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# FULL-FIELD GRAIN-STRAIN MAPPING OF SAND USING NEUTRONS

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Granular media are highly complex materials since they are characterised by the mobility and interaction of their constituent particles. Under the effect of loading certain areas carry the load while other, neighbouring areas, fall into a less or even completely unloaded state. This inhomogeneous behaviour, which might also exhibit significant variations as the loading develops (i.e., loaded clusters of grains might shift into an unloaded state and vice versa), is associated with the existence of force-chains [1]; a micro-scale network of spatially continuous lines of forces between grains that are constantly readjusting throughout the grain skeleton as the deformation evolves. To this end, understanding the (micro-) mechanisms associated with the distribution and evolution of forces/stresses through granular assemblies will provide significant insight of the overall behaviour of granular matter during deformation, until mechanical failure of the material is reached.

In recent years neutron diffraction scanning has been successfully used as a new experimental tool for studies on granular materials under load, inferring force/stress distribution from crystallographic (grain) strains [2,3]. In this work the use of the neutron diffraction technique has provided the opportunity to measure the "grain strains" in a quartz sand specimen (i.e., the strains in the crystal lattices of the constituent non-bonded elastic-brittle grains of a sand sample) during mechanical loading, as a function of an applied boundary load. Through the elastic properties of averaged gauge volumes of grains, full-field mappings of the grain-strain distribution evolution were produced (Fig.1)

The experimental method involves prismatic samples of sand ($D_{50}$ = 210 μm) loaded in a specially designed plane-strain cell (experiments performed at the neutron diffraction instrument SALSA, at the Institut Laue-Langevin, France). The loading was realised in steps over a load-unload cycle (Fig.1) with a confining pressure of 3 MPa. At each load step the loading was paused with a fixed piston displacement while scanning diffraction measurements were made over a 2D grid of 50 points, using rows of five 2x2x2 mm$^3$ gauge-volumes through the thickness of the sample. The 2D diffraction mappings of crystal strains at each load step show a spatially structured grain-strain distribution, based on the averaging of the sum of the 5 small volumes at each point of the 2D grid.

Further experiments are underway with a new version of the loading device, which allows simultaneous Digital Image Correlation (DIC) measurements to take place. As a result, a multiscale characterisation of the total, “macroscopic” strain field (DIC) and the force transmission (neutron diffraction) in the sample will be possible.

## References

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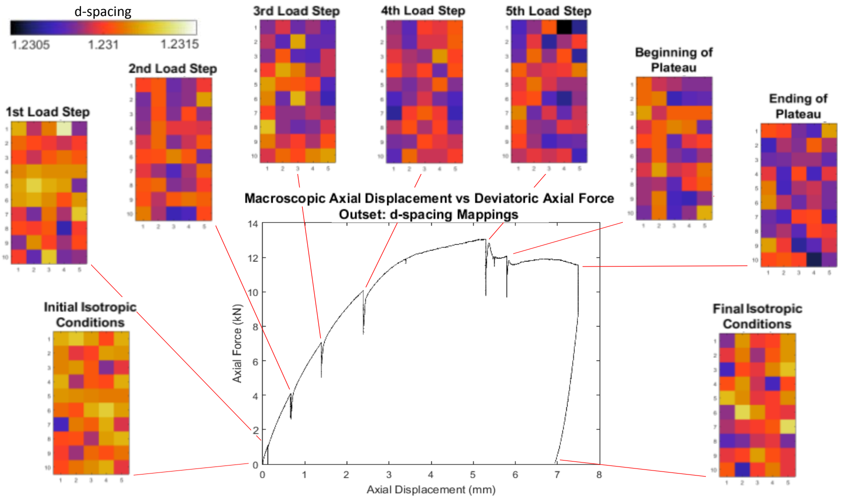

*Figure 1: Macroscopic axial displacement as a function of the deviatoric axial force. Outset: 2D grain-strain mappings (white being less compressed and black being more) per load step.*