11th. World Congress on Computational Mechanics (WCCM XI)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

INCIPIENT MOTION FOR NON–COHESIVE SEDIMENT ELLIPSOIDAL PARTICLES BY THE DISCRETE ELEMENT METHOD (DEM)

R. Bravo[1], P. Ortiz[1] and J.L Pérez–Aparicio[2]

[1] University of Granada, Esc. Ing. Caminos. Campus Fuentenueva. 18071 Granada, Spain, rbravo@ugr.es, portiz@ugr.es
[2] Dep. of Continuum Mechanics and theory of Structures, Universitat Politécnica de Valéncia, 46022 Valencia, Spain, jopeap@upvnet.upv.es

Key words: *Sediments, Ellipsoidal particles, Shields diagram, Discrete Element Method*

Initiation of grain motion on a sedimentary bed by the action of fluid flows is a long research, treated since the experiments of Shields [1] to, e.g., analytical works of Dey [2] or numerical simulation based on the Discrete Element Method (DEM) by Bravo et. al. [3]. Main goal of research is to establish a relationship for the non-dimensional critical shear stress $\tau^\star$ necessary to produce the motion of a grain in terms of the friction Reynolds number $Re^\star$. However, both analytical and numerical solutions currently assume severe restrictions in the formulation. In particular, spherical particles have been considered in almost all cases, while real sediment grains constituting landforms and forming river and coastal beds show a wide variety of shapes. To consider the effect of complex forms in the starting movement of particles, ellipsoidal particles allow a broad range of realistic sediment shapes, from spheres to (nearly) discs.

In this work we study the initiation of motion of ellipsoidal particles by novel analytical and numerical approaches. The analytical method considers the equilibrium of an ellipsoidal particle resting on a rough sediment bed and computes the critical shear stress for the starting motion by rolling or sliding. The numerical procedure simulates the starting motion by the DEM, introducing an aggregate of particles as sedimentary bed (see figure 1). Initiation of motion is examined taking into account frictional contact interaction with the bottom particles. Additionally, DEM computes the evolution of motion after breakage of equilibrium. In analytical and numerical methods, fluid interaction is modeled by introducing drag coefficients for non–spherical particles [4].

Experimental results by Shields [1] show relevant dispersion on threshold stress due to the variety of shape, compactness and orientation of bed particles. The analytical and numerical models presented here take into account these factors in its underlying physics, resulting in solutions in good agreement with observations.

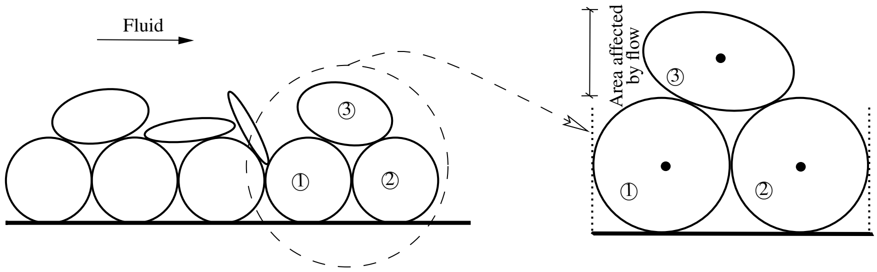

Figure 1: Sediment bed with composed by the repetition of the simple pattern of spheres on the bottom and a series of ellipsoids on the top with an stable orientation (right)

Results for initiation of motion by DEM and analytical approaches are presented as a relation for $\tau^\star$ as a function of $Re^\star$ for spheres and inclined ellipsoids (see figure 2), along with experimental data of Shields [1]. The mode of initiation of motion in the analytical approach corresponds to the curve for the lowest value of $\tau^\star$. Instead, DEM detects the mode of incipient motion by itself, giving a unique answer. Numerical results for stress are regularly higher than analytical: while analytically threshold can be precisely identified, the numerical procedure (resembling a laboratory technique) distinguishes the initiation of motion by measuring a finite displacement of the particle.

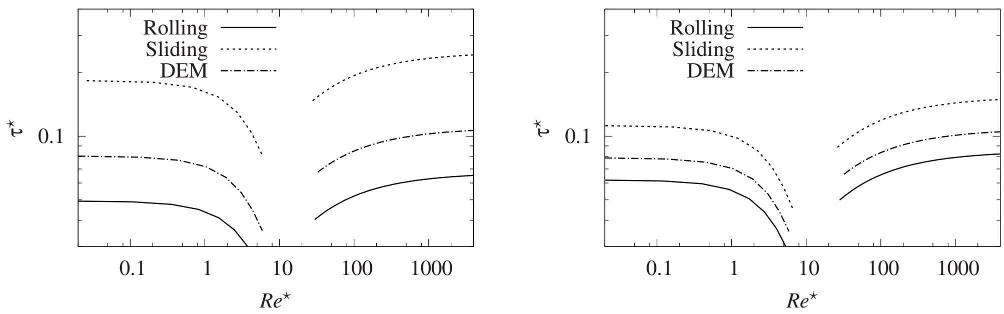

Figure 2: $Re^\star$–$\tau^\star$ relation for an spherical (left) and ellipsoidal particles (right) with the analytical and numerical (DEM) approaches.

REFERENCES

[1] A. Shields. Application of similarity principles and turbulence research to bed–load movement. *Tech. Rep., Lab. for Hydraulic, Water Resources*, 1936.

[2] S. Dey, Sediment threshold. Applied Mathematical Modelling , Vol. **23**, 399–417, 1999.

[3] R. Bravo, P. Ortiz, J.L. Pérez-Aparicio. Incipient sediment transport for non–cohesive landforms by the discrete element method (DEM). *Applied Mathematical Modelling*, http://dx.doi.org/10.1016/j.apm.2013.08.010, 2013.

[4] M. Mando and L. Rosendahl. On the motion of non–spherical particles at high Reynolds number. *Powder Technology*, 202, 1–13, 2010.