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2018

Document Version:
Other version

Link to publication

Citation for published version (APA):
Athanasopoulos, S., Hall, S., Couples, G., Kelleher, J., & Pirling, T. (2018). *Multiscale Analysis of Sand Under Load: A Novel Neutron Diffraction Based Experimental Approach*. Abstract from 29th ALERT Workshop, Aussois, France.

Total number of authors:
5

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Keywords: Granular mechanics; Full-field measurements; Grain-strain; Stress distribution; Neutron Strain Scanning; Digital Image Correlation; Plane strain.

Abstract

The theoretical enrichment of continuum models for granular materials that take into account strain localisation processes down to the microscale level (i.e., grain scale) is still ongoing and has always been highly dependent on the available experimental data and its quality. To this end, over the past few years there has been a great effort to develop new experimental approaches to provide missing information on the state of strain and stress deep inside granular media.

Neutron Strain Scanning (NSS) is a diffraction–based technique that has been successfully used to determine the force/stress distribution in granular materials under load (e.g., [1-3]), by measuring the variations in interplanar distances of crystals (i.e., the crystallographic – or grain – strains). The work presented here is part of a PhD research project that involves the development of a specially designed plane strain loading apparatus for the realisation of NSS experiments on granular geomaterials, in combination with other material testing full-field measurement methods, such as Digital Image Correlation (DIC) and Ultrasonic Tomography (UT).

Herein, a review of representative results from the first NSS – DIC experiments on quartz sand under load are presented, focusing on the potential of the suggested experimental approach. These experiments were realised at the ENGIN-X time-of-flight neutron strain scanner [4], at the ISIS spallation source in the UK, and the monochromatic stress diffractometer SALSA [5], at the reactor–based neutron source of ILL in France. The main objective is to use spatially resolved neutron diffraction to map out the evolution of grain strains under loading, so as to infer the stress distribution throughout the material, from a continuum point of view (i.e., force chains between grains cannot be visualised), and its evolution with – localised – deformation. Associating the stress distribution determined from NSS with the simultaneous measurement of the total strain field, through DIC, and traditional boundary measurements, will enable a completely novel multiscale analysis of granular (geo-) materials. In addition, the future development of the apparatus, to incorporate simultaneous

UT measurements for the investigation of the evolution of the elastic properties of the material, is discussed.

References

[1] Hall S.A. et al., 2011, Granular Matter, 13, 251-254

[2] Wensrich C.M. et al., 2012, Granular Matter, 14, 671-680

[3] Zhang J.F. et al., 2016, Powder Technology, 292, 23-30

[4] Santisteban J.R. et al., 2006, J. of Applied Crystallography, 39, 812-825

[5] Pirling T. et al., 2006, Materials Science and Engineering A, 437, 139-144