Non-linear inertial loading and the onset of structural ringing

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With an increasing trend towards deep water production, the susceptibility of offshore structures to dynamic response has become an important issue. Indeed, this has been bough to the forefront by a new response phenomenon, commonly referred to as ‘ringing’, which is thought to be associated with steep near-braking waves. At present, neither the occurrence of ‘ringing’ or the mechanisms which produce this high frequency transient response are fully understood. In particular, current design solutions, which employ linear-based predictions, are unable to account for the observed behaviour.

To address these points, this dissertation presents results quantifying the non-linear components of the problem. This has been achieved through a detailed programme of numerical and experimental investigations, which has concentrated on inviscid, irrotational and potential-flow conditions. This in turn has been used to assess the loading and response which contributes directly towards the onset of structural ‘ringing’. The assessment of non-linear terms is addressed as follows. Firstly, a detailed description of the kinematics within a flow field was modelled and validated highlighting significant contributions from the higher-order terms. Secondly, non-linear terms which arise from the evaluation of forces on a slender body and bodies within the diffraction regime were investigated. Thirdly, a dynamic model representative of the response was also determined. On the basis of these individual non-linear terms, the overall effect was investigated for extreme 2-D transient waves impacting a single, vertical, surface-piercing cylinder extending from the bed upwards. The present results clearly demonstrate that the most significant ‘errors’ arising in present design practice can be accounted for by a detailed description of the kinematics within the flow field.