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Soil liquefaction: a competition between buoyancy forces and ground acceleration

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When seismic waves travel through certain soils, these can lose resistance to shear, and become liquid-like: they display a thixotropic behavior. The buildings and structures lying on them can then subside, or sink partly in the soild, while mud volcanoes are formed around pipes and cracks where the liquefied soil exits. We show how a simple criterium considering the density of the solid part of the soil, the density of the fluid and the horizontal peak ground acceleration (PGA) can render for the main mechanical characteristics of the soil with respect to liquefaction, and categorize this behavior between: (a) solid like behavior, (b) liquefaction, (c) complete convection.

Using hybrid numerical simulations, taking into account both the presence of the fluid and a granular behavior for the solid bulk composing the soil, we confirm this simple analytical criterion. We also show it using saturated shaken experiments with a controlled amplitude and frequency, and different type of granular densities and fluid saturation profile. We show that the liquefaction effect is maximum when the top of the water table is close to the surface. We show that these simulations confirm the analytical criterion, to a large extent, apart from small deviations at slow frequencies and large vibration amplitudes, more prone to liquefaction than the high frequency vibrations with a similar PGA.