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Abstract of Keynote Speech

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“Soil-atmosphere interaction in embankments”

Professor, Yu-Jun Cui

Ecole des Ponts ParisTech, France

Dr. Yu-Jun Cui was Panel Member of Géotechnique for three years. He is now Associate Editor of Canadian Geotechnical Journal, Vice Chief Editor of Journal of Rock Mechanics and Geotechnical Engineering, Panel Member of Géotechnique Letters. He is also editorial board members of several other Journals. He was selected by TC106 and delivered the first European Distinguished lecture on unsaturated soils in 2016.

ABSTRACT:

The stability of earth constructions depends strongly on the climatic conditions. In dry seasons, excessive water evaporation can lead to surface cracking, modifying the hydro-mechanical behaviour of soils and thus compromising the constructions’ stability. In wet seasons, significant water infiltration leads to reduction of suction and thus decrease of the mechanical performance of constructions. The drying/wetting cycles that the constructions undergo constantly can only come to enhance the detrimental effects. These points have widely investigated in the laboratory, but rarely addressed in the field. In this lecture, two cases studies are firstly presented, one is an experimental embankment with two compacted silty soils and another is an experimental embankment with lime/cement treated silty/clayey soils. Emphasis is put on the atmospheric conditions changes and the subsequent changes in suction and water content in the embankments. A numerical tool is also developed, allowing the soil hydro-mechanical behaviour to be analysed through consideration of atmosphere interaction. This numerical tool is based on an appropriate water evaporation model on one hand, and on a coupled thermal and hydraulic fluids flows on other hand. It is successfully applied to the analyses of the hydro-mechanical behaviour of two embankments in terms of changes of suction and water content, showing that it is possible to analyse the earth constructions’ behaviour based on the recent knowledge developed in unsaturated soil mechanics, provided that appropriate water evaporation model is adopted.

“Unsaturated Soil Mechanics for Disaster Prevention and Maintenance of Traffic Infrastructure in Snowy Cold Region”

Professor, Tatsuya Ishikawa
Hokkaido University, Japan

- 1987-1989 Graduate School of Engineering, Kyoto University
- 1999 granted Dr. Eng. from Kyoto University
- 2002-2013 Professor in Hokkaido University
- 2002-213 Secretary of ISSMGE TC 202 (Transportation Geotechnics)

ABSTRACT:

In snowy cold regions, the 0 °C isotherm may penetrate deep into soil ground, thereby causing some geotechnical problems specific to cold regions such as the swelling of pavement surface due to frost heave, the cracking in asphalt-mixture layer due to freeze-thaw, and the slope failures at cut slope and embankment in snow-melting period. Such phenomena are thought to accelerate deterioration of traffic infrastructures and losing of the functions. The primary cause is deemed to be the increase in degree of saturation due to snowmelt and/or ice lens melting in addition to the change in deformation-strength and water retention-permeability characteristics of soils resulting from freeze-thawing. Hence, it is indispensable to examine the influence of rapid increase in water content during thawing periods as well as the freeze-thawing of pore fluid on the hydro-mechanical behaviour of unsaturated soil ground for establishing a precise prediction method of natural disasters and a rational design method of transportation infrastructures in snowy cold regions.

This keynote lecture reviews and summarizes previous researches related to the unsaturated soil mechanics for the disaster prevention and maintenance of traffic infrastructures in snowy cold region from the viewpoints of experimental and analytical studies. To this end, this keynote lecture presents two case studies, namely “slope stability problem” and “pavement rutting problem” in thawing periods. In both problems, this keynote lecture first discusses the mechanical behaviour of the soil slope during freezing and thawing based on the results of the long-term field measurement of soil slope in Hokkaido and full-scale and small-scale model tests of soil slopes and pavement subjected to freeze-thaw actions. Next, it discusses the change in the physical properties, the water retention-permeability characteristics, and the deformation-strength characteristics of geomaterials caused by freeze-thaw actions based on the results of various types of laboratory element tests under saturated and unsaturated conditions. Last, it discusses the applicability of numerical simulations, which can consider the interactions among thermal analysis, seepage analysis, and deformation analysis, to the failure mechanism analysis of soil slopes and the deformation analysis of pavement in snowy cold regions from the viewpoint of the variation in water content due to snow and ice lens melt and the change in material properties due to freeze-thaw. Finally, this keynote lecture discusses the contributions of unsaturated soil mechanics to the disaster prevention and maintenance of traffic infrastructures in snowy cold region in terms of the mechanism of the slope failures and pavement rutting, and its influencing factors by comparing the phenomena in temperate regions with those in snowy cold regions.

“Soil-Water Characteristic Curves – Determination, Estimation and Application”

Associate Professor, Eng Choon Leong

Nanyang Technological University, Singapore

Dr. Leong Eng Choon is currently an Associate Professor at Nanyang Technological University, Singapore. He has over 30 years of teaching experience in geotechnical engineering and is an active researcher in unsaturated soils and soil dynamics. He has published more than 320 journal and conference papers. He is currently an editorial board member of several journals and is an active reviewer for many journals. He has won several awards, notably the Excellence in Reviewing for the Geomechanics for Energy and the Environment journal in 2018, the Koh Boon Hwee Mentor award in 2013, and the ASTM best paper award in 2006. He is also active in the national standardization programmes in SPRING, Singapore. He is the lead author and co-author of the books entitled “Guide to Research Projects for Engineering Students - Planning, Writing, Presenting” and “Mechanics of Residual Soils, 2nd Edition”, respectively.

ABSTRACT:

The soil-water characteristic curve (SWCC) or water retention curve is a relationship between water content in a soil and suction. The SWCC was first plotted by Edgar Buckingham, a soil physicist, in 1907 for six soils ranging in texture from sand to clay. It was adopted for use in unsaturated soil mechanics by the geotechnical engineering community. The SWCC is now almost treated as the index property of unsaturated soils. It has been used as a proxy for permeability and shear strength of unsaturated soil. Most soils have a sigmoidal SWCC, otherwise known as a unimodal SWCC as opposed to a bimodal SWCC which has been found for some soils. Although determining the SWCC is easier than determining permeability or shear strength for unsaturated soil, the test is still time-consuming and it is not easy to determine the entire SWCC. Incomplete or insufficient SWCC data may lead to an incorrect SWCC and hence inaccurate determination of permeability and shear strength. Progress has been made to expedite the experimental determination of SWCC as well as estimating the SWCC from basic soil properties using pedotransfer functions. In addition, SWCC has been represented using volumetric water content, gravimetric water content or degree of saturation. Different representations may have dire consequences on its application. Determining the SWCC using volumetric water content or degree of saturation presents challenges in estimating the instantaneous volume during the experiment. In this paper, the current state-of-the-art in determining, representing and estimating SWCC and its applications are described and critically examined.

"Effect of stress and suction on resilient modulus of compacted unbound materials"

Professor, Seong-Wan Park

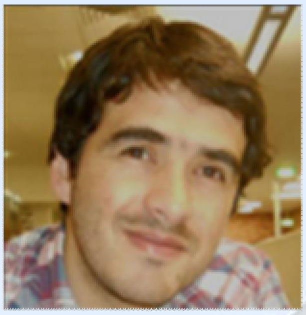
Dankook University, Korea

- Professor, Dankook University (2003–Present)
- Member of ISSMGE (TC106) and core member (ISSMGE TC202)
- Editor-in-Chief, Journal of Korean Geotechnical Society (2015-2017)
- Senior Editor, KSCE Journal of Civil Engineering(2016-Present)
- Senior Researcher, Korea Institute of Construction Technology (2000-2003)

ABSTRACT:

Over the last several decades there has been a significant shift from the use of empirical approaches towards the use of mechanistic models and unsaturated soil mechanics to characterize and predict the behavior of transportation infrastructure and geomaterials. Particularly, resilient modulus is an important mechanical parameter for the study of the behavior of unbound materials under cyclic and traffic loadings. Some studies have indicated that soil suction has an effect on resilient modulus of unbound materials and that there is a non-linear response of this feature for geomaterials during the loading process. Nevertheless, an assessment that couples the dependency of resilient modulus on stress and suction is still lacking. This study addresses this through a detailed analysis of resilient modulus under moisture conditions using suction stress concept on unsaturated soils. Results show a non-linear variation of resilient modulus with stress and that suction stress has a significant influence on it. The model proposed to couple the effect of moisture and stress on resilient modulus presents better prediction performance of compacted unbound materials.

“Environmental degradation of clayey rocks”



Senior Lecturer, Jubert Abdres Pineda

The University of Newcastle, Australia

Dr. Jubert Pineda received a Bachelor Degree in Civil Engineering from the Santo Tomas University (Bogotá, Colombia). He obtained a Master Degree in Geotechnical Engineering from the National University of Colombia and a PhD Degree in Geotechnical Engineering from the Technical University of Catalonia (UPC, Barcelona) in 2012. At present he works as Senior Lecturer at the Priority Research Centre for Geotechnical Science and Engineering (PR-CGSE) in the University of Newcastle Australia.

Dr. Jubert Pineda has been involved in several research and consulting projects associated with unsaturated soils, stability of dams founded on clayey rocks as well as high-quality sampling and testing of soft soils. His current research interests include mechanics of soft soils, unsaturated soils, mechanics of hard soils-soft rocks and more recently Geo-Engineering problems related to Energy and Sustainability.

ABSTRACT:

Clayey rocks are common in many countries, and are frequently present in civil engineering projects. A recurrent observation in these materials is their transitional nature, which emerges mainly when they are excavated and exposed to weathering processes as those caused by cyclic variations in relative humidity (RH) or suction. Marls, shales, claystones, mudstones, siltstones and very stiff clays are examples of materials that undergo these changes. Despite intrinsic geological differences, clayey rocks show two similar characteristics: (i) a behaviour intermediate between rock and soil; and (ii) a high ‘degradation’ potential ability to change their mechanical properties, transforming the clayey rock into a soil. This transition is especially relevant when the rock is exposed to unloading and environmental effects, which may leads to stability problems or unexpected deformation of geotechnical infrastructure.

Rock degradation has commonly been related to increase in water content due to cyclic variations in relative humidity. Such cyclic behaviour is accompanied by irreversible volume changes, reduction in rock strength and rock stiffness as well as increase in rock permeability. Tracking of the variations in mechanical properties is fundamental for proper understanding of the rock degradation phenomena.

In this presentation, the mechanisms leading to the degradation of clayey rocks when exposed to environmental effects are evaluated. The main aspects controlling the degradation of clayey rocks are studied in this presentation: (i) the number of applied RH cycles, N, (ii) their amplitude, DRH, (iii) the influence of the stress level ($p-u_a$), (iv) the effect of the fluid used to induce rock saturation (liquid water or vapour) and (v) the chemistry of the pore fluid. Particular emphasis is given to the consequences of the relative humidity cycling on rock microstructure. The development and implementation of non-conventional experimental techniques for inducing and tracking rock degradation, at micro and ‘macro’ scales, is described. An experimentally-based framework of behaviour is presented which may be used in practice for the evaluation of the degradation potential of clayey rocks.

"Field techniques for measuring soil hydraulic properties in unsaturated soils"

Professor, Yuji Takeshita

Okayama University, Japan

ABSTRACT:

It is well established that filed or in-situ measurements of the soil hydraulic properties are essential to practical and accurate prediction of water movement in unsaturated soils such as natural slope, embankment, landfill and agricultural field. The soil hydraulic properties consist of the saturated hydraulic conductivity, the unsaturated hydraulic conductivity and the soil water characteristic curve defined as a relationship between water content and matric potential (the suction of a soil).

The hydraulic conductivity of unsaturated soils should be measured in the field. Because air bubbles are usually entrapped in porous media when they are saturated by infiltrating water, the saturated hydraulic conductivity measured in unsaturated soil is lower than the truly saturated hydraulic conductivity measured by laboratory experiments and is often referred to as a field-saturated hydraulic conductivity. Field methods for determining the field-saturated hydraulic conductivity of unsaturated soils include constant head infiltration and/or gravity drainage events for near-surface application. For measuring the soil water characteristic curves, it is often difficult to interpret in-situ measurements unless carefully controlled boundary conditions are applied. As a results, the soil water characteristic curves are most generally measured in the laboratory experiments using well-controlled initial and boundary conditions. Whereas laboratory experiments have the advantage of being easy, quick and precise, a major disadvantage is that they lead to soil properties that are often non-representative of field conditions.

Since analyses of the soil hydraulic functions are ultimately directed toward field-scale processes, determination of in-situ properties is more relevant than data obtained from laboratory analyses. This keynote speech will review the current status of field experimental techniques of measuring the soil hydraulic properties in the near surface of unsaturated sandy soils and illustrate their utility for determining key parameters affecting seepage flow in the unsaturated soils. A few areas in need of further investigation will be outlined.

“Three-phase coupled seismic analyses of unsaturated/saturated grounds”

Professor, Ryosuke Uzuoka

Kyoto University, Japan

- 2017.4-present Professor, Kyoto University
- 2010.4-2017.3 Professor, Tokushima University
- 2004.3-2010.3 Associate Professor, Tohoku University
- 2001.8-2004.3 Assistant Professor, Tohoku University
- 1999.1-2001.8 Researcher, Earthquake Disaster Mitigation Research Center, RIKEN
- 1990.4-1998.12 Research Engineer, Hazama Corporation

ABSTRACT:

Some Asian countries share a similar natural environment and face the same threats from natural disasters such as earthquake, typhoon, heavy rainfall, flood, and landslide. What makes a bad situation even worst is that these natural disasters very often did not come alone, which is known as combined disasters. For example, a heavy rain and an earthquake likely occur sequentially in a relatively short period. A three-phase coupled analysis will be a promising tool to discuss dynamic behaviors of unsaturated/saturated grounds such as slopes and embankments during combined disasters. The author reviews recent developments on three-phase coupled seismic analyses. The equations governing the dynamic deformation of unsaturated soil were derived based on porous media theory and constitutive models. The effect of pore air pressure on cyclic behavior of unsaturated sandy soil is discussed through the simulations with three-phase and simplified two-phase analyses. The validity of three-phase coupled analyses is shown through simulations of seismic behaviors of slopes and embankments.

“Volume change behavior of highly compacted GMZ bentonite under chemo-hydro-mechanical conditions”

Professor: Weimin Ye

Tongji University, China

Dr. Weimin YE is a Professor of geological/geoenvironmental engineering in School of Civil Engineering at Tongji University in Shanghai. He earned his PhD in Structure Engineering from Tongji University, with specialization in excavation and geo-environmental protection. Dr. YE’s area of expertise is geological/geoenvironmental engineering with particular emphasis in Unsaturated Soil Engineering. He is conducting research in compacted bentonite for using as buffer materials in deep geological repository for disposal of high level radioactive waste in China. In this direction, he is exploring the engineering properties of GMZ bentonite under Chemo-thermo-hydro-mechanical coupling conditions. He has more than 200 publications including more than 80 international journal papers and got 5 awards from the local government for contributions to research.

ABSTRACT:

Due to its low hydraulic conductivity, high swelling capacity and good adsorption properties, the Gaomiaozi (GMZ) bentonite has been selected as potential buffer/backfill materials for construction of artificial barriers in the deep geological repository for disposal of high-level nuclear waste (HLW) in China. During the long-term operation of a repository, the compacted bentonite will inevitably experience wetting or drying processes with hydration or dehydration of groundwater with different concentrations. Furthermore, these processes will take place in the repository with a limited space and certain geo-stresses generated by the upper geological formations.

In this work, compacted GMZ bentonite with an initial dry density of 1.70 g/cm^3 was hydrated with distilled water and NaCl solutions. For a given suction, the measured void ratio of specimen saturated with distilled water is slightly larger than those of the specimens saturated with salt solutions after the drying equilibrium is reached. The degree of saturation of compacted GMZ bentonite specimen increases as the salt concentration increases under the same total suction. A modified soil water retention curve (SWRC) equation was proposed to account for the effect of void ratio and salt solutions on the drying behavior of the specimens. Verifications reveal that the proposed equation can satisfactorily describe the SWRCs of compacted GMZ bentonite saturated with different concentrations of salt solutions. In the meantime, volume change behavior of highly compacted GMZ bentonite was studied under coupling chemo-hydro-mechanical conditions. Using a modified oedometer, cyclic wetting and drying tests were conducted on compacted GMZ bentonite with infiltration of NaCl solutions under different constant vertical stresses. Specimens were infiltrated with different concentrations of NaCl solutions during the wetting tests and a suction-control method was used in the drying tests. Results show that the swelling strain on wetting and the shrinkage strain on drying decrease with the increase of the vertical stresses or the concentration of NaCl solutions. Plastic deformations mainly occurred in the first wetting and drying cycle and decreased with the increase of the vertical stresses. However, the accumulated plastic deformation increased with increasing concentration of NaCl solutions, which could be attributed to the effects of osmotic consolidation. Based on the test results, a modified Barcelona Expansive Model (BExM) model with consideration of the influences of NaCl solutions with

different concentrations was proposed in this work. The micro-/macro- coupling equations f_D (suction reduction) and f_I (suction increase) were improved for the specimens saturated with different concentrations of NaCl solutions. Simulations show that the modified BExM model can be used satisfactorily to describe the wetting/drying behavior of compacted GMZ bentonite specimens with consideration of the influences of NaCl solutions with different concentrations.

“A Photogrammetry-Based Method to Measure the Total and Localized Volume Changes of Unsaturated Soil Specimens during Triaxial Testing”

Associate Professor: Xiong Zhang

Missouri University, USA

Dr. Xiong Zhang is an associate professor in the Department of Civil, Architectural and Environmental Engineering at the Missouri University of Science and Technology (Missouri S&T). His research focuses on development of advanced laboratory techniques to rapidly characterize geomaterials, constitutive modeling coupled hydro-mechanical behavior of unsaturated soils, numerical modeling of climate-soil-structure interaction, slope stability analysis, soil stabilization and ground improvement, and frozen ground engineering. He was one of the two speakers of ASCE Geo-Institute (GI) Unsaturated Soils Committee Webinar on “Introduction to Constitutive Modeling of Unsaturated Soils.”

Dr. Zhang is currently serving as an Editorial Board Member of Canadian Geotechnical Journal. He also serves as a vice chair of ASCE GI Shallow Foundation Committee and committee member of several nationwide technical committees such as ASCE GI Committee on Design of Residential Structures on Expansive Soil Standards, ASCE GI Pavement Committee, TRB AFP60 Committee on Engineering Behavior of Unsaturated Soils, and TRB AFS20 Committee on Soil and Rock Instrumentation.

ABSTRACT:

Triaxial tests have been widely used to evaluate the soil behavior. In the past few decades, many methods have been developed to measure the volume changes of unsaturated soil specimens during triaxial testing. Literature review indicates that until now measuring the volume changes of unsaturated soil specimens during triaxial testing remains a major challenge for researchers.

In this study, a noncontact method is developed to measure the total and local volume changes of unsaturated soil specimens using a conventional triaxial test apparatus for saturated soils. The method is simple and cost-effective, requiring only a commercially available digital camera to take images of an unsaturated soil specimen during triaxial testing from which accurate 3D model of the soil specimen is reconstructed. In this proposed method, the photogrammetric technique is utilized to determine the orientations of the camera where the images are taken to an accuracy to 3-5 microns, multiple optical ray tracings are employed to correct the refraction at the air-acrylic cell and acrylic cell-water interfaces, and a least–square optimization technique is applied to estimate the coordinates of any point on the specimen surface. Validation tests indicated that the accuracy for the point measurements is less than 76 microns in the water and less than 0.25% for total volume measurements. Methods are also developed to calculate the total volume and localized strains based upon the 3D discrete measurement points on the specimen surface.

This method was awarded the “2016 International Innovation Award in Unsaturated Soil Mechanics” by TC106 within the International Society for Soil Mechanics and Geotechnical Engineering.