Imperial College London

Stephen Masterton

Nonlinear wave-structure interaction: scattering, forcing and dynamic response

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Supervisor: Professor C. Swan

Abstract / Description of Thesis

This thesis investigates nonlinear wave-structure interaction appropriate to a range of offshore structures; specifically, high-frequency wave scattering, nonlinear loading and dynamic response. The focus is on Gravity Based Structures (GBS's) although there are important implications for floating structures. The motivation arose as a result of observations of transient structural deflections, or *ringing*, arising on large surface-piercing columns within the inertial loading regime, but small enough to fall outside the linear diffraction regime $(D/\lambda > 0.2)$. While the initial focus was to investigate nonlinear loading, a number of related effects were also investigated.

The work reports detailed experimental observations undertaken in a new, state-of-the-art 3D wave basin. These included temporal and spatial measurements of wave scattering and run-up, global loading and dynamic response. The experimental facility was commissioned and calibrated to reliably recreate a range of incident waves, including simple regular waves to realistic, irregular, short-crested wave groups. By applying a progressive build up of complexity, new insights into the wave-structure interaction problem were identified.

A wide parameter range was investigated using three column diameters: 10m, 20m and 30m at full-scale. A flow regime is highlighted where the existing force models prove highly inadequate. These deficiencies are discussed in physical terms by relating the unpredicted nonlinear loading to the pattern of unexpected high-frequency wave scattering.

A representative, multiple column GBS was also considered with column diameters within the flow regime identified above. Unsurprisingly, existing force models again prove inadequate. However, the effect of leg-leg interactions was demonstrated to be less significant than previously anticipated. Finally, the dynamic response was investigated. Using a traditional "*mass spring damper*" model it was shown that the dynamic response of both single and multiple column structures can be successfully modelled, provided the forcing is accurately predicted.