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Geometric strengthening of fluid-sheared granular beds[1] ABE CLARK, Yale University, MARK SHATTUCK, City College of New York, NICHOLAS OUELLETTE, Stanford University, COREY O'HERN, Yale University
— Fluid flowing over a granular bed exerts a shear stress on the grains. Predicting when grains move is crucial to, e.g., understanding geomorphology or mitigating soil erosion. Grain structure is assumed to play a crucial role in determining bed strength, either through packing density or contact angles of surface grains. Experiments have documented bed strengthening, even for beds of nearly monodisperse grains (i.e., excluding segregation effects), but the relevant state variables that determine bed strength are not understood. We perform molecular dynamics simulations of granular beds that search for stability under a model fluid shear force with overdamped dynamics. We find that the strength of these beds is determined primarily by the contact structure, not compactification. We observe critical scaling and a diverging length scale in the grain dynamics near a nonzero value of the applied shear force, which denotes the strongest configuration of an infinite granular bed. Notably, our numerical value agrees with experiments in the limit of low shear Reynolds number, where a heretofore unexplained plateau is observed in the critical stress versus shear Reynolds number. Our results suggest that this plateau is related to granular bed structure, not fluid mechanical effects.

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