Report:
Using the BM05 beamline of the ESRF we carried out experiments on granular dynamics. Let us mention that this report is submitted with an important delay. The reasons of this delay are explained at the end of this report.

We first study the memory effects in granular media at the scale of the grains. Let us mention that granular compaction exhibits a glassy behavior, so granular systems should display memory effects. To prove this point, Josserand et al. (Josserand2000) carried out experiments on the response function of a granular packing undergoing compaction due to sudden perturbation of the tapping acceleration (equivalent to the temperature for a classic glassy system see Richard2005). These authors drive three granular packings to the same packing fraction with three different tapping intensities Γ1, Γ2 and Γ3 with Γ1 < Γ2 < Γ3. Then the three packings are tapped at the intensity Γ2 and for a short time their behaviours depend on the previous value of the tapping acceleration. In other words, short-time memory effects are observed: the future evolution of the packing fraction depends not only on its initial value but also on its history. Therefore packing fraction alone is not sufficient in order to fully characterize a granular packing. The missing information should be hidden in the local structure of the packings.

Recently we demonstrate by means of numerical simulations that these memory effects can be explained by a difference in the number of contacts for the different packings. In other words two packings with the same packing fraction can have a different mean number of contacts. The experiments performed in the ESRF do not confirm these results. This is probably due to the polydispersity of the granular system use. Indeed it seems that memory effects are less important for polydisperse packings. This point have to be explored carefully before to carry out new experiments with less polydisperse packings.

Preliminary experiments using a penetrometer have also been carried out. Cone penetration testing (CPT) is a standard method for evaluation of soil strength for construction purposes, in which a rod with a conical tip is inserted into the ground for measurement of resistive forces, pore pressure, etc. Classic theories in soil mechanics such as the bearing capacity and cavity expansion theories offer possible mechanisms by which the motion of soil particles exert forces on the penetrometer (Yu & Mitchell 1998; van den Berg 1994). With sufficient number of fitting parameters these theories offer reasonable predictability of soil strength. Microscopic validation of these theories requires, in addition to information obtained by the standard penetrometer, the following:
1)soil material which allows imaging of the interior of the bulk,
2)imaging techniques with sub-particle resolution,
3)computer algorithms to track the motion of individual particles.
Past attempts by others to directly image the soil movement during CPT have been limited to a quasi 3D geometry in which a penetrometer in the shape of a half cylinder, pressed against a glass side window, was lowered into a real soil sample as illustrated in (van den Berg 1994). Since the introduction of transparent soil simulant, new imaging techniques have been tried with much success. For example, vertical cross sections of transparent soil illuminated by a laser sheet have been analyzed by digital image correlation (Sadek et al. 2003). Difficulties in imaging the motion of particles through volume scans, however, have yet to be overcome. Certain anisotropies in the displacement field of particles, for example, can be observed only when one has data from a full volume scan. X-ray tomography is thus a powerful tool. Our preliminary results show that rearrangements spread furthest not directly under the penetrometer but in a ring around the penetrometer. In addition, preformed stress chains in the

material influence the particle rearrangements. Unfortunately as mentioned above the beamline is not perfect for our study. This is even more true in the case of the penetrometer case, for which the positions of all the grains around the the penetrometer should be scanned. Moreover the metal used for the penetrometer was not adapted to the experiments: it creates artefacts on the reconstructed images. We spend more than two years working on the correction of these artefacts. This explains the delay in the submission of this report.

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