Influence of seepage and inclination on the initiation of motion of non-spherical sediment particles: a numerical approach

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ABSTRACT

The influence of seepage and inclination of the bed on the incipient motion of ellipsoidal particles that compose a sediment bedform is analysed using a numerical approach based on the Discrete Element Method (DEM). The particles are modelled as ellipsoids to take into account the non-spherical nature of real sediment particles.

Under certain flow conditions (flow shear stress **τ***), the interaction of flow with the surrounding particles causes the breakage of equilibrium of each individual particle and the initiation of motion of the most superficial layer. The flow interaction is modelled by drag and lift forces that take into account both the ellipsoidal nature of the particles and its orientation. The seepage flow introduces a vertical force in the particle and modifies the horizontal velocity profile, which also modifies the drag force.

The particles-contact interactions also play an important role in the inception of motion. The Discrete Element Method (DEM) is a numerical tool suitable to simulate the evolution of systems composed by multiple interacting particles. It computes the kinematics of each individual particle subjected to the action of external forces (flow interactions) and contacts. DEM resembles the conditions of the experiments since it provides the evolution of motion and the update of the flow interacting forces. Previous formulations based on analytical procedures only compute the flow conditions for the breakage of the equilibrium but cannot compute the subsequent motion.

The incipient motion is traditionally established in the geophysical community as an experimental-analytical relationship between the dimensionless flow Reynolds number **Re*** and the critical shear stress **τ*** that produces the initiation of motion, see [1]. The experimental and previous analytical and numerical works assume that the particles are spherical, see [2] and [3], hypothesis that does not represent the real configuration of sediment bed layers. This work extends the previous results by a numerical relationship for wide variety ellipsoids, inclinations and seepage conditions. The numerical results are compared with the experiments, showing the ability of DEM to reproduce experimental outcomes that analytical formulations cannot provide.

REFERENCES

[1] P.L. Wiberg and J.D. Smith, "A theoretical model for Saltating Grains in Water", *Journal of Geophysical Research*, **90**, 7341-7354 (1985).

[2] R. Bravo, P. Ortiz and J.L. Pérez-Aparicio, "Analytical and discrete solutions for the incipient motion of ellipsoidal sediment particles ", *Journal of Hydraulic Research*, http://dx.doi.org/10.1080/00221686.2017.1289263 (2017).

[3] R. Bravo, P. Ortiz and J.L. Pérez-Aparicio, "Incipientsedimenttransportfornon-cohesive landforms by the discrete element method (DEM)", *Applied Mathematical Modelling*, **38**, 4, 1326-1337 (2014).