Exploration of the Motion-Induced Quicksand Effect With Vertical Rotation

Yeganeh, Parham (School: George C. Marshall High School)

Motion-induced quicksand, or secondary rheology, refers to the sinking of an object into dry sand fluidized by distant movement in the same granular medium. In granular environments like deserts, significant disturbances are caused by tunnel boring machines, which rotate vertically to excavate underground. This prompted an investigation into the effect of rotation speed and relative horizontal/vertical positioning of a vertically-rotating underground cylinder on the sinking velocity of a surface object in dry sand. A 4.5cm diameter cylinder buried in a container of fine, dry sand was rotated by a motor at constant rates of 10-30rpm.The sinking velocity of a small, steel sphere (intruder) was measured with a varying horizontal axis of +/- 0-5cm from the center, and at vertical distances of 2-6cm sand depth between the intruder and cylinder. After video tracking the intruder sinking, a linear regression was used to obtain sinking velocity in mm/s. Sinking velocity increased linearly with angular velocity. Sinking velocity peaked directly above the cylinder and decayed asymmetrically with increasing horizontal distance. Vertical distance results exhibited steep nonlinear decay with increasing depth. These results demonstrate the first empirical evaluation of secondary rheology with vertical rotation in dry granular media. This can be used in scaling studies for applicable tunneling parameters, to refine relationships or computational models in the field of granular physics, or to platform further research regarding directional asymmetry.

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