Multiscale Analysis of Sand Under Load: A Novel Neutron Diffraction Based Experimental Approach

Athanasopoulos, Stefanos; Hall, Stephen; Couples, Gary; Kelleher, Joe; Pirling, Thilo

2018

Document Version:
Other version

Link to publication

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Multiscale Analysis of Sand Under Load: A Novel Neutron Diffraction Based Experimental Approach

S. D. Athanasopoulos 1*, S. A. Hall 1,2, G. Couples 3, J. F. Kelleher 4 and T. Pirling 5

1 Division of Solid Mechanics, Lund University, Lund, Sweden
2 Lund Institute of Advanced Neutron and X-Ray Science, Lund, Sweden
3 Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, United Kingdom
4 ISIS Pulsed Neutron & Muon Source, Rutherford Appleton Laboratory, Harwell Oxford, Didcot, United Kingdom
5 Institut Laue Langevin, Grenoble, France

*[

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