Can interlocked grains reduce the mobility of gravel bed rivers?

M.A. Wydzga¹, M.A. Hassan², J.G. Venditti³, T. Dunne¹

¹Department of Earth Science, University of California, Santa Barbara, Santa Barbara, CA 93106
²Dept. of Geography, University of British Columbia, Vancouver, BC, V6T 1Z2, CANADA
³Department of Earth and Planetary Science, University of California, Berkeley, CA 94720

Channel stability of gravel bed streams is enhanced by coarsening and structural modification of the bed, which determines the bed’s resistance to entrainment, and hence the mobility of particles on the bed. In this study we propose a grain-scale classification system that qualitatively and quantitatively describes grain-to-grain interactions of fluvially re-worked gravel beds. The quantitative measure takes the form of the ratio of the vertical plucking force \(F_{\text{vertical}}\) required to remove a grain from a static, dry bed divided by the weight of the grain \(F_{\text{weight}}\). \(F_{\text{vertical}}/F_{\text{weight}}\) is an empirical measure of the restraining effect of neighboring grains and can range between 1 when the bed is loosely packed to >> 1 when the grains are interlocked. Preliminary results from a large (30 m long and 0.86 m wide) flume channel suggest that individual grains range from being loosely arranged on the bed (mean \(F_{\text{vertical}}/F_{\text{weight}} \sim 1\)) to highly packed or interlocked grains (mean \(F_{\text{vertical}}/F_{\text{weight}} \sim 5\)). Preliminary field data from ephemeral rivers have a mean value of approximately 3 times the weight of the grain. Packing arrangements observed and measured both in the flume and in the field include loose, interlocked, imbricated, embedded, and partially buried grains. These results suggest that the equations for predicting the mobility of coarse heterogeneous sediments may require reexamination before application to channels downstream of dams and in other natural, low sediment supply channels where tight interlocking is expected to occur.