

# INTERNATIONAL SOCIETY FOR SOIL MECHANICS AND GEOTECHNICAL ENGINEERING



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# Administrative report of TC35 – Micro-geomechanics

## Compte rendu technique de la No. CT 35 – Micro-géotechniques

M.D.Bolton – *University of Cambridge, UK*

### 1 TERMS OF REFERENCE

TC35: Micro-Geomechanics is a newly formed committee. Its Terms of Reference have been defined as:

1. To promote co-operation and exchange of information about the behaviour of soil grains and granular interactions, so as to clarify the fundamental micro-mechanisms of the behaviour of soils.
2. To encourage a micro-structural understanding of significant macroscopic behaviours such as compressibility, anisotropy, yielding, creep, cyclic liquefaction, shear rupture and tensile fracture.
3. To open up a discussion on the use of micro-structural measurements to clarify the selection and raise confidence in the use of continuum parameters in engineering practice.
4. To co-operate with other groups to provide a focus for the physical origins of ground behaviour related to micro-structure; links will be sought with TC34 Deformation of Earth Materials, TC29 Stress-Strain Testing of Geomaterials in the Laboratory, TC26 Calcareous Sediments, TC25 Tropical and Residual Soils, TC22 Indurated Soils and Soft Rocks, and TC2 Centrifuge and Physical Model Testing.
5. To widen the scientific basis of geomechanics by linking with groups applying micro-mechanics to the study of granular materials in other fields of application such as rock mechanics, metal powders, ceramic pressings, and food processing.
6. To facilitate discussions between research workers proposing DEM numerical simulations of soil aggregates and researchers using corresponding laboratory tests, especially with regard to the observation of grain crushing and reorientation.
7. To maintain the existing working group on soil crushability, and to report progress at a workshop to be organised as part of a Satellite Conference to the 15th ICSMGE, Istanbul, in August 2001. This venue will also provide the first opportunity for a meeting of the full TC35.
8. To work towards the promotion and planning of an International Symposium on Micro-Geomechanics to be held at some time between the 15th and the 16th ICSMGE to disseminate progress across the whole field defined in these terms of reference.

### 2 MEMBERSHIP

**Chairman:**

M.D.Bolton (UK)

**Secretary:**

M.Coop (UK)

**Core members:**

A.F.L.Hyde (UK)

G.R.McDowell (UK)

M. Hyodo (Japan)

O.Kusakabe (Japan)

Y.Nakata (Japan)

H.Sakaguchi (Japan)

H.A.Joer (Australia)

D.W. Airey (Australia)

R. Wang (China)

B.Muhunthan (USA)

C.Santamarina (USA)

J-M.Konrad (Canada)

L.Rothenberg (Canada)

J.Lanier (France)

An invitation has been made via the web-site <http://www-g.eng.cam.ac.uk/TC35/Index.html> for other interested research workers to associate themselves with the work of the Committee and Professor Bolton can also be contacted by e-mail at [mdb@eng.cam.ac.uk](mailto:mdb@eng.cam.ac.uk)

### 3 MOTIVATION

The proposal for a Technical Committee on Micro-Geomechanics arose from six considerations.

- i. There is a widespread acknowledgement that micro-mechanics is making a substantial contribution to other branches of materials engineering, including high-strength composites and ceramics, and that applications to granular materials are being made in other fields as diverse as asphalt road pavements, pharmaceuticals and food processing. The general aim of micro-mechanics is to identify fundamental mechanisms at the scale of significant microstructure and thereby clarify the definition of tests and parameters that will be useful at macroscopic scale. This is especially significant where macroscopic failures involve material behaviour that is poorly understood. The recent introduction within soil mechanics of micro-mechanisms for grain crushing are proving extremely helpful in shedding light on both dilatant shearing (related to sliding failures) and volume compressibility (related to settlement damage). Further work is needed to demonstrate the different roles of grain damage and rearrangement in the context of soil plasticity and hysteresis. It may then be possible to clarify such phenomena as anisotropy, creep, cyclic liquefaction, and collapse through destructuring.
- ii. The ongoing specialisation of geotechnology within sub-disciplines such as tunnelling, pile driving, geo-synthetics, ground improvement etc, has tended to draw attention away from the unifying theme of the mechanics of soils. Yet there is much to be gained from a holistic approach. An understanding of grain size effects in pile driving should bear some relation to similar effects regarding anchorages or reinforced soils, for example. Micro-geomechanics can provide a focus to counter-balance the tendency for duplication due to over-specialisation.
- iii. The means of investigating micro-mechanics is now expanding. Grain crushing can be related to changes in grading of soils before and after testing in the laboratory. New tech-

niques have become available for the rapid determination of particle size distributions and measurements of specific surface. Resin injection permits the detailed description of microstructure following certain deformation paths. There is also increasing use of cameras to image soil grains and abstract their displacements in real time. The real-time visualisation of sands during CPT or pile penetration should offer the prospect of penetrometer correlations which are dimensionally consistent and that have physical meaning.

- iv. An international group of research workers studying soil crushability have organised two workshops on the topic, in Sheffield University in the UK in 1997, and at Yamaguchi University in Japan in 1999. The last meeting showed clearly that all granular soils are crushable, and that soil crushability is a key to their behaviour under all stress levels. Sand behaviour in complex stress-path tests can be normalised using similar precepts to those of critical state soil mechanics that have previously been applied to clays. Plasticity in clays is then seen to be analogous with grain crushing observed in sands. This seems to offer a new synthesis over-arching "cohesive" and "granular" materials. On a practical level, the group has made progress in identifying useful test protocols, measurement techniques, and statistical methods, to explore and verify micro-mechanical models in the laboratory.
- v. There are continuing advances in Discrete Element Models (DEM) which can represent an aggregate of grains, including crushable grains, in a numerical simulation. The link between behaviour observed in physical element tests and in DEM simulations can provide a significant stimulus to fundamental understanding.
- vi. Soil constitutive models are also being derived directly from simple micro-mechanical principles. It is increasingly apparent that a realistic treatment of soil grains - including the effects of elastic contacts, sliding, crushing, and rearrangement - offers a fruitful avenue to discuss the whole spectrum of soil behaviour. In this way, the plethora of parameters apparently required to describe soil deformations might be reduced to a few which have proven physical significance at the micro-level. It is often the lack of a proper understanding of parameters and behaviour that obstructs the geotechnical engineer, not the inability to make calculations based on those parameters once they have been selected. It should be possible to introduce these new theoretical insights to expand the framework of critical state soil mechanics and soil plasticity, so that a greater confidence can be felt in applying constitutive models to "difficult" soil behaviour.

#### 4 PLANS

The new TC 35 was established in January 2000, and terms of reference were confirmed in February. The aim of the new TC35 is to develop granular perspectives of soil behaviour based on the observation of soil grains and fabric, and the micro-mechanics of deformation and flow. One outcome should be an improvement in the physical understanding of conventional soil parameters. Another should be the development of advanced techniques of soil characterisation which can accompany conventional soil testing.

The subsequent work of the chairman, together with an initial steering committee comprising Masayuki Hyodo, Adrian Hyde, Matthew Coop, Yukio Nakata and Glenn McDowell, has been to put in hand plans for inaugural activities. An informal steering group meeting was hosted by Professor Hyodo in Yamaguchi University in July. This was followed by an Informal Workshop on Micro-Geomechanics at Cambridge University in December which heard 15 presentations from staff and research students from 6 UK universities and from Yamaguchi University. The success of this meeting encouraged the steering group to accept the offer of Professor Togrol to organise a one-day Satellite Conference in Istanbul on 25 August 2001, immediately before the

15th ICSMGE, on "Fundamentals of Soil Behaviour" which will explore the granular perspective in geomechanics. Ten active research workers from four countries have agreed to make short presentations of their recent work, in order to stimulate discussion. There will then follow a Grand Inquisition into the physical meaning of soil parameters, led by Professor Muir Wood, and assisted by an expert panel. The first full meeting of TC35 will follow the next day, when we look forward to meeting many representatives for the first time.

Other plans are in hand. Discussions are taking place with Professor Vardoulakis for TC34, in order to have some interaction during Powders and Grains 2001 in Sendai, in May 2001. The US National Science Foundation is considering sponsoring an Invited Workshop on Micro-Geomechanics in Cambridge in 2002. Professor Hyodo has kindly organised the publication of the proceedings of the International Workshop on Soil Crushability, which was held in Yamaguchi University in August 1999, and is exploring the opportunities for hosting a TC35 International Symposium in Japan in 2004. We hope new members will make presentations at these meetings, and propose new activities in various regions arising from their own enthusiasms.