Optimal resistance in impact and penetration of parallel rods in a granular medium

YANG DING, LIONEL LONDON, MATEO GARCIA, DANIEL GOLDMAN, Georgia Institute of Technology, School of Physics — Inspired by foot and toe morphology in sand-running lizards, we study in laboratory experiment and experimentally validated Molecular Dynamics (MD) simulation the resistance force during penetration of parallel rods (diameter 1.27 cm) into a granular medium of plastic spheres (diameter $d = 0.6$ mm) as a function of rod separation $l$. We measure the normal force exerted on the rods by the medium both during normal penetration at constant velocity ($\approx 10$ cm/sec) and during normal impact after freefall (impact velocity $\approx 2.5$ m/sec). For constant velocity penetration, the resistance force increases linearly with increasing penetration depth. The slope of this curve (force/depth) displays a maximum as a function of $l$ at $l \approx 1.6d$. In the impact studies, we observe a maximum in the collision force at $l \approx 1.6d$ and a minimum in penetration depth at $l \approx 2d$. The extrema are correlated with an increase in lateral force between the rods indicating that jammed grains increase the effective surface area during penetration.

$^1$Work supported by the Burroughs Wellcome Fund.