Reynolds number effects in the turbulent flow around a rectangular cylinder

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The separating and reattaching flow over bluff bodies with sharp edges is expected to reach an asymptotic state for sufficiently high Reynolds numbers. In the present work the effects of the Reynolds number are investigated in the turbulent flow around a rectangular cylinder with chord-to-thickness ratio $c/D = 5$. Three direct numerical simulations are performed, for the first time, at Reynolds numbers from $Re = 3000$ up to 14000 (based on the free-stream velocity and D). The flow configuration used is the object of a benchmark campaign, known as BARC[1], dedicated to deepening the current understanding of separated and reattached flows and providing practical information on the fluid dynamics of a wide range of bluff bodies of interest in civil and wind engineering. The mean flow field exhibits a significant Reynolds number dependence. The effect mainly consists in an anticipation of the triggering of turbulence and in a shaping of the mean flow pattern rather than in a sizing of its dimensions, as shown in Fig. 1(a). For sufficiently high Reynolds numbers, $Re \geq 10^4$, the flow solution is found to approach a high Reynolds number regime independent by fluid viscosity. This can be observed by the asymptotic state reached at the highest Reynolds number by characteristic parameters such as the drag coefficient, the vortex shedding Strouhal number, and the mean reattachment length. The latter is shown in Fig. 1(b) for the present work and for other numerical and experimental realizations spanning a wider Reynolds number interval. These and more in-depth considerations suggest that the range of Reynolds numbers investigated is at the transition to high Reynolds number regime for the flow around the rectangular cylinder. The results obtained might improve our current understanding of separating and reattaching flows, and lead to the development of turbulence models of greater accuracy and wider applicability in civil and wind engineering applications.

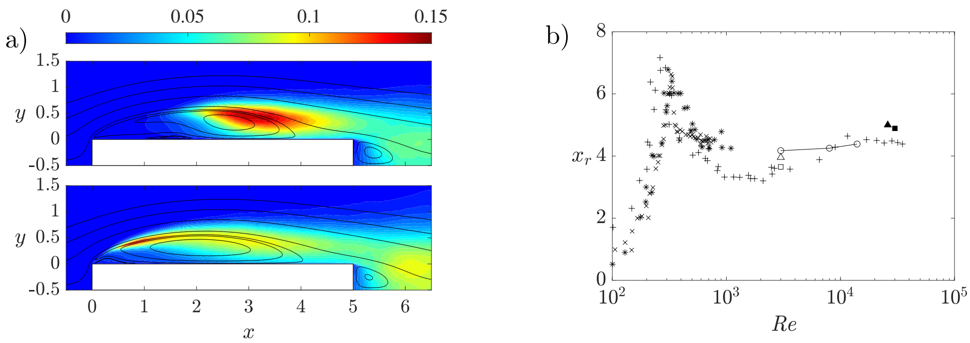

Figure 1: (a) Turbulent kinetic energy field and mean velocity paths at $Re = 3000$ (top) and 14000 (bottom). (b) Mean reattachment length vs Reynolds number for rectangular cylinders of different aspect ratios: ◯, present data; other symbols, data in the literature.

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[1] Bruno et al., *J. Wind Eng. Ind. Aerodyn.*, **126**, 87-106 (2014)