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Water in granular media: the essential parameter controlling liquefaction

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During an earthquake, certain soils can loose their ability to support shear and liquefy. This effect can cause buildings and man-made constructions to sink into the soil. We study this using sinking of geometrically simple objects in shaken, well controlled, granular media. We study what mechanical parameters (for the medium, shaking and intruder) control the response and govern the intrusion of the objects and liquefaction of the granular medium. We implement both numerical simulations and laboratory experiments where a spherical object lies on the top of a granular medium shaken by a horizontal motion at controlled frequency. We study systematically the effect of the presence of water, of the horizontal peak ground acceleration (PGA) imposed, of the medium particles density, of the intruder size and density, and eventually of the intruder shape.
Both numerical and physical experiments show that the water and the PGA are the most influencing parameters. We show that the liquefaction effect is maximal when the water table reaches the surface of the granular medium and when the PGA allows the small particles to slide on each other but is not strong enough to allow the intruder object to slide on small particles.
The study about density variations shows that intruder objects enter faster into the medium when it is composed of lighter particles. Experiments and simulations show that a smaller intruder penetrates deeper into the medium, respective to their isostatic depth. Eventually the shape of the object has also a real effect, as shown in recent studies (T. A. Brzinski III, P. Mayor, and D. J. Durian, Phys. Rev. Lett. 111 168002 (2013)). Our experiments shows that cylinders lying on the granular medium are more stable under horizontal shaking than the same cylinder attached to a ring buried in the medium below, mimicking buildings foundations. We are currently modeling this observation with numerical simulations.