Vortex-induced vibration of a square-section cylinder with incidence angle variation

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Vortex-induced vibration (VIV) occurs when vortex shedding from a body results in fluctuating forces that, in turn, cause the body to vibrate. This can result in undesired large-amplitude vibrations leading to structural damage or catastrophic failure. While much has been done on the VIV of a circular cylinder less has been done on other canonical bluff bodies, such as rectangular cylinders. The present experimental work studied the VIV of a square cross-section cylinder in a water channel, with three different incidence angles ($\alpha = 15°, 30°$ and $45°$). The influence of geometry on the body's oscillation amplitude and frequency response, and its wake structure over a range of reduced velocity were investigated. The oscillations were measured at a low mass damping ratio of $m^*\zeta = 0.013$, which was comparable to the circular cylinder system with $m^*\zeta = 0.013$ studied by Khalak & Williamson (1997)[1]. The comparison showed that the incidence angle change had a significant impact on amplitude response. For $\alpha = 15°$ the maximum non-dimensional amplitude was $A^* = 1.11$, 10% larger than the circular case, as shown in figure 1 (a). Asymmetric amplitudes with respect to the cylinder's equilibrium position in still water were observed in $\alpha = 15°$ and $30°$ cases, due to the one-sided nature of the mean lift force. Compared with the circular cyinder, the square cylinder locked on to the structural natural frequency in water over a smaller reduced velocity regime. An oscillation frequency drop was found in the $\alpha = 15°$ case, during which the cylinder experienced its largest amplitude response. The wake structure for each case in the different flow regimes was determined using particle image velocimetry and will also be presented.

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[1] A. Khalak and C.H.K. Williamson, *Journal of Fluids and Structures* **11**, 973-982 (1997).

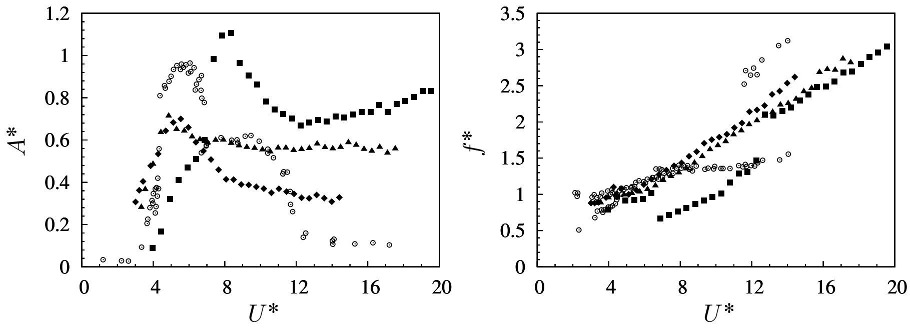

Figure 1: Comparison of dynamic response between present study of a square cylinder [with three incidence angles $\alpha = 15°$ (■), $30°$ (▲) and $45°$ (◆)] and a circular cylinder case study (⊙) by Khalak & Williamson (1997): (a) Non-dimensionalised response amplitude ($A^* = A/h$) versus reduced velocity ($U^* = U/f_{Nw}h$); (b) Non-dimensionalised oscillation frequency ($f^* = f/f_{Nw}$) versus reduced velocity.