Abstract

This study presents the turbulent flow characteristics in loose boundary streams in case of immobile and entrainment threshold beds, flows past a protruding particle and the flow in the vicinity of the gravel-bed.

In flows over entrainment-sediment beds, the departure in the time-averaged streamwise velocity distributions from the logarithmic law that occurs near the bed is less than that for immobile beds. Near the bed, a damping in the Reynolds shear stress for sediment-entrainment is higher than that for immobile beds. Anisotropy analysis suggests that the entrainment threshold beds satisfy isotropy better than the immobile beds. The third-order correlations indicate that during sediment-entrainment, a streamwise acceleration is prevalent. Energy budget evidences that for the sediment-entrainment, the pressure energy diffusion changes drastically to a negative magnitude indicating a gain in turbulence production. Quadrant analysis reveals that sweeps are the dominant mechanism towards the sediment-entrainment.

In the turbulent wall-wake flows, the profiles of the defects in the streamwise velocity, Reynolds shear stress and turbulence intensities exhibit some degree of similarities on the vertical and horizontal planes. Based on the three-dimensional Reynolds averaged Navier-Stokes (RANS) equations, the similarity solution for the profiles of the velocity defect in steady-state wall-wake flows is theoretically obtained. Energy budget data show that the turbulent and pressure energy diffusions oppose each other. The quadrant analysis reveals that in wall-wake flows, sweeps are the governing mechanism.

In the spatially-averaged turbulent flow characteristics over gravel-beds, the logarithmic-law for the spatially-averaged streamwise velocity is preserved above the interfacial sub-layer, while streamwise velocity within the interfacial sub-layer can be represented by a second-order polynomial. The spatially-averaged Reynolds shear stress distribution within the form-induced and interfacial sub-layers has a considerable damping below the virtual bed level. The quadrant analysis suggests that sweeps are the prevalent mechanism near the virtual bed level. Within the interfacial sub-layer, the quadrant plots of the form-induced velocities form a pseudo-elliptical shape which shrinks to a small circle with an increase in vertical distance above the interfacial sub-layer. Within the interfacial sub-layer, the turbulent production reduces sharply and the pressure energy diffusion changes drastically to a negative magnitude.

Keywords: Flow characteristics; Turbulence; Open channel flow; Wake flow; Spatial-averaging; Quadrant analysis; Bursting events