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Editorial
Soil mechanics at the grain scale: issue 2

This second volume of the themed issue on 'Soil mechanics at the grain scale' offers some insights into the influence of particle and inter-particle contact characteristics on the behaviour of soils. These breakthroughs are provided by the carefully planned combination of micro-mechanical measurements, conventional soil mechanics laboratory and in-situ tests, and numerical analyses based on the discrete element method (DEM) and on continuum mechanics. Novel methods are proposed to characterise the complex geometry of soil particles, by means of measuring their roughness, sphericity, roundness, circularity and regularity, and to relate these to their mechanical response such as their stiffness and strength. We discover how these properties of the soil at the grain scale affect the normal compression line and the angle of shearing resistance at the meso-scale (Cavaretta *et al.* 2010). The grain size, shape and surface area are also found to affect cementing in soils such as gas hydrates, which in turn influences their strength and stiffness (Clayton *et al.* 2010). Soil behaviour is complicated by the fact that the characteristics of soil grains can change, for example as particles are abraded and crushed in shear bands near pile shafts, thus affecting the capacity of the piles (Yang *et al.* 2010).

The DEM is generally considered to be the obvious tool to reproduce soil behaviour at the grain scale. However, numerical results from DEM simulations do not always match experimental results. The characterisation of particle morphology and inter-particle contacts will help inform DEM modellers of new types of contact models that could be developed to reduce these discrepancies. One aspect of the research carried out using DEM is the validation of numerical results against 'real' soil data. In this issue, we are shown how the shapes of particles can affect the maximum and minimum void ratios of computed samples that can then display strain-induced anisotropy owing to particle orientation, while their roughness affects the inter-particle shear resistance (Abireddy & Clayton, 2010). In the same line of thought, Yimsiri & Soga (2010) look at the effect of initial fabric, modelled by the initial normal contact distributions, on the simulated response of an assembly of grains. This emphasises that using the DEM and interpreting computed data requires an insider's knowledge and subtle judgement.

Despite some limitations, we can agree that the DEM provides a very useful tool to explore the underlying physical micro-mechanisms behind phenomena such as creep (Kwok & Bolton, 2010) or suffusion (Muir Wood *et al.*, 2010). Kwok & Bolton (2010) show that the rate process theory, originally borrowed from chemistry (Eyring, 1936; Kuhn & Mitchell, 1993), can be applied to a contact model in DEM to simulate successfully the change in creep rate with time. Muir Wood *et al.* (2010) use DEM simulations as a vehicle to validate a continuum model that takes account of the effects of initial grading and its evolution on the critical state line of soils. Simulations using the DEM can also be used to decipher complex soil behaviour such as that of railway ballast, and we see in Lu & McDowell's (2010) paper how this requires innovation by way of modelling grain properties, here as particle clumps with bonded small balls as asperities, to allow for abrasion to be reproduced while keeping the computational time reasonable.

The strength of the research presented here lies in the continuous attempt to link the observations made at the microscopic scale to the overall material response, whether in experiments or in numerical analyses. The gap between continuum constitutive models developed in research and those used in practice is widening as more sophisticated models are created to simulate complex phenomena of soil behaviour such as cementing or creep, yet they often tend to use large numbers of parameters that are not straightforward to determine and/or lack any physical meaning. The effort demonstrated in this issue, whether it is fundamental or applied, must be maintained so as to refine our definition and determination of meaningful parameters for numerical models, and improve the confidence of the users.

Béatrice Baudet (Editorial Chair)
and Malcolm Bolton (TC35 Chair)

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