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LOW-REYNOLDS-NUMBER FLOW AROUND A SQUARE CYLINDER AT INCIDENCE: STUDY OF BLOCKAGE, ONSET OF VORTEX SHEDDING AND OUTLET BOUNDARY CONDITION

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SUMMARY

Calculations of unsteady 2D flow around a square cylinder at incidence ($\alpha = 0° - 45°$) are presented. The Reynolds numbers are low ($Re = 45$–200) so that the flow is presumably laminar. A von Kármán vortex sheet is predicted behind the cylinders with a periodicity which agrees well with experiments. An incompressible SIMPLEC code is used with a non-staggered grid arrangement. A third-order QUICK scheme is used for the convective terms. The time discretization is implicit and a second-order Crank–Nicolson scheme is employed. At the outlet of the computational domain a convective Sommerfeld boundary condition is compared with a traditional Neumann condition. The convective boundary condition is shown to be more effective in reducing the CPU time, reducing the upstream influence of the outlet and thus reducing the necessary downstream extent of the domain. A study of the effects of spatial resolution and blockage is also provided. The onset of vortex shedding is investigated by using the Stuart–Landau equation at various angles of incidence and for a solid blockage of 5%. A number of quantities such as Strouhal number and drag, lift and moment coefficients are calculated. © 1998 John Wiley & Sons, Ltd.

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1. INTRODUCTION

The flow around slender cylindrical bluff bodies has been the subject of intense research in the past, mostly by experiments but recently also by using numerical simulation. This flow situation is popular not only because of its academic attractiveness but also owing to its related technical problems associated with energy conservation and structural design. This type of flow is of relevance for many practical applications, e.g. vortex flowmeters, buildings, bridges, towers, masts and wires.

Under normal circumstances and when these bluff structures are exposed to cross-flow, there is a massive separated region downstream of the body. Owing to wake instabilities, a time-periodic oscillation develops at some critical onset Reynolds number Re_{cr}. This is the Bénard–von Kármán

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