A review of blockage and wall effects on flow-induced vibrations of various bluff bodies

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Abstract

Flow-induced vibration is of importance in many engineering applications as it causes immediate or fatigue damage to structures due to large vibration amplitudes and massive increases in unsteady forces compared with the case of stationary structures. Bluff bodies subjected to fluid flow are unconfined or confined by two parallel walls or by one wall in many engineering applications and nature (Fig. 1). They may undergo vortex-induced vibrations and/or galloping depending on the body shape and the confinement degree. Given the basis of applications and strong wall-cylinder interactions, we aim to critically review the literature on the effect of wall confinement on flow-induced vibrations of various bluff bodies including circular, square, rectangular, and rounded-corner cylinders at different values of Reynolds number, mass ratio, and damping ratio. Synthesized are the effects of the flow confinement by two walls or one wall on vibration response, frequency response, lock-in, hysteresis in vortex-induced vibration (VIV), width of VIV, aerodynamic force, vortex shedding, motion trajectory, phase lag, and galloping at different ranges of mass ratio, damping ratio, and Reynolds number. For a circular cylinder, when the blockage ratio is increased, the maximum vibration amplitude in VIV becomes small, the VIV range shrinks and shifts to smaller reduced velocities, and hysteresis between initial and lower branches comes into being. The shift in the VIV range ensues from the increased natural vortex shedding frequency with the increased blockage ratio. For a square cylinder, the effect of blockage ratio on vibration amplitude is not straightforward but depends on the cylinder mass ratio.