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On the dynamics of shallow gravel bed flow

Seyed Hossein Mohajeri (1,2), Maurizio Righetti (1), Geraldene Wharton (2), and Angela Gurnell (2)

(1) Department of Civil and Environmental Engineering, University of Trento, Italy (seyed.mohajeri@unitn.it), (2) School of Geography, Queen Mary University of London, England

Flow dynamics on a gravel bed is a popular research subject because of environmental implications and especially in the presence of sediment transport. However, some features of flow dynamics on gravel beds are not completely understood and many questions remain open, especially in the context of the turbulence structure of the flow field and sediment transport. Due to the low submergence characteristics of the flow, the dynamics of the turbulent flow field, especially at the bed region, cannot be regarded as a classical boundary roughness problem, sensu Nikuradse (Nezu and Nakagawa, 1993) due to the strong spatial and temporal variation of the flow field. Over the past decade, in order to properly take into account the spatial heterogeneity, spatial averaging of time averaged values have become common. Besides,recently a trend to understand the role of gravel bed statistical properties, such as structure function of the bed elevation, on the statistics of the near-bed flow has been proposed. Although much research considers gravel beds by spatial averaging and research has been conducted on the effects of bed characteristics on near bed flow and sediment transport, only a few studies consider both together.
In the present study, the results of 2D PIV measurement coupled with high accurate measurement of the gravel bed characteristics and the turbulence properties of the low submergence gravel bed flow as related to the bed properties are presented. The double averaging method was used in the analysis. Furthermore, in order to have a better insight into the dynamics of transport processes at the bed, a simple quadrant analysis, based on the Lu and Willmarth method, was implemented (Lu and Willmarth, 1973). Finally, the turbulent integral length scale was calculated both near and far from the gravel bed.
The time and double averaged results show an agreement with the previous studies. Moreover, the result of quadrant analysis shows the sweep is dominant between crest and above and through the gravel, and ejection is dominant and reaches a maximum in the middle of the water column. The calculated integral length scale profile tends to a constant value far from the gravel bed, similar to past research. However, it shows a linear behavior in a region near the gravel crest. Interestingly, the integral length scale at the bed tends to assume values close to the value of the bed elevation standard deviation, which was suggested as representative of bed roughness (Nikora and et.al, 1998).

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