the basin water clean, it was not considered practical to build a fixed model using the more conventional approach of a sand core and cement render, as described later.

Furthermore, standard Admiralty charts do not provide sufficient spatial resolution for the necessary reproduction of the bathymetry. Therefore, Trinity House conducted a survey of the area with two vessels. Topographic information was obtained from drone surveys and archive drawings (Figure 1).

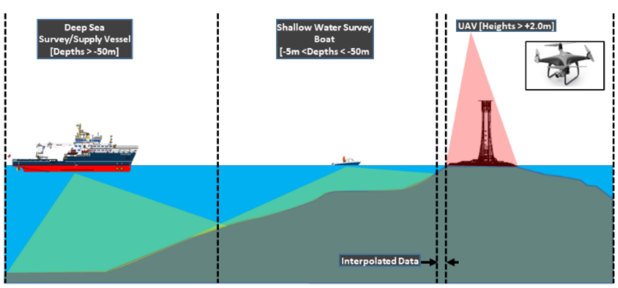

Figure 1 - Bathymetry and topography surveys

The lower region was constructed using vertical, parallel ribs of marine ply, representing sections through the reef. These provided a structure over which flexible ply was fixed to form the surface of the reef (Figure 2), which was then treated with waterproofing. Onto this region, horizontal marine ply was fixed, representing the contours of the surface-piercing rock (Figure 3). Wood filler was used to produce a continuous surface.

Figure 2 - Ribbed sub-structure of the reef bathymetry

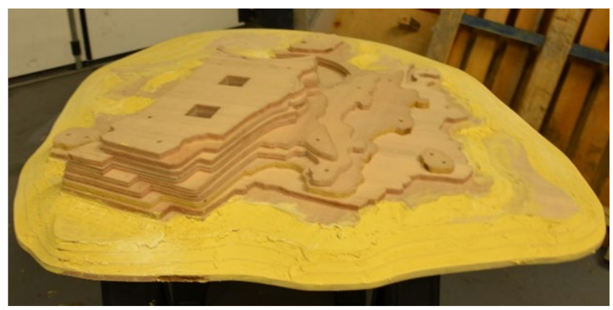

Figure 3 – Marine ply contours for the topography

WOLF ROCK LIGHTHOUSE MODEL

The lighthouse was constructed by 3D printing 11 individual pieces. The core of the lighthouse model had an aluminium C-section to provide strength. This was connected to a 6-axis load cell, providing force and moment information. Along the centre-line and around the circumference of the lighthouse 12 pressure transducers were fixed to provide the spatial distribution of the wave loading (Figure 4).

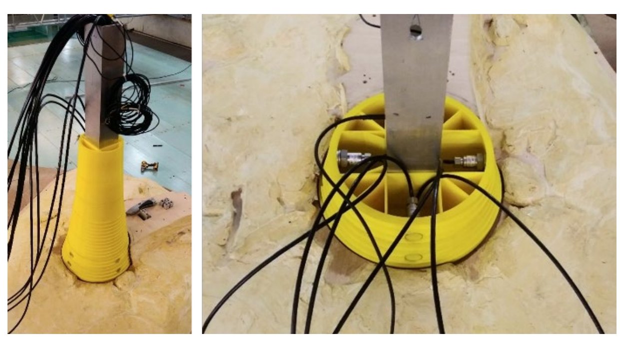

Figure 4 - Cabling for pressure transducers and load cell in the partially-completed lighthouse model

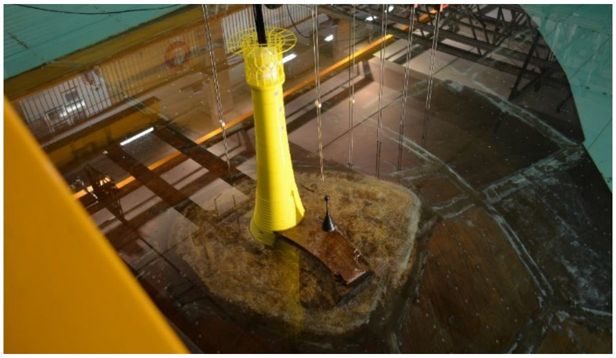

Figure 5 - Completed lighthouse model in the Ocean basin

Once the construction was completed the movable floor was lowered into the water until the correct water depth around the model was achieved (Figures 5 &6). Wave gauges were positioned at strategic locations around the model, with further information on water surface elevations provided by two cameras.

WATER LEVEL AND WAVE CONDITIONS

A 1 in 100 year return period water level was used, corresponding to a prototype water level of 6.9 m above chart datum. This included predictions for water level increase to 2067 (McMillan *et al*. 2011; *Palmer et al*. 2018).

Regular and irregular waves, and focused wave groups were used for the tests. Focused waves were based on the NewWave theory (Tromans *et al*., 1991; Whittaker *et al*. 2016). Wave conditions corresponded to a range of return period from 1 in 10 year to 1 in 250 year conditions, predicted for the year 2067. These were estimated using a non-stationary Bayesian inference to describe the increasing long-term trend in extreme wave heights for the Wolf Rock location (Raby *et al*. 2019). This built upon a stationary approach developed earlier in the project and described in detail by Antonini *et al*., (2019).

RESULTS

Results have revealed the dependence of the total force on the wave height and steepness. It is also evident that the forces differ significantly from predictions of Wienke & Oumeraci (2005).

CONCLUSIONS

An ambitious model build of a 1:40 scale model of a rock lighthouse and surrounding bathymetry has been undertaken, to try to understand the hydrodynamic loading on a particular rock lighthouse. More details of the instrumentation, wave conditions and selection of hydrodynamic results will be presented. The presentation will also describe other approaches developed in STORMLAMP for estimating the load more generally, so that it can be obtained for a variety of lighthouse geometries.

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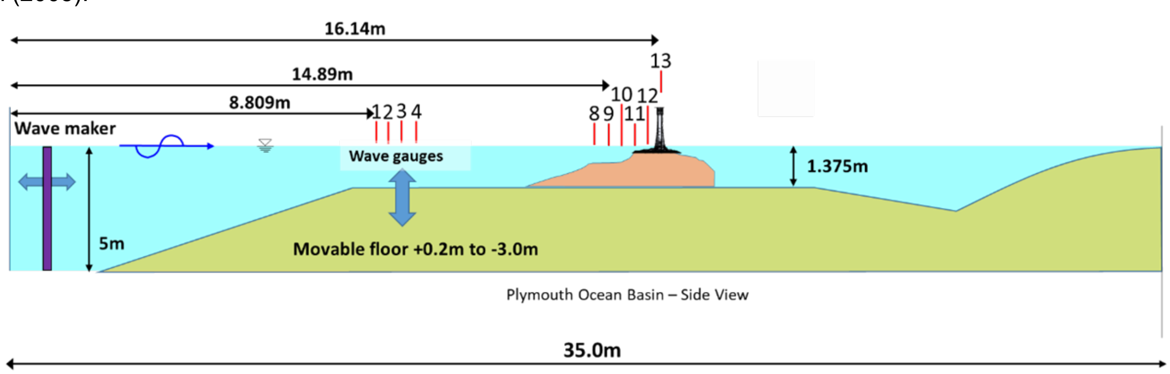

Figure 6 - Schematic diagram of cross-section through the Ocean basin and model