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Flow around Surface-Mounted Permeable Cubes on Solid Surfaces

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Abstract

A wind tunnel experiment was administered to characterize the flow surrounding rectangular prisms of varying permeability, each set mounted on a stationary plane-bed surface and subsequently on an erodible bed. Laser-Doppler anemometer measurements of the horizontal and vertical velocity components were obtained during a grid that included a neighbourhood adjacent to the windward face, enveloped the free end of the shape, and extended ≈6.5 element heights downwind of the rear wall. From these component measurements, the entire velocity (Tuw), turbulence intensity (TI), Reynold Stress (RS) and therefore the turbulence K.E. (TKE) were calculated throughout the sampling array. As compared to an impermeable same-sized cube, the near-surface TKE and RS were substantially reduced within the wake flow behind the permeable elements. Within the plane-bed experiments, TI generally increased downwind of the permeable cubes, opposite to the trend for the impermeable form. The excellence in TI was less pronounced, however, when the bed morphology developed scour marks. The impermeable cube had the most important amount of abrasion relative to its volume, in response to strong downwash along its windward face and therefore the development of an active horseshoe vortex. This coherent flow structure wasn't detected for all permeable forms and therefore the amount of scour was orders of magnitude less. This study would suggest that for restricting erosion, the efficiency of a surface-mounted element are often improved by making the walls of the shape permeable instead of solid, thereby increasing energy dissipation within the wake flow while reducing vortex impingement and bed shear stress. The study of the flow around surface-mounted, sharp-edged obstacles placed in a channel is fundamental to the understanding of the flow mechanisms for complex two- and threedimensional geometries. There exists a considerable amount of published data for flows over two-dimensional geometries such as ribs and fences. However, there are markedly fewer studies in the literature concerned with the flow around threedimensional obstacles. Of these, most are limited to the study of a single parameter, for example, the reattachment length. It is therefore the aim of this study to provide a general description of the flow around three-dimensional obstacles. Based on the flow visualization experiments performed for obstacles of different aspect ratio (width-to-height), the changes in the flow patterns as a function of aspect ratio are discussed qualitatively. Additionally, large-scale parameters such as the reattachment and separation lengths are discussed quantitatively. The flow around single, surface-mounted, prismatic obstacles submerged in a boundary layer at high Reynolds numbers depends on a large number of parameters.

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