Geophysical Research Abstracts
Vol. 19, EGU2017-10474, 2017
EGU General Assembly 2017

Development of a custom-made "smart-sphere" to assess incipient entrainment by rolling

Manousos Valyrakis (1), Vasileios Kitsikoudis (2), Athanasios Alexakis (3), and Jon Trinder (1)

(1) University of Glasgow, School of Engineering, Infrastructure and Environment Research Division, Glasgow, United Kingdom (manousos.valyrakis@glasgow.ac.uk), (2) Division of Hydraulics, Department of Civil Engineering, Istanbul Technical University, Maslak 34469, Istanbul, Turkey, (3) Network Rail, UK

The most widely applied criterion for sediment incipient motion in engineering applications is the time- and space-averaged approach of critical Shields shear stress. Nonetheless, in the recent years published research has highlighted the importance of turbulence fluctuations in sediment incipient motion and its stochastic character. The present experimental study investigates statistically the link of the response of a "smart-pebble" to hydrodynamics in near-critical flow conditions and discusses how such a device can be utilized in engineering design.

A set of specifically designed fluvial experiments monitoring the entrainment conditions for a "smart-pebble", were carried out in a tilting, recirculating flume in turbulent flow conditions while three-dimensional flow measurements were obtained with an acoustic Doppler velocimeter. The "smart-pebble" employed herein is a custom-made instrumented sphere with 7 cm diameter, which has a number of sensors embedded within its waterproof 3D-printed plastic shell. Specifically, the "smart-pebble" is equipped with miniaturized, off the shelf, low-cost, three-dimensional acceleration, orientation and angular displacement sensors. A 3D-printed local micro topography of known geometry was installed in the flume's test section and the "smart-pebble" was placed there in order to facilitate the analysis. Every time the "smart-sphere" is displaced by the flow a downstream located pin blocks its full entrainment. This allows for continuous recording of the entrainment events due to the passage of energetic events, after which the "smart-pebble" returns to its resting pocket. The "smart-pebble" device under such a configuration allows the recording of normally indiscernible (with the naked eye) vibrations, twitching motions, and full entrainments for the studied particle, allowing its analysis from a Langrangian framework. During the incipient motion experiments the retrieved data are stored in an internal memory unit or transferred online with short-range Wi-Fi antennas. In addition, two high-speed commercial cameras are used to monitor the process and provide additional information. The hydrodynamic force that the "smart-pebble" is subject to is expressed with the recently proposed impulse and energy criteria, which imply that a sufficient energetic turbulent flow structure requires not only a hydrodynamic force above a certain threshold but this force has to be exerted for sufficient time for momentum transfer to occur efficiently. It is found that the probability of entrainment for the "smart-pebble" is linked to the number of energetic flow events above a threshold level. The findings of this experimental study aim to shed more light in coarse sediment incipient motion and pave the way for the utilization of such devices in the field in actual engineering applications.