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Quantified neutron and x-ray imaging in geomechanics

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The understanding of the mechanics of geomaterials (i.e., soils and rocks) is central to many civil and research engineering projects. However the deformation of these materials is very complex with multi-scale phenomena (from interactions of individual grains to the evolution of deformation structures). Furthermore, these materials have inherent heterogeneity, both from their formation and in their mechanical behaviour with the evolution of localised deformation features such as fractures and shear-bands. In the presence of such heterogeneity, standard experimental measures (where stresses and strains are measured at points on a specimen boundary) loose their pertinence as they can only, at best, provide some average macroscopic response, which is not representative of the actual material behaviour.

So-called "full-field" methods overcome many of the limitations of standard experimental approaches in that properties and processes can be characterised throughout test specimens as opposed to at discrete points at the surface. In this context, neutron and x-ray imaging techniques play a central role, as they permit 3D characterisation of the interior of samples including during experiments where the samples might be contained within some experimental device (thus allowing 4D imaging of the sample evolution). However to fully exploit the power of these methods requires data analysis procedures that can pull out quantified information on the properties and processes of interest. In this presentation, examples from a number of projects where neutron and x-ray imaging have been used to explore the mechanics of geomaterials will be provided. The examples include: in-situ x-ray tomography of sand undergoing triaxial compression; 3D Digital Image Correlation to derive continuum displacement and strain fields from time-lapse 3D images; discrete image-based grain tracking to derive full particle kinematics for many thousands of sand grains; tracking of fluid-flow through localised deformation features in a sandstone.

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