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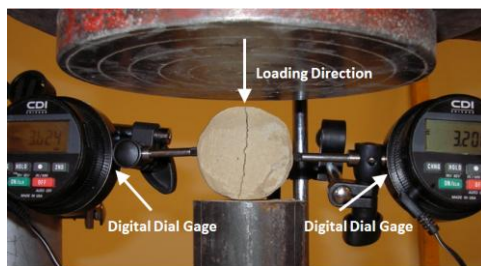


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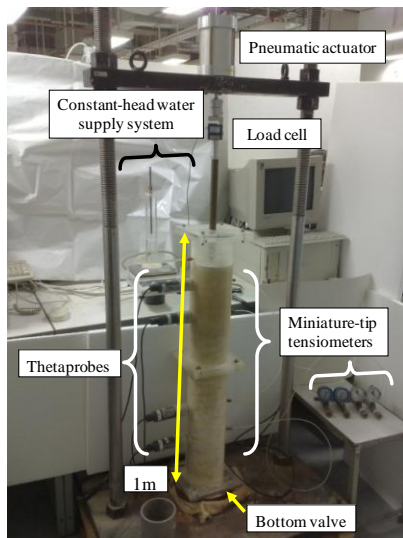


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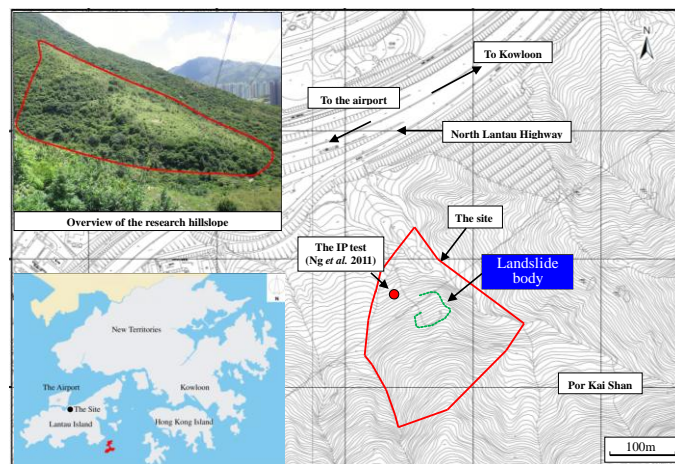
***Charles W. W. Ng & Apiniti Jotisankasa***



Indirect tensile strength testing on dry soil specimen  
(Puppala *et al.* 2012)



Stress-controllable 1D soil column  
(Ng & Leung 2012)



Saprolitic hillslope for full-scale field monitoring in Hong Kong  
(Leung *et al.* 2011)



Probe locator for installing  
high capacity tensiometer  
(Toll *et al.* 2012)



# GEOTECHNICAL ENGINEERING

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## **PREFACE**

Most of the Earth's land surface comprises unsaturated geomaterials, which often pose geotechnical hazards such as rainfall-induced landslides to societies and serviceability problems to high speed rail links founded on collapsible and expansive unsaturated soils. However, the vast majority of text books, conference proceedings and journal articles investigate mainly saturated soil mechanics, which is only a special case of unsaturated soil mechanics. With intensive building and construction activities in countries like China, India, Central and South America and Africa on foundation soils that are often unsaturated, geotechnical engineers can no longer ignore the complication of unsaturated soils and the challenges they present. In developed countries, many geo-environmental problems such as nuclear waste disposal also involve unsaturated soil mechanics heavily. Research on unsaturated soils has therefore been a major focus in many universities and research institutions over the last two decades.

This special issue contains eight keynote papers selected from the 5<sup>th</sup> Asia-Pacific Conference on Unsaturated Soils held in Pattaya, Thailand, between 29 February and 2 March 2012. The series of Asia-Pacific Conferences on Unsaturated Soils began in Singapore in 2000. With the continued support of the Technical Committee on Unsaturated Soils (TC106) of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE), the 2nd, 3rd, and 4th conferences were held in 2003 in Osaka, Japan, in 2007 in Nanjing, China and in 2009 in Newcastle, Australia, respectively. These conferences have proven to be a fruitful forum where researchers and practitioners in the region and beyond gathered enthusiastically to present their latest research findings and development and to exchange ideas on the subject.

### **Guest Editors**

**Charles W.W. Ng**

**Apiniti Jotisankasa**

## **GEOTECHNICAL ENGINEERING**

### **ACKNOWLEDGEMENT**

This March 2012 Issue of the Journal is on Soil Behaviour of Unsaturated Soils and Engineering Applications and it includes papers from well known researchers as drawn from Thailand, United States of America, Hong Kong, Australia, Singapore and the United Kingdom.

The Guest Editors of this Issue are Prof. Charles W. W. Ng at the Department of Civil and Environmental Engineering in the Hong Kong University of Science and Technology and Dr. Apiniti Jotisankasa at the Department of Civil Engineering, Kasetsart University Bangkok. Both Editors are internationally well known for their research and professional activities in Unsaturated Soil Mechanics and Engineering.

We are fortunate to have eight excellent contributions by authors who have spent a life time with unsaturated soil mechanics and engineering from: W. Mairiang, A. Jotisankasa and S. Soralump; J.D. Nelson, K.C. Chao, D.D. Overton and R.W. Schaut; C. W. W. Ng and A. K. Leung; A.J. Puppala, T. Wejrungsikul, V. Puljan and T. Manosuthikij; H. Rahardjo, A. Satyanaga, E. C. Leong; J.R. Standing; D.G. Toll<sup>1</sup>, J. Mendes<sup>1</sup>, P.N. Hughes, S. Glendinning and D. Gallipoli<sup>3</sup>; and D.J. Williams. Among other topics it deals with the development of unsaturated soil mechanics as a discipline; unsaturated expansive soils and foundation problems; unsaturated soil slopes and stabilization measures; some mining applications of unsaturated soil mechanics and finally the most important area of climate change and the role of unsaturated soil mechanics in engineering applications.

The material contained in this issue of the journal would be of great value to engineers as well as researchers dealing with engineering activities in unsaturated soils. The Guest Editors Prof. Charles W.W. Ng and Dr Apiniti Jotisankasa and the contributors are thanked for their untiring efforts and meticulous work which made this special issue to be possible and released well in time. We have had great guest editors for the 2011 Issues as: Jie Han; Tatsunori Matsumoto, Der Wen Chang; Chang Yu Ou and Dariusz Wanatowski. It is a pleasure to begin the Year 2012 with this excellent issue with such eminent persons like Prof. Charles W. W. Ng and Dr Apiniti Jotisankasa. Likewise we look forward to the most valued help from Prof. Ikuo Towhata, Prof Der Wen Chang, Dr. Ivan Gratchev; Prof. Malek Bouazza and Mr Tom Lunne and Prof de Groot for the June, September and December Issues.

**K.Y. Yong  
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### **March 2012 ISSUE ON UNSATURATED SOIL MECHANICS AND ENGINEERING**

**Charles W. W. Ng & Apiniti Jotisankasa**  
Guest Editors

**PROFESSOR CHARLES W.W. NG** is Chair Professor at the Department of Civil and Environmental Engineering and the Director of Geotechnical Centrifuge Facility at the Hong Kong University of Science and Technology. He obtained his Ph. D from the University of Bristol, UK in 1992; and subsequently joined the University of Cambridge as a Research Associate before returning to Hong Kong in 1995. He was elected as an Overseas Fellow at Churchill College, Cambridge, in 2005. Professor Ng is a Chartered Civil Engineer (CEng) and Fellow of the Institution of Civil Engineers (FICE), the American Society of Civil Engineers (FASCE), the Hong Kong Institution of Engineers (FHKIE) and the Hong Kong Academy of Engineering Sciences (FHKEng). He holds the title of Chang Jiang Scholar (Chair Professorship) by the Ministry of Education in China and he is an appointed Board Member of the International Society of Soil Mechanics and Geotechnical Engineering. Currently Professor Ng is Associate Editor of the Canadian Geotechnical Journal. He has published widely on slope instability problems, behaviour and mechanics of saturated and unsaturated soils, soil-structure interaction problems such as tunnels, piles and deep excavations. He is the main author of two reference books including "Soil-Structure Engineering of Deep Foundations, Excavations" and "Tunnels and Advanced Unsaturated Soil Mechanics and Engineering".

**DR. APINITI JOTISANKASA** is currently an Assistant Professor at the Department of Civil Engineering, Kasetsart University Bangkok. After obtaining his BEng degree in Civil Engineering from Kasetsart University in 1999, he pursued his MSc and PhD in Soil Mechanics at Imperial College London with the generous support of the Anandamahidol Scholarship from Thailand. His research topics for the PhD degree was on the Collapse behaviour of a compacted silty clay: the work which culminated in several world-leading journal papers such as *Geotechnique*, and the *ASCE Journal of Geotechnical and Geoenvironmental Engineering*. After being awarded the PhD degree in 2005, he started working for Kasetsart University as a lecturer in geotechnical engineering and his research area has been mainly on application of unsaturated soil mechanics on practical geotechnical engineering problems, such as rainfall-induced landslide, excavation, embankment stability, bio-slope engineering, geohazard mitigation, etc. He also lead a team consisting of geotechnical as well as electrical engineers who develop a wireless system for monitoring of slope behaviour such as pore water pressure (negative/positive) and slope movement. Dr Apiniti is the recipient of the Best paper award (Geotechnical Engineering) in the National Convention in Civil Engineering 2009 from the Thai Geotechnical Society and Chai Mukthabhan foundation for his work on the behaviour of instrumented volcanic soil slope subject to rainfall. In 2011, he was awarded the Young Technologist Award from the Foundation for the Promotion of Science and Technology under the Patronage of His Majesty the King of Thailand. Dr. Apiniti has been secretary general of the Thai Geotechnical Society since 2009 and currently a member of the TC106 (Unsaturated soils) of the International Society of Soil Mechanics and Geotechnical Engineering.

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## Special Issue on Unsaturated Soil Mechanics And Engineering

*Guest Editors: Charles W. W. Ng & Apiniti Jotisankasa*

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**Cover Photograph: Unsaturated Soil Mechanics And Engineering**

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- American Petroleum Institute (API) (1993). Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design, API Recommended Practice 2AWSD (RP 2A-WSD), 20th edition, 1993, p191
- Earth, J.B., and Geo, W.P. (2011) "Asian Geotechnical amongst Authors of Conference Publications", Proceedings of Int. Conference on Asian Geotechnical, publisher, city, pp 133-137.
- Finn WDL and Fujita N. (2002) "Piles in liquefiable soils: seismic analysis and design issues," Soil Dynamics and Earthquake Engineering, 22, Issues 9-12, pp731-742

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