EUROPEAN SYNCHROTRON RADIATION FACILITY
INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

	Experiment title: Quantification of damage evolution in a stiff-clay by combined 3D x-ray microtomography image correlation and ultrasonic velocity analysis	**Experiment number**: ma280
Beamline: ID15-A	**Date of experiment**: from: 11-JUL-07 to: 14-JUL-07	**Date of report**:
Shifts: 9	**Local contact(s)**: Marco DI MICHIEL	*Received at ESRF:*

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Report:

The aim of this experiment was to assess damage evolution within stiff-clay (Beaucaire marl) samples through *in-situ* triaxial loading tests with x-ray microtomography on ID15A and to quantify the strain development by 3D digital image correlation (DIC) of the micro-tomographic images. In addition ultrasonic velocity tomography was to be carried out before and after the *in-situ* loading tests, with the aim of integrating such data with the 3D strain and so to develop "damage-law" models linking strain and elastic property evolution.

The tests followed the procedure established over previous experiments on ID15A by the Laboratoire 3S-R team, using the specifically designed triaxial load cell. Two in-situ "drained" triaxial tests were successfully carried out on the stiff-clay samples with x-ray micro-tomography. Micro-tomography images were acquired before confinement was applied, after the application of an isotropic confining load and throughout the shear phase at key points in the loading during the "linear" par of the loading and before, at and after the peak load was achieved, finally images were captured after the confining load was removed. A few months later the samples were rescanned on ID15A to assess the effects of drying, which will influence the post-mortem ultrasonic velocity analysis. The pre-mortem ultrasonic velocity analysis proved difficult, due to damaging of

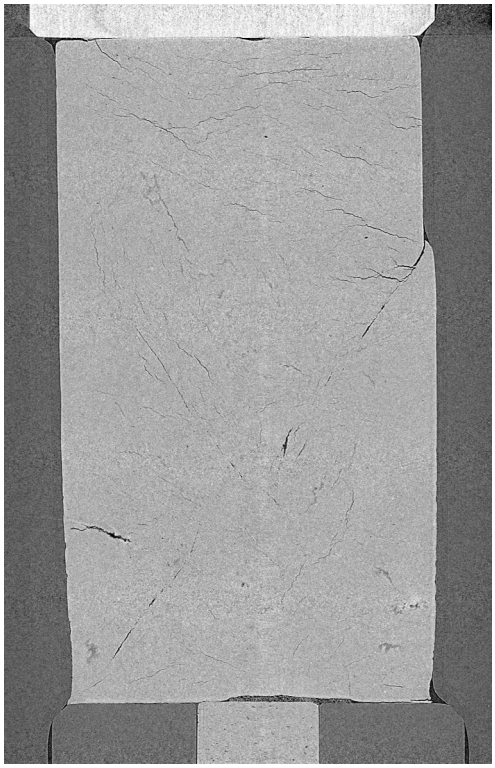

Figure1: vertical slice through tomography image of LBU1 Beaucaire marl sample at the end of the test

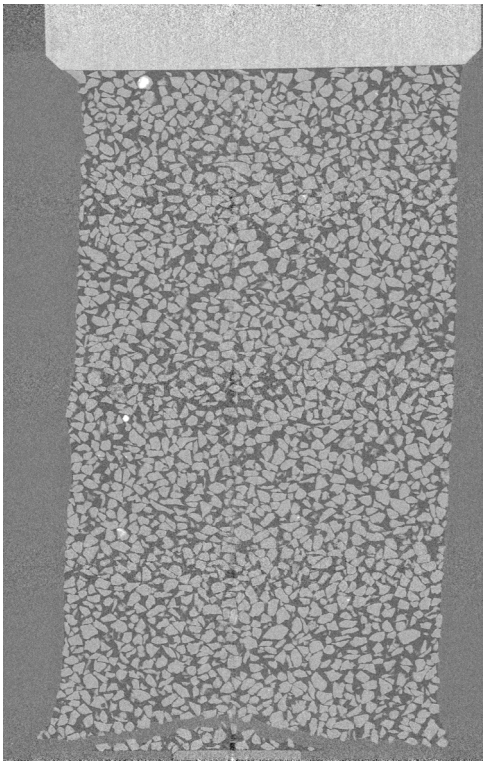

Figure 2: Vertical slice through the tomography image of the S28_SYN2 Hostun Sand sample at the peak load

the samples during the data acquisition, and so was abandoned (however post-mortem velocity analysis is ongoing).

Tomography images show that the samples were heavily fractured at the end of the tests (See figure 1), but a lot of this fracturing opened up when the confining pressure was removed. Earlier in the test localised shear failures can be observed in the tomography images near to and after the peak in the loading curve (either after they have opened or earlier as faint possible denser zones) but their early development is not very visible. With the 3D DIC analysis the initiation and propagation of these shear zones is clearer and is noted to start before the peak in the loading curve; DIC analyses is on-going.

In addition to the objective of carrying out two tests on the clay, two further tests were carried out, using the same set up and experimental procedure, on a granular material (Hostun sand). The aim of these tests was to investigate if it is possible to observe the development of strain localisation with x-ray micro-tomography and to thus characterise this with DIC. The two tests yield good data to test these ideas and initial analysis using 3D-DIC show for the first time that the development of localised shear failure can be characterised (see Figure 2). Further development is in progress that aims to better apply DIC to granular materials.

The results from this work (tomography and 3D-DIC) are to be presented in the following:

X-ray µCT and 3D digital image correlation to study localised deformation in geomaterials under triaxial compression, S.A. Hall, N. Lenoir, G. Viggiani, P. Bésuelle and J. Desrues, 2008, EGU, Vienna.

Combining x-ray CT and 3D digital image correlation for studying localized deformation in stiff clay under triaxial compression, G. Viggiani, S.A. Hall, N. Lenoir, P. Bésuelle and J. Desrues, 2008, 8IWBIDG, Calgary

Combining x-ray CT and 3D digital image correlation for studying strain localization in granular materials, N. Lenoir, Y. Pannier, S.A. Hall, M. Bornert, P. Bésuelle, J. Desrues and G. Viggiani, 2008, 8IWBIDG, Calgary, Canada.

Characterisation of localised deformation in granular geomaterials using x-ray (micro)tomography and 3D-volumetric digital image correlation, S.A. Hall, N. Lenoir, Y. Pannier, J. Desrues, M. Bornert, G Viggiani, P. Bésuelle, M. Di Michiel and J. Otani, 2008, Photomechanics, Lougbourough, UK.