B.Sc. Thesis Project
Mixing soils to shield earthquakes

MultiScale Mechanics (UTwente)

Goal: To study how improved soils can make large areas invisible to earthquakes, via numerical simulations and lab experiments.

Background: Seismic shielding, where the soil is modified in order to attenuate or deflect seismic waves, is an emerging technology to protect earthquake-prone regions. This approach is especially relevant for areas where e.g. gas drilling (Groningen) or carbon storage results in earthquakes, as installing seismic isolations within existing buildings is challenging. Early studies demonstrate that macroscopic holes (about 10m depth and 1m diameter) can provide substantial seismic shielding [1], but the required solid barriers are invasive, expensive, and hardly applicable to large areas. Those artificially engineered soils are usually referred as *seismic metamaterials*. Their design is inspired by concepts well established for acoustic and mechanical vibration applications where the metamaterials, are used to control and attenuate the propagation of acoustic and elastic waves. However, in a seismic event, much lower frequency (1-10 Hz) long wavelength (10-1000 m) elastic waves are generated, posing significant complexity to the design of effective and feasible metamaterial based isolation devices.

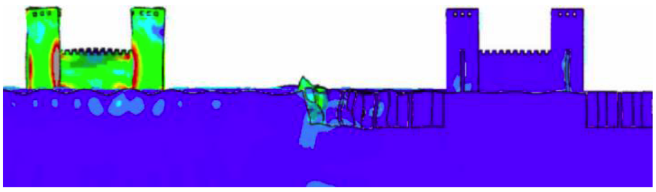

Figure 1: Schematic of the effect seismic shields in soils [1].

The M.Sc project will focus on developing a novel technology where soil is mixed with particle scatters, in order to shield the frequencies relevant for earthquakes hazards. Scatter particles can be natural products or engineered via 3D printing. The problem will be addressed at different scales, via either numerical numerical simulations or small-scale laboratory experiments.

[1] M. Miniaci et al., Large scale mechanical metamaterials as seismic shields, New J. Phys. 18, 08304 (2016).

Method: A particle-level numerical simulation technique known as the Discrete Element Method (DEM) will be used to simulate soil mixtures. The numerical method is state of the art in the MSM group and the softwares is available, open-source. Simulations will be conducted in parallel with wave-propagation experiments carried on on manufactured 3D printed particle samples. By an accurate comparison of the two approaches, numerics will reveal aspects of the mixtures behaviour that are difficult to observe by classic laboratory tests.

Depending on the choice of a numerical or experimental approach, the M.Sc project might include an internship at the partner laboratory in Stuttgart University in order to perfororm complementary experiments. The experimental plan and the actual length of the internship will be arranged with the M.Sc candidate and the partner university.

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