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Experimental study of liquefaction and fluid transport: effects of the low-permeability layer

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We report the results of laboratory experiments exploring how the water in a saturated granular medium (glass beads) migrates upwards when it is liquefied by an impulsive vibration. We conduct experiments in a two-layered medium where the upper layer has a lower-permeability and study how it affects the fluid migration. The permeability is controlled by the particle size. In a two-layered medium, we find that the pore water which has originated from the bottom layer temporary accumulates at the interface of the two boundaries, and then ascend through the upper layer in the form of a horizontal sheet or vertical channels. We find that these two different discharge styles are controlled by the permeability ratio of the two layers. We study the temporal change of thickness of the two layers and find that there are three stages; 1: the slope of the upper surface is levelled by the impulse, 2: the pore water is discharged from the bottom layer and accumulates at the interface, after which it migrates upwards, 3: water discharge ends, and the particles settle down. We measured the relaxation time needed for the discharge and compaction to end. Because low-permeability layer inhibits pore water from rising, longer time is needed for a two-layer case compared to the one-layer case. When the particle size of the upper layer is about 1/3 or less of that of the lower layer, relaxation time becomes independent of the bottom particle size. We modelled the relaxation time by introducing the effective permeability of two-layered medium, and find that it explains the measurements well.

Keywords: permeability, Darcy’s law, packing fraction, low-permeability layer