LUND UNIVERSITY

A Biaxial Plane Strain Apparatus for Neutron Diffraction-based Experiments on Granular Rocks

Athanasopoulos, Stefanos; Hall, Stephen; Nordin, Axel; Nikoleris, Giorgos; Couples, Gary; Kelleher, Joe; Pirling, Thilo

2015

Document Version:
Other version

Link to publication

Citation for published version (APA):
Athanasopoulos, S., Hall, S., Nordin, A., Nikoleris, G., Couples, G., Kelleher, J., & Pirling, T. (2015). *A Biaxial Plane Strain Apparatus for Neutron Diffraction-based Experiments on Granular Rocks*. Abstract from 26th ALERT Workshop, Aussois, France.

Total number of authors:
7

General rights
Unless other specific re-use rights are stated the following general rights apply:
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

Read more about Creative commons licenses: https://creativecommons.org/licenses/

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.

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

A Biaxial Plane Strain Apparatus for Neutron Diffraction-based Experiments on Granular Rocks

S. D. Athanasopoulos[1*], S. A. Hall[1,2], A. Nordin[3], G. Nikoleris[3], G. Couples[4], J. F. Kelleher[5], T. Pirling[6]

[1]Division of Solid Mechanics, Lund University, Lund, Sweden

[2]European Spallation Source AB, Lund, Sweden

[3]Division of Product Development, Lund University, Lund, Sweden

[4]Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, United Kingdom

[5]ISIS, Rutherford Appleton Laboratory, Chilton, Didcot, United Kingdom

[6]Institut Laue Langevin, Grenoble, France

**[stefanos.athanasopoulos@solid.lth.se]*

Keywords: Granular rocks, Plane-strain apparatus, Neutron diffraction, Grain-strain, Strain mapping

Abstract

This work considers the development of a new "plane-strain" biaxial loading device (Figure 1) for granular rocks through which the full-field investigation of strain evolution at different scales will be possible. Multiscale strain measurements will be accomplished by combining Neutron Diffraction with Digital Image Correlation (DIC) during plane-strain loading. The experimental set-up will also, in the future, include ultrasonic tomography to monitor the full-filed evolution of elastic properties.

Neutron Diffraction scanning has recently been successfully used to investigate force/stress distribution in granular materials under load. More specifically, Hall et al. (2011) showed that grain strains can be measured over a small gauge volume of a sample consisting of tens-of-thousands of sand grains. Further to that, Wensrich et al. (2012) produced in-situ mapping of the distribution of stress as an average over the volume of particles of a copper powder inside a solid die, excluding the voids. The key aim of this work is to extend the approach of Hall et al. (2011) to map spatial variations and evolutions of granular strains in rocks under loading, to investigate how forces are transmitted through the material and how this evolves with (localised) deformation. The simultaneous measurement of total strain fields (including porosity changes) through DIC and the use of samples with different cementations, will allow the characterisation of the mechanisms that act at different stages of deformation towards failure and how this is influenced by the degree of cementation.

Combining the different experimental techniques in a single apparatus requires certain constraints imposed by the different techniques and their combination to be addressed. A characteristic example relates to the combination of the design demands of the neutron measurements and of the high pressure needed to perform experiments under realistic in-situ conditions. The first requires the device walls to be as thin as possible to allow the maximum number of neutrons to reach the sample, whereas the second requires the walls to be thick enough to sustain the required confining pressures. A first prototype of the device, without high pressure, has been tested (including for neutron penetration) at UK's neutron facility, ISIS. Results from this first proof-of-concept

experiment, including 2D grain strain mappings for prismatic samples of sand loaded over a load-unload cycle, will be presented. Furthermore, the optimisation of the device, in terms of both mechanics and neutron scattering, for the construction of the second version, with confining pressure, will be presented and results of a first experiment with this device at the ILL neutron source in France will be discussed.

References

Hall S.A. et al., 2011, Granular Matter, 13, 251-254
Wensrich C.M. et al., 2012, Granular Matter, 14, 671-680

Figures

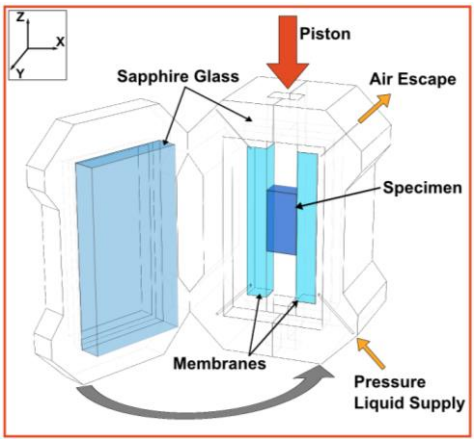

Figure 1 : *Initial schematic of the prototype "plane-strain" biaxial loading device.*