VORTEX-INDUCED VIBRATION OF CIRCULAR CYLINDRICAL STRUCTURE WITH DIFFERENT ASPECT RATIOS

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ABSTRACT

The purpose of this thesis is to study the Vortex-Induced Vibration (VIV) response of cylindrical offshore structures. The present study deals with the forces on the structure and amplitude of the structural vibration. For a bluff body exposed to the fluid flow, a VIV response can arise which leads to undesirable forces acting along the body causing fatigue and serious harm to the structure. This work focuses on VIV generation from an elastically mounted cylindrical structure with varying aspect ratio. Studies in offshore engineering have shown that the VIV of a longer structure such as riser and spar structure can be fundamentally different from a low aspect ratio structure such as circular Floating Production Storage Offloading (i.e., Sevan FPSO).

Complementary approaches have been employed to study the VIV phenomenon. A series of experiments were done in an enclosed towing tank to investigate the response amplitudes, hydrodynamic forces, lock-in region, Strouhal number and frequency response while varying the aspect ratio (L/D) of the cylinder from $L/D = 0.5$ to 13. The experiments were conducted in a uniform current flow and limited to a single degree of freedom movement in the transverse direction. Comparisons were made between Computational Fluid Dynamics (CFD) simulations and experimental results of the same configurations. Three-dimensional forced vibration simulations were performed to capture the forces on the structure for varying structure aspect ratio. The correlation length of the vortex cells was observed to be affected by vortex shedding and the proportions of the tested structures.

Aside from experimental and CFD approach, a semi-empirical model was shown to be successful in fundamentally modelling the wake development and vortex shedding. In order to capture the analytical solution of the VIV phenomenon, a wake oscillator model (WOM) was studied and compared with the experimental and numerical simulation results. An existing published WOM was modified to include the influence of the aspect ratio using present experimental data obtained from free vibrating cylinders in water. The capability of the modified model was illustrated through comparisons between the model predictions and results obtained previously from experiments and CFD simulations.

The current study has produced several important results. The study has shown that the amplitude response of the floating structure depends on the aspect ratio of the structure. The reduction in amplitude was significant as the aspect ratio reduced to a very low aspect ratio $L/D = 0.5$. It was found that the decrease in the response amplitude is accompanied by a decrease in the correlation