Conference reports

The International Workshop on Granular Matter, Budapest, Hungary

Following an initiative taken by Dr. Emoke Imre of Óbuda University, Budapest, Hungary, an International Workshop on Granular Matter was jointly organised by Óbuda University, Budapest, Hungary, The Hungarian Academy of Sciences (HAS), BME Morpho-dynamics Research Group, Hungary and the School of Engineering and The Built Environment, Napier University, Edinburgh, UK, on 12th June 2018. The workshop was supported by a diverse group of scientists, including the 6th Section of Engineering Sciences and the Institute for Soil Sciences and Agricultural Chemistry, HAS, Eötvös Loránd Physics Society, Thermodynamics Group, Scientific Soc. of Silicate Industry, the International Society of Soil Mechanics & Geotechnical Engineering (ISSMGE) and the Department of Engineering Geology and Geotechnics, BME, Hungary. The theme of the workshop is on the topics, grading entropy, constitutive modelling including unsaturated soils, discrete element methods (DEM).

The workshop aims to provide an opportunity for the research groups and DEM schools from UK, Spain, Hungary etc. (i) to work together on the planned Theme Issue publications mostly related to grading entropy and constitutive equations of the *Granular Matter Section* of the 14- Joint European Thermodynamics Conference (2017, Budapest, Hungary); and (ii) to discuss some relating topics for the coming ISC6 conference to be held in 2020 in Budapest, Hungary. There were 38 participants coming from five main universities and research institutes in Hungary. The invited speakers were from (i) the Department of Civil and Environmental Engineering, Geotechnical Division, UPC, Barcelona in Spain, (ii) Universities of Swansea and Edinburgh in UK, and (iii) Department of Mechanical Engineering, University of Bratislava, Slovakia.

A brief program of the workshop is given below.

Part 1. Unsaturated soil modelling in terms of the grading curve

Part 2. Modern constitutive laws

- A nonlinear continuum theory of finite deformations of elastoplastic media
- Large strain plasticity for soils using the Particle Finite Element Method
- Effect of crushing on critical states of soils
- A non-equilibrium foundation of thermodynamics
- Nonlinear Theories and Dry Friction)

Part 3. Grain shape and DEM

- Linking true sphericity and particle rotation to calibrate DEM contact models
- Tracking critical points on evolving curves and surface
- Frustrated packing in a granular system under geometrical confinement
- Breakage properties and DEM modelling of Ballast material
- Analysis of particle movement of open mixing screws
- Calibration algorithm for discrete element models
- Multiple shear bands in granular materials

Part 4. Grading Entropy and DEM.

- New aspects of the grading curve characterization
- Mean or fractal gradings, natural soils, internal stability, strong force chains and probability
- Preliminary study on the relationship between various physical properties and the grading entropy parameters
- Breakage grading entropy path – A rock classification alternative

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Plenary lecturers and presentation topics are:

- *M. Arroyo*: Effect of crushing on critical state of soils: a DEM-based study
- *Barreto, D. McDougall, J. and Imre, E.* Volumetric consequences of mass loss in soils - A micro-mechanical perspective
- *Écsi, L. and Ván, P*: A nonlinear continuum theory of finite deformations of elastoplastic media
- Lőrincz, J., Imre, E., Trang, P. Q., Fityus, S., Casini, F., Guida, G., Gálos, M., Kárpáti L., Szendefy, J., and Barreto, D.. Mixture composition change and grading entropy – A rock classification alternative?
- *Monforte, L., Arroyo, M., Carbonell, J. M., and Gens, A.* Large strain plasticity for soils using the Particle Finite Element Method.
- *Pande, G. N.* Pore size distribution & microstructure of saturation – key elements for rational description of mechanical behaviour of unsaturated soils.

In the topic of grading entropy and DEM, the main findings were:

- The grading entropy is the sum of mathematically precise and statistical entropy, called entropy coordinates. The first coordinate is a mean log diameter (similar to d_m) and is related to internal structure and internal stability of soil. The second coordinate is an effective fraction number, similar to the coefficient of uniformity c_u. Introducing the space of all possible grading curves with a fixed diameter range, the conditional maximum of the second coordinate for each, fixed mean log diameter value uniquely defines a single, mean grading curve with finite fractal distribution, a small part of these may characterize the natural soil.
- The internal stability rule defined in terms of the entropy coordinates is successfully proved by all case studies and is connected to the internal structure by DEM studies and by micro CT imaging. However, the probability of being stable is decreasing to practically zero with increasing fraction number *N* while the soils in nature are generally internally stable due to degradation.
- The degradation is a spontaneous process. Its entropy path shows a linkage with the entropy principle – the grain size distribution becomes fractal. The stability state of the internal structure suddenly increases at the appearance of smaller grains sizes.

Further research is planned on (i) grading curve and model parameter relations; (ii) internal stability and internal structure relations, (iii) the statistical entropy of pore size distribution and DEM micro-variable distributions, using these through the entropy principle to define "final states" and unsaturated soil models.

In the topic of constitutive modelling of unsaturated soils, the main findings were:

- New models were proposed to utilize novel constitutive laws (including large strain rates, particle crushing, dynamic effects) to describe the penetration process.
- A new friction constitutive law was suggested including static and sliding friction being thermodynamically consistent.
- A physically sound model was suggested for unsaturated soils based on the grading curves and pore size geometry with less parameter number than the well-known models.

Further research is planned on the suggested models which are planned to be presented in ISC6.

Emoke Imre