EFFECTS OF "DYNAMIC AMPLIFICATION" ON SMALL-SCALE EXPERIMENTAL MEASUREMENTS OF COASTAL STRUCTURES AND THEIR IMPLICATIONS

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BACKGROUND

Experimental investigation, using physical models, plays a key role in coastal and ocean engineering. However, slamming wave loads can cause vibration in the apparatus and, if the loading signal contains frequencies around the natural frequency of the structure, the structure may resonate.

LABORATORY MEASUREMENTS

There are no existing proven techniques to directly measure the impact force (Total Force). Instead, a load cell is typically attached to a test rig in order to measure the response of the structure. As a result, force-response measurements, of a vibrating test rig, will show characteristic "dynamic amplification" in the measured signal. Several filter tools are available to remove this effect to obtain cleaner force signal measurements. These include: frequency domain filtering, wavelet analysis, empirical mode decomposition (EMD), ensemble empirical mode decomposition (EEMD), and deconvolution techniques (Huang, 2014, Antonini, 2021). However, comparative studies reporting the strengths and weakness of different filtering techniques or how effective they are at remove the "dynamic amplification" are difficult to find in the literature.

Therefore, this paper provides guidance on how to: plan an experimental model study, including impulsive wave loading; design an appropriate data processing methodology, to separate slamming forces from total force responses, and; interpret the experimental results (Figure 1, Figure 2 and Figure 3).

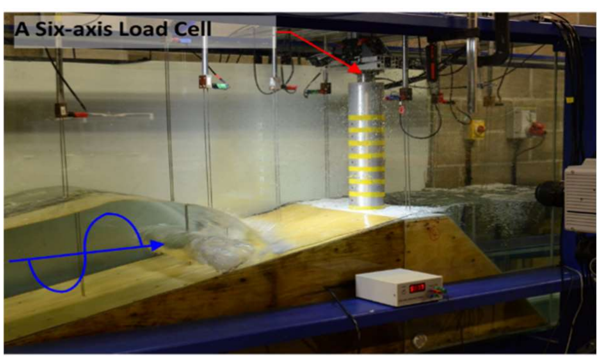

Figure 1 - Experimental setup in the Wave Flume Dassanayake et al. (2019).

First, this paper describes the "dynamic amplification" problem and methods to recover pressure/force signals by filtering out structure responses based on data from four experimental campaigns as summarised in Table 1.

Table 1: Experimental data sets used during the current study.

Date Set	Test Facility & Reference	Project Reference & Structure
01	Plymouth 35m Wave Flume (UK)	STORMLAMP: STructural behaviour Of Rock Mounted Lighthouses At the Mercy of imPulsive waves
	Dassanayake et al. (2019)	Vertical cylinder upon a shoal
02	Plymouth Ocean Basin (UK)	STORMLAMP: STructural behaviour Of Rock Mounted Lighthouses At the Mercy of imPulsive waves
	Raby (2019)	Wolf Rock lighthouse
03	Delta flume (The Netherlands)	WALOWA: WAve LOads on Walls
	Kortenhaus et al. (2017)	Vertical sea wall
04	Plymouth 35m Wave Flume (UK)	FROTH: Fundamentals and Reliability of Offshore Structure Hydrodynamics
	Hu et al. (2017)	Wave impact with a rigid and elastic wall

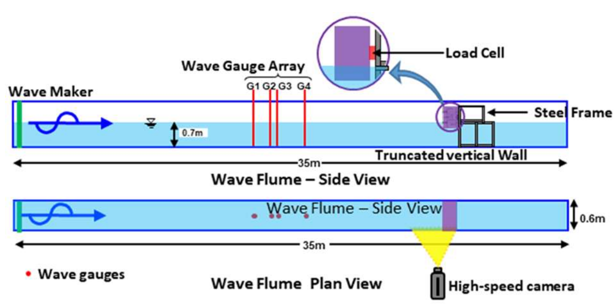

Figure 2 - Experimental setup in 35m flume of the COAST Laboratory at the University of Plymouth

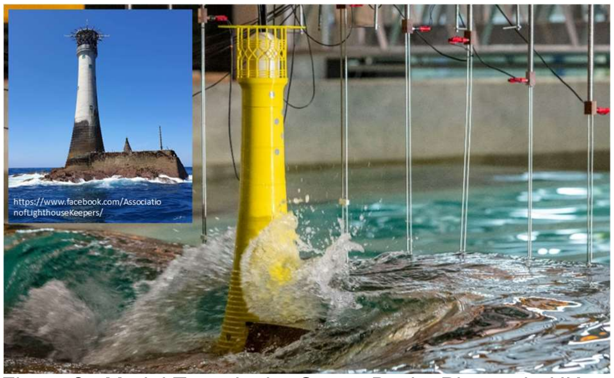

Figure 3 – Model Tests in the Ocean Basin, Plymouth, UK

Then filtered small-scale force and pressure measurements are compared with numerical modelling results, from computational fluid dynamics (CFD) simulations, to validate the filtering methodologies.

Finally, scaled-up force time series are analysed and compared with the measurements (Figure 4). Moreover, when constructed, the real structure will also undergo "dynamic amplification". More often dynamic characteristics of the prototype structure will not be available during the experimental studies.

This paper further discusses whether the selection of a poor model setup or a wrong data processing technique/sequence will underestimate the actual responses of the structure when exposed to adverse environmental loadings.

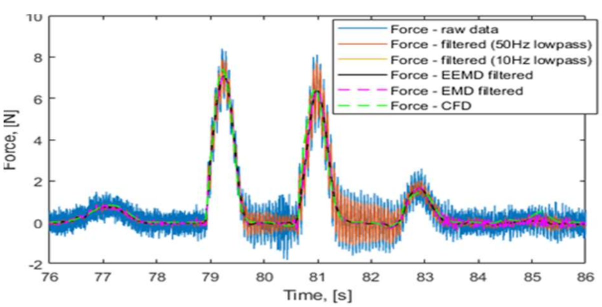

Figure 4 – Comparison of measured and filtered forces.

CONCLUDING REMARKS

Most of the published literature on wave loads on coastal and offshore structures explicitly address dynamic force components (or peak force). Many writers filtered out the quasi-static component using a basic filtering technique to extract slamming force components. This approach is not suitable for applications such as impulsive wave loads on offshore lighthouse structures (Dassanayake, 2019a). From the structural point of view, total force and duration are more relevant than the peak force or slamming force for the structures considered in this study when assessing the structure responses due to slamming loads. Therefore, Total Force separation from Total Force Responses using either the EEMD or deconvolution technique appeared to be the two best methods.

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