

LARGE EDDY SIMULATION OF OPEN-CHANNEL FLOW OVER A LAYER OF SPHERES

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The paper presents results of a Large Eddy Simulation (LES) of the flow in an open channel where the channel bed is roughened with one layer of spheres. The roughness height k , which corresponds to the sphere diameter d is 0.23 of the channel depth. The Reynolds number Re_τ , based on the average friction velocity u_τ and the channel depth h is approximately 2820. The flow configuration was selected to correspond to laboratory experiments of Detert (2005), which are currently in progress. Mean streamwise velocities from the LES are compared with the measured data and the distributions of the calculated turbulence intensities are evaluated by comparing them with empirical relationships for flow over rough walls suggested by Nezu (1977). As Figure 1 below indicates, the time-averaged streamwise velocity distribution of the LES agree very well to the experiments and to the log law for rough surfaces. The occurrence of low- and high-speed streaks is examined and their spanwise spacing is quantified. Figure 2 presents turbulent fluctuations of the streamwise velocity just above the spheres. As can be seen the flow is organized into alternating streaks, which exhibit a constant spacing. This spacing corresponds fairly well with values previously reported by other researchers. Moreover, sweeps and ejections are shown to occur near the roughness elements. Figure 3 presents an instantaneous distribution of the streamwise velocity fluctuation together with the fluctuating velocity vector ($u'-w'$) in two selected x-z slices. The figure illustrates the presence of vortical motion, especially near the elements. Above the crest of the spheres, ejection events, where slower fluid is expelled away from the wall, and sweep events where slower fluid is pushed towards the elements, can be detected. With help of the present Large Eddy Simulation we furthermore reveal the amalgamation process i.e. ejection of fluid into the outer layer associated with vortex growth.

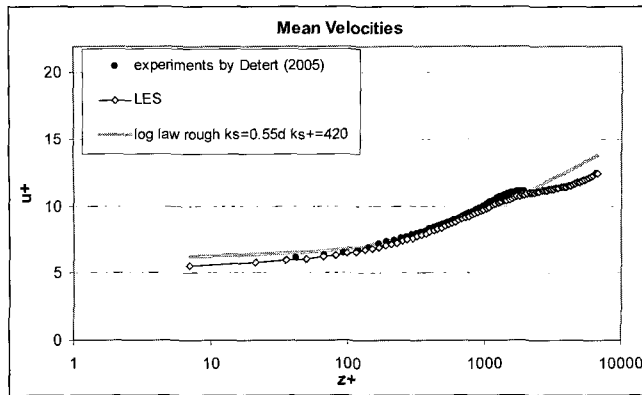


Fig. 1 Comparison of time averaged streamwise velocities to experiments and to the log law

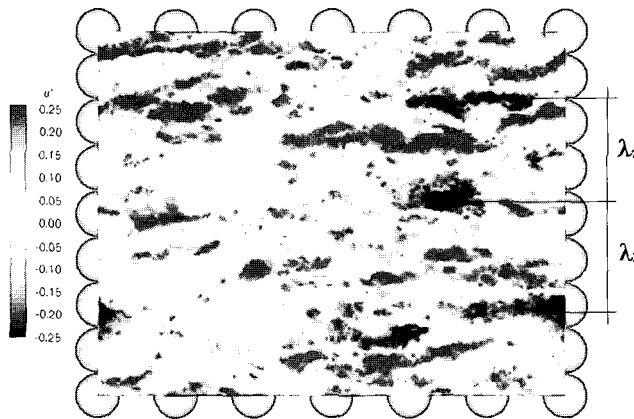


Fig. 2 Instantaneous streamwise velocity fluctuations in a x - y plane just above the spheres

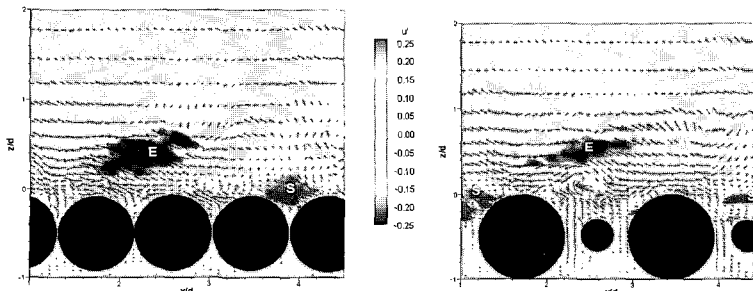


Fig. 3 Instantaneous streamwise velocity fluctuations and fluctuating vectors in two selected x - z planes