A computational study of the hydrodynamic forces on a rough wall

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The hydrodynamic interaction of a fluid with a rough wall results in a net force on the roughness elements. This can cause erosion of the roughness elements – an important aspect for sediment transport in rivers or the transport of solid media by fluids in mechanical applications. In order to deepen the understanding of the processes that lead to erosion, a direct numerical simulation of a turbulent open channel flow over a fixed rough bed was carried out. In the simulation spherical roughness elements were discretized by means of the immersed boundary method developed by [1].

The flow field statistics of the simulation compare well to data of previous studies with respect to the mean flow field as well as the turbulence statistics [2]. Furthermore, the instantaneous flow field exhibits the expected formations of streaks and of large structures that extent over the entire water depth as well as the formation of smaller coherent structures.

As a first step to deepen the understanding of the erosion mechanism, the particle forces are analyzed systematically by means of a statistical approach. The obtained results are compared with the experimental data of [3]. Agreement of the force statistics is obtained when the results of each case are normalized with the bulk velocity and the particle diameter. Nevertheless, the experimental and numerical setups differ with respect to Reynolds number, particle size, water depth to particle size ratio, particle shape and particle arrangement. The agreement between the obtained particle force statistics therefore indicates that the average force generating mechanism is persistent over a wide range of flow parameters.

References

1. M. Uhlmann, J. Comp. Physics, **209**(2), 448-476, (2005).
2. O. Flores and J. Jiménez, J. Fluid Mech., **566**, 357-376 (2006).
3. B. Hofland, PhD-Thesis, TU Delft, (2005).

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