Summary of ISC6 Workshop

Inverse problems

"Particle shape, particle size distribution and their link to geotechnical behaviour"

– Professor Gyan Pande memory workshop –

Organizer: ISSMGE HNC

Workshop date and location
Date: 16h to 20h October 1st 2021
Location: Hungarian Academy of Sciences
Chair: Ágnes Bálint
Secretary: Nadaprapha Binsaaeteh, Emőke Imre

TOPICS

- internal stability, internal structure, particle migration, filtering, segregation
- soil properties and behaviour in relation to grain and pore size distribution, particle shape
- particle breakage, degradation, the entropy principle, applications

Significant advance has been made to recognise the effect of particle distribution and the shape characteristics on the mechanical behaviour of geomaterials. The grading entropy coordinates enable to represent (entire) particle size distributions by two statistical variables; a mean log diameter and a generalised uniformity coefficient.
Representing each grading curve by these two grading entropy coordinates in a 2-dimensional space, suffusion and internal stability, filtering and segregation criteria were postulated.
Particle breakage / degradation affects shearing behaviour and critical states because of evolving particle size distributions as well as particle shape.
The entropy principle through the grading entropy may control breakage and critical states. Similarly, it has been shown that entropy parameters can be used to represent the grading curve changes under mechanisms involving mass loss, such as biodegradation and dissolution.
Finally, it has been well documented that the physical properties (e.g. permeability of granular materials) depend on the particle size distribution and can be approximated through the grading entropy parameters. However, particle shape may modify these relations.

SUMMARY

„The Grading curve workshop organised as a workshop in memory of Professor Gyan Pande took place on 1st of October 2021 in a hybrid format in Budapest, Hungary and online. A very interesting program was prepared by the organising team covering different topics of granular soil behaviour, its experimental study and modelling using different approaches, e.g. discrete element modelling or fractal approaches. I believe that the resulting exchange of different scientific views on the common topic of grading curve will stimulate a common research project submission."
"The workshop covered a lot of interesting topics, and the geotechnics issues had more interesting aspects for my own research than I had thaught during my first glance through the program, as only recently, I realized how "fines" affect my own model systems with fluid."

PROGRAM

Opening on behalf of the Hungarian Academy of Sciences:Prof. János Józsa (a few words on Professor Pande)

Hans-Georg Mattutis: Shape effects, friction

Abstract: H.-G. Matuttis is working mainly on the micro-mechanics of granular materials, with the discrete element method for dry and fluid-immersed systems. His main research objectives for dry systems are the effects of shape and friction on macroscopic quantities like strength and density. For fluid-immersed systems, his
prevalent interest is on lubrication- and buoyancy effects between particles in fluids, to clarify the underlying mechanisms of liquefaction in earthquakes and landslides which are such common disaster phenomena in his adopted country Japan.

Wiebke Baille, Negar Rahemi, Wichtmann: Effect of fines content on the undrained shear behaviour of sandy soils

An extensive experimental study of the undrained behaviour of sand- low plastic fines mixtures considering both the full range of fines contents from zero to 100% and from low to very high initial relative densities. The behaviour could be clearly distinguished between coarse-dominated and a fines-dominated region, where the threshold fines content was found to be about 32%. Based on the experimental data, a normalised critical state line function including the effect of fines content could be determined separately for the coarse-dominated and the fines-dominated region. However, the deduced relationship between the instability stress ratio and state parameter, the former indicating the stress condition at the onset of liquefaction, was very well defined for the coarse-dominated region, whereas larger deviations from the best fit line occurred in the fines-dominated region, indicating that other factors beside state parameter control the onset of liquefaction in low plastic fines.

Imre et al: Comment on internal stability with rule and test results of Rahemi and Goudarzy

Abstract: A series of 60 triaxial compression tests were conducted on Hostun sand - silt mixtures by Rahemi to investigate the effects of fines on the undrained monotonic response of sand. The results demonstrated that the transitionally stable mixtures with increasing fine content can increasingly be prone to liquefaction if all possible initial relative densities are considered. In a similar study, the boundary between the "fines-in-sand" and "sand-in-fines" micro-structure, the threshold fines content was found by Goudarzy at around A=2/3.

The grading entropy parameters are various statistical means. The base entropy S_0 is a kind of dimensionless mean log diameter, which is similar to d_m. Its normalized value the relative base entropy parameter A is a normalized mean log diameter, varying between 0 and 1 with a shift symmetry in the log diameter axis, the extremes are related to the minimum and maximum log diameters. A indicates the relative distance of the mean and the minimum log d value. It is a continuous internal stability measure, the A<2/3 condition indicates internally unstable soils.

The rule can be interpreted such that in Zone I (if A < 2/3) no structure of the large grains is present, the coarse particles “float” in the matrix of the fines and become destabilized when the fines are removed by piping. In the complementary zone (A = 2/3 and A > 2/3), it can be postulated that the coarse particles form a skeleton and total erosion cannot occur. In Zone III, the structure of larger particles is inherently stable.

James Leak, Daniel Barreto, Vasiliki Dimitriadi, E. Imre : Fine content and liquefaction

Abstract: The presence of fine particles is known to have significant effects on the mechanical response of soils. Specifically, the ability for fines to either increase of decrease a soils liquefaction susceptibility has been a topic of interest. Typical measures for liquefaction susceptibility in soils with fines content (Fc) typically rely on particle descriptors such as C_u or d_{50}. This may be problematic as traditional particle descriptors do not recognize the effect of Fc on the occurrence of liquefaction. Grading entropy coordinates effectively ‘condense’ the whole of a particle size distribution (PSD) to a single point on a Cartesian plane, accounting for the information in the distribution. In this presentation, grading entropy coordinates are used to analyse 122 PSDs from Fc studies on liquefaction. It is suggested that increasing the Fc of a soil works to (overall) increase its liquefaction susceptibility by decreasing the soils internal stability and disrupting coarse grain particle contacts. Moreover, the normalised base entropy (A) has been shown to be related to the transmission of course-

grain particle fabric and has been applied to the determination of the equivalent intergranular void ratio (e*). Hence, a modified equation for e* is also proposed.

Shuyin Feng: Saturated permeability k in data bases

Abstract: A comprehensive study on the hydraulic conductivity of different road construction materials. Three exceptionally large databases, each consists over a thousand hydraulic conductivity test data of different road construction materials, were presented. Calibrated transformation models based on the databases, which enable quick but reliable hydraulic conductivity predictions were then introduced. Statistical analysis on the transformation models validated the effectiveness of some less commonly used predictors for hydraulic conductivity such as the grading entropy and the water content ratio.

János Török: Edwards Statistical Physics in granular matter

Abstract: Theoretical Physics approach of Edwards is related to packing of spheres, 2+e dimensional frustrated granular system.

Min Wang: Role of Gradation Curve in Description of Mechanical Behavior of Unsaturated Soils

Abstract: The importance of soil water retention characteristics in modelling the hydro-mechanical response of unsaturated soils has been well recognised by many investigators in recent years. Determination of strain-dependent soil water retention curve (SWRC) is likely to be extraordinarily difficult. It is shown that SWRC can be computed from the gradation curve and the calculation result is consistent with the experimental results obtained from pressure plate tests.

Casini – Guida : Evolution of grading curve sue to breakage and described by Weibull distribution

Abstract: This contribution presents the results of an experimental investigation of the mechanical behaviour of granular materials with crushable grains under one-dimensional compression at medium to high stress. The material used for the experimental work is a Light Expanded Clay Aggregate (LECA) whose grains break at relatively low stress. Reconstituted samples were prepared with different initial grain size distributions and their evolution observed under one-dimensional compression. The grain size distributions before and after testing were used to calibrate a bimodal model obtained from the superposition of two Weibull functions. The observed evolution of the micro and macro diameters on loading are linked to the characteristics of the one-dimensional compressibility curve obtained under displacement controlled conditions, such as its shape and two characteristic stress values, namely the pre-consolidation stress and the stress corresponding to the point of inflection.

Daniel Barreto: DEM study of Critical state using contact force entropy

Abstract: A DEM study shows that Critical state can be defined using contact force entropy.

John McDougall: The grading curves on the entropy diagram – a representation of salt dissolution and grading entropy diagram

Abstract: Mass loss effect (indicated by parameter L) is introduced. The leaching salt out of a granular matter during an oedometer test is examined in the grading entropy diagram where a coupling between particle loss and phase volume changes emerges. The impact of salt loss on the sand skeleton:

1. Small salt particles: nestle within the voids. Removal of these particles has little impact on the remnant load bearing structure producing a near equivalent increase in void space. A significant increase in void ratio with minimal settlement, $L \approx -1.0$.
2. Large salt particles: related to the amount of particles in combination with force chains:
    a. Small amounts of salt, few particles occupy force chains; dissolution occurs with little effect on the load-carrying capability. Settlement is minimal $L \rightarrow -1.0$.
    b. Larger amounts of salt, particle size effects emerge. Particle rearrangement occurs due to buckling and collapse of strong force chains. Settlement is greatest and attains its highest value $L \rightarrow -0.45$.

Experimental data presented show how both the amount and size of particles control overall volume and void ratio changes. Settlement is observed to be related primarily to the amount of particle loss and secondly to particle size. Void ratio increase is related to particles loss but insensitive to particle size.

Ákos Nemcsics: Some aspects to the surfacial pattern and the volumetric granular distribution of the histrorical walling built from uncut stones

Abstract: This written contribution is dealing with the investigation of walling structures in view point of pattern morphology and granular distribution. The investigated wallings are historical objects or built by historical technology. These walling were produced from uncut stones. On the surface, we observed periodicity and self-affine behaviour. In the granular distribution, power law was detected. The investigations were carried out party with on-site measurements and partly with the help of image processing.

Cv-s

James Leak:

James is a final-year Ph.D. candidate at Edinburgh Napier University. Using both the discrete element method (DEM) and grading entropy, he studies particle size distribution (PSD) effects on a variety of soil behaviors, including but not limited to: Liquefaction susceptibility, particle breakage & energy criteria in soils.

Min Wang: Role of gradation curve in description of mechanical behavior of unsaturated soils

Min Wang is a researcher at Fluid Dynamics and Solid Mechanics Group, Los Alamos National Laboratory, USA. His main research interests are Computational Mechanics, Geomechanics, and multiphase fluid mechanics.

Shuyin Feng: Hydraulic conductivity assessment of road construction materials: transformation models

Shuyin Feng is a Ph.D. student in Civil Engineering at the University of Bristol. She graduated with a Master of Science Research in Civil Engineering from the same university in 2017. Her research focuses on the investigation of soil hydraulic conductivity
characteristics and she is supervised by Dr. Paul Vardanega and Professor Erdin Ibraim.

Janos Török: Edwards statistical physics in granular matter modelling

Dr. Janos Torok is an associate professor at the department of theoretical physics, faculty of natural science, Budapest University of Technology and Economics, Hungary. He graduated MSc in Physics, Eotvos University Budapest, and graduated his Ph.D. in Physics (”Shearing of granular materials”). His main research interests are granular materials, fragmentation, social science, the Morphodynamics of pebble, and social networks.

Daniel Barreto: A DEM study on critical state behaviour using contact force entropy

Daniel works at Edinburgh Napier University as Lecturer and Head of the Research Centre for Civil Engineering. He obtained his Ph.D. at Imperial College London in 2010 and he spends most of his free time cycling and doing DEM-related research.

Casini – Guida: Evolution of grading curves due to breakage described by Weibull distribution

Francesca Casini

Francesca Casini is an Associate Professor at Università Degli Studi Di Ibrahim Tor Vergata,
charging the course “Foundation” and “Excavation and Retaining Walls”. Dr. Casini is interested in fundamental soil mechanics in dry, saturated, and unsaturated conditions,
frozen soils, grain crushing, and its relevance to engineering applications.

Giulia Guida

Giulia Guida, researcher at Università degli Studi di Roma Tor Vergata, who has main research interested in multi-phase coupled numerical analyses (chemo-hydro, thermo-hydro), micro-mechanics of granular crushable materials, fractal analysis of contours.

Written contribution

Ákos Nemcsics:

Ákos Nemcsics is ordinary professor on the Obuda Univerity. He is the head of the Reseach Group for Materials and Environmental Science. He is dealing with self-assembling phenomenon in natural and in artifical environment. He is researching the general driving laws of self-assembling from nano structures to urbanistic. He received the "Researcher of the Year Award" for his work on self-assembled nanostructures in 2010.