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MULTISCALE MECHANICS OF QUARTZ SAND UNDER LOAD WITH NEUTRON DIFFRACTION AND DIGITAL IMAGE CORRELATION

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Since the first photoelasticity-based experimental works on force transmission through glass particles in the 1950s (e.g., [1]), there have been several studies, using various methods, in the effort of characterising the distribution and development of forces/stresses throughout granular (geo-)materials (e.g., [2]). In recent years, Neutron Strain Scanning (NSS) has been successfully used as a new experimental tool to infer the force/stress distribution in granular media under load (e.g., [3]), by measuring the variations in interplanar distances of crystals (i.e., the crystallographic – or grain – strains).

The presented work considers a novel plane-strain experiment performed on a quartz sand specimen with the time-of-flight neutron strain scanner ENGIN-X, at the ISIS spallation source in the UK, see Figure 1. NSS provided the opportunity to measure over a 2D grid of gauge volumes in the specimen, the averaged crystallographic strains of the constituent grains of each gauge volume, during mechanical loading and as a function of an applied boundary load. In parallel, photographs of the specimen in the plane-strain direction were being acquired continuously through a sapphire window, to derive the strain field of the specimen by Digital Image Correlation (DIC).

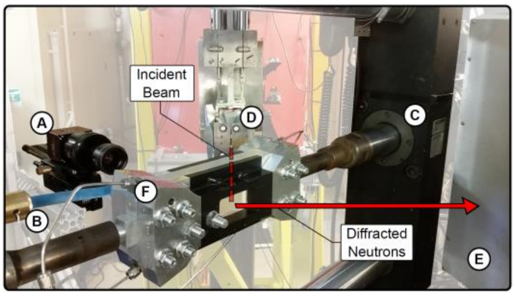

Figure 1: *The experimental setup in ENGIN-X. A: High resolution camera. B: Lighting system. C: Stress rig. D: Beam defining optics system. E: Detector. F: Connection of the apparatus to the pressure controller.*

From the NSS data, full-field mappings of the microscale stress distribution were derived for each load step of the loading, see Figure 2–top for load step 9, as well as single "micro-stress" average values for each of the produced mappings, see Figure 2–bottom. By associating traditional macroscale boundary measurements with the mesoscale DIC-derived strain field and the NSS-inferred microscale stress distribution, a completely novel multiscale analysis for granular (geo-) materials has been enabled.

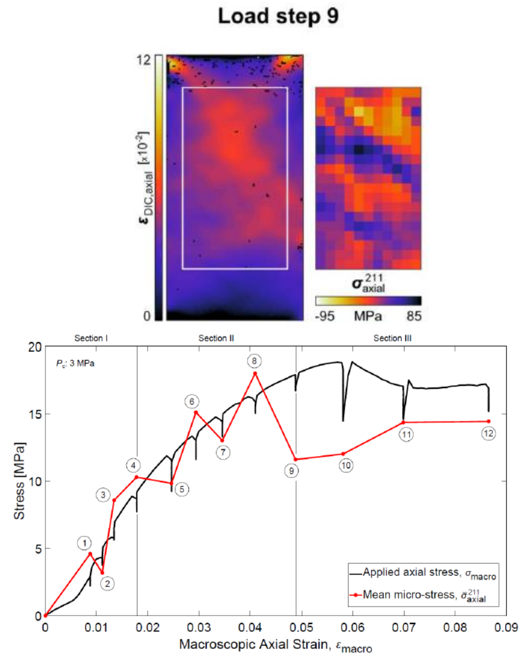

Figure 2: *(Bottom) The applied axial stress and the mean axial component of the micro-stress as functions of the macroscopic axial strain. (Top) The DIC-derived axial component of the total strain field (left) and the NSS-derived mappings of the axial component of the total micro-stress (right) for load step 9.*

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