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ISSMGE Bulletin

Volume 9, Issue 3
June 2015

International Society for Soil Mechanics and Geotechnical Engineering

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EDITORIAL BOARD

Research Highlights

Texas A&M University (TAMU)
The Geotechnical Engineering and Geomechanics Group

The Geotechnical Engineering and Geomechanics group at Texas A&M University is currently composed of eight faculty members that cover a wide range of research topics and teaching activities. They are part of the Zachry Department of Civil Engineering, which is the largest Civil Engineering (CE) program in the United States (with more than 60 faculty, nearly 1000 undergraduate students, and over 400 graduate students) and among the top CE Departments in the country. The Geotechnical Engineering and Geomechanics Group provides guidance to more than 60 graduate students and is in charge of undergraduate classes related to Geotechnical Engineering and Soil Mechanics. Specialized laboratory facilities and state-of-the-art computer labs provide support to the research and academic activities of the group.

This report presents first brief bios of the faculty, then the research activities (grouped in 14 main areas) are briefly introduced, and finally the Sponsors that have facilitated the research activities are acknowledge

- Geotechnical faculty at Texas A&M University
- Main research areas and topics at TAMU
- Sponsors

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

Geotechnical Faculty at Texas A&M University

Dr Charles Aubeny
Professor
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Dr Aubeny was appointed as a Professor in the Zachry Department of Civil Engineering TAMU in September 2012. He obtained his first degree in Civil Engineering from the University of Arizona. His Master (1984) degree is from University of Colorado at Denver and his Ph.D. (1992) degree is from the Massachusetts Institute of Technology. He was appointed as Assistant Professor in January 1999 and Associate Professor in September 2006. Prior to coming to Texas A&M University he served 8 years in earth dam design with the US Bureau of Reclamation and 6 years in consulting in the Sacramento area specializing in dams and levees. His research focus is in offshore geotechnics, and he has published on suction caissons, drag embedded plate anchors, suction embedded anchors, steel catenary risers and mudmat foundations. More information about Professor Aubeny can be found at: https://ceprofs.civil.tamu.edu/caubeny/index.html

Professor Jean-Louis Briaud
Distinguished Professor and Buchanan Chair Holder
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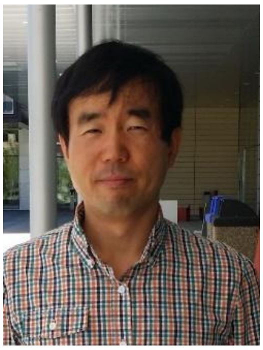
Professor Jean-Louis Briaud is a University Distinguished Professor and Holder of the Spencer J. Buchanan Chair in the Zachry Department of Civil Engineering at Texas A&M University and a Professional Engineer. He received his Bachelor degree at the ESTP in France in 1972 and his Ph.D. degree from the University of Ottawa in Canada in 1979. His expertise is in foundation engineering and more generally geotechnical engineering. He has served as President of the Association of Geotechnical Engineering Professors in the USA (USUCGER), President of the Geo-Institute of the American Society of Civil Engineers, President of the International Society for Soil Mechanics and Geotechnical Engineering, and is the current President of the Federation of International Geoengineering Societies. Among other awards, he has received the ASCE Ralph Peck Award and the Cross USA Lecturer Award from the USA, the CGS Geoffrey Meyerhof Foundation Engineering Award from Canada, the Honorable Aitalyev Medal from Kazakhstan, and is a member of the National Academy of Natural Sciences in Russia. Over the last 30 years, Dr Briaud has conducted about 10 million dollars of research most of which was on foundations and retaining walls. He has supervised 50 PhD students and 90 Master students. He is the author of a new book entitled 'Geotechnical Engineering' and one entitled 'The Pressuremeter'. He has published about 300 articles and reports in geotechnical engineering. He enjoys tennis, soccer, and rugby, and plays jazz piano at the amateur level. Web page: https://ceprofs.tamu.edu/briaud/

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group



Dr Minsu Cha
Assistant Professor

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Dr Cha joins the Zachry Department of Civil Engineering Texas A&M University in August 2015 as an assistant professor. He has been a postdoctoral fellow and research assistant professor in the Civil and Environmental Engineering Department and the Petroleum Engineering Department at the Colorado School of Mines. He received his Ph.D. and M.S. in geotechnical engineering from Georgia Tech and degrees in civil and environmental engineering from KAIST, Korea (M.S.) and from Pusan National University, Korea (B.S.). His research interests lie in the study of fundamental concepts and engineering solutions that address geo-challenges related to energy and sustainability, such as sediment dissolution, reservoir geomechanics, CO_2 geostorage, hydrate-bearing sediments, and geothermal energy, and the development of innovative research tools to investigate these areas. He has also had extensive experience in the fabrication/instrumentation of lab-scale geophysical methods and particulate discrete element modeling.

Dr Dallas N. Little
Professor
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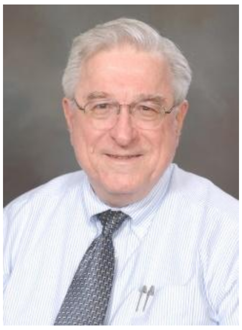
Professor Little is Regents Professor and E. B. Snead Chair Professor in the Zachry Department of Civil Engineering at Texas A&M University. He has worked extensively in infrastructure materials for over 40 years and has published over 210 refereed journal articles in soils stabilization, asphalt technology and infrastructure materials engineering. He is Honorary Saudi Aramco Chair Professor at King Faisal University in Saudi Arabia, Adjunct Professor at the University of Saskatchewan, and Honorary Professor at Aston College in the UK. He is a distinguished member of the American Society of Civil Engineers. More information about Professor Little can be found at: https://ceprofs.civil.tamu.edu/dlittle/

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group



Dr Robert L. Lytton
Professor
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Dr Lytton was promoted to Professor in the Zachry Department of Civil Engineering at TAMU in September, 1976. His BS in Civil Engineering was obtained from the University of Texas at Austin in 1960.His Master's and Ph.D.'s degrees were obtained from the same University in 1961 and 1967, respectively. He served as an Assistant Professor at the University of Texas 1967-1968 and then was sent as a Post-Doctoral Fellow of the U.S. National Science Foundation to work with the Australian Commonwealth Scientific and Industrial Research Organization, Division of Applied Geomechanics, 1969-1970. He returned to the United States as an Associate Professor with the Texas A&M University and an Associate Research Engineer with the Texas A&M Transportation Institute. His research has been directed at applying mechanics principles to soils, soil -structure interaction, various construction materials including base course, concrete and asphalt, and the use of impulse testing and ground penetrating radar with pavements. He held the U.S. patent on the Systems Identification Analysis of Subsurface Radar Signals. He is a principal author of the three editions (1980, 1996, 2003) of the Post-Tensioning Institute Slab-on-Expansive Soil design manual. He was a two term chairman of the Transportation Research Board committee on Environmental Factors Except Frost (now known as Engineering Behavior of Unsaturated Soils). He has been honored with being selected to present several Distinguished Lectures and invited presentations. He is also the recipient of several prestigious awards. He holds the endowed Fred J. Benson Chair in Civil Engineering. More information about Professor Lytton can be found at: https://ceprofs.civil.tamu.edu/lytton/

Dr Zenon Medina-Cetina
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Dr Medina-Cetina graduated with honors as Civil Engineer from the Autonomous University of Yucatan UADY (Mexico) in 1994. He obtained his Master of Engineering in Geotechnical Engineering at the National Autonomous University of Mexico (UNAM) in 1996, where he also worked as Researcher and Faculty. Through a Fulbright Scholarship he completed his Master of Science and PhD at the Johns Hopkins University in 2004 and 2006 respectively. He joined the Norwegian Geotechnical Institute NGI in Oslo in 2006 where he held a dual appointment at the Computational Geomechanics Division CGD and at the International Centre for Geohazards ICG. Since 2008 he serves as the Director of the Stochastic Geomechanics Laboratory SGL at the Civil Engineering Department at Texas A&M University, and holds a Joint Faculty Appointment at the Petroleum Engineering Department. In 2014 he was promoted from Assistant to Associate Professor with Tenure at Texas A&M. More information about Dr Medina-Cetina can be found at: http://ceprofs.civil.tamu.edu/zmedina/

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

Dr Jose M. Roesset
Emeritus Professor

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Dr Roesset got his Sc.D. from Massachusetts Institute of Technology (MIT) in 1964. He was in the faculty at MIT from 1964 to 1978, at University of Texas (UT) Austin from 1978 to 1997, and at Texas A&M from 1997 to 2011. He is a member of the National Academy of Engineering (NAE), and a corresponding member of the Academy of Engineering of Mexico and the Royal Academy of Engineering of Spain, and an honorary member of ASCE. His areas of research are Soil Dynamics, Geotechnical Earthquake Engineering, Dynamic Soil Structure Interaction, Dynamics of Foundations and Soil Characterization by Geophysical Methods.

Dr Marcelo Sánchez
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Dr Sánchez was appointed as an Associated Professor in the Zachry Department of Civil Engineering Texas A&M University in September 2009. He obtained his first degree in Civil Engineering from Universidad Nacional de San Juan (Argentina). His Master (1996) and Ph.D. (2004) degrees are from the Universidad Politecnica de Catalunya (UPC, Barcelona, Spain). In May 2005, he was appointed as a Lecturer (equivalent to Assistant Professor) by the University of Strathclyde in Glasgow, Scotland, UK. In April 2008, he was promoted to Senior Lecturer (equivalent to Associate Professor). His expertise lies in the analysis of Thermo-Hydro-Mechanical and Chemical (THMC) coupled problems in geological media. He has been involved in problems related to energy geotechnics, behavior of unsaturated soils, and transportation geotechnics. He is the founding and current chairman of the Technical Committee TC308 on Energy Geotechnics of the ISSMGE. More information about Dr Sánchez can be found at:
https://ceprofs.civil.tamu.edu/msanchez/index.html

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

Main Research Areas and Topics at Texas A&M University

a. Aggregates

a.1 Modeling of anisotropic, stress and suction-dependent behavior of granular base material
a.2 Measurement of aggregate characteristics with the aggregate imaging system
a.3 Activation energy characteristics of the alkali-silica reactions of aggregates in concrete

b. Compaction

b.1 Compaction innovations and control based on soil modulus
b.2 Quality control/quality assurance of compaction of asphalt, base course and subgrade soils with ground penetrating radar

c. Energy geotechnics

c.1 Geothermal energy - Energy piles
c.2 Design of nuclear waste disposal
c.3 Behavior of gas hydrate bearing sediments
c.4 Design of Compressed Air Energy Storage (CAES)
c.5 Geomechanical integrity of reservoirs and fault reactivation

d. Foundations (shallow and deep foundations)

d.1 National geotechnical experimentation site
d.2 Shrink-swell soils and the design of foundations for light buildings
d.3 Slabs-on-expansive soils design manual
d.4 Design of drilled piers in expansive soils
d.5 Downdrag on uncoated and bitumen coated piles
d.6 Mudmats
d.7 Suction caissons
d.8 Protection of embassies against suicide trucks
d.9 Pressuremeter and horizontally loaded piles
d.10 Behavior of large mats under high loads: two case histories

e. Non-destructive testing

e.1 Falling weight deflectometer
e.2 Soil strength from geophysical measurements
e.3 Continuous measurement of modulus, density and water content of in-place base courses using methylene blue and ground penetrating radar

f. Offshore geotechnics

f.1 Seabed interactions with steel catenary risers
f.2 Soil stiffness for well conductor fatigue analysis
f.3 Performance of plate anchors

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

g. Pavements

g.1 Design of pavements on expansive soils
g.2 Developed the principles and applications of distributed continuum fracture
g.3 Generalized Drucker-Prager plasticity yield criterion
g.4 Healing properties of asphalt mixtures
g.5 Methylene blue versus percent fines content characteristic curve for base course materials

h. Probabilistic geomechanics

h.1 Probabilistic calibration of soil specimens
h.2 Stochastic design of early warning systems
h.3 Uncertainty analysis on remoulded undrained shear strength of marine clay
h.4 Varying dimensional bayesian acoustic waveform inversion for 1D semi-infinite heterogeneous media
h.5 Joint states of information from different probabilistic geo-profile reconstruction methods

i. Railroad geotechnics

i.1 High speed trains geotechnics
i.2 Uneven settlements of railroads settlements on shrink-swell soils

j. Retaining walls

j.1 Mechanically stabilized earthfill (MSE) wall design to resist barrier impact
j.2 Design cut-type tie back retaining walls in expansive soils
j.3 MSE walls
j.4 Full scale retaining wall experiments and design guidelines
j.5 Interaction between drilled shaft MSE wall
j.6 Behavior of soil nails in high plasticity clays

k. Scour and erosion

k.1 Scour at bridges
k.2 Meander migration
k.3 Levee design for overtopping erosion

l. Slopes

l.1 Shallow slope failures in expansive soils

m. Soil stabilization

m.1 Thermodynamic phase diagrams
m.2 Non-traditional stabilizers

n. Unsaturated soils

n.1 Modeling the behavior of expansive clays
n.2 Desiccation cracks in soils
n.3 Modified state surface approach
n.4 Stress dependent and suction sensitive modulus of granular soils
n.5 Measurement of soil suction in the field using ground penetrating radar

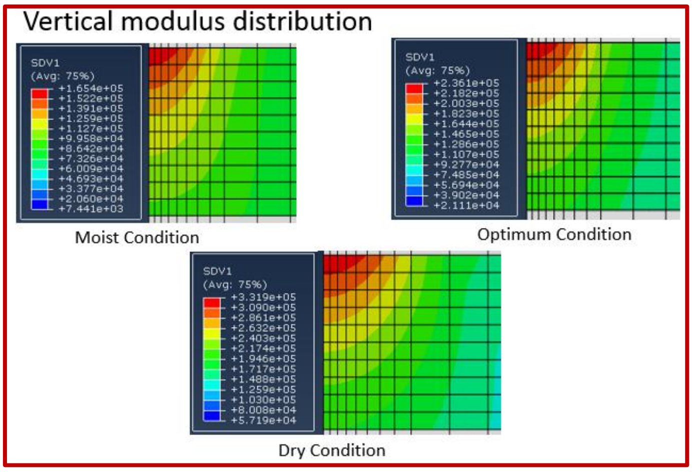
Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

Aggregates

a.1 Modeling of anisotropic, stress and suction-dependent behavior of granular base material

Models of anisotropic, stress and suction-dependent granular materials must include not only the vertical, horizontal and shear moduli but also their permanent deformation behavior under repeated loading. Such models must take into account the geometric characteristics of the aggregates, including their gradation and their distributions of shape, angularity, and texture. The testing required to generate the data on which these models are based is simpler than previous protocols and take into account the fact that the stress states that these materials will be exposed to are governed by the anisotropy.



Relevant publications:

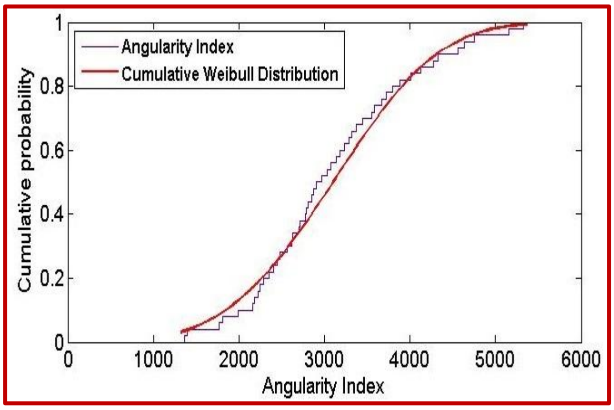
• Epps J, Sebesta S, Hewes B, Sahin H, Button JW, Luo R, and Lytton RL (2012). "Developing a Mixture Design Specification for Flexible Base Construction," Texas Department of Transportation, Report No. FHWA/TX-12/0-6621-2, Vol. 2

• Ashtiani RS, Luo R, and Lytton RL (2010). "Performance Prediction and Moisture Susceptibility of Anisotropic Pavement Foundations," *ASCE Geotechnical Special Technical Publication No. 203*, Paving Materials and Pavement Analysis: 327-334

For more information contact: Prof. Robert Lytton

a.2 Measurement of aggregate characteristics with the aggregate imaging system

In addition to the gradation of an aggregate which affects the performance of that aggregate under repeated load are the geometric characteristics of the individual aggregates, namely its shape, angularity and its texture. The Aggregate Imaging System (AIMS) in use at Texas A&M generates the cumulative distribution of these characteristics from a representative collection of the aggregates and fits them with a Weibull distribution. Thus each of these aggregate geometric properties is characterized by scale and shape parameters which have been found to be essential to predicting the performance properties of the aggregate, including the moduli and permanent deformation properties. The figure shows a typical set of distributions of the shape, angularity and texture of an aggregate.



Relevant publications:

• Gu F, Sahin H, Luo X, Luo R, and Lytton RL (2014). "Estimation of Resilient Modulus of Unbound Aggregates Using Performance-Related Base Course Properties." *Journal of Materials in Civil Engineering,* Vol 27(6): 04014188. ASCE

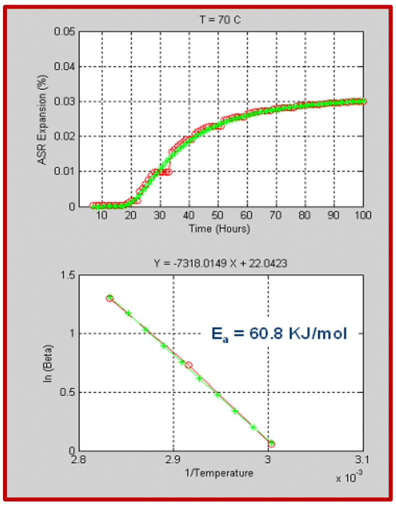
For more information contact: Prof. Robert Lytton

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

a.3 Activation energy characteristics of the alkali-silica reactions of aggregates in concrete

The development of the Alkali-Silica Reaction (ASR) in concrete generates deterioration of the concrete including surface cracks. In airport pavements, these surface cracks produce loose particles which can severely damage jet engines or propellers. The key to understanding this serious deterioration mechanism is the Activation Energy of the aggregate which is measured by exposing it to various temperatures when immersed in a highly alkaline environment. The figure shows a typical volume expansion measurement made at 70^0 C using a dilatometer developed at TAMU.



The logarithm of the slope of the S-shaped curve indicates a rate process which, when plotted against the inverse of the absolute temperature produces the Activation Energy of the aggregate. This simple test has consistently and correctly ranked the aggregates that are known to be the most destructive in producing ASR damage.

Relevant publications:

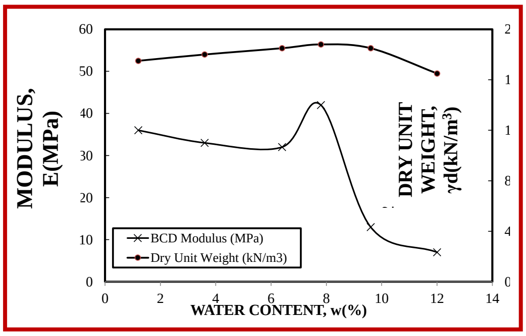
- Ghanem H, Zollinger DG, and Lytton RL (2010). "Predicting ASR Aggregate Reactivity in terms of its Activation Energy". *Journal of Construction and Building Materials*, Vol. 24 (7): 1101-1108.
- Ghanem H, Zollinger D, Lytton RL, and Ghanem N. (2014). "Determining Aggregate Reactivity in Various Alkaline Solutions." Proceedings of Institution of Civil Engineers: Construction Materials, 167(3): 151-161.

For more information contact: Prof. Robert Lytton

Compaction

b.1 Compaction innovations and control based on soil modulus

Compaction specifications are typically based on the maximum dry density and the optimum water content. However the dry density is not used in the design but often it is the soil modulus. Therefore it would make more sense to use a target modulus and water content rather than a target dry density and water content. The research project consisted of developing a new device to quickly measure the modulus in the field as well as on top of the Proctor mold. It consists of a thin steel plate instrumented with strain gages which record the amount of bending for a given load generated by the operator leaning on the device (side figure). Results obtained by performing the test on top of the proctor mold which gives the data on the other figure.



Relevant publications:

- Briaud J-L, Li Y, Rhee K, (2006). "BCD: A Soil Modulus Device for Compaction Control". *Journal of Geotechnical and Geoenvironmental Engineering*, Vol 132 (1): 108-115. ASCE.
- Briaud J-L (2013). "Geotechnical Engineering: Unsaturated and Saturated Soils", John Wiley and Sons, New York, 1000 pages. (Chapter 20: Compaction).

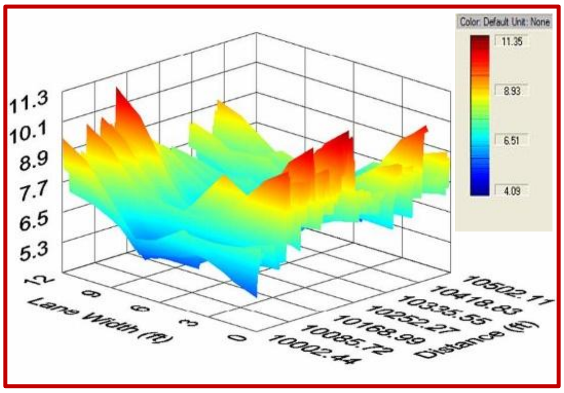
For more information contact: Prof. Jean-Louis Briaud

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

b.2 Quality control/quality assurance of compaction with ground penetrating radar

The ability to analyze a ground penetrating radar signal to determine the composition of a pavement layer requires a combination of electromagnetic wave propagation theory and micromechanics. The result is to be able to determine the asphalt content, density, and percent air as well as the thickness of the asphalt layer. In concrete, the same combination produces the density, evaporable water content and percent air in the concrete layer. In subgrade soil or base course materials, it produces the water content, percent air and density. The figure shows the results of a GPR survey of the dielectric constant of the subgrade soil beneath a pavement. Lane width surveys such as illustrated in the figure are made with a four antenna array.



Relevant publications:

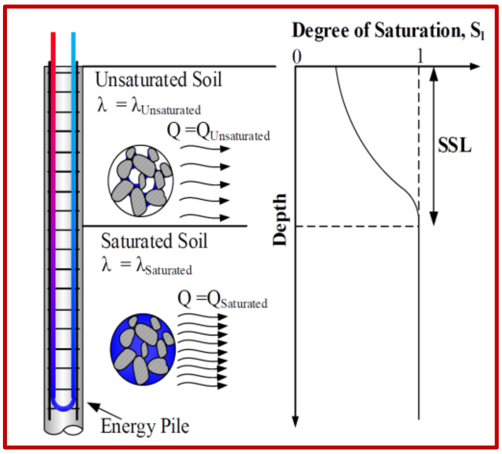
• Lytton R.L. (2011). "Use of Ground Penetrating Radar in Construction Quality Assurance and Quality Control," Proceedings, XI Congreso Internacional de Ingenieria Civil, Universidad Autonoma de Queretaro, Queretaro, Mexico.

For more information contact: Prof. Robert Lytton

Energy geotechnics

c.1 Geothermal energy - energy piles

Energy piles are bi-functional foundation elements used as structural support as well as ground heat exchanger for shallow geothermal energy systems. Because they are relatively short, energy piles may be partially embedded in unsaturated soils. Saturation conditions influence the thermal properties of the ground and therefore the heat exchange rate, which in turn affects the efficiency of energy piles. Our research activities in this area focus on: i) a better understanding of this kind of system in cooling dominate climate, ii) the developing of methods to measure in-situ the thermal conductivity of soils, iii) effect of partial saturation on the efficiency of energy piles, and iv) thermal and mechanical performance of energy piles.



Relevant publications:

• Akrouch G, Sánchez M, and Briaud J-L (2014). "Thermo-Mechanical Behavior of Energy Piles in High Plasticity Clays". *Acta Geotechnica,* Vol. (9): 399-412. DOI: 10.1007/s11440-014-0312-5.

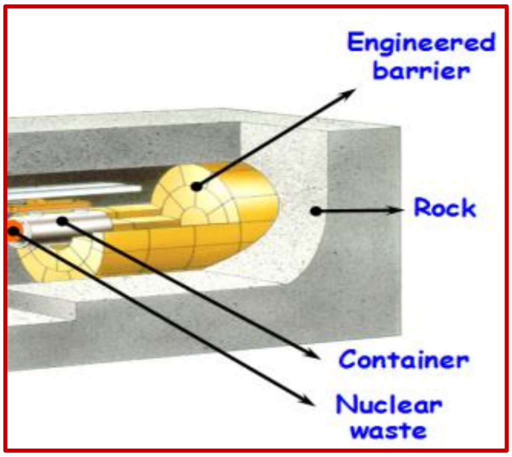
• Akrouch G, Briaud J-L., Sánchez M. "Thermal Cone Test to Determine Soil Thermal Properties". *Journal of Geotechnical and Geoenvironmental Engineering ASCE* (in print).

For more information contact: Prof. Jean-Louis Briaud or Associate Prof. Marcelo Sánchez

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

c.2 Design of nuclear waste disposal



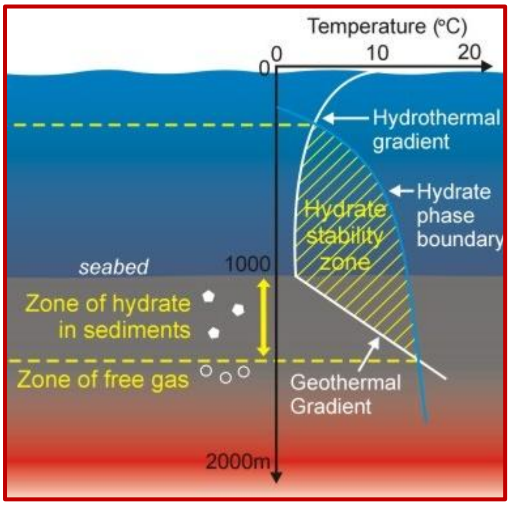
The main objective of a geological repository for high level radioactive waste is to safely contain the highly pollutant waste for a very long period of time, generally measured in thousands of years. Complex Thermo-Hydro-Mechanical and Chemical (THMC) processes are anticipated in the near and far fields around the repository. Current efforts at TAMU are related to the upgrading of coupled THMC numerical codes, and analysis of the short and long term behavior of repositories under actual geological conditions, as well as the development of advanced constitutive models capable of capturing the complex behavior of the barrier materials.

Relevant publications:

- Sánchez M, Gens A, and Guimarães L. (2013). "Thermal-hydraulic-mechanical (THM) behavior of a large-scale in situ heating experiment during cooling and dismantling". *Canadian Geotechnical Journal*, Vol. 49: 1169-1195. doi:10.1139/T2012-076.
- Sánchez M, Gens A, and Olivella S (2012). "Thermo-Hydro-Mechanical Analysis of a Large Scale Heating Test incorporating material fabric changes". *International Journal for Numerical and Analytical Methods in Geomechanics* vol. 36 (4): 391-42. DOI: 10.1002/nag.1011.

For more information contact: Associate Prof. Marcelo Sánchez

c.3 Behavior of gas hydrate bearing sediments



Gas hydrates are crystalline clathrate compounds made of water and a low molecular gas like methane. Methane hydrates form and exist under (high) pressure and (low) temperature conditions that are common in sub-permafrost layers and in deep marine sediments. Methane hydrate sediments are highly compacted (stable) under deposit conditions and are likely to behave as a bonded sedimentary soil. However, methane hydrates are characterized by a metastable structure which dissociate if stability conditions are disturbed.

Hydrate dissociation lead to large volume change that strongly affects the sediment behavior. Our ongoing research at TAMU focuses on developing a state of the art coupled multiphysical simulator to assist in the development of optimal and technically viable strategies for methane production in both marine and permafrost settings.

Relevant publications:

- Sánchez M, Santamarina JC, and Shastri A, Gai X. "Analysis of Coupled THCM Processes Involving Gas Hydrate in Soils". (submitted)

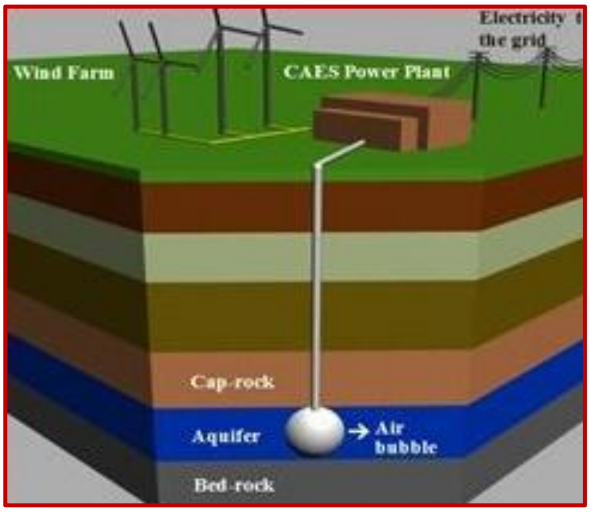
For more information contact: Associate Prof. Marcelo Sánchez

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

c.4 Design of CAES (Compressed Air Energy Storage)

The underground storage of compressed air is a favorable and low-cost option for balancing off-peak electricity demands. Large volume of air can be compressed and stored in the ground during low-demand electricity periods. This pressurized air can then be released to generate electricity during high-demand times. The natural formations around a CAES facility are subjected to significant perturbations in its Thermo-Hydraulic and Mechanical (THM) field. Our current research efforts at TAMU focus on a better understanding of this kind of system.



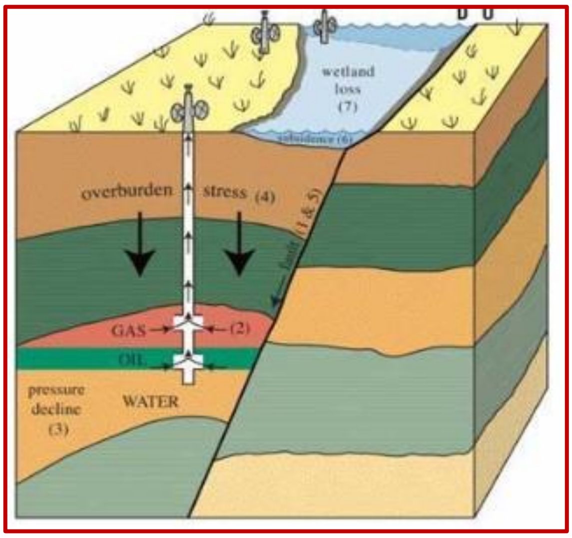
Relevant publications:

• Sanchez M, Shastri A, and Le T (2014). "Coupled Analysis of an Underground Compressed Air Energy Storage Facility in Sandstone". *Géotechnique letters* 4:157–164. DOI:10.1680/geolett.13.00068

For more information contact: Associate Prof. Marcelo Sánchez

c.5 Geomechanical integrity of reservoirs and fault reactivation

The injection of water (or CO_2) at high pressure is a common practice to enhance oil production. A crucial component of this activity is the estimation of the maximum pressure at which the fluids can be injected without inducing the reactivation of pre-existing faults that may exist in the formation. To estimate the maximum allowable injection pressure we have proposed a novel approach based on: a coupled hydro-mechanical formulation (for the numerical analyses); a criterion based on the total plastic work (for the fault reactivation); and the evidence theory (for uncertainty quantification).



Relevant publications:

• Cabral L., Guimarães L, Horowitz B. and Sánchez M. (2014). "Coupled Hydro-Mechanical Fault Reactivation Analysis Incorporating Evidence Theory for Uncertainty Quantification". *Computer and Geotechnics* 56: 202–215. DOI: 10.1016/j.compgeo.2013.12.007.

• Cabral L, Sánchez M, Guimarães L, Santos E, and Horowitz B. (2014). "Defining Maximum Injection Pressures in an Offshore Petroleum Reservoir Using the Evidence Theory for Uncertainty Quantification" *Journal of Petroleum Science and Engineering* (under review).

For more information contact: Associate Prof. Marcelo Sánchez

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

Foundations (shallow and deep foundations)

d.1 National geotechnical experimentation site

A small number of dedicated sites for full scale experimentation have been selected by the National Science foundation and the Federal Highway Administration to provide a wealth of well documented data. The National Geotechnical Experimentation Site (NGES) at TAMU is made of two sites. One is made of a medium dense silty sand down to 15 m and the other is made of a very stiff clay down to the same depth. At these sites many large scale experiments have been conducted by researchers worldwide (e.g. a full scale embankment with an instrumented culvert, 2 full scale retaining walls, 9 drilled shafts up to 25 m deep, 3 post grouted drilled shafts, 20 impact driven and vibro driven H piles, six 15 m long ground anchors, and 12 soil nails). Along with those full scale experiments results is a large amount and variety of lab soil and in situ soil tests.

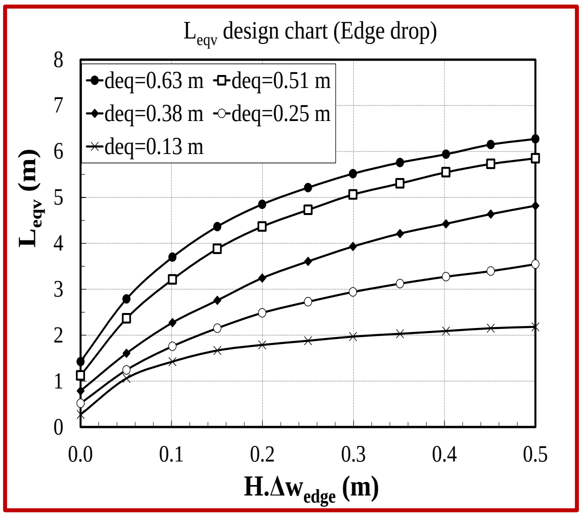
Relevant publications:

- Briaud J-L (1997). "The National Geotechnical Experimentation Sites at Texas A&M University: A Summary", Internal Report NGES-TAMU-007, Zachry Dpt. of Civil Engineering, Texas A&M University.

For more information contact: Prof. Jean-Louis Briaud

d.2 Shrink-swell soils and the design of foundations for light buildings

Light buildings on shrink-swell soils may experience distortion because the rain and the evaporation affect the edges more than the center of the foundation. One of the best and most economical types of foundation (~100$/m²) to remedy this situation is a stiffened slab on grade also called waffle slab. The idea is to design a foundation which is stiff enough that any edge deflection will not cause undue distortion of the foundation and therefore the structure. This method requires the knowledge of the change in water content over the seasons and the depth to which this change in moisture is expected. It proceeds by trial and error and gives the bending moment, the shear in the beams as well as the distortion which can then be compared to tolerable limits for the building type. The figure shows one of the proposed design charts.



Relevant publications:

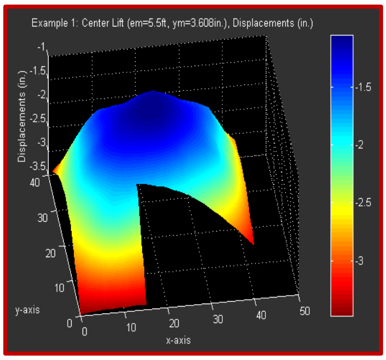
- Briaud J-L, Abdelmalak R, Zhang X (2010). "Design of Stiffened Slabs on Grade on Shrink Swell Soils". Keynote Lecture, Proceedings of the International Conference on Unsaturated Soils called UNSAT 2010, September 2010 in Barcelona, Spain, CRC Press-Balkema-Taylor and Francis Group.
- Briaud J-L, (2013). "Geotechnical Engineering: Unsaturated and Saturated Soils", John Wiley and Sons, New York, 1000 pages. (Chapter 17: Shallow Foundations)

For more information contact: Prof. Jean-Louis Briaud

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

d.3 Slabs-on-expansive soils design manual



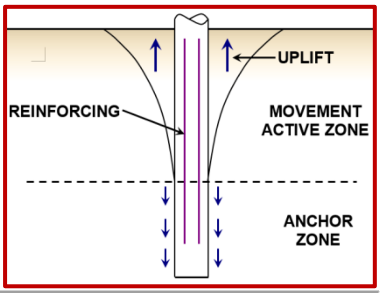
The original slab-on-expansive soil design manual was developed at TAMU co-authored by W. Kent Wray and R. L. Lytton in 1980. Subsequent editions have had input from engineers in the Post-Tensioning Institute Slab-On-Ground committee and were published in 1996 and 2003. The design equations were based upon a wide variety of finite element plate-on-curved elastic half space runs. A new edition is coming soon.

Relevant publications:

• Post-Tensioning Institute. (2004). "Design of Post-Tensioned Slabs-on-Ground." 3rd Edition, Phoenix, Arizona.

For more information contact: Prof. Robert Lytton

d.4 Design of drilled piers in expansive soils

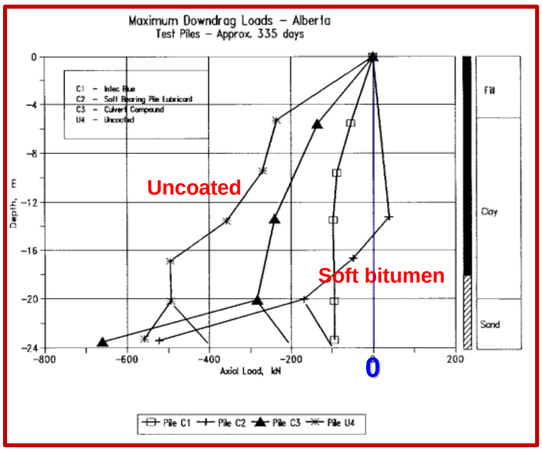


The design of successful drilled piers in expansive soils must take into account the stresses that occur in the pier during wetting (uplift, illustrated below) and drying while taking into account the wet and dry design suction envelopes. This design procedure is being completed, field tested and applied in cooperation with the Houston Foundation Performance Association and can be accessed through their web-site.

For more information contact: Prof. Robert Lytton

d.5 Downdrag on uncoated and bitumen coated piles

In most usual situations the soil moves down less than the pile and as a result the soil carries the pile. Downdrag takes place anytime the soil moves down with respect to the pile. In that case the soil imposes a downdrag load on the pile; this phenomenon is also called negative friction. The use of bitumen to decrease the negative friction to an acceptable level was the subject of a very large project in the USA and Canada where 12 full scale heavily instrumented piles, coated and uncoated were load tested and then subjected to downdrag. The results were used to calibrate a numerical model and numerical simulations were used to develop guidelines for single piles and pile groups.



Relevant publications:

• Briaud J-L (1997). "Bitumen Selection for Downdrag on Piles". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 123 (12): 1127–1134. ASCE.

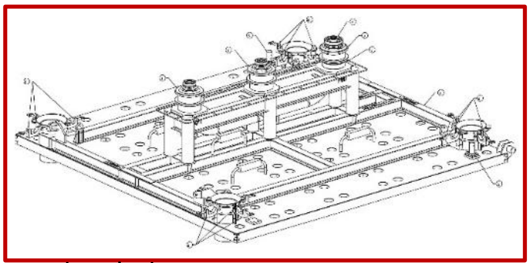
• Briaud J-L (2013). "Geotechnical Engineering: Unsaturated and Saturated Soils", John Wiley and Sons, New York, 1000 pages. (Chapter 18: Deep Foundations)

For more information contact: Prof. Jean-Louis Briaud

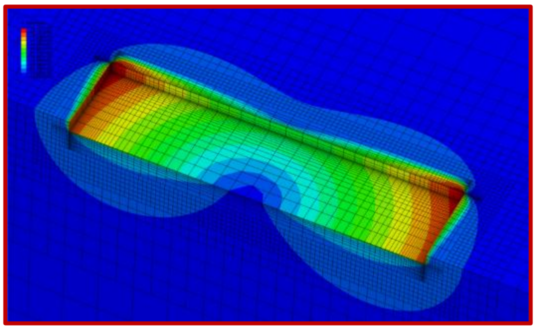
Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

d.6 Mudmats



Mudmats are a common shallow foundation used for subsea systems. When used for applications such as providing restraint for thermal loading of pipelines, they can be subjected to six degree of freedom loading conditions, often with a disproportionately large component of horizontal and torsion loading that is relatively uncommon for conventional foundations. Research in this area utilizes numerical methods to develop interaction relationships, from which simplified plastic limit analyses are formulated for routine design use.

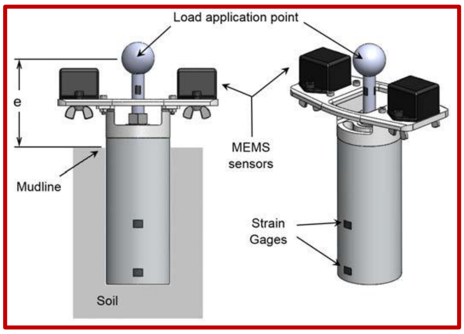


Relevant publications:

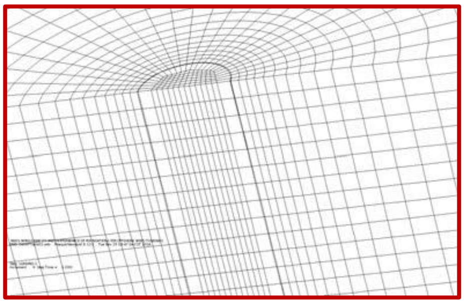
- Nouri H, Biscontin G, and Aubeny CP (2014) "Undrained sliding resistance of shallow foundations subject to torsion," *ASCE Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 140 (8): 04014042.
- Murff JD, Aubeny CP, and Yang M (2010) "The effect of torsion on the sliding resistance of rectangular foundations," *Intl. Symposium on Frontiers in Offshore Geotechnics*, Perth, Australia.

For more information contact: Prof. Charles Aubeny

d.7 Suction caissons



Suction caissons offer an attractive alternative to driven piles for offshore foundations and anchors, due to their cost-effectiveness and relative ease of installation. Originally developed for offshore oil-gas exploration and production, recent attention is directed toward providing foundations and anchor for offshore floating renewable energy systems. Current research at TAMU investigates load capacity under combined loading conditions, particularly for conditions of extreme load eccentricity. The research methodology involves finite element modeling, development of plastic limit formulations, and recent centrifuge model tests conducted at Rensselaer Polytechnic Institute.



Relevant publications:

- Murali M, Grajales F, Beemer R, Biscontin G, and Aubeny C (2015) "Centrifuge and Numerical modeling of monopoles for offshore wind towers installed in clay" *Proceedings of the ASME 2015 34th International Conference on Ocean, Offshore and Artic Engineering OMAE2015*, St John's Newfoundland.
- Aubeny, C.P., Han, S.W., and Murff, J.D. (2003) "Inclined load capacity of suction caisson anchors". *Intl. J. for Numerical and Analytical Methods in Geomechanics*, Vol. 27, 1235-1254.

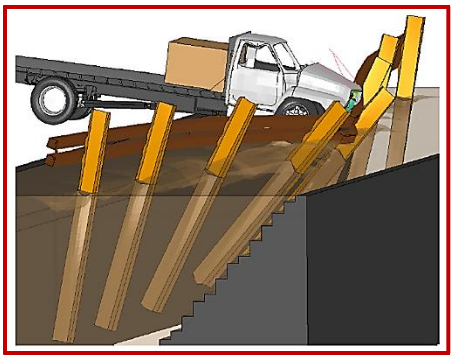
For more information contact: Prof. Charles Aubeny

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

d.8 Protection of embassies against suicide trucks

Protection of sensitive facilities against vehicle impact is becoming more and more important. The research in this area also serves to advance our knowledge in roadside safety with barriers and guard rails to redirect errant vehicles. A typical installation will have a pile installed at a depth varying from 1 to 3 m deep, with other piles installed in an in-line group with a spacing varying from 3 to 10 m and connected with a beam. A series of full scale crash tests on single piles and groups of in line piles were conducted with advanced instrumentation being collected within the 200 milliseconds duration of the crash event. These data were then used to calibrate the LS-DYNA simulation model. In the end a simple set of two Excel spread sheets were developed to predict the behavior of the protection system.



Relevant publications:

- Asadollahi Pajouh M, Briaud J-L, Mirdamadi A., (2015). "Simple Analysis of any Vehicle Impact on any Group of In Line Piles in any Soil". Final Report to the Department of State, Security Division, Washington, USA.

For more information contact: Prof. Jean-Louis Briaud

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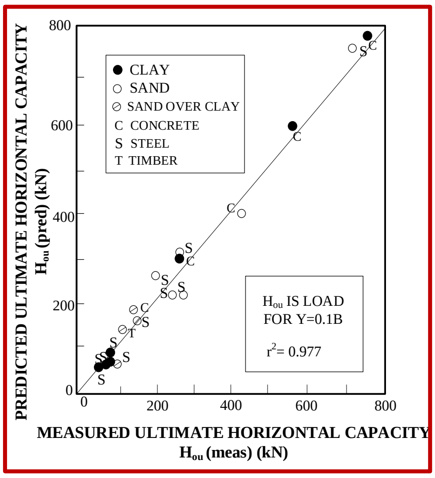
d.9 Pressuremeter and horizontally loaded piles

The pressuremeter (PMT) is the best tool to predict the behavior of horizontally loaded piles because of the close analogy of loading between the PMT and the pile. This analogy was studied theoretically and analytically to propose a simple equation for the ultimate horizontal load that the pile can carry. In the case of vertically loaded pile, a common design sequence consists of calculating the ultimate load applying a safety factor to obtain the working load and checking the settlement under that load. This approach makes a lot of sense but is not the one taken for horizontally loaded piles. In this project a parallel approach to the vertical load approach was developed. Based on the theoretical considerations mentioned above and a database of 20 pile load tests with associated PMT tests, a simple equation was developed giving the ultimate horizontal load as a function of the PMT limit pressure, the pile width, and the pile transfer length. Then this ultimate horizontal load is divided by 3 and the horizontal displacement was found to be within the range of 0.8 to 2.5% of the pile diameter.



Relevant publications:

- Briaud J-L (1997). "SALLOP: Simple Approach for Lateral Loads on Piles". *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 123 (10): 958-964. ASCE.
- Briaud J-L (2013). "Geotechnical Engineering: Unsaturated and Saturated Soils", John Wiley and Sons, New York, 1000 pages. (Chapter 18: Deep Foundations)

For more information contact: Prof. Jean-Louis Briaud

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

d.10 Behavior of large mats under high loads: two case histories

The large mat foundation of two historical 160 m high column monuments were studied in light of the soil data available: the Washington Monument in Washington DC erected in 1885 and the San Jacinto Monument in Houston erected in 1936. Both mats are about 38 m by 38 m and are subjected to high pressures (450 kPa and 250 kPa respectively). These two case histories are very interesting because the settlement of both structures has been monitored since the end of construction. The estimated settlement of the Washington Monument is 1.2 m and required underpinning while the San Jacinto settled 0.35 m. This gave an opportunity to compare measured and calculated values of the settlement.

Relevant publications:

• Briaud J-L, Smith B, Rhee K-Y, Lacy H, Nicks J (2009). "The Washington Monument Case History", *International Journal of Geoengineering Case Histories*, Vol.1 (3): 170-188

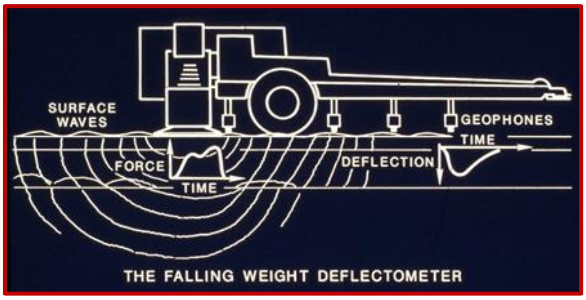
• Briaud J-L, Koohy Y, Nicks J, Jung I, (2015). "San Jacinto Monument: New Soil Data and Analysis Including Subsidence", *Journal of Geotechnical and Geoenvironmental Engineering*, ASCE. Vol 141 (6):04015023.

For more information contact: Prof. Jean-Louis Briaud

Non-destructive testing

e.1 Falling weight deflectometer

Impulse testing of pavements with a Falling Weight Deflectometer (FWD) has many capabilities that are not commonly used, including the back-calculation of the viscoelastic properties of the pavement layers. The paper below describes the principles by which such an analysis is done. The program DBSID (written at TAMU) converts the time-histories of the impulse load and of the deflections of the multiple geophones into frequency dependent material properties of multiple pavement layers.



Relevant publications:

• Lytton RL (1989). "Backcalculation of Pavement Layer Properties," Nondestructive Testing of Pavements and Backcalculation of Moduli, ASTM STP 1026, A.J. Bush III and G.Y. Baladi, Eds., American Society of Testing Materials, Philadelphia, pp. 7-38

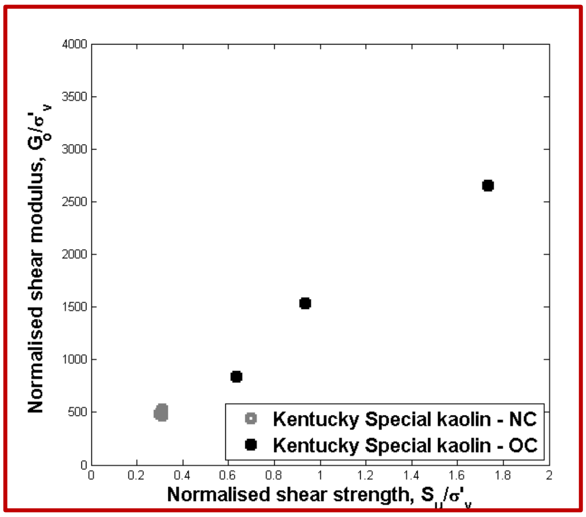
For more information contact: Prof. Robert Lytton

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

e.2 Soil strength from geophysical measurements

Knowledge of seabed soils is essential if offshore and nearshore structures are to be safely designed and properly built. A large part of the commercial and operational risk involved in these works relates to uncertainties about the properties of the soil at the site. It is therefore necessary to perform sufficient investigation to evaluate these risks thoroughly. Recent research at TAMU has aimed to quantify the magnitude and material uncertainty when characterizing the engineering properties (i.e. void ratio, water content, strength) of soft clay using geophysical methods. Shallow sediments are targeted for this research.



Relevant publications:

- Murali M, Biscontin G, and Aubeny C (2015) "Soil strength from geophysical measurements" *International Ocean and Polar Engineering Conference*, ISOPE2015, Kona.

For more information contact: Prof. Charles Aubeny

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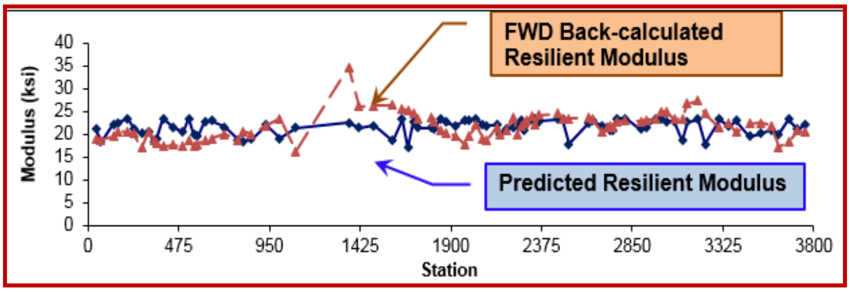
e.3 Monitoring of base courses using methylene blue and ground penetrating radar

Ground penetrating radar and methylene blue measurements are used together to determine the resilient modulus, density, water content and matric suction from data collected at highway speeds. The resilient modulus calculated from the radar data using a stress- and suction-dependent modulus model, were matched with the results of a falling weight deflectometer survey of the same pavement layer with the results seen below. About twenty thousand resilient modulus measurements were made with the radar data on a 4.5 miles project. The radar scan took approximately thirty minutes.



Relevant publications:

- Sahin H. (2014). "Nondestructive Test Methods for Rapid Assessment of Flexible Base Performance in Transportation Infrastructures." Ph.D. Dissertation, Texas A&M University, College Station, Texas.

For more information contact: Prof. Robert Lytton

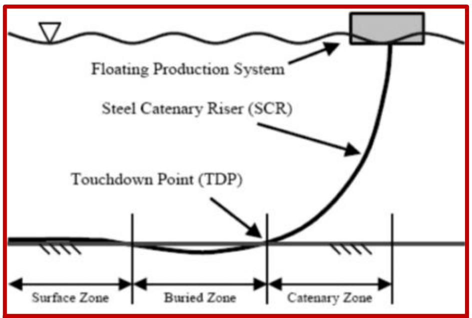
Research Highlights (Con't)

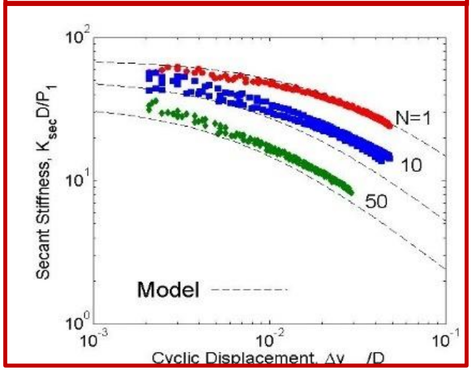
Texas A&M University – The Geotechnical Engineering and Geomechanics Group

Offshore Geotechnics

f.1 Seabed interactions with steel catenary risers

Steel catenary risers are often the alternative of choice to transport of hydrocarbons between offshore floating structures and other facilities. Cyclic wave-induced motions create a major design concern as regards the fatigue life of the risers. Seabed stiffness involves a number of complex processes including stiffness degradation under cyclic loading, consolidation and thixotropic recovery during rest periods, and separation of the pipe from the seabed during large excursions. TAMU recently developed a soil spring model in collaboration with the Norwegian Geotechnical Institute, using data from single-element physical model tests in West African marine clay.





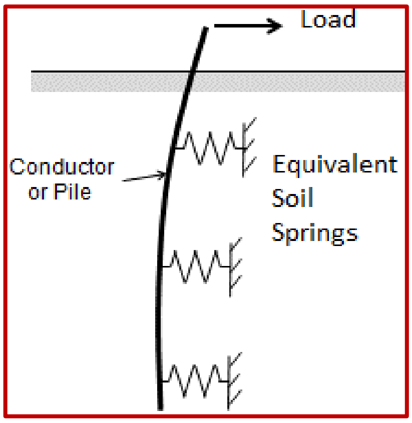
Relevant publications:

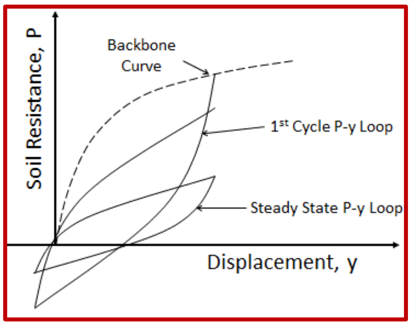
- Aubeny C, White TA, Langford T, Meyer V & Clukey E (2015) "Seabed stiffness model for steel catenary risers" *Proceedings of the International Symposium on Frontiers in Offshore Geotechnics ISFOG15*, Oslo.
- Aubeny, C.P. and Biscontin, G. (2008) "Interaction model for steel compliant riser on soft seabed". *Society of Petroleum Engineers Journal, Projects, Facilities and Construction*, Vol. 3 (3): 120077-PA.

For more information contact: Prof. Charles Aubeny

f.2 Soil stiffness for well conductor fatigue analysis

An important consideration in design of deep-water riser-well systems is fatigue life, which is very sensitive to soil reactions along the conductor. In practice, lateral cyclic resistance is often modeled using Winkler springs, known as 'p-y' springs. Under cyclic loading soil resistance degrades from its value under conditions of virgin displacement to a steady-state response. Geotechnical centrifuge tests on instrumented model piles provide bending moment profiles from which p-y curves may be calculated. Research is now in progress for extending the p-y approach to describe: 1) true nonlinear behavior, 2) degradation of soil resistance from the backbone curve to the steady state condition and 3) soil response for general conditions of cyclic loading about non-zero mean displacement.





Relevant publications:

- Zakeri A, Clukey E, Kebadze B, Jeanjean P, Walker D, Piercy G, Templeton J, Connelly L & Aubeny C (2015) "Recent advances in Soil Response Modeling for Well Conductor Fatigue Analysis and Development of New Approaches" *Offshore Technology Conference* OTC-25795-MS.

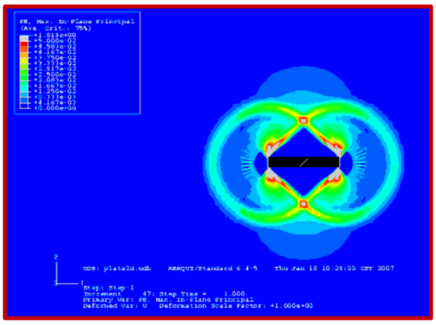
For more information contact: Prof. Charles Aubeny

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

f.3 Performance of plate anchors

Plate anchors provide an efficient anchorage for mooring offshore floating structures. Drag-embedded anchors are very economical and often the anchor of choice for deep-water hydrocarbon exploration. Suction-embedded anchors offer precise positioning and may also be used for permanent deep-water production floating systems. Critical aspects of anchor performance include its ability to embed, load capacity and performance under the unintended load orientations that can occur under extreme hurricane loading. Ongoing research involves numerical modeling of basic anchor performance, development of plasticity-based design models, and laboratory model tests. One current area of focus is plate anchor performance in stratified soil profiles.



Relevant publications:

- Aubeny CP, and Chi CM (2014). "Analytical model for vertically loaded anchor performance". *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 140 (1): 14-24. ASCE
- Yang M, Aubeny CP, and Murff, J.M. (2012) "Behavior of suction embedded plate anchors during keying process" *Journal of Geotechnical and Geoenvironmental Engineering*. Vol 140 (1): 14-24. *ASCE*

For more information contact: Prof. Charles Aubeny

Pavements

g.1 Design of pavements on expansive soils

The development of a design procedure for pavements on expansive soils was supported by the Texas Department of Transportation. It is based on multiple years of monitoring of the roughness that expansive clay subgrades impose on the overlying concrete and asphalt surfaced pavements. It is also based on the volume change that is expected with a change of suction beneath any given wheel path. The computer program WinPRES (Windows Pavement Roughness on Expansive Soils) was developed to allow the design of pavements to control the level of roughness that develops over the pavement-life.

Relevant publications:

- Lytton RL, Aubeny CP, and Bulut R (2004). "Design Procedure for Pavements on Expansive Soils," Reports No.FHWA-TX-05- 0-4518-1, -2, and -3, Texas Transportation Institute, Texas A&M University System, College Station, Texas, Volumes 1,2, and 3.

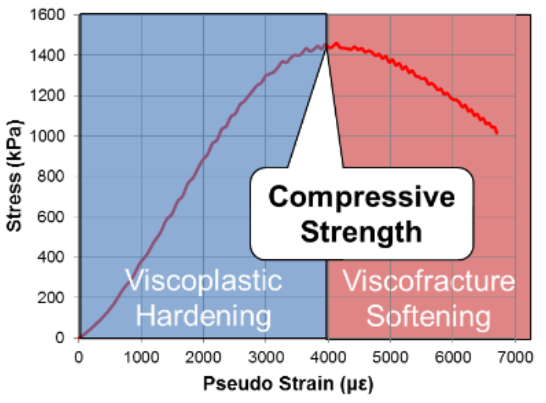
For more information contact: Prof. Robert Lytton

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

g.2 Developed the principles and applications of distributed continuum fracture

This original contribution to mechanics formulated the relation between viscoplasticity and viscofracture of a viscoelastic material. In this application, the material is an asphalt mixture. The onset of fracture is different whether the material is being loaded in tension or compression and the compression formulation must account for the anisotropy of the material composition. A viscoelastic version of the elastic Griffith crack growth criterion was derived for both tension and compression. It also required the derivation of a more general plastic yield criterion.



Uniaxial strength test; (strain control)

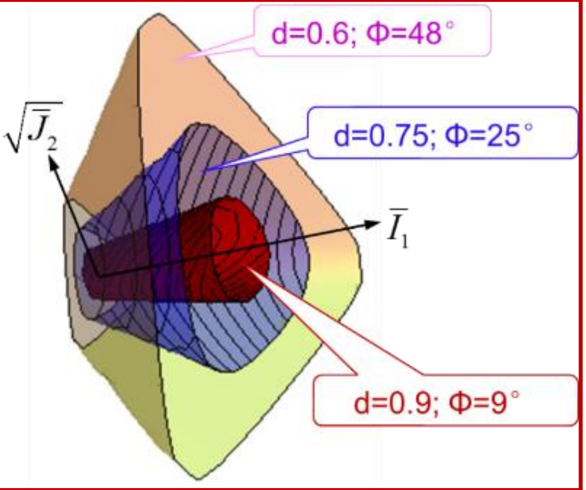
Relevant publications:

- Zhang Y, Luo R, and Lytton RL (2012). "Characterizing Permanent Deformation and Fracture of Asphalt Mixtures by Using Compressive Dynamic Modulus Tests". *Journal of Materials in Civil Engineering*, Vol. 24 (7): 898-906.
- Zhang Y, Luo R, and Lytton RL (2014). "Anisotropic Modeling of Compressive Crack Growth in Tertiary Flow of Asphalt Mixtures." *Journal of Engineering Mechanics*, Vol. 140 (6): 04014032.

For more information contact: Prof. Robert Lytton

g.3 Generalized Drucker-Prager plasticity yield criterion

A commonly used plastic yield criterion is the Extended Drucker-Prager formulation which is limited in its applications by the fact that it cannot maintain a convex yield surface for internal friction angles larger than 22°. This required the formulation of what we term the Generalized Drucker-Prager plastic yield criterion. This criterion allows the material to be anisotropic in compression and extension which is essential to accurately represent asphalt mixtures and many geomaterials. It also allows the material to have internal friction angles that range from 0 to 90 degrees while maintaining a convex yield surface.



Relevant publications:

- Zhang Y, Bernhardt M, Biscontin G, Luo R, and Lytton, R. L. (2014). "A Generalized Drucker-Prager Viscoplastic Yield Surface Model for Asphalt Concrete." *Materials and Structures*, Springer; in press.
- Zhang Y, Luo R, and Lytton RL (2013). "Characterization of Viscoplastic Yielding of Asphalt Concrete". *Construction and Building Materials*, Vol. 47: 671-679.

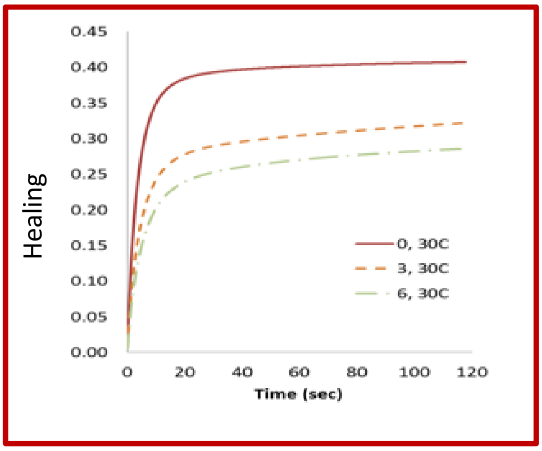
For more information contact: Prof. Robert Lytton

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

g.4 Healing properties of asphalt mixtures

Most construction materials not only fracture but also heal between load applications. The mechanics principles made it possible to formulate the mechanics of healing and its application to asphalt mixtures in tension. This required the development of a new materials test, the creep and step recovery (CSR) test and the analysis of the test data to produce the mixture material properties that contribute to healing. Measurements were made to determine the effects of different binders and binder contents, air voids, temperature, damage, and aging on the ability of a material to heal. The figure below shows the effects of temperature and aging on the ability of an asphalt mixture with 7% air voids to heal.



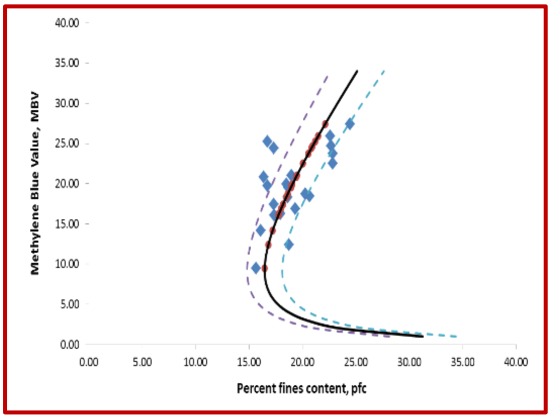
Relevant publications:

• Luo X, Luo R, and Lytton RL (2013). "Characterization of Recovery Properties of Asphalt Mixtures". *Construction and Building Materials*, Vol. 48: 610-621.

For more information contact: Prof. Robert Lytton

g.5 Methylene blue versus percent fines content characteristic curve for base course materials

A key to being able to determine the quality of compaction of a base course is to measure the characteristic curve of the Methylene Blue Value (mg/g) versus the percent fines content as shown in the graph below which illustrates a poor quality base which has high plastic fines. Base courses that perform well plot on the lower limb of the MBV-vs-pfc curve.



Relevant publications:

• SahinH, Gu F, Tong Y, Luo R, and Lytton RL (2013). "Unsaturated Soil Mechanics in Design and Performance of Pavements." Proceedings, 1st Pan American Conference on Unsaturated Soils, Cartagena, Taylor and Francis, Colombia.
• Sahin H, Gu F, and Lytton R (2014). "Development of Soil-water Characteristic Curve for Flexible Base Materials Using the Methylene Blue Test." *Journal of Materials in Civil Engineering*, Vol (27) 04014175.

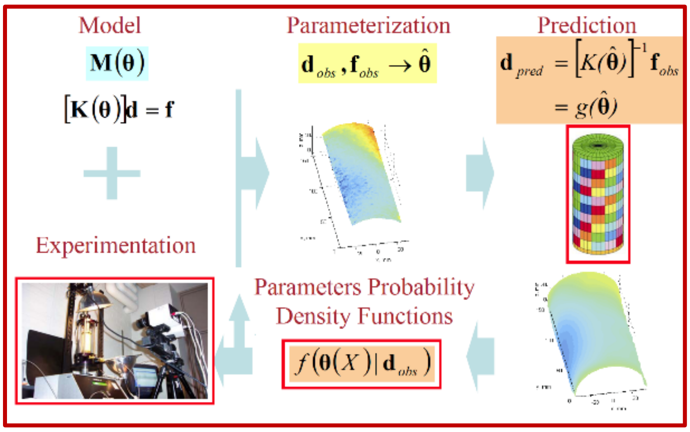
For more information contact: Prof. Robert Lytton

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

Probabilistic geomechanics

h.1 Probabilistic calibration of soil specimens



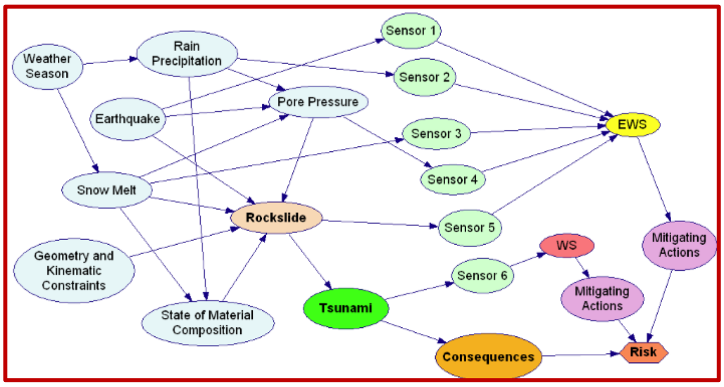
This research consists in exploring the effects of imperfect initial specimen geometry, platen-soil and apparatus compliance, and material heterogeneity on the constitutive model calibration process from triaxial tests with non lubricated platens. The technique of 3D-Digital Image Correlation (3D-DIC) was used to measure, from digital images, full-field displacements over sand specimen surfaces throughout triaxial compression tests, as well as actual specimen initial shape, and deformations associated with platen and apparatus compliance and bedding settlement. Using 3D finite element models allowing varying degrees of material variability in the solution of the inverse problem, allowed to study the effect of material heterogeneity.

Relevant publications:

• Medina-Cetina Z. and Rechenmacher AL (2009). "Influence of Boundary Conditions, Specimen Geometry and Material Heterogeneity on Model Calibration from Triaxial Tests," *International Journal for Numerical and Analytical Methods in Geomechanics*, Vol. 34 (6): 627-643. doi/10.1002/nag.833

For more information contact: Associate Prof. Zenon Medina-Cetina

h.2 Stochastic design of early warning systems



Early warning systems (EWS) are monitoring devices designed to avoid or to mitigate the impact posed by a threat. Since EWS are time sensitive or stochastic, it is necessary to develop a design methodology that defines the integration of the participating monitoring information sources, the identification of potential warning thresholds, and the associated risk within an explicit causal analysis. This research discuss a framework for a stochastic design of an early warning system, introducing a risk measure as the reference variable that encapsulates the different effects retrieved by the monitoring instruments. A Bayesian approach is proposed as a suitable tool for integrating and updating the joint states of information and the warning levels as the information flows through the warning system.

Relevant publications:

• Medina-Cetina Z. and Nadim F (2008). "Stochastic Design of an Early Warning System," *Georisk, Assessment and Management of Risk for Engineered Systems and Geohazards*, Vol. 2 (4): 223 – 236. doi/full/10.1080

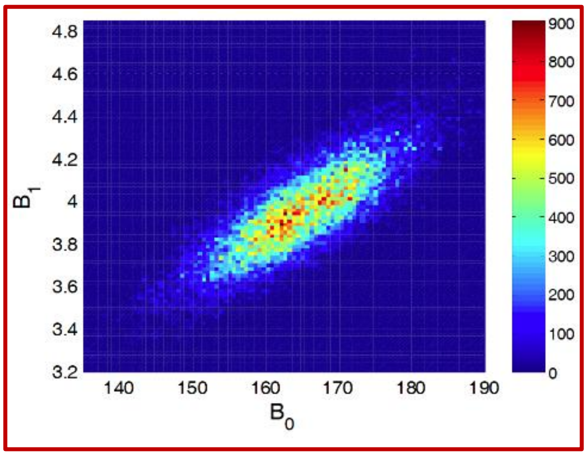
For more information contact: Associate Prof. Zenon Medina-Cetina

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

h.3 Uncertainty analysis on remoulded undrained shear strength of marine clay

Remoulded undrained shear strength is used to indicate the evolution of the post-failure behavior of seafloor soil, estimate the rheological properties of debris flows and the drag forces on seafloor structures exerted by a submarine slide, and calculate the penetration resistance of skirt walls. This research explores the influence of uncertainty on relationships between undrained shear (S_u) and liquidity index (LI) as a potential predictor of the remoulded soil strength. Special emphasis is made on assessing the uncertainty inherent to undrained shear strength when the definition of the proposed model is updated from a global to a local (regional) data set.



Relevant publications:

- Yang S, Medina-Cetina Z, and Nadim F (2010). "Uncertainty Analysis on Remoulded Undrained Shear Strength of Marine Clay", *Georisk, Assessment and Management of Risk for Engineered Systems and Geohazards, Geotechnical Safety and Risk Part 2* (Limit-State Design Methodologies), Vol. 4 (1): 43 – 50. doi/full/10.1080

For more information contact: Associate Prof. Zenon Medina-Cetina

h.4 Varying dimensional Bayesian acoustic waveform inversion for heterogeneous media

This research introduces a methodology to infer the spatial variation of the acoustic characteristics of a 1D vertical elastic heterogeneous earth model via a Bayesian calibration approach, given a prescribed sequence of loading and the corresponding time history response registered at the ground level. This involves solving an inverse problem that maps the ground seismic response onto a random profile of the ground stratigraphy (i.e. a 1D continuous spatial random field). From a Bayesian point of view, the solution to an inverse problem is fully characterized by a posterior density function of the forward model random parameters, which explicitly overcomes the solution's non-uniqueness. This subsurface earth model is parameterized using a Bayesian partition model, where the number of soil layers, the location of the layers' interfaces, and their corresponding mechanical characteristics are defined as random variables.

Relevant publications:

- Esmailzadeh S, Medina-Cetina Z, Kang JW, Kallivokas LF (2015). "Varying Dimensional Bayesian Acoustic Waveform Inversion for 1D semi-infinite heterogeneous media". *Probabilistic Engineering Mechanics*, Vol. 39: 56-68. doi:10.1016/j.probengmech.2014.11.002

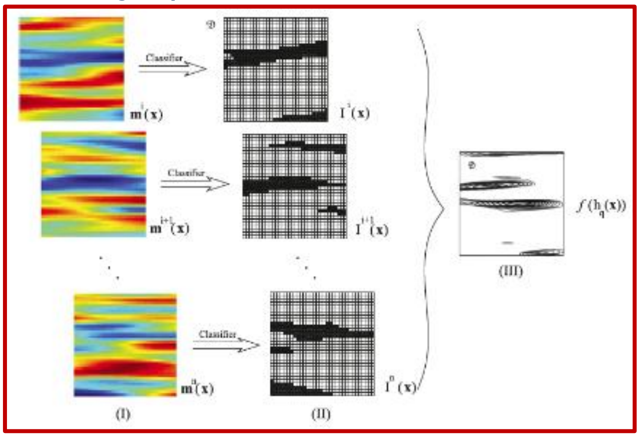
For more information contact: Associate Prof. Zenon Medina-Cetina

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

h.5 Joint states of information from different probabilistic geo-profile methods

Development of technologies for site characterization has grown at a faster pace compared to the development of decision-making methods required for the assimilation of inferences they generate. In the case of geophysical surveying, such dephase adds to the dependency on the use of expert's judgment in the interpretation of geophysical mappings. A systematic assimilation of this type of geo-surveying evidence is required, in particular for the integration of spatial geomorphological information (i.e. stratigraphy), characterized from different geophysical methods. Current effort at TAMU focuses on developing a methodology to address this challenge by the use of a probabilistic approach.



Relevant publications:

• Medina-Cetina Z, and Esmailzadeh S (2014). "Joint States of Information from Different Probabilistic Geo- Profile Reconstruction Methods," *Georisk: Assessment and Management of Risk for Engineered Systems and Geohazards*, Vol 8 (3): 171-191. DOI:10.1080/17499518.2014.939411

For more information contact: Associate Prof. Zenon Medina-Cetina

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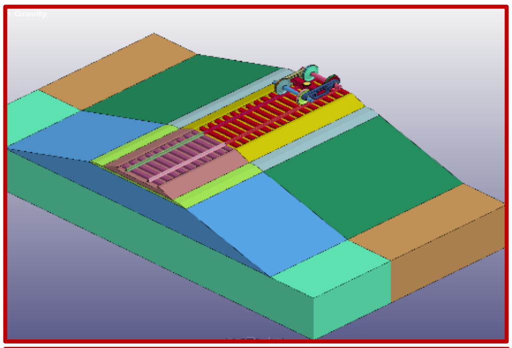
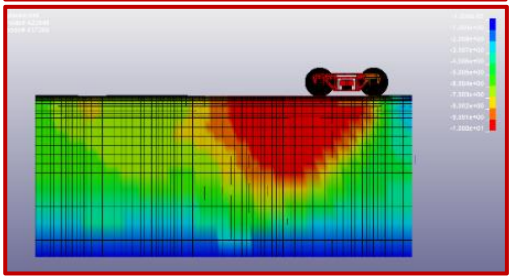
Railroad geomechanics

i.1 High speed trains geotechnics

High speed train (HST) embankments are being constructed in the USA. Two major lines will join Los Angeles to San Francisco on one hand and Houston to Dallas on the other. One of the issues is what happens when the high speed train passes ground Mach 1. This phenomenon is similar to the sonic boom of the airplane when it passes Mach 1. More precisely, the HST generates a surface wave which propagates in front of the train at slow speeds. At high speeds the train may go faster than the surface wave that it generates. The critical speed at which the train goes as fast as the surface wave may be well within the speed of high speed trains particularly for soft soils (say 300kph). The problem is to know if, when the train passes ground Mach 1, the train vibrations are amplified to the point of potentially derailing the train. This was studied by numerical simulations using LS-DYNA and the results give the amplification factor at Ground Mach 1.





Relevant publications:

• Briaud J-L, and Rezaei Tafti S. (2015). "Ground Mach 1 and high speed train stability" interim report to the Texas A&M Transportation Institute and the University Transportation Center for railway safety

For more information contact: Prof. Jean-Louis Briaud

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

i.2 Uneven settlements of railroads settlements on shrink-swell soils

Problems associated with continuous settlement are typically observed in railroads in Texas. Different physical mechanisms can be behind these issues. Natural soils in Texas are dominated by shrink-swell clays (also known as expansive soils). These kinds of clays are characterized by significant expansions and contractions when they are subjected to wetting and drying processes, respectively. Railways on shrink-swell soils are subjected to huge solicitations associated with the volume changes of the soil, generally leading to unacceptable uneven settlements. We are combining field investigation, laboratory tests and numerical modeling to advance our current understanding of this problem. We have selected an instrumented Union Pacific railroad section to perform the field investigation and monitoring. We are looking at the mechanisms behind these problems and also at some possible remedial solutions. The field and laboratory investigations are supported with numerical analysis.

Relevant publications:

- Sánchez M, Wang D, Briaud J-L, and Douglas C (2014). "Typical Geomechanical Problems of Railroads on Shrink-swell soils". *Transportation Geotechnics*, Vol 1 (4): 257–274. doi:10.1016/j.trgeo.2014.07.002.

For more information contact: Associate Prof. Marcelo Sanchez

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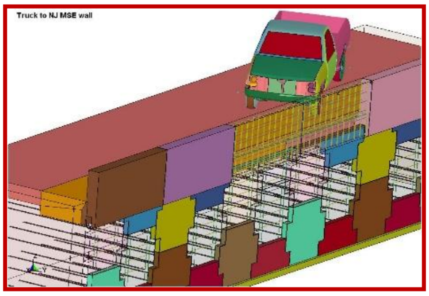
Retaining walls

j.1 Mechanically Stabilized Earthfill (MSE) wall design to resist barrier impact



Roadside safety guard rails are typically anchored in the soil by installing a short pile to a depth of about 1m. In the case of MSE retaining walls this is not possible as there is no soil on the back side of the pile to resist the impact of the vehicle. Instead an L shape barrier moment slab is the system is chosen to redirect the vehicle (figure). In this system the moment slab must be wide enough to keep the barrier from rotating excessively during impact. A series of vehicle impacts against full scale MSE walls have been carried out with complete instrumentation of the wall and the L shape barrier. The vehicles included a 1.5 ton pick-up truck, a 7 ton single unit truck, and a 40 ton tractor trailer (18 wheeler) at speeds ranging from 80 to 100 kph. During the 200 millisecond impact all the instrumentation data were collected including the load in the reinforcement, the acceleration of many components, and the deflection of the barrier and the wall. These expensive data were used to calibrate the models and a parametric study was conducted to develop design guidelines for such conditions.

Relevant publications:

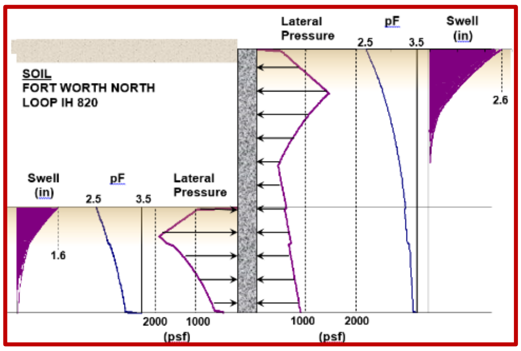
- Kim K, Briaud J-L, Bligh R., Abu-Odeh A, Saez D. (2012), "Design Guidelines and Full Scale Verification for MSE Walls with Traffic Barriers", *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 137 (6):690-699, ASCE

For more information contact: Prof. Jean-Louis Briaud

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

j.2 Design cut-type tie back retaining walls in expansive soils



Design of retaining walls in expansive soils must take into account the horizontal swelling pressure that develops behind the wall. The swelling pressure is diminished by the deflection of the wall away from the soil and this interaction must also be taken into account. If the retaining wall has tie-back cables, their effect on restraining the outward deflection of the wall must also be accounted for. This is the subject of a research project that was completed cooperatively between TAMU and the Univ. of Texas at San Antonio. The project included in situ measurements on such walls to verify the theory and to refine the design approach. More info can be found in the paper below.

Relevant publications:

- Papagiannakis AT, Bin-Shafique S, and Lytton RL (2011). "Retaining Structures in Expansive Soils," Proceedings, XV Euro Conference on Soil Mechanics, Athens, Greece.

For more information contact: Prof. Robert Lytton

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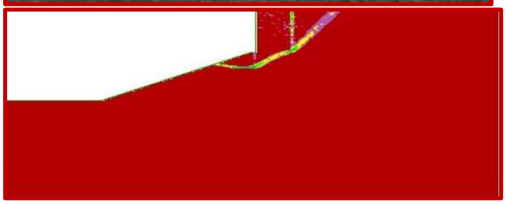
j.3 MSE Walls



Since their appearance in the 1970s, mechanically stabilized earth (MSE) walls have become a majority among all types of retaining walls due to their economics and satisfactory performance. However, Texas Department of Transportation (TxDOT) engineers have expressed concerns about both design assumptions and methodology, including soil parameter selection, to meet the required stability limits and possible failure modes. A recent project examined the assumptions and the analysis methods based on data collected from TxDOT and other projects, laboratory testing, statistical analyses, back analyses of the historical data, and numerical simulations.

Relevant publications:

- Charles P. Aubeny, Giovanna Biscontin, Jie Huang, Vishal S. Dantal, Rafat Sadat, and Sazzad Bin-Shafique, Design Parameters and Methodology for Mechanically Stabilized Earth (MSE) Walls (2014) FHWA/TX-14/0-6716-1, TxDOT.

For more information contact: Prof. Charles Aubeny

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

j.4 Full scale retaining wall experiments and design guidelines

Two large scale heavily instrumented retaining walls were built at the National Geotechnical Experimentation Site at TAMU. The soil at the site is a silty sand with an SPT blow count of 20 bpf, a CPT point resistance of 9000 kPa, a PMT limit pressure of 1000 kPa and PMT modulus of 9000 kPa. One wall was a 10 m high 60 m long tieback wall (soldier pile and lagging), the other was a 10 m high 60 m long vertically reinforced wall (soil cement columns). Both are top down construction walls and the instrumentation which included strain gages, inclinometers, displacement targets, was monitored during excavation and for one year after completion. Numerical simulations were used to extend the value of the large scale experiments and led to design guidelines. Soil nailed walls used in unimpeded turn around were also studied with associated recommendations.

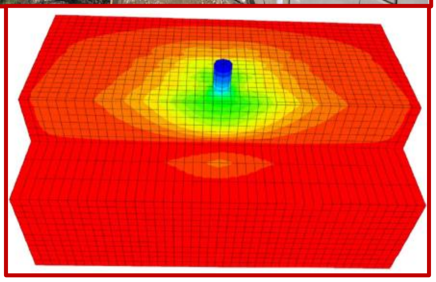
Relevant publications:

- Briaud J-L, Lim Y, (1999). "Tieback Walls in Sand: Numerical Simulation and Design Implications". *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 125 (2): 101-111, ASCE.
- Briaud J-L, Nicholson P, Lee J, (2000). "Behavior of a Full-Scale VERT Wall in Sand". *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 126 (9): 808-818, ASCE.

For more information contact: Prof. Jean-Louis Briaud

j.5 Interaction between drilled shaft MSE wall

The interactions between Mechanically Stabilized Earth (MSE) walls and drilled shafts are generally disregarded. However, the interaction between drilled shafts and MSE wall is inevitable and has to be addressed appropriately in the design and construction of MSE wall. We are investigating this problem by: i) performing a full scale horizontal loading tests (until failure) on a new densely instrumented MSE wall, ii) monitoring two actual MSE walls under actual operational conditions with imbibed shafts, and iii) simulate the interaction between MSE walls and shaft by numerical models to interpret the tests and to study different geometries and boundary conditions.



Relevant publications:

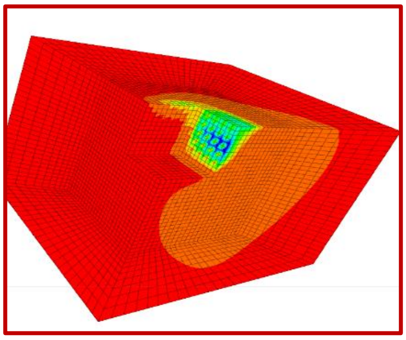
- Aghahadi M, Sánchez M, and Briaud J-L. "Experimental and Numerical Study of a MSE wall subjected to lateral load" (in preparation).
- Briaud J-L, Sánchez M, and Aghahadi M (2015). "Interaction between drilled shaft MSE wall". Final Report to the Texas Department of Transportation, USA

For more information contact: Prof. Jean-Louis Briaud or Associate Prof. Marcelo Sanchez

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

j.6 Behavior of soil nails in high plasticity clays



Our activities are aimed at achieving a better understanding of the creep behavior of soil nails walls in high-plasticity clays. Creep behavior depends mainly on load level. Field investigation, laboratory tests and numerical modeling are being used to study the effect of stress level on creep behavior of soil nails. The field studies comprise both: loading and creep tests at the National Geotechnical Experimental Site (NGES), TAMU; and load tests and monitoring of an actual soil nail wall selected by the Texas Department of Transportation (TxDOT). Laboratory tests complement the information gathered from the field. Numerical models (based on limit state analysis and finite element method) are being used to study in more details the behavior of soil nails in high plasticity clays, looking at the effect of different geometries soil properties and boundary conditions.

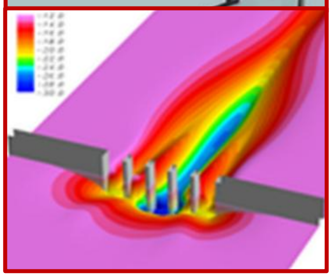
Relevant publications:

- Sánchez M., Briaud J-L, Mahdavi M. Gang B. (2015). "Behavior of soil nails in high plasticity clays" Final Report to the Texas Department of Transportation, USA

For more information contact: Associate Prof. Marcelo Sanchez or Prof. Jean-Louis Briaud

Scour and erosion

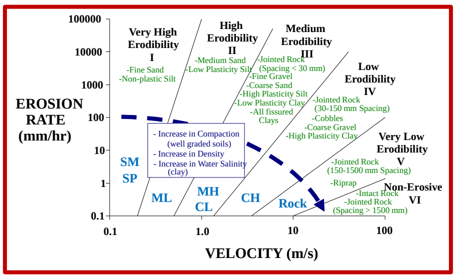
k.1 Scour at bridges



There are about 600,000 bridges in the USA and 500,000 are over water. 1502 bridges have collapsed between 1966 and 2005 at an average rate of one bridge collapsing every 10 days and 60% of the time it is due to scour. This alarming collapse rate has decreased significantly in recent years as research has given better tools for the engineer to design against scour. Some of this research was conducted at TAMU including the development of a device 'EFA' to measure the erodibility of the soil on a site specific basis. A scour depth calculation methodology using the result of the EFA was developed for pier scour, contraction scour and abutment scour. A probability of exceedance methodology was developed to quantify the probability that the predicted scour depth would be exceeded for a chosen design flood. Finally, the observation method was assembled to give a significantly improved prediction of future scour depth based on past observation of flow and measured scour.

Relevant publications:

- Briaud J-L (2015) "Scour depth at bridges: method including soil properties: I maximum scour depth prediction", *Journal Geotech. Geoenvironmental Eng.*, 141(2), 04014104, ASCE.
- Briaud J-L (2015). "Scour depth at bridges: method including soil properties: II time rate of scour prediction". *Journal Geotech. Geoenvironmental Eng.*, 141(2), 04014105, ASCE.

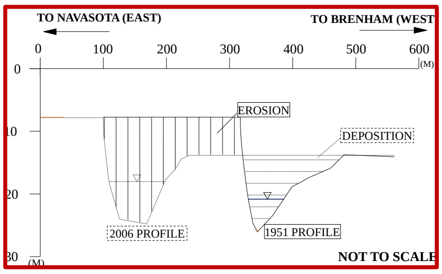


For more information contact: Prof. Jean-Louis Briaud

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

k.2 Meander migration



Meander migration in rivers can create serious problems because the movement of the meander may endanger a bridge or a highway embankment. A large scale project was undertaken to develop a reliable prediction method. This project included very large scale laboratory flume experiments of meanders in sand and in clay, field meander site studies with sampling and erosion testing, numerical simulations, development of a simple prediction methodology as well as the observation method for meander migration prediction. This observation method makes use of past migration movement together with the associated flood hydrograph to obtain the large scale site specific erosion model.

Relevant publications:

• Yeh P-H, Park N, Chang K-A, Chen H-C, Briaud J-L (2011). "Time dependence channel meander migration based on large scale laboratory experiments." *Journal of Hydraulic Research*, 49, 617-629.

• Briaud J-L (2008), "Case Histories in Soil and Rock Erosion: Woodrow Wilson Bridge, Brazos River Meander, Normandy Cliffs, and New Orleans Levees". The 9th Ralph B. Peck Lecture, *Journal of Geotechnical and Geoenvironmental Engineering*, Vol 134 (0): 1425-1447, ASCE.

For more information contact: Prof. Jean-Louis Briaud

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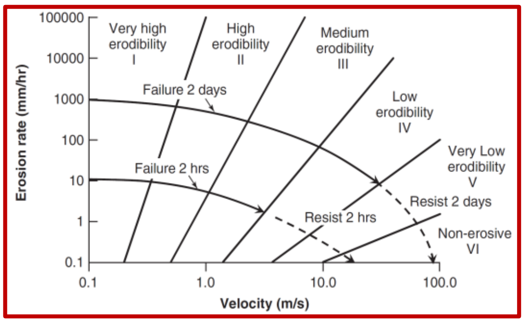
k.3 Levee design for overtopping erosion

Levees can be overtopped during extreme events including hurricanes and river floods. One distinction is that hurricanes might overtop a levee for about 2 hours while river floods can over top a levee for 2 days. During overtopping the velocity on the dry side of the levee can reach up to 10 m/s while the water velocity in rivers during a flood maybe around 3 m/s. During hurricane Katrina which devastated the New Orleans area in 2005, samples were collected from the levees and tested in the EFA. Knowing which overtopped levees resisted the 2 hour overtopping and which failed, an overtopping chart was developed for 2 hour events. Similarly during the Mississippi flood of 2008, samples were collected from the overtopped levees and tested in the EFA. Knowing which overtopped levees resisted the 2 day overtopping and which failed, an overtopping chart was developed for 2 day events.



Relevant publications:

• Bernhardt ML, Briaud J-L, Govindasamy AV, Lim SG, Kim D, Leclair M, Bea RG, Rogers D, Storesund R (2010). "Mississippi River levee failures in 2008: Winfield Pin-Oak and Brevator case histories", *International Journal of GeoEngineering Case Histories*, International Society for Soil Mechanics and Geotechnical Engineering.

• Briaud J-L (2013). "Geotechnical Engineering: Unsaturated and Saturated Soils", *John Wiley and Sons*, New York, 1000 pages. (Chapter 23: Erosion of soils and scour problems).

For more information contact: Prof. Jean-Louis Briaud

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

Slopes

l.1 Shallow slope failures in expansive soils

Shallow slope failures are common to unsaturated soils but a rational explanation of their mechanism has been elusive. The research project which was supported by the Texas Department of Transportation together with field observations of numerous such shallow slides permitted the development and verification of a mechanics approach to predicting the unsaturated conditions under which these slope failures will occur. The paper summarizes the mechanism and the findings.

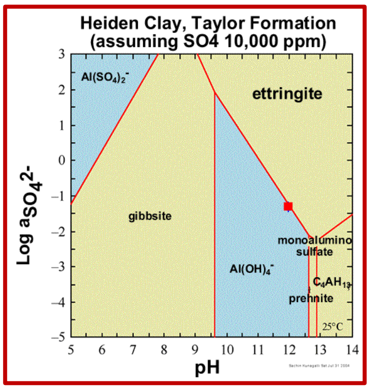
Relevant publications:

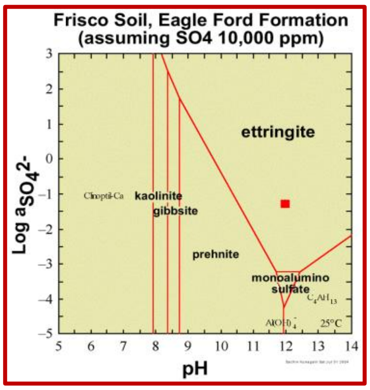
• Aubeny CP, and Lytton RL (2004). "Shallow Slides in Compacted High Plasticity Clay Slopes". *Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 130(7): 717-727.

For more information contact: Prof. Charles Aubeny

Soil stabilization

m.1 Thermodynamic phase diagrams





Chemical stabilization of soils in areas of the world where expansive clay soils abound is critical to the stability of the structure, building or roadway involved. Chemical stabilization with calcium-based stabilizers has been proven world-wide to be an effective treatment to promote changes in the surface chemistry of clay colloids making them less prone to volumetric changes and, in most cases, providing effective cementitious and pozzolanic-induced strength gain. Until very recently principles of thermodynamics have not been considered in the development of chemical reactions promoting the formation of new minerals and pozzolanic/cementitious products that are the source of the stabilization process and provide the basis for determining the durability and efficacy of the reaction. Work at TAMU has demonstrated that the application of principles of chemical solubility, equilibrium and the application of thermodynamics through phase diagrams has been successful in predicting the formation of deleterious reactions and has been equally successful in predicting methods to avert such reactions by the use of additives, alteration of traditional construction protocols, and/or a combination of each. At present, more sophisticated phase diagrams and thermodynamic models are being developed to provide insight in how to more efficaciously stabilize expansive clay soils and at the same time avert deleterious reactions such as those caused by sulfate bearing compounds.

The figures demonstrate the risk of the formation of a very expansive mineral, ettringite, as a function of pH and sulfate content (activity) in lime treated Heiden and Fisco clay soils from Texas. In the figure, the red "square" represents the locus of a pH of about 12.0 (typical of a well-treated clay soil with lime or Portland cement) and a sulfate activity (function of concentration) of about 10,000 mg/Kg. The position of the red square relative to the ettringite polygon helps to identify the risk of ettringite formation which is substantially higher for the Frisco soil.

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

Relevant publications:

• Little DN, Nair S, and Herbert B (2010). "Addressing Sulfate-Induced Heave in Lime Treated Soils," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 136(1): 110-119. ASCE.

• Nair S, and Little DN (2011). "Mechanisms of Distress Associated with Sulfate Induced Heave in Lime Stabilized Soils", *Journal of the Transportation Research Board*, Best Paper Award in Soil Mechanics Division, Washington, D. C., N° 2212: 82-90. ASCE

For more information contact: Prof. Dallas Little

m.2 Non-Traditional Stabilizers

Texas A&M researchers have developed non-traditional soils stabilizers and have investigated their role in deep treatment of clay soils throughout the "active zone" to mitigate the impact of volumetric changes due to changes is suction profiles within the active zone. One such stabilizer group are sulphonated oils which have existed in several forms for a number of years; however, their value and risk is now under laboratory and field investigation with emphasis on validation of mechanisms and the efficacy of diffusion of the low viscosity amendment in the process of injection.

Texas A&M researchers are developing specific polymers to stabilized clay and non-clay soils. These stabilizers have proven to be surprisingly effective at relatively low concentrations and have proven to provide an increased toughness and extended fatigue resistance compared to cementitously treated soils. A terpolymer with ionic, anionic and non-ionic sites is being investigated as a generally effective treatment for a wide range of soils.

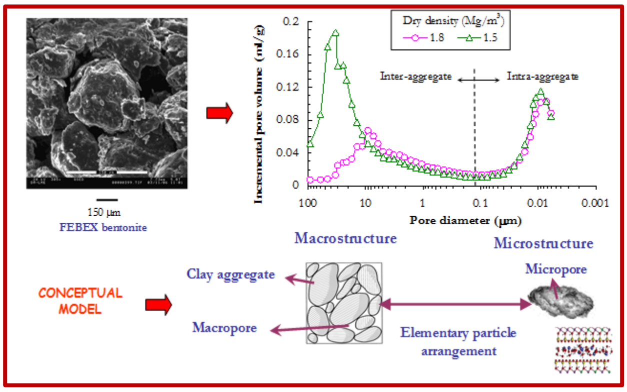
Relevant publications:

• Iyengar SR, Masad E, Rodriquez A, Bazzi H, Little DN, and Hanley H (2013), "Pavement Subgrade Stabilization Using Polymers: Characterization and Performance", *Journal of Materials in Civil Engineering, American Society of Civil Engineering*, Vol. 25(4): 472-483. ASCE

For more information contact: Prof. Dallas Little

Unsaturated soils

n.1 Modeling the behavior of expansive clays



A major motivation to study the behavior of expansive clays is their possible use as engineered barriers and seals materials in radioactive waste repositories. However, the interest on these materials is not limited to nuclear waste disposal applications, but they are present in other engineering problems such as shallow and deep foundations in shrink-swell soils, slopes, desiccation and crack formation in soils in arid regions, and clay based liners for waste isolation. Current efforts at TAMU focuses on enhancing a double structure model that consider the two dominant pores sizes typically observed in expansive clays: the macrostructure,

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composed by the global arrangements of clay aggregates, with macropores between them, and the microstructure, which corresponds to the active clay minerals and their vicinity. The double structure model also contemplates the mutual interactions between these two basic pore levels. The figure below illustrate the adopted conceptual model and the references provide detailed information about the constitutive model for expansive clays.

Relevant publications:

- Sánchez M, Gens A, Guimarães L, and Olivella S (2005). "A double structure generalized plasticity model for expansive materials". *Int. Jnl. for Num. and Anal.l Meth. in Geomechanics* 29:751–787. DOI: 10.1002/nag.434.
- Gens A, Vallejan B, Sánchez M, Imbert C, Villar MV, and Van Geet M. (2011). "Hydromechanical behaviour of a heterogeneous compacted soil: experimental observations and modeling". *Géotechnique* vol. 61(5): 367 –386. DOI: 10.1680/geot.SIP11.P.015.

For more information contact: Associate Prof. Marcelo Sanchez

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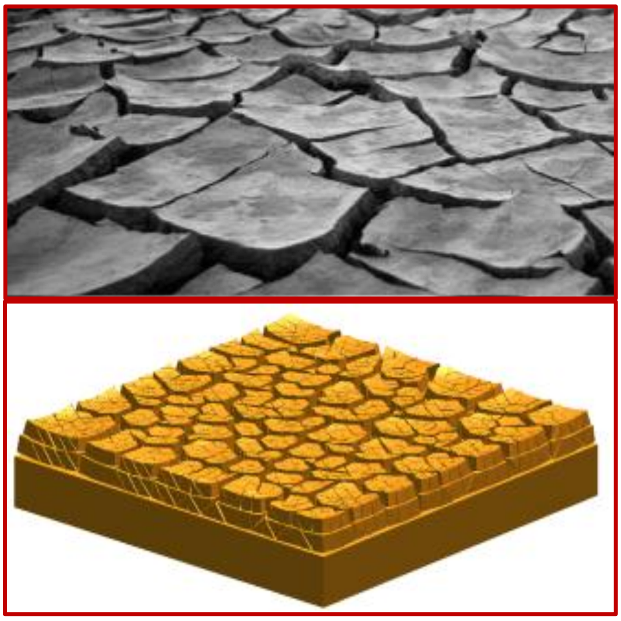
n.2 Desiccation cracks in soils



The formation and propagation of cracks in drying soils are highly complex phenomena that are receiving increasing attention in the last few years. Current research efforts at TAMU are related to the study of existing and new experimental methods to detect the 3D crack networks, as for example, crack detection techniques based on 3D laser scanners and electrical resistivity imagining. Ongoing research at TAMIU also focus on developing new numerical techniques to model the formation and propagation of drying cracks in soils, as for example, the mesh fragmentation technique recently proposed in the framework of a collaboration with Professors Osvaldo Manzoli (UNESP, Brazil) and Leonardo Guimarães (UFPE, Brazil). More information about the experimental and numerical research at TAMU is detailed in the contributions below.

Relevant publications:

- Sánchez M, Atique A, Kim S, Romero E, and Zielinski M (2103). "Exploring Desiccation Cracks in Soils using a 2-D Profile Laser Device". *Acta Geotechnica* Vol. 8 (6): 583-596. DOI 10.1007/s11440-013-0272-1
- Sánchez M, Manzoli O, and Guimarães L. "Modeling 3-D Desiccation Soil Crack Networks Using a Mesh Fragmentation Technique". *Computers and Geotechnics*. Vol 62: 27-39. DOI: 10.1016/j.compgeo.2014.06.009

For more information contact: Associate Prof. Marcelo Sanchez

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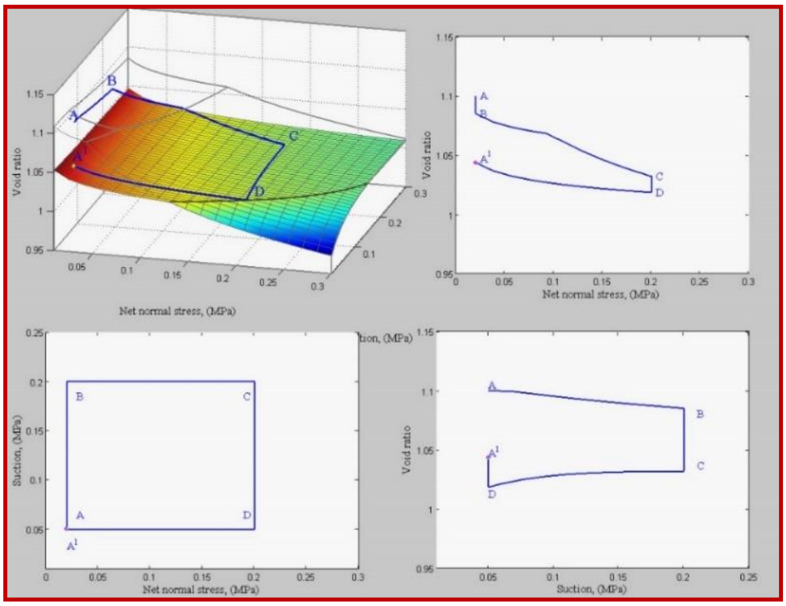
Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

n.3 Modified state surface approach

This formulation of the volume and water (mass) content change in an elasto-plastic geomaterial as a function of changes in matric suction and net normal stress predicts the results of following a multitude of stress paths. The papers listed give numerous examples of the application of the Modified State Surface Approach and compares this approach with published data from other investigators.



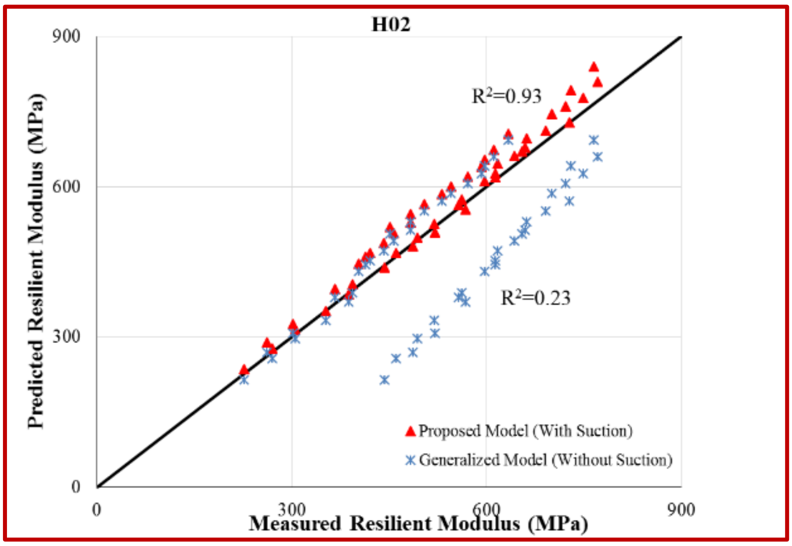
Relevant publications:

- Zhang X, and Lytton RL (2009). "Modified State Surface Approach on Unsaturated Soil Behavior Study (I) Basic Concept." *Canadian Geotechnical Journal*, Vol. 46: 536-552. DOI: 10.1139/T08-136.
- Zhang X, and Lytton RL (2012). "Modified State-Surface Approach to the Study of Unsaturated Soil Behavior. Part III: Modeling of Coupled Hydro-mechanical Effect." *Canadian Geotechnical Jnl*, Vol. 49: 98-120. DOI: 10.1139/T11-089.

For more information contact: Prof. Robert Lytton

n.4 Stress dependent and suction sensitive modulus of granular soils

This formulation is a compact constitutive relation for the stress- and suction-dependent modulus of geomaterials has been applied to the anisotropic moduli of base course materials and verified with laboratory tests on a wide range of such materials. The graph show the error that occurs when the suction is left out of the formulation.



Relevant publications:

- Gu F, Sahin H, Luo X, Luo R, and Lytton RL (2014). "Estimation of Resilient Modulus of Unbound Aggregates Using Performance-Related Base Course Properties." *Journal of Materials in Civil Engineering*, Vol 27: 04014188. ASCE

For more information contact: Prof. Robert Lytton

Research Highlights (Con't)

Texas A&M University – The Geotechnical Engineering and Geomechanics Group

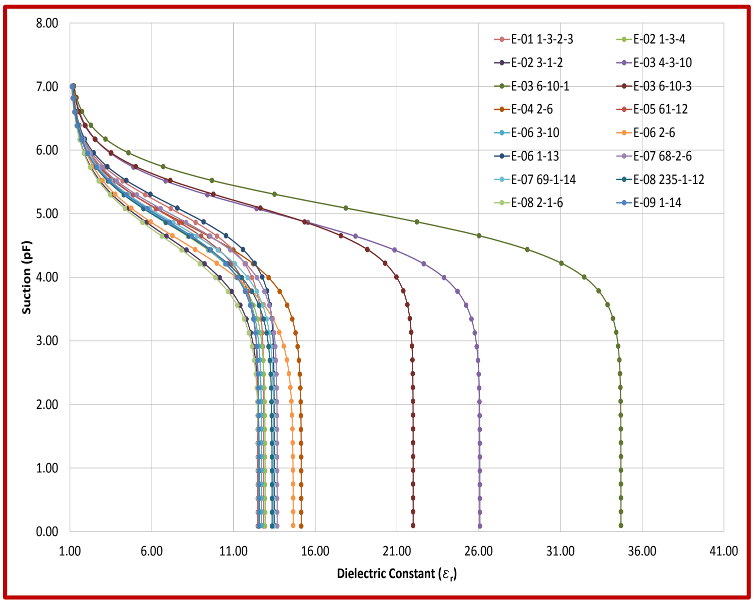
n.5 Measurement of soil suction in the field using ground penetrating radar

An essential element to using Ground Penetrating Radar for construction Quality Control or Quality Assurance of compacted geomaterials is to generate the suction-vs-dielectric constant characteristic curve. Several such curves are in the figure below representing a wide variety of base courses, some of which are known to be excellent and others are known to be poor quality. The four antenna GPR array allows a lane width scan of the dielectric constant of an as-compacted base course material with the data being collected at highway speeds.

Relevant publications:

- Sahin, H. (2014). "Nondestructive Test Methods for Rapid Assessment of Flexible Base Performance in Transportation Infrastructures." Ph.D. Dissertation, Texas A&M University, College Station, Texas.

For more information contact: Prof. Robert Lytton



Research Highlights (Con't)

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Sponsors

The Geotechnical Engineering and Geomechanics Group at TAMU would like to acknowledge the support from the following sponsors that have been made possible the research detailed above.

- ABS Consulting
- ADSC, International Association of Foundation Drilling
- Association of American Railroads (AAR)
- Colorado Department of Transportation
- Consejo de Ciencia, Innovación y Tecnología del Estado de Yucatán (CONCIYTEY)
- European Commission
- Environmental Soil Stabilizers
- Federal Aviation Administration (FAA)
- Federal Highway Administration (FWA)
- Fugro Geoconsulting
- Gardline Group
- Grupo Plenum
- Massachusetts Department of Transportation
- Minerals Management Service (currently BOEM)
- Murphy Oil
- National Energy Technology Laboratory (NETL) – DoE (Department of Energy) US
- National Cooperative Highway Research Program (NCHRP) - IDEA program
- NCHRP Research program
- National Lime Association
- Norwegian Geotechnical Institute Inc. (NGI Inc.)
- PETROBRAS (Petróleo Brasileiro S.A)
- Qatar Foundation
- Research Partnership to Secure Energy for America (RPSEA) & Department of Energy (DoE, US)
- Sandia National Laboratories (DoE, US)
- Simula Geosciences and Statoil
- Spencer J. Buchanan Chair
- Texas A&M Engineering Experiment Station (TEES)
- Texas A&M Transportation Institute
- Texas Department of Transportation
- Union Pacific Railroads
- University of Wyoming
- US Army Corps of Engineers
- US National Science Foundation (NSF)
- US Department of State
- Western Research Institute

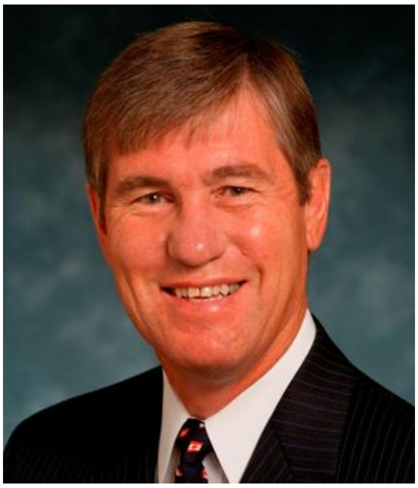
Report from past ISSMGE president

Federation of International Geo-Engineering Societies

FedIGS

FEDERATION OF INTERNATIONAL GEO-ENGINEERING SOCIETIES

A report by
Jean-Louis Briaud
President of FedIGS
Distinguished Professor, Texas A&M University



13 May 2015

Report from past ISSMGE president (Con't)

Federation of International Geo-Engineering Societies

WHAT IS FedIGS?

FedIGS is an umbrella organization linking international professional societies in the field of "Geo-Engineering" and serving to facilitate cooperation among them

The current members are

ISSMGE	International Society for Soil Mechanics and Geotechnical Engineering
ISRM	International Society for Rock Mechanics
IAEG	International Association for Engineering Geology and the Environment
IGS	International Geosynthetics Society

Members retain their complete autonomy and there are no dues.

WHAT ARE THE GOALS OF FedIGS?

The goals of FedIGS are:

1. Facilitate cooperation within the geo-engineering profession
2. Coordinate activities in areas of overlapping interest
3. Raise the public awareness and the profile of the geo-engineering profession
4. To remain a lightly structured, inexpensive, and unobtrusive organization

HISTORY OF FedIGS

The evolution of FedIGS can be summarized in the following two figures. In a first phase (1936 to 2000), ISSMGE, ISRM, IAEG, and then IGS were formed. There was a consistent desire to collaborate, several discussions took place but no formal structure was established and each attempt to get organized faded. In a second phase (2000-2009) there was a recognition that a formal structure was essential and FedIGS bylaws were proposed. The councils of the three founding societies (ISSMGE, ISRM, and IAEG) approved the FedIGS bylaws. In 2010, FedIGS saw a significant restructuring with a simplified vision for the organization described in Figure 3.

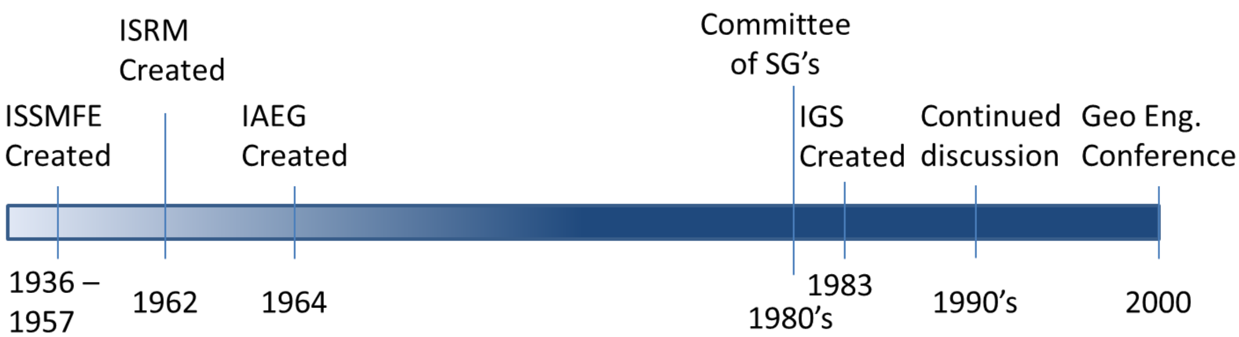


Figure 1. First phase – 1936 – 2000

Report from past ISSMGE president (Con't)

Federation of International Geo-Engineering Societies

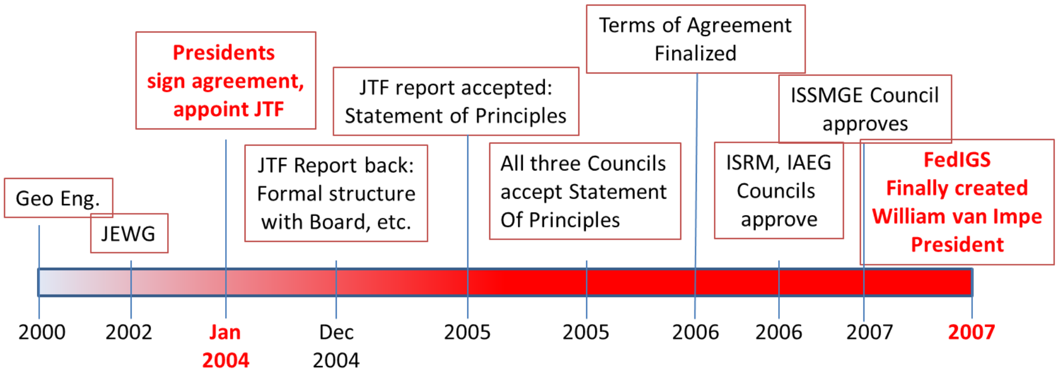


Figure 2. Second phase - 2000 - 2009

1. No dues paid by member societies
2. FedIGS is unfunded; each member society pays its own way and so does the president
3. One meeting per year attended by presidents, past presidents and secretaries general
4. Limited number of joint technical committees in areas of clear overarching needs
5. No corporate associate members from industry
6. No FedIGS conferences; instead emphasize cooperation between member conferences
7. Emphasis on learning from each other and sharing successes and difficulties
8. Increase in size (IGS joins in 2014)
9. Simple web site currently sponsored by IGS

Figure 3. FedIGS since 2010

PRESIDENTS OF FedIGS

The presidents of FedIGS have been:

William Van Impe (Belgium)	2007-2010
Neilen van der Merwe (South Africa)	2010-2013
Jean-Louis Briaud (USA)	2014-2017

MY VISION AS PRESIDENT

My vision as president is summarized in the Figure below

Underlying Principles

1. I will preserve the freedom of each member society
2. I will foster cooperation
3. I wish to listen to your ideas and wishes
4. I have some ideas of my own
5. I believe in action after discussion

Some ideas

1. Bring in more members
2. Review JTCs. Are JTF more appropriate or just different?
3. Active cooperation (e.g.: Eng. Geol. Short course at ISSMGE conf.)
4. Keeping informed of each others activities
5. Web site?
6. Practitioner-professor partnership

Figure 4. My vision

Report from past ISSMGE president (Con't)

Federation of International Geo-Engineering Societies

FedIGS BOARD MEMBERS

The current FedIGS board members are presented in the figure below

ISSMGE

1. **President: Roger Frank**
2. **Past President: Jean-Louis Briaud**
3. **Secretary General: Neil Taylor**

ISRM

1. **President: Eda Quadros**
2. **Past President: Xia Ting Feng**
3. **Secretary General: Luis Lamas**

IAEG

1. **President: Scott Burns**
2. **Past President: Carlos Delgado**
3. **Secretary General: Faquan Wu**

IGS

1. **President: Russell Jones**
2. **Past President: Jorge Zornberg**
3. **Secretary General: Elizabeth Peggs**

Figure 5. FedIGS Board Members in 2015

SUMMARY OF TORINO MEETING - 2014

The FedIGS Board met in Torino where it was hosted by IAEG at the occasion of the 2014 IAEG International Conference. Figure 6 is a summary of the items discussed at the meeting.

Reports from IAEG, ISSMGE, ISRM, IGS

Web Site – yes but simple and linking to individual societies

New Members – ICOLD?

Cooperation items – shared sessions, short courses

Joint Technical Committees -

1. Landslides – (Luciano Picarelli, Italy)
2. Data – (David Toll, UK)
3. Education – (to be determined)

Professor-Practitioner partnership

1. Web site with research needs
2. Case history papers

Copyright agreement

ISSMGE Foundation

Bylaws need to be adjusted

Next meeting

1. 2015 - ISRM China – 4-7July2015
2. 2016 – IGS – Miami, USA – 15April2016
3. 2017 – ISSMGE? – Seoul - 2017

Figure 6. Summary of Torino 2014 FedIGS meeting

Report from Member Society

Chinese Taipei Geotechnical Society (CTGS)
Re-run of 47th Terzaghi Lecture in Taiwan (7th – 21st March 2015)

An international well-known geotechnical scholar, the fellow of National Academy of Engineering and professor in Department of Civil Engineering of University of Taxes Austin, Dr Kenneth Stokoe - invited by Chinese Taipei Geotechnical Society (CTGS), to visit Taiwan from 7th to 21st of March 2015 for almost 2 weeks. His visit is mainly funded by the Ministry of Science and Technology, Executive Yuan, Taiwan and other sponsors include Department of Construction Engineering of National Taiwan University of Science and Technology (NTUST), Department of Civil Engineering of National Cheng-Kung University (NCKU), Department of Civil Engineering of National Chiao-Tung University (NCTU), CECI Engineering Consulting Engineering Inc. (CECI), National Centre of Research on Earthquake Engineering (NCREE), CTGS, Sustainable development committee of CICHE and Kaohsiung City Professional Civil Engineer Association.

Dr Stokoe delivered his five presentations based on three topics in Taipei City, Hsinchu County and Tainan City respectively. Dates and places of his touring presentations were at 10th and 11th of March in NTUST (Taipei City), 13th of Match in NCKU (Tainan City), 18th of March in NCTU (Hsinchu County) and 19th of March in CECI back in Taipei City again. Among his presentations in Taiwan, the one and only presentation that Dr Stokoe delivered on the 10th of March to his Taiwanese fans had the same content in which that he presented back in the 47th Terzaghi of Year 2011; the re-run seminar on the 10th of March in Taipei brought to his fans more of his fruitful researching results.

Topics of the speeches which Dr Stokoe provided in Taiwan are (together with the link of presentation file)

1. Seismic Measurements and Geotechnical Engineering
   http://www.tgs.org.tw/download/data/2015/03/47th_Terzaghi_Prof._Stokoe_0310.pdf

2. The Increasing Role of Seismic Measurements in Geotechnical Engineering
   http://www.tgs.org.tw/download/data/2015/03/Prof._Stokoe_presentation_0318.pdf

3. Effectiveness of Inhibiting Liquefaction Triggering by Shallow Ground Improvement Methods: Field Shaking Trials with T-Rex in Christchurch, New Zealand
   http://www.tgs.org.tw/download/data/2015/03/Prof._Stokoe_presentation_0313.pdf

Not only that Dr Stokoe visited three universities during this two-week stay in Taiwan which includes NTUST, NTCU and NCKU but as well as NCREE and CECI. Dr Stokoe's speeches have broadens the horizons in the geotechnical engineering field; he introduces the new knowledge of large-scaled geotechnical earthquake in-situ tests, which led to the enhancements in evaluating soil dynamic properties, hence, assist in promoting skills and technologies of the engineering field. Through the collaborative meetings of the industry-academia, government and researches, this helps to exchange best practices and benefits to current researches relating to large-scaled geotechnical earthquake engineering in-situ tests and liquefactions in Taiwan.

Photo 1. Group photo after the delivery of Terzaghi Lecture on 10th of March in NTUST

Report from Member Society (Con't)

Chinese Taipei Geotechnical Society (CTGS)

Re-run of 47th Terzaghi Lecture in Taiwan (7th – 21st March 2015)

Photo 2. Professor Stokoe responded questions raised by Professor Fang, Y. S., President of CTGS after delivery of Terzaghi lecture on 10th of March in NTUST

Photo 3. Photo taken during the presentation by Professor Stokoe on 13th of March in NCKU

Report from Member Society (Con't)

Chinese Taipei Geotechnical Society (CTGS)

Re-run of 47th Terzaghi Lecture in Taiwan (7th – 21st March 2015)

Photo 4. After delivery of the lecture of Professor Stokoe and academic staffs of NCKU on 13th of March in NCKU

Photo 5. Professor Fang, Y. S. giving tour guide of the disaster protection centre of NCTU to Professor Stokoe during the visit on 18th of March

Report from Member Society (Con't)

Chinese Taipei Geotechnical Society (CTGS)

Re-run of 47th Terzaghi Lecture in Taiwan (7th – 21st March 2015)

Photo 6. Group photo taken after delivery of speech in CECI together with Professor Li, John, Chairman of CECI and Dr Lee, S. M. (session chair) on 19th of March

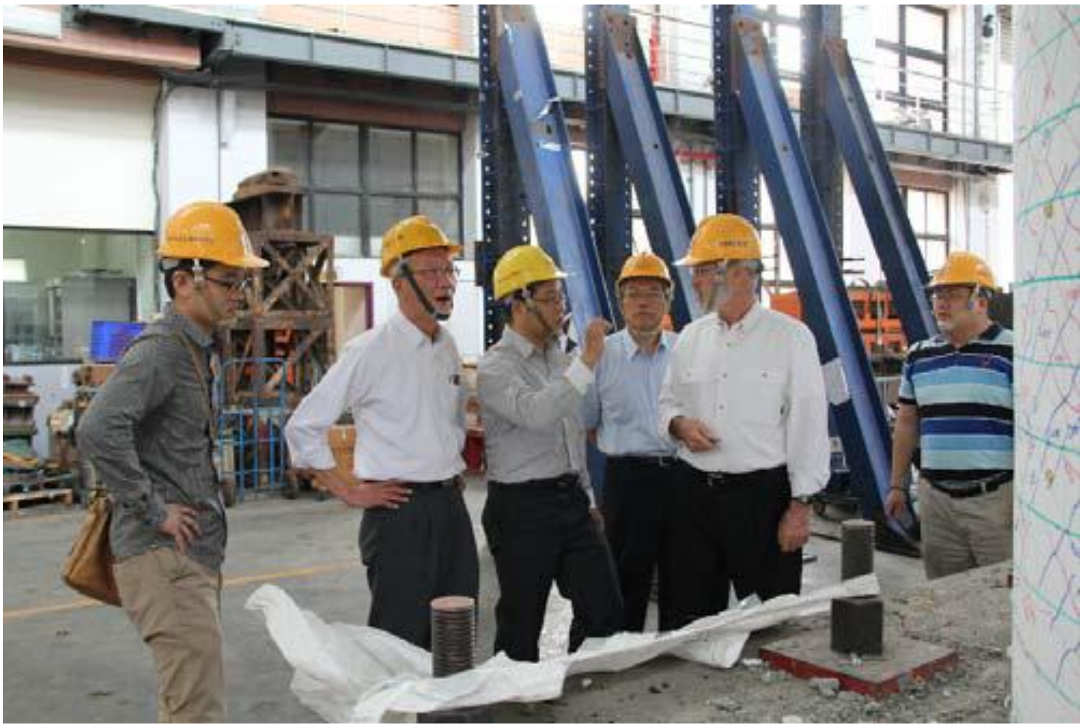


Photo 7. Professor Chen, C. S. discussing the test and related facilities of NCREE to Professor Stokoe during the visit on 20th of March

Prepared by: Ni, S. H. Tony, Hsiung, B. C, Benson, Yang, Kuo- Hsin,

Major Project

Innovative Foundation Design for Happy Valley Underground Stormwater Storage Scheme, Hong Kong

G.S.K. Chou[1], K.W.N. Ko[2]
[1]*General Manager - Technical, Chun Wo Construction & Engineering Co. Ltd, Hong Kong*
[2]*General Manager - Special Projects, Chun Wo Construction & Engineering Co. Ltd, Hong Kong*

ABSTRACT

This paper presents an innovative design approach for the foundations of an underground stormwater storage tank situated in Happy Valley, Hong Kong. The innovative design, first initiated by the Contactor, i.e. Chun Wo Construction & Engineering Co Ltd, mitigated some 533 rock socketted H-piles in the Conforming Design. The solution not only abated the adverse impacts of the piling works on the neighbourhood, but also avoided the emission of approximately 8,043 tonne of CO_2-e into the atmosphere which has a similar effect of planting 205,938 trees. The first phase of the project has been completed in April 2015.

1. Introduction

Flooding incidents as a result of major rainstorms are not unusual in Hong Kong. In June 2008, Hong Kong had its heaviest rainfall in 124 years. A lot of areas, including Tung Chung, Happy Valley and Wan Chai districts were flooded severely (Figure 1). To alleviate the problem in Happy Valley and Wan Chai area, a long-term solution has been proposed by the Drainage Services Department (DSD), the Government of the Hong Kong Special Administrative Region (HKSAR) which entails construction of an underground stormwater storage tank (USST), storing temporarily part of the stormwater collected from the upstream catchment for attenuating the peak flow in the downstream drainage system after heavy rainstorms. This scheme, known as Happy Valley Underground Stormwater Storage Scheme (HVUSSS), reduces substantially the risk of flooding to the low-lying areas of Happy Valley and Wan Chai districts. Chun Wo Construction & Engineering Company Limited (Chun Wo) has been commissioned by the DSD to undertake the construction works under an Engineering & Construction Contract (Contract No. DC/2012/03). Following the commencement of works, Chun Wo proposed an innovative Cost Savings Design (CSD) for the foundation of the USST in which 533 numbers of pre-bored H-piles up to 55m in length are mitigated.

(a) (b) (c)

Figure 1. Flooding incidents in Hong Kong: (a) North Lantau Expressway, near Tung Chung, (b) Happy Valley Recreation Ground, (c) Wan Chai District

1.1 The Site

The HVUSSS project site is situated in Happy Valley, Hong Kong Island, within the Happy Valley Recreation Ground surrounded by the horse-racing field of the Hong Kong Jockey Club (Figure 2).

Major Project (Con't)

Innovative Foundation Design for Happy Valley Underground Stormwater Storage Scheme, Hong Kong

The closest distance of the race track to the site is about 26m from its eastern edge. The site is relatively flat with elevations varying from +4.3mPD to +5.0mPD, and is mostly used as football pitches managed by the Leisure and Cultural Services Department (LCSD). The USST is beneath football pitches 2, 3, 4, 6 and 12.

Figure 2. Location of HVUSSS project site; Insert: Project site in Happy Valley Recreation Ground, surrounded by the horse-racing field of the Hong Kong Jockey Club (Images from Google Map)

1.2 Scope of Works

The scope of HVUSSS comprises construction of an inlet structure, a twin-cell box culvert with overflow weirs and controlling penstocks, a USST with a minimum capacity of 60,000m^3 and an integrated pump house to receive overflow during severe rainstorms. The civil and structural works being constructed include:

(a) A USST with a capacity of 60,000m^3 and an integrated pump house;
(b) A 400m long twin-cell box culvert (4,000mm×2,000mm); and
(c) Modification of an existing box culvert and construction of a stilling basin, a fan room, access manholes, drainage and sewer diversion works.

The works are separated into two phases, meeting the needs of the users of the existing Happy Valley Recreation Ground. In Phase 1, the works (in pink, Figure 3) include about half of the USST, a stilling basin, a box culvert, twin drainage pipes, a pump house and a fan room. Thereafter, football pitches 2, 3, 4 and 8 will be re-turfed sequentially, whereas in Phase 2 the remaining portion of the USST (in purple, Figure 3) will be constructed, followed by re-turfing at football pitches 6 and 12.

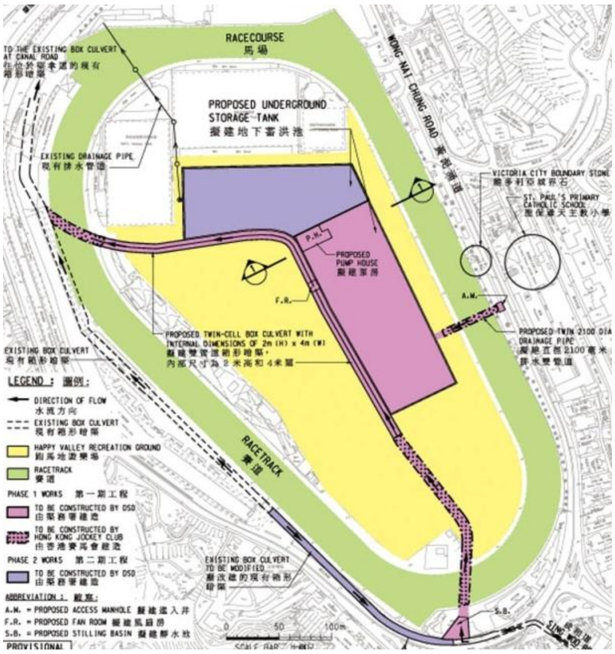


Figure 3. Working plan & arrangement of HVUSSS

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Innovative Foundation Design for Happy Valley Underground Stormwater Storage Scheme, Hong Kong

2. Site Geology

2.1 General Geology

According to the previous and the recent additional borehole records, the ground strata beneath the site consist of 1 to 5m of fill on the ground surface. Layers of alluvial sand, silt and clay up to a depth of 13m, with inter-bedded clayey to sandy marine deposit found over the northern and western portion of the site. Decomposed granite (Grade VI, V and IV) is encountered at depths between 20 to 50m. Rock head of granite (Grade III or better) is encountered at elevations ranging from –30mPD at the east side to –50mPD at the west side. The top level of soil strata are summarized in Table 1 below. A particular section showing the geological profile in relation to the USST is shown in Figure 4.

Table 1. Top level of soil strata

Strata	Top Level (mPD)
Fill	5.40 to 0.28
Alluvium	4.40 to -12.77
Marine Deposit	0.44 to -7.34
Colluvium	-4.78 to -0.78
CDG	-9.49 to -58.83
HDG	-7.77 to -59.23

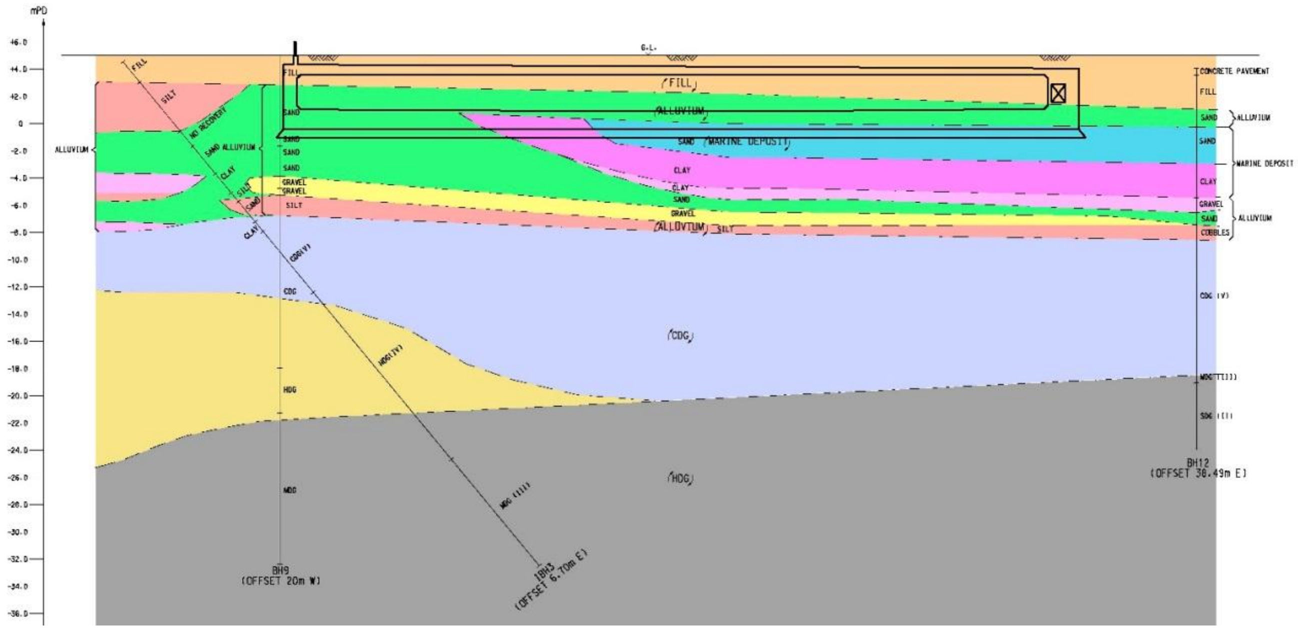

Figure 4. Conforming piling layout plan of the USST

2.2 Groundwater Condition

Standpipes were installed in a number of drillholes during the ground investigation works. Fieldworks were carried out from July 2010 to February 2011. Available groundwater monitoring records have been used to review the groundwater condition. The measured highest groundwater levels are between +4.99mPD to +2.88mPD and the measured lowest groundwater levels between +4.61mPD to +2.83mPD, both declined from the hillside at the southeast to the lower ground at the northwest.

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Innovative Foundation Design for Happy Valley Underground Stormwater Storage Scheme, Hong Kong

3. Conforming Design of Foundations

3.1 General Arrangement

The structure of the USST and the integrated pump house is L-shaped on plan, 58.5m to 69.5m wide, 161.1m and 231.5m along the outer edges of the legs (Figure 5). The invert of the tank varies from +1.10mPD at the outer corners around the pump house to –0.9mPD near the midpoint. The contract drawings show that the tank and pump house are supported by 533 nos. of pre-bored steel H-piles (Grade S460 UC 305×305×180 and 305×305×223kg/m, with lengths ranging from 40 to 60m) socketted into bedrock, sustaining compressive loads from 5,045kN to 7,354kN and tension loads from –431kN to –2,457kN. The dead weight of the tank is lighter than the original soil mass replaced by the tank, and the tank is thus subject to upthrust from the groundwater. Piles in the Conforming Design are to hold down the tank when it is empty in most of its operation life. The conforming piling layout is shown in Figure 5.

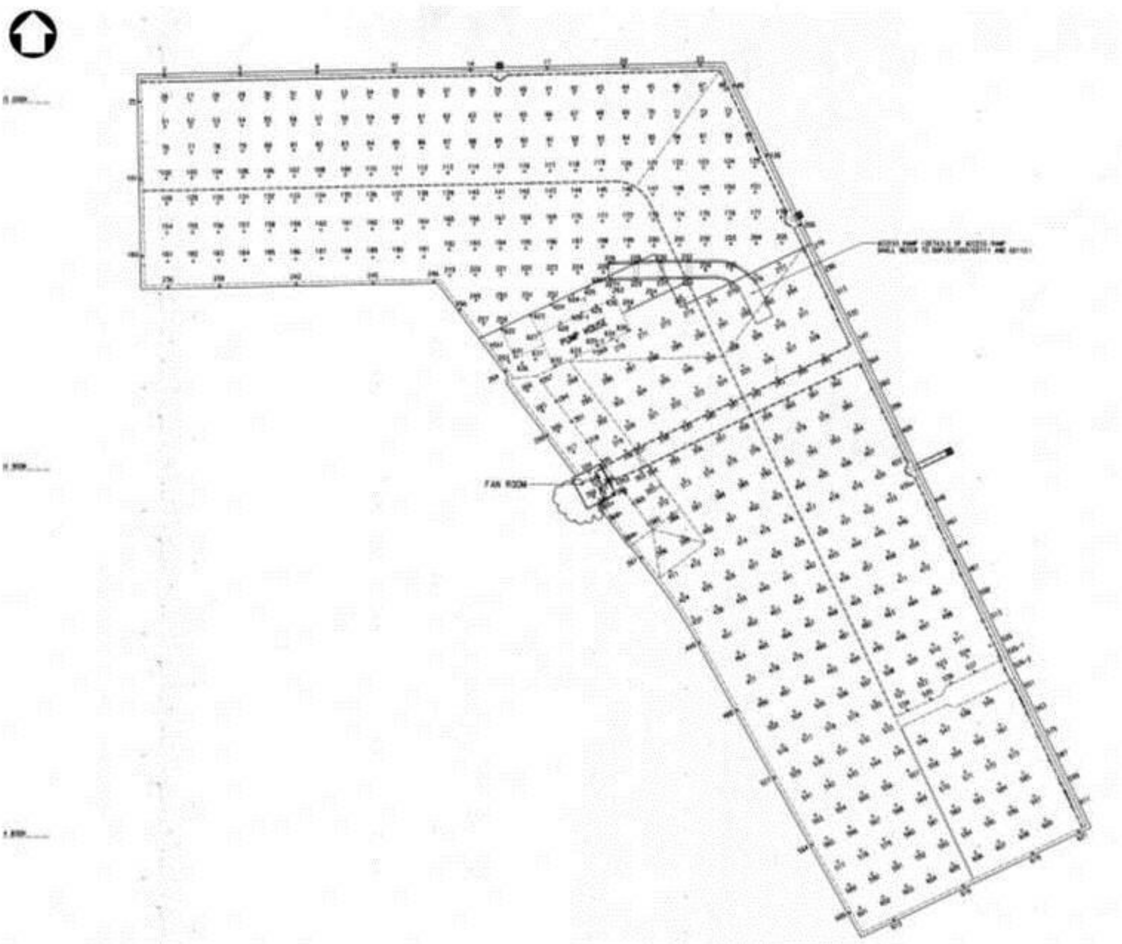

Figure 5. Conforming piling layout plan of the underground stormwater storage tank

3.2 Resistance to Buoyancy – Statutory Requirements

In Hong Kong, checking of a structure against buoyancy is stated in the Code of Practice for Foundations (2004) published by the Buildings Department. A structure may resist buoyancy by its own weight plus any other suitable anchoring resistance such as tension piles or ground anchors. Any structure satisfying either one of the following criteria, further checking on the stability of the structure against overturning due to buoyancy may not be explicitly required:

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Innovative Foundation Design for Happy Valley Underground Stormwater Storage Scheme, Hong Kong

(a) A minimum factor of safety (FoS) of **1.5** against flotation which is due to the highest anticipated groundwater level whereas the resistance is taken as the combined dead loads and permitted anchoring resistance (Figure 6a).

(b) A minimum factor of safety of **1.1** against flotation where buoyancy is due to the highest possible groundwater level and the resistance is taken as the minimum dead loads only (Figure 6b).

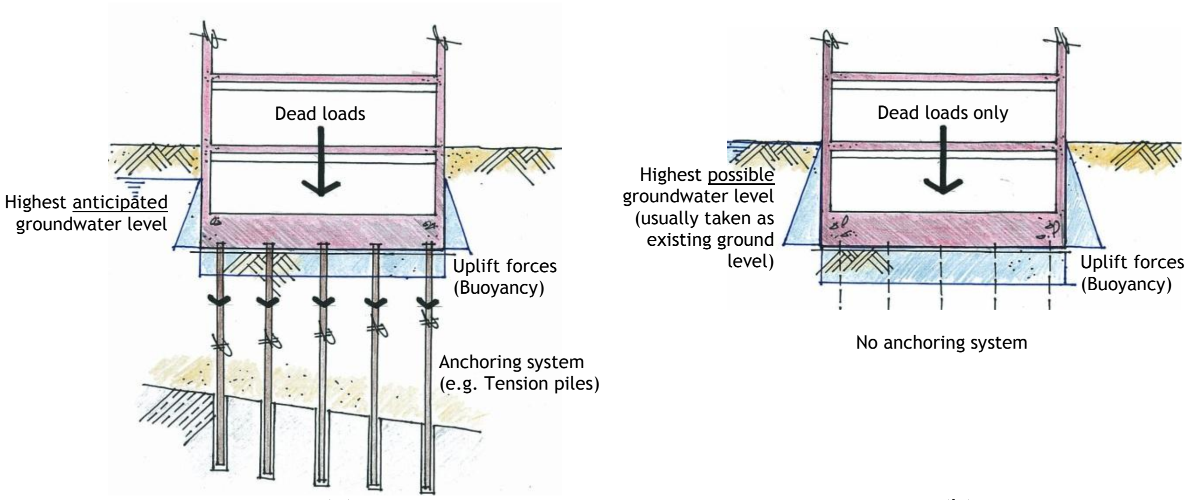

Figure 6. Statutory requirements for buoyancy check in different conditions: (a) FoS ≥ 1.5, (b) FoS ≥ 1.1

3.3 Construction Issues / Constraints

Typical installation cycle for pre-bored H-piles comprises of drilling of a hole, inserting H-pile segments, splicing of H-piles by welding, testing of welds and grouting. The construction work is particularly prone to delay owing to the following issues and constraints:

(a) **No obstruction to viewing of horse racing** – The horse-racing field must remain operational during construction. The horse-racing season runs in the dry season from September to July in the following year, when drilling work will be performed. All plants and un-spliced piles will have to be positioned and lowered (Figure 7a) before the racing in order not to obstruct the viewing (Figure 7b).

(b) **Potential impact on construction programme** – As mentioned above, construction work must be performed with minimal impact to operation of the horse-racing field. Drilling operation and mobilisation of drilling equipment will be limited to only the off hours each day. In addition, there is a risk of insufficient piling rigs in view of the constrained construction programme and the large amount of pile installation work involved.

(c) **Risk of settlement owing to piling** – Pre-bored holes for H-pile are drilled using a down-the-hole drill. During this drilling process, compressed air is injected to drive the drill bit and to expel the excavated materials out to the air at ground level. However, the compressed air may cause blow-out and/or caving-in of weak layer forming voids around the drillhole. As a result, settlement of nearby ground may occur due to subsidence of ground towards the voids. While settlement during construction is always undesirable, the adverse effect of settlement to this project would be particularly significant due to the potential danger presented to field users including jockeys and horses (Figure 7c).

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Innovative Foundation Design for Happy Valley Underground Stormwater Storage Scheme, Hong Kong

(a) (b) (c)

Figure 7. (a) General site setup for pre-bored H-pile works, (b) No visual impacts during horse-racing, (c) Risks to users of the horse-racing field

4. Cost Savings Design of Foundations

In view of the issues / constraints listed in Section 3.3 above and taken account of the need to counteract against flotation, several design ideas as outlined below have been considered and the selected solution is explained Sections 4.1 to 4.5 below.

(a) **Bored piles** – This design enhancement uses bored piles of 1.5m to 2m diameter to replace the H-piles. Preliminary assessment indicated that the number of could be reduced to about 150 numbers. Still, the relative long cycle of installation might cause overall delay on the foundation programme.

(b) **Mini-piles** – This design enhancement entails groups of 4 to 6 mini-piles to replace each H-pile. In comparison with H-piles, mini-piles installation employs lighter plants and no welding tests are required. However the large number of mini-piles to be required could offer small saving in construction time.

(c) **Ballasted raft** – This design enhancement employs thickened base slabs (and side walls) to counteract the upthrust from the groundwater. Preliminary estimates indicated that the base slab may need to be increased to 3.5m thick for invert at -1.1mPD to provide the necessary dead weight to provide a FoS of exceeding 1.1 as required under foundation code. The deep excavation and the large amount of excavated materials generated are undesirable in view of the limited access available for the Happy Valley site.

(d) **Raft within cut-off wall on sub-soil drains** – This design enhancement entails founding the USST on a raft surrounded with a cut-off wall. A system of sub-soil drains is employed to maintain the groundwater at just below the raft slab using small sump pumps, resolving the requirements to resist the upthrust in the Conforming Design. The cut-off wall could also be doubled as excavation support during the construction of the tank.

4.1 Innovative Design

After a series of deliberation with the relevant parties, a CSD using a raft with cut-off wall to be installed around the perimeter of the USST and a sub-soil drainage system to be installed underneath the tank, pumping station and the fan house (Figure 8b), is considered favourable in offering significant time and cost savings to the project. The provision of cut-off wall and sub-soil drains will create a favourable externally dry condition at the USST which can eliminate the groundwater infiltration into the tank in long term. Thus, the common maintenance problem due to water ingress through construction joints can be avoided. Since the groundwater table can be maintained at a low level, there is chance to optimise the thickness of the base slab to further reduce the construction volume and time.

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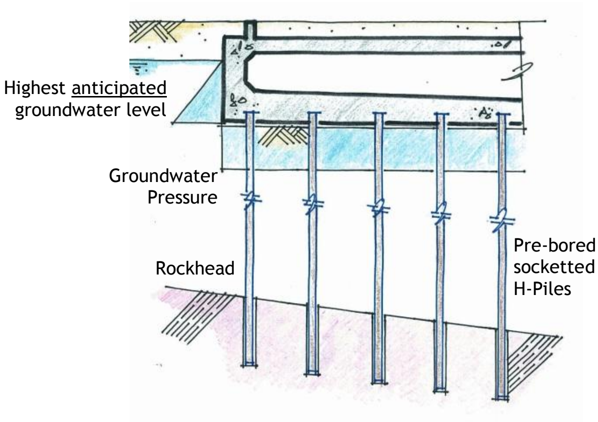
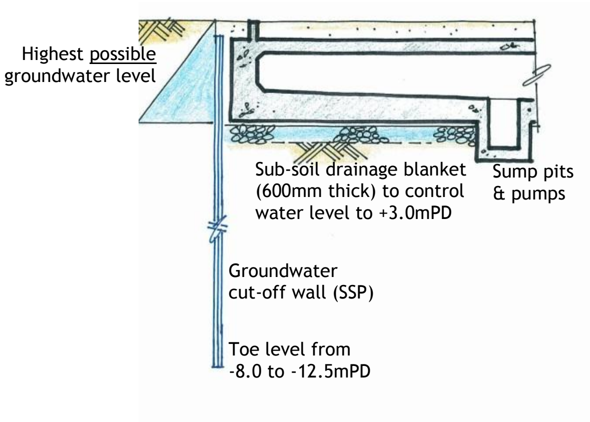
Innovative Foundation Design for Happy Valley Underground Stormwater Storage Scheme, Hong Kong



(a)



(b)

Figure 8. (a) Conforming foundation for the USST, (b) CSD foundation for the USST

4.2 Water Cut-Off Wall

The principal type of cut-off wall for this type of design is either sheet pile wall or diaphragm wall. Their respective merits/ demerits are discussed below.

Sheet pile wall

Sheet pile wall is interlocking sections of steel material and is installed by driving or vibrating interlocking sheet piles into the ground. Since they can be installed without major excavation work, they are less expensive to build. Corrosion rate of sheet piles is minimal in common ground. The average corrosion rate of structural steel above seabed ranges between 0.04 to 0.08 mm/year. Durability of sheet pile wall installed in land with non-corrosive environment is expected to be more than 50 years. Leakage may occur through interlocks but can be prevented by incorporating sealing material that expands when hydrated.

Diaphragm wall

Diaphragm wall is usually constructed by slurry trench technique. The subsoils at the project site predominantly consist of alluvial clay and sand layers and are prone to induce large ground movements (due to caving-in) which are highly undesirable in view of the stringent restrictions on ground movements. Diaphragm wall is also more expensive than sheet pile wall. For these reasons, sheet pile wall is chosen over diaphragm wall for the CSD.

4.3 Provision of Subsoil Drains & Sump Pumps

Groundwater flow within the confine of the cut-off wall is to be drained by a layer of 600m thick fine gravels with embedded 100 to 150mm diameter perforated HDPE pipes connecting to a pump sump (Figure 9a). A layer of non-woven polypropylene geotextile is placed between the drainage layer and native soil to provide separation and reinforcement. The drained groundwater is to be pumped out with a set of low cost small submersible duty and stand-by pumps. The collected groundwater is also used to supplement the water supply to the irrigation system for the football pitches within the Happy Valley Recreation Ground.

As a fail-safe measure, a set of 32 relief wells (Figure 9b) is proposed through the base slab to allow underground water to be drained into the USST in case of pump failure. Each relief well contains a 5m long perforated overflow pipe that embedded underground and opens to the bottom of the tank. If the pumps fail, groundwater can be drained via the flap valve at the top of the wells into the tank to prevent building up of excessive upthrust.

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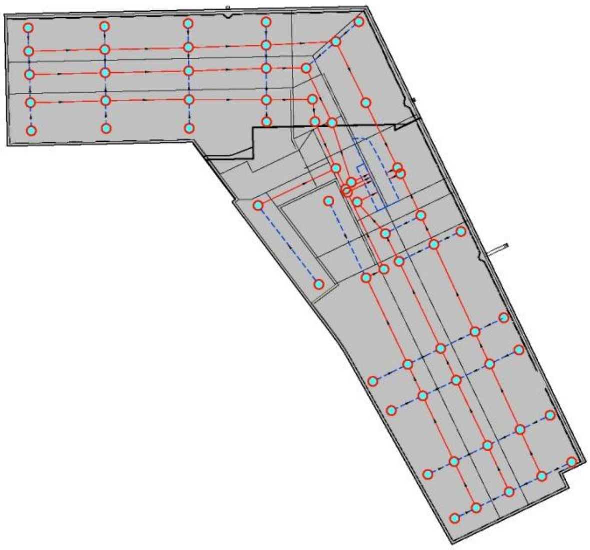

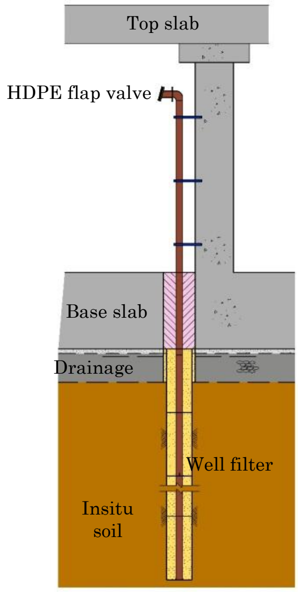

(a) (b)

Figure 9. (a) Layout plan of sub-soil drainage system, (b) Indicative arrangement of relief wells

4.4 Design Methodology

Cut-off wall and sub-soil drain

Type FSP III steel sheet piles are installed to form a permanent physical barrier to limit the groundwater seepage towards the sub-soil drainage system underneath the USST, and this in turn reduces the uplift on the USST. A series of steady state seepage analyses has been carried out to estimate the quantities of seepage underneath the cut-off wall towards the raft foundation using computer program SEEP/W 2007. A hydraulic head of +3mPD is assumed to be maintained along the base of the raft foundation. In the seepage model, the leakage of the clear interlock of the sheet piles (taken as $2.5\text{x}10^{-7}$m/s) is input to simulate the seepage of groundwater through the interlocks. The proposed sheet pile toe levels are between –8.0mPD to –12.5mPD. The results indicate that the rates of water influx can be removed with typical submersible pumps. Some seepage analysis result is shown in Figure 10.

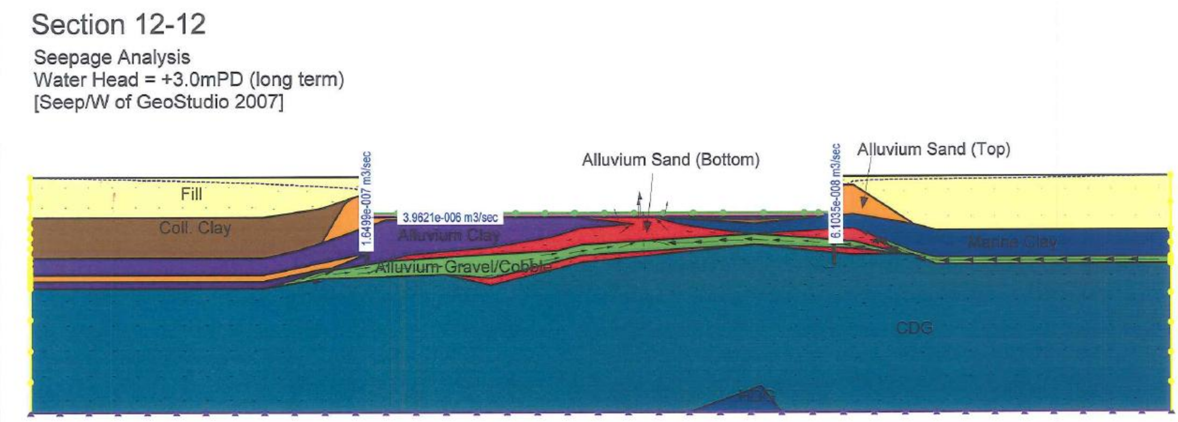

Figure 10. Seepage analysis using PLAXIS

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Raft foundation stability

The ultimate limit states of bearing failure of the raft foundation has been checked and confirmed using factored material parameters and loadings in accordance with GEOGUIDE 1 (2000). The existing GI information reveals that inferred founding materials are mainly alluvium with SPT-N value of about 10, with local areas of marine deposit encountered at the northern and western portions of the foundation. In the design calculation, the lower values of c' and ø' of 0kPa and 33° respectively corresponding to that determined from testing of marine deposit are adopted for the estimate of the allowable bearing capacity. The ultimate bearing capacity is determined based on Vesic's Equation.

The critical load case with no flotation due to groundwater acting on the USST is adopted for estimating the maximum bearing pressure. A FoS of 3 is applied to obtain the allowable soil bearing pressure. The result shows that soil beneath the foundation is structurally safe to support the USST. The checking for sliding and overturning failures are considered not necessary in view of the geometry and symmetric loading of the storage tank.

Ground movement and long-term consolidation settlement

Initial assessment indicated that the change in contact pressure at the base slab of the USST is negative and will therefore not causing long term consolidation settlements. A detail check has been carried out, using computer program PLAXIS (ver.9.02), to confirm the changes of ground stresses for the soils below the raft foundation in various stage of construction and operation of the tank. Sensitive structures in the vicinity of the USST are the LCSD Changing Rooms and the Stand. Foundations of both structures are empty box structures. Their loadings are assessed with reference to the as-built foundation records. Surcharge of 20kPa and 10kPa for LCSD Changing Rooms and the Stand are assumed respectively.

Six sections (Sections 7, 7A, 8, 10, 11 & 12) across the north, mid and south portions of the USST are selected for the model analyses. The dimensions of the soil layers in the analysed sections are interpolated from results of the drillholes.

The results of the long term consolidation settlement analysis, taking account of the various timing and loading from the structures, show no excessive total and differential settlement that may cause damage to adjacent installations, and that no excessive stresses are induced in the tank structure. The soil-structure interactions for various stages are also reviewed to assess the stress, lateral deflection, ground settlement, strut forces, shear force and bending moment developed of the earth retaining structures in ELS design. Some analysis result is shown in Figure 11.

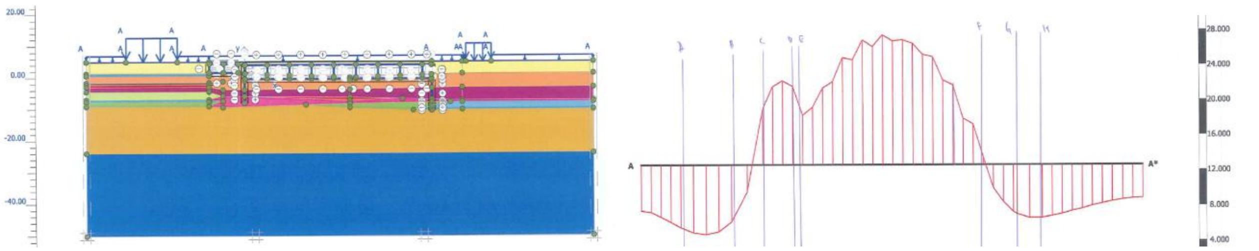

Figure 11. Deformation analysis using PLAXIS

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4.5 Whole Life Cost

Whilst the proposed CSD will decrease the need for future maintenance of the concrete structures of the USST and pump house due to infiltration of groundwater, it will incur operation and maintenance cost to maintain the cut-off wall, sub-soil drainage and pumping system. The whole life cost of the CSD has been studied with respect to the items below, and it is estimated that there is a net cost saving to be gained.

Underground storage tank

Under the Conforming scheme, the underground concrete structures will be in contact with groundwater fluctuating with tidal cycles. It is expected that concrete repairing works due to water ingress through construction joints are frequently required. This cost can be avoided in the proposed CSD in which the outer faces of the external walls of the storage tank are kept in a dry condition.

Submersible pumps

Under the CSD, additional maintenance of the duty and standby pumps in the groundwater withdrawal chamber is required. The pump sump should be cleaned by either digging the sediment out of the silt traps or by using a vacuum device at least once a month. Sump grates should be clear of rubbish and silt. Carrying out these maintenance works requires approximately 30 man-hours per month. In addition, the pumps will need to be replaced every 10 years or a total of 4 times over the design life. The pumps will be operated 24 hours a day all year, and it is estimated that the annual power consumption of pump will be 125,000kWh.

Drainage system

Under the proposed scheme, additional works are required to maintain efficient operation of the subsoil system. Regular inspections and maintenance of subsoil drains are necessary to prevent blockage by fine sediments and/or debris that infiltrated into the system. Maintenance works required for the sub-soil drainage system include regularly monitoring the discharge rate at the outlets, as well as monthly cleaning of the junction manholes and annual inspection of pipes and manholes. The maintenance includes:

(a) Discharge rates monitoring from sub-soil drains by automatic sensor at v-notch weirs with monthly manual measurement of v-notch for calibration;
(b) Monthly cleaning of junction pipes and manholes;
(c) Annual inspection of pipes, by CCTV if needed. Clearing of debris in the HDPE pipes can be carried out by rodding and flushing with air/water jets.

Monitoring system

Unusual rises in piezometric head could be an indication of pump failure or reduced performance of the subsoil drainage system. Therefore, a monitoring system including piezometers inside and outside the cut-off wall at various locations is necessary to demonstrate that the designed groundwater levels within the cut-off walls can be maintained. Monitoring work will include regular checking and recording of the underground water level during high and low tides. A monitoring program will be needed to identify monitoring and emergency protocol procedures. Implementation of this monitoring program will include development and adoption of the protocol procedures, as well as training for maintenance workers. It is estimated that monitoring and the associated work will require 20 man-hours per month.

Irrigation system

According to the requirements in the contract, the rain gun flow rate for football pitches 2, 3, 4, 6, 8 and 12 is 14 litres/second. At this rate, the estimated volume of irrigation water saved by the CSD is approximately 46,000m^3/year.

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Innovative Foundation Design for Happy Valley Underground Stormwater Storage Scheme, Hong Kong

5. Green & Low Carbon Construction

5.1 Water Harvesting System

An element of the works under the HVUSSS is the reconstruction of an irrigation system comprising an above ground water tank (144m^3) next to the LCSD management office connected to WSD supply and a system of distribution pipes and watering points. A viable option for the use of collected underground water is the provision as a source of water supply for the irrigation system. As a result of the CSD, the clean underground water collected below the raft can be used to supplement the irrigation water. The preliminary calculation indicates a flow rate of about 2.9x10^{-5} m^3/s/m run of section or about 1000m^3/day. The amount is subject to confirmation by the results of further ground investigation including pumping tests but the order of magnitude of inflow indicates a good opportunity for providing a good supply for the irrigation water.

The proposed system includes an underground storage and sedimentation chamber at the downstream end of the groundwater collection pipes and feeds to a pump chamber. Submergible pumps remove the collected underground water and feed it to the above ground water tank. The new system for conveyance of underground water comprises submergible pumps and connects to the above ground water tank that supply to the watering points. Pipes provide connection to the 144m^3 water tank of the irrigation system for delivery of underground water for irrigation use.

5.2 Omission of Pre-Bored H-Piles

As a result of the CSD, 533 nos. of pre-bored steel H-piles (Grade S460 UC 305×305×180 and 305×305×223 kg/m, lengths from 40 to 60m) have been omitted. Taking an average length of 55m for each pile, it can be demonstrated that approximately 4,040 tonne of structural steel has been saved.

5.3 Life cycle and embodied carbon of structural steel (H-Piles)

The life cycle of structural steel can be separated into 7 stages from the extraction of raw materials through the manufacture of the product (referred to as 'cradle-to-gate') to final material disposal and recycling (Figure 12).

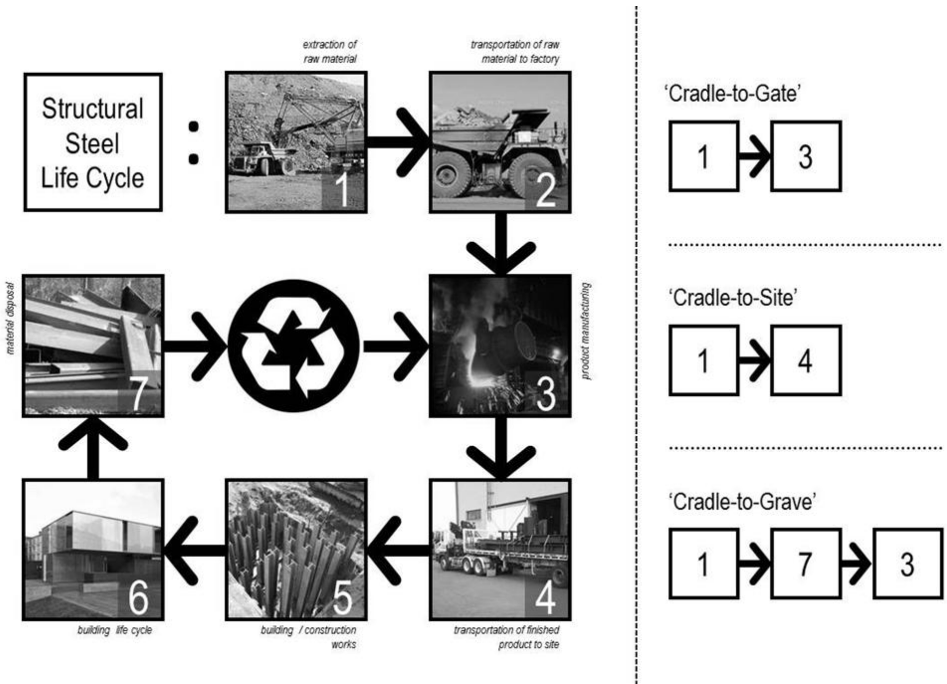

Figure 12. Life cycle of construction material (H-Sections)

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The carbon dioxide (CO_2) or carbon dioxide equivalents (CO_2-e) emitted into the atmosphere in order to produce structural steel can be measured as Embodied Carbon (EC). Embodied carbon contributes a significant portion of the life cycle carbon footprint of the built environment. The construction sector is the second largest contributor of the carbon footprint in Hong Kong and 85% of the carbon footprint associated with the construction sector is embodied in imported goods and services.

According to the values in the ECO-CM website of the Hong Kong University of Science and Technology (http://ihome.ust.hk/~cejcheng/ec/carbonInventoryLocalized.html), the EC for steel sections is 1.988kg CO_2-e/kg (cradle-to-gate) and 2.037kg CO_2-e/kg (cradle-to-site). Given the steel tonnage saved, emission of 8,043 tonne of CO_2-e has been prevented. This gives a similar effect of planting 205,938 nos. of trees in Hong Kong according to the Sustainability Report 2013 prepared by the ArchSD.

5.4 Other benefits

Other benefits that have been gained via the CSD are as follows.

(a) **Substantial reduction of traffic impact to existing road network** – Due to the reduction in deployment and mobilisation of construction plants and equipment under the CSD, vehicular traffic destined to/ from the project site is substantially reduced (Table 2). The lowering of the traffic load/ demand on existing streets/ highways allows for better safety and operations.

Table 2. Reduction in Use of Construction Plants / Equipment

Reduction in Use of Construction Plants / Equipment on Streets / Highways	Total Reduction
1. Piling rigs	40 rig-day
2. Transportation of H-sections to site	260 truck journey
3. Dumping trucks for disposal of excavated material from pile holes	250 journey
4. In-fill grout for pre-bored H-piles	533 concrete trucks

(b) **Reduction of nuisance** – Due to the shortened construction programme and the elimination of pile foundations, noise, and polluted water generated from construction activities such as mobilisation and pile driving is reduced. Project risks associated with disturbance to local residents and operations of the horse-racing field are minimised.

(c) **Improvement in air quality** – The reduction in emission from associated construction vehicles or idling equipment would reduce exposure of individuals in residences and businesses in the vicinity of the staging area to pollutants in the exhaust. Construction equipment may include, but is not limited to, dump trucks, loaders, excavators, diesel driven generators, and compressed air units for construction power.

(d) **Reduced impact on racing track and adjacent facilities** – The existing race track and the some of the HKJC's facilities are located in close proximity of the site. The pre-boring for piles in the original scheme is prone to ground movements due to caving-in when the pile hole is being formed through the upper alluvial deposit. The innovative CSD removed this risk due to the elimination of piles.

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The selected progress photos in Figure 13 show the construction of part of the USST.

(a) (b) (c)

Figure 13. (a) Installation of cut-off wall using silent piler, (b) Casting of base slab of the USST, (c) Excavation and lateral support for construction of the USST

Acknowledgements

This paper is published with the kind permission of the DSD, the Government of the HKSAR. The authors wish to express their gratitude for the effort of the project team of both the DSD and Chun Wo. The authors would also like to thank Black & Veatch Hong Kong Limited for the design support for the CSD described in this paper.

References

Architectural Services Department (2013). *Keep Going Green. Sustainability Report*. Government of Hong Kong Special Administrative Region.

Black & Veatch HK Ltd (2012). *Innovative Design Enhancement Proposal, Happy Valley Underground Stormwater Storage Scheme*. Hong Kong.

Buildings Department (2004). *Code of Practice for Foundations*. Government of Hong Kong Special Administrative Region.

Drainage Services Department (n.d.). *Innovative Features, Happy Valley Underground Stormwater Storage Scheme, Hong Kong*. Retrieved from http://hvusss.eksx.com/. Government of Hong Kong Special Administrative Region.

Geotechnical Engineering Office (2000). *GEOGUIDE 1 – Guide for Retaining Wall Design*. Government of Hong Kong Special Administrative Region.

Lo M.C. and Cheng C.P. (n.d.) *Localization Based Carbon Inventory*, HKUST. Retrieved from http://ihome.ust.hk/~cejcheng/ec/carbonInventoryLocalized.html.

Young Members' Arena

The International Geosynthetics Society (IGS)

Abstract

This article discusses who the IGS Young Members are, what they aim and their role within the International Geosynthetics Society (IGS).

1. Introduction

The International Geosynthetics Society (IGS) was founded in 1983, by a group of geotechnical engineers and textile specialists. The Society brings together individual and corporate members from all parts of the world, who are involved in the design, manufacture, sale, use or testing of geotextiles, geomembranes, related products and associated technologies, or who teach or conduct research about such products.

The aims of the IGS are:

- To collect and disseminate knowledge on all matters relevant to geotextiles, geomembranes and related products, e.g. by promoting seminars, conferences, etc.
- To promote advancement of the state of the art of geotextiles, geomembranes and related products and of their applications, e.g. by encouraging, through its members, the harmonization of test methods, equipment and criteria.
- To improve communication and understanding regarding such products, e.g. between designers, manufacturers and users and especially between the textile and civil engineering communities

The IGS has 43 chapters globally, over 3,000 individual members over 500 student members and including 161 corporate members.

2. Formation of Young members of the IGS

Part of the IGS structure includes task forces where young member's activities and interests are managed. This task force is led by Dr Nathalie Touze-Foltz, the Chair of IGS Young Members Operational Committee. Dr Touze-Foltz facilitated the launch of the Young members committee at Eurogeo 5 conference in Valencia, Spain in September 2012, by giving the student awards recipients from various regions at that conference an opportunity to be part of the first Young IGS Members (YMC) committee.

The criteria was that you had to be under 35 years old and have an interest in Geosynthetics through either as being a member through your regional chapter or a student member with IGS directly.

The aim of this committee was to involve young members at an early stage of their studies or careers in activities and/or tasks of the IGS through their respective regional sub-committees (Americas, Europe and Africa and Australasia).

Furthermore, it was also aimed at creating a mentorship platform, developing and pursuing new ideas for young members as the IGS sees them the next generation.

The aims of the YMC are:

- To promote young members participation at all levels possible within the IGS structures, including but not limited to council committees, task forces, technical committees and at regional chapter levels.
- Develop and maintain a membership list for all young IGS members in all regions and actively manage the participation in IGS activities and events.
- Create and develop a social media platform for awareness and communication such as Facebook, Wikipedia, and LinkedIn to which geosynthetics education, events and activities can be communicated on.

Young Members' Arena (Con't)

The International Geosynthetics Society (IGS)

- Develop a network to support the students/ young members at university level and the transition into the world of employment, by connecting them to corporate members of the IGS for possible employment opportunities or further research work opportunities.
- Assistance in technical tasks within the IGS such as translation of IGS official terminology and glossaries list into various languages as such French, Spanish, Portuguese and Italian, amongst other tasks.
- Organisation of interaction/networking sessions with the Geosynthetics industry, and other young member associations in the Engineering sphere to stimulate activate awareness of the group.

2.1 Structure of Young Members Committee (YMC)

Since the formation of the YMC in September 2012, the YMC was formed into three regions, Africa and Europe, Americas (North and South) and Asia-Pacific regions. After the first official meeting in November 2013, the young members decided to merge all the various YMC regions into one committee. This was done because the formation of the YMC was fairly new we wanted to ensure that its growth is integrated evenly amongst all regions. This allowed for active participation from all YMC regions based on the small numbers of members that were currently involved.

2.2 YMC Success Story

The first success story of the YMC came in September 2013, where the committee worked very hard at ensuring a successful young members conference at the 10ICG Berlin conference. The conference organisers worked with the YMC in organising a young members technical paper presentation were over 40 young members submitted papers from across the globe, however only 10 papers could be selected and presented due to time and allocation constraints.

The YMC further held a strategic planning session at the conference with the following aims;

1. Report back to other members on task and activities completed to date.
2. Discussion on the framework and constitution of the young members.
3. Drawing up areas where YMC need to work on in the next year in all regions. With emphasis on a technical agenda to work together with the IGS technical committees.
4. Stimulate more interest of young members to be actively involved especially in North America and Asia Pacific region, with the aim of forming committees in these regions.
5. Engage with IGS committee on areas were YMC need support and assistance in.
6. Networking session between young members from both IGS and Geotechnical Engineers Association.
7. Formation of partnership with other young member associations such as ISSMGE YMPG

YMC are continually working hard and aim to host a young member's conference in 2018 in conjunction with a regional IGS conference. We certainly are keen and welcome more young members on board. Should you have any further questions or requests on how you can become a member in your region, please send me an email at inyirenda@gseworld.com

The YMC have a social media presence, both in the form of a Facebook page and a twitter account.

Please follow us at.
https://www.facebook.com/YoungIGS
Www.twitter.com/IgsYoung
http://www.geosyntheticssociety.org/

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The International Geosynthetics Society (IGS)

Photo 1. Photo of Young Members with IGS past presidents and present president taken at the 10ICG Berlin

Irene N. Nyirenda
Young IGS members - President (Hamburg, Germany)
email: inyirenda@gseworld.com

Conference Report

The 3rd International Conference and Exhibition on Tunnelling and Underground Space 2015 (ICETUS2015)

The 3rd International Conference and Exhibition on Tunnelling and Underground Space was successfully organised by The Institution of Engineers, Malaysia (IEM) from 3rd – 5th March 2015 at the Dorsett Grand Subang Hotel, Subang Jaya, Selangor Darul Ehsan. The theme of the Conference was Sustainable Transportation in Underground Space Development. This Specialty Conference was well attended by 207 participants globally. The Conference was supported by The Institution of Civil Engineers (ICE) with many members attended the conference.

The International Tunnelling and Underground Space Association (ITA) gave strong support by holding its Executive Committee meeting in Petaling Jaya Hilton Hotel to coincide with the ICETUS2015. A Pre-Conference Workshop entitled “Tunnels for Transport in Urban Areas” was also jointly organised by Tunnelling and Underground Space Technical Division of IEM and the ITACET Foundation on 28th February and 1st March 2015 at the Tan Sri Prof Chin Fung Kee Auditorium, Wisma IEM, Petaling Jaya, Selangor Darul Ehsan. The workshop was attended by 40 participants. Technical Session 1 started with Mr. Soren Eskesen delivering his paper on “Why go underground in urban areas” and “General aspects of urban tunnelling – Environmental issues”. Mr. Felix Amberg presented his paper on “Presentation of the different tunnelling methods in urban areas and elements for the choice of the method”.

Mr. T. Babendererde delivered his lectures on “Slurry shield, EPB, soil conditioning” and “Segmental lining design for mechanized tunnelling” during Session 2. Papers on “Excavation methods and basics aspects of design” and “Ground reinforcement, support, lining” were presented by Mr. T. Celestono in Session 3. During Session 4, Mr. S. Eskesen delivered his paper on “Risk management for urban tunnels”, Mr. D. Peila on “Site investigation and “Health & Safety” by Ms. R. Haug. Ms. E. Chiriotti presented her paper on “Geotechnical monitoring” while Mr. F. Amberg delivered his lecture on “TBM Monitoring”. Session 6 started with Case Studies 1 on “TBM Solution & Leak Sealing Repair” by Mr. Kah Fai Lee and Case Studies 2 on “Metro case studies – SYSTRA” by Mr. E. Leca. Mr. Gusztav Klados delivered his lecture on “KVMRT Project: TBM Procurement and Tunnelling” while Ir. Dr Ooi Lean Hock delivered his lecture on “Site Investigation, Advance Works before Tunnelling and Instrumentation and Monitoring for KVMRT Project”.

The Workshop ended at 6.30 pm on 1st March 2015. Ir. Dr Ooi Teik Aun presented mementos and Certificates of Appreciation to all the lecturers.

At the Opening Ceremony of ICETUS2015 in the morning of 3rd March 2015, the Organizing Committee Chairman Ir Dr Ooi Teik Aun delivered his welcoming speech and this was followed by the ITA President Mr. Søren Degn Eskesen who reported that:

1. More than 1500 delegates and participants from the ITA family met at the last meeting in Iguassu in Brazil in May 2014 on the occasion of the ITA 40th General Assembly and World Tunnel Conference 2014 (WTC2014);
2. The General Assembly approved the ITA Strategic Plan going forward to 2016

As part of the strategy it was decided on an updated vision:

The ITA Vision

“ITA - the leading international organization promoting the use of tunnels and underground space through knowledge sharing and application of technology.”

Conference Report (Con't)

The 3rd International Conference and Exhibition on Tunnelling and Underground Space 2015 (ICETUS2015)

Y.Bhg. Dato' Ir. Lim Chow Hock, The President of IEM, then delivered his address and declared opened the Conference followed by a visit to the Exhibition booths. After the morning tea break, the ITA President Mr Søren Degn Eskesen delivered the Opening Keynote Lecture entitled "Construction Challenges for Urban Tunnelling - The Copenhagen Metro Circle Line". Following this was Keynote Lecture 1 by Professor Yong Kwet Yew, Chairman, Association of Geotechnical Societies in Southeast Asia & Vice President (Campus Infrastructure) at the National University of Singapore entitled "Learning Lessons from the Construction of Singapore Downtown Line". Keynote Lecture 2 was delivered by Mr. Felix Amberg, ITA Honorary Treasurer and President of Amberg Technologies entitled "Sustainability through Value Preservation of Underground Infrastructure". Keynote Lecture 3 was delivered by Professor Jenny Yan, ITA Council member and The China Railway Southwest Research Institute Co. Ltd entitled "Key Issues of Urban Tunnels for the Changsha-Zhuzhou-Xiangtan Intercity Railway".

In addition to these Keynote Lectures, there are 6 Special Lectures, 2 Technical Sessions and 1 Special Session by MMC-Gamuda on KVMRT Underground/Tunnelling Works (SBK Line) consisting of 27 papers. In this conference we are able to successfully share our experiences and innovations from tunnelling projects in Norway, Switzerland, Germany, Hong Kong, Thailand, Singapore, Malaysia and Taiwan and also enable transfer of technology to be effected.

There was also a technical visit to the KVMRT Tun Razak Exchange Site in Kuala Lumpur on 5th March 2015.

The Conference attracted 13 exhibitors of wide ranging tunnelling activities.

MMC-Gamuda was the Main Sponsor. China Railway Engineering Equipment Ltd Corp and Herrenknecht AG were the Gold Sponsors, Sepakat Setia Perunding Sdn Bhd as the Silver Sponsor and BSG Construction (Malaysia) Sdn Bhd was the Bronze Sponsor.

On the whole the ICETUS2015 and the Pre-Conference Workshop were very successful.

Photo I. Group picture of ITA and IEM Council members with the Organizing Committee members

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The 3rd International Conference and Exhibition on Tunnelling and Underground Space 2015 (ICETUS2015)

Photo 2. Organizing Chairman delivering his welcoming address

Photo 3. ITA President delivering his Welcoming Speech

Conference Report (Con't)

The 3rd International Conference and Exhibition on Tunnelling and Underground Space 2015 (ICETUS2015)

Photo 4. IEM President delivering his Welcome Address and declared opened the Conference

Photo 5. Visit to exhibition booth by IEM President and the VIPs

Conference Report (Con't)

The 3rd International Conference and Exhibition on Tunnelling and Underground Space 2015 (ICETUS2015)

Prepared by

Ir. Dr Ooi Teik Aun, Hon FIEM, FICE, FMIArb, FMSA

Ir. Dr Ooi Teik Aun is the Organizing Committee Chairman of ICETUS2015. He is Founder Chairman of IEM TUSTD, Founder Chairman of IEM CESIG, Chairman of Dispute Resolution Practice (DRP) Subcommittee. He is also an Advisor for Consulting Engineering Special Interest Group (CESIG). Ir. Dr Ooi is an Honorary Fellow of IEM, Fellow of The Institution of Civil Engineers, Fellow of the Malaysian Institute of Arbitrators and Past President and is ICE Country Representative for Malaysia. He is President of Southeast Asian Geotechnical Society (2010-2016).

Hot News

JTC-1 TR3 Forum

International Society for Soil Mechanics and Geotechnical Engineering
International Association for Engineering Geology and the Environment
International Society for Rock Mechanics
International Geotextile Society

Joint Technical Committee JTC-1

JTC-1 TR3 Forum
'Slope Safety Preparedness for Effects of Climate Change'

18 and 19 November 2015
Naples, Italy

This Forum provides a platform for JTC-1 members and other collaborators who are participants of the TR3 project on 'Slope Safety Preparedness for Effects of Climate Change' to present their country reports. The country reports cover the state-of-the-art on the projected results of advanced modelling of climate change and impact of extreme weather events, the corresponding implications on slope safety, and the range of possible landslide risk management strategies and actions that are called for in combating, or adapting to, climate change effects. This Forum offers a unique opportunity for reviewing and consolidating the state of practice in relation to slope safety preparedness for climate change effects, knowledge sharing and transfer, strategic discussion of pertinent issues, and reaching consensus on the key issues of concern, the major gaps in current knowledge and the way forward for enhanced and more robust landslide risk management.

Apart from disseminating the above mentioned country reports, the Forum will also endeavour to come up with a summary position paper on this important subject area targeting the geotechnical profession at large, together with a strategic statement targeting policy-makers, government administrators and the like, on behalf of JTC-1. Discussion on the above targeted deliverables will be led by a Steering Group, which comprises Professor Luciano Picarelli (JTC-1 Chairman), Dr Suzanne Lacasse (Norwegian Geotechnical Institute) and Ir Ken Ho (Hong Kong Geotechnical Engineering Office). A protocol on continued knowledge sharing and transfer on this subject area by the participants of TR3 project will also be explored.

For further information, please contact Dr Wing Sun via e-mail: hwsun@cedd.gov.hk

For registration and conference logistics, please contact
Prof Luciano Picarelli via e-mail: picarell@unina.it,
Prof Luca Comegna via e-mail: luca.comegna@unina2.it, or
Dr Guido Rianna via e-mail: G.Rianna@cira.it

Supporting Organizations:
University of Naples Federico II and Euro-mediterranean Center on Climate Change

Event Diary

ISSMGE EVENTS

Please refer to the specific conference website for full details and latest information.

2015

7ème Journées Africaines de Géotechnique
Date: Tuesday 30 June 2015 - Friday 03 July 2015
Location: Hôtel President, YAMOUSSOUKRO, Cote D'Ivoire (Ivory Coast)
Language: FRENCH
Organizer: CTGA
Contact person: Dr ETIENNE MARCELIN KANA
Address: 5, rue Monseigneur Graffin, B.P. 20369, Yaoundé, Cameroon
Phone: +237 6 99 50 05 10
E-mail: emk2cm@yahoo.fr

International Symposium on Geohazards and Geomechanics
Date: Thursday 10 September 2015 - Friday 11 September 2015
Location: University of Warwick campus, Coventry, United Kingdom
Language: English
Address: University of Warwick, Library Road, Coventry, CV4 7AL, Coventry, United Kingdom
E-mail: C.Voulgari@warwick.ac.uk
Website: http://www2.warwick.ac.uk/fac/sci/eng/research/civil/geo/conference/

European Young Geotechnical Engineers Conference
Date: Friday 11 September 2015 - Saturday 12 September 2015
Location: Durham University, Durham, United Kingdom
Language: English
Organizer: BGA
Contact person: Dr Ashraf Osman
Address: School of Engineering and Computing Sciences, Durham University, DH1 4QU, Durham, United Kingdom
Phone: +44 191 3342425
E-mail: ashraf.osman@durham.ac.uk

XVI European Conference on Soil Mechanics and Geotechnical Engineering
Date: Sunday 13 September 2015 - Thursday 17 September 2015
Location: Edinburgh International Conference Centre, Edinburgh, Scotland, United Kingdom
Language: English
Organizer: British Geotechnical Association
Contact person: Derek Smith
Address: Coffey Geotechnics Limited, The Malthouse, 1 Northfield Road, RG1 8AH, Reading, UK
Phone: +44 1189566066
Fax: +44 1189576066
E-mail: derek_smith@coffey.com
Website: http://www.xvi-ecsmge-2015.org.uk/

Event Diary (Con't)

2015

GEO-EXPO 2015 Scientific and Expert Conference in Zenica, Bosnia and Herzegovina
Date: Friday 18 September 2015 - Saturday 19 September 2015
Location: Faculty of Polytechnical Engineering, University of Zenica, Zenica, Bosnia and Herzegovina,
Language: Bosnian, Croatian, Serbian, English
Organizer: Geotechnical Society of Bosnia and Herzegovina
Contact person: Prof. Sabid Zekan
Address: Univerzitetska 2, 75000, Tuzla, Bosnia and Herzegovina
Phone: +387 61 56 22 77
Fax: +387 35 32 05 70
E-mail: geotehnika@geotehnika.ba
Website: http://www.geotehnika.ba

Workshop on Volcanic Rocks & Soils
Date: Thursday 24 September 2015 - Friday 25 September 2015
Location: Isle of Ischia, Italy
Language: English
Organizer: Associazione Geotecnica Italiana (AGI)
Contact person: Ms. Susanna Antonielli
Address: Viale dell'Università 11, 00185, Roma, Italy
Phone: +39 06 4465569 - +39 06 44704349
Fax: +39 06 44361035
E-mail: agi@associazionegeotecnica.it
Website: http://www.wvrs-ischia2015.it/

6th International Conference on Earthquake Geotechnical Engineering
Date: Sunday 01 November 2015 - Wednesday 04 November 2015
Location: Christchurch, New Zealand
Contact person: The Conference Company
Address: PO Box 3727, Christchurch, New Zealand
Phone: +64 3 365 2217
Fax: +64 3 365 2247
E-mail: 6icege@tcc.co.nz
Website: http://www.6icege.com

The 15th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering -New Innovations and Sustainability
Date: Monday 09 November 2015 - Friday 13 November 2015
Location: Fukuoka International Congress Center, Fukuoka, Kyushu, Japan
Language: English
Organizer: The Japanese Geotechnical Society
Contact person: Toshifumi Mukunoki
Address: 2-39-1 Kurokami, Chuou-ku, Kumamoto, JAPAN,860-8555,Kumamoto, Japan
Phone: +81-96-342-3535
Fax: +81-96-342-3535
E-mail: 15tharc@kumamoto-u.ac.jp
Website: http://www.jgskyushu.net/uploads/15ARC/

Event Diary (Con't)

2015

XV Pan American Conference on Soil Mechanics and Geotechnical Engineering
Date: Sunday 15 November 2015 - Wednesday 18 November 2015
Location: Hilton Hotel, Buenos Aires, Buenos Aires, Argentina
Language: Spanish - Portuguese - English (simultaneous translation)
Organizer: Argentinean Society for Soil Mechanics and Geotechnical Engineering
Contact person: Dr. Alejo Oscar Sfriso
Address: Rivadavia 926 Suite 901,C1002AAU, Buenos Aires, Buenos Aires, Argentina
Phone: +541143425447
Fax: +541143423160
E-mail: presidente@saig.org.ar
Website: www.panam2015.com.ar

Geo-Environment and Construction European Conference
Date: Thursday 26 November 2015 - Saturday 28 November 2015
Location: Polis University, Tirana, Albania
Language: Albanian, English
Organizer: Polis University, Albanian Geotechnical Society and Co-PLAN
Contact person: Msc. Eng. Erion Bukaçi
Address: Polytechnic University of Tirana, Faculty of Civil Engineering,1001, Tirana, Albania
E-mail: erion.bukaci@gmail.com, Correspondence and information, MSc. Eng. Erdi Myftaraga (erdi.myftaraga@hotmail.com), Prof. Dr. Luljeta Bozo (lulibozo@gmail.com)

International Conference on Soft Ground Engineering ICSGE2015
Date: Thursday 03 December 2015 - Friday 04 December 2015
Location: Singapore, Singapore
Language: English
Organizer: Geotechnical Society of Singapore
Contact person: Dr Kam Weng Leong
Address: OPE3, Faculty of Engineering, NUS, 117578, Singapore
E-mail: ICSGE2015@nus.edu.sg
Website: http://www.geoss.sg/icsge2015

The 1st International Conference on Geo-Energy and Geo-Environment (GeGe2015)
Date: 4th and 5th December 2015 (Friday and Saturaday)
Location: The Hong Kong University of Science and Technology (HKUST), Hong Kong
Language: English
Organizers: HKUST, Chongqing University, Hohai University and Zhejiang University in mainland China, and EPFL in Switzerland
Contact person: Ms Shirley Tse
Address: The Geotechnical Centrifuge Facility, HKUST, Clear Water Bay, Kowloon, Hong Kong
Phone: +852-2358-0216
Fax: +852-2243-0040
E-mail: gege2015@ust.hk
Website: http://gege2015.ust.hk

Event Diary (Con't)

2015

GIFT - Geotechnics for Infrastructure and Foundation Techniques
Date: Thursday 17 December 2015 - Saturday 19 December 2015
Location: Govt. College of Engineering (Established 1853 AD), PUNE, MAHARASHTRA, India
Language: English
Organizer: Indian Geotechnical Society, Pune Chapter
Contact person: Prof. Yashwant Apparao Kolekar
Address: Associate Professor, Geotechnical Engineering Division, Dept. of Civil Engineering, Govt. College of Engineering, Wellsley Road, Shivajinagar, 411005, PUNE, MAHARASHTRA, INDIA
Phone: +91-20-25507070 / +91-9420963672
Fax: +91-20-25507299
E-mail: igc2015pune@gmail.com
Website: http://www.igc2015pune.in/GUI/index.aspx

2016

Under-ground Construction Prague 2016
Date: Monday 23 May 2016 - Wednesday 25 May 2016
Location: Clarion Congress Hotel Prague Prague, Czech Republic
Language: English
Organizer: Czech Tunnelling Association
Contact person: SATRA, spol. s r. o.
Address: Sokolská 32, 120 00, Prague 2, Czech Republic
Phone: +420 296 337 181
Fax: +420 296 337 189
E-mail: ps2016@satra.cz
Website: http://www.ucprague.com

NGM 2016, The Nordic Geotechnical Meeting
Date: Wednesday 25 May 2016 - Saturday 28 May 2016
Location: Harpan Conference Centre, Reykjavik, Iceland
Language: English
Organizer: The Icelandic Geotechnical Society
Contact person: Haraldur Sigursteinsson
Address: Vegagerdin, Borgartún 7, IS-109, Reykjavik, Iceland
Phone: +354 522 1236
Fax: +354 522 1259
E-mail: has@vegagerdin.is
Website: http://www.ngm2016.com

Event Diary (Con't)

2016

International Mini Symposium Chubu (IMS-Chubu)
Date: Thursday 26 May 2016 - Saturday 28 May 2016
Location: Disaster Mitigation Research Building, Nagoya University, Nagoya, Aichi, Japan
Language: English
Organizer: The Japanese Geotechnical Society
Contact person: International Affairs Department, Japanese Geotechnical Society
Address: 4-38-2 Sengoku, Bunkyo-ku, 112-0011, Tokyo, Japan
Phone: +81-3-3946-8671
Fax: +81-3-3946-8678
E-mail: kokusai@jiban.or.jp
Website:
https://www.jiban.or.jp/index.php?option=com_content&view=article&id=1737:2016052628&catid=16:2008-09-10-05-02-09&Itemid

SEAGC2016
Date: Tuesday 31 May 2016 - Friday 03 June 2016
Location: Dorsett Grand Subang, Subang Jaya, Selangor, Malaysia
Language: English
Organizer: Malaysian Geotechnical Society and Institution of Engineers, Malaysia
Contact person: SEAGC2016 Secretariat
Address: c/o IEM Training Centre Sdn Bhd, No.33-1A (1st Floor) Jalan 52/18, PO Box 224 (Jalan Sultan), 46720, Petaling Jaya, Selangor, Malaysia
Phone: +(603) 7958 6851
Fax: +(603) 7958 2851
E-mail: seagc2016@gmail.com/ choy.iemtc@gmail.com
Website: www.mygeosociety.org/SEAGC2016

12th International Symposium on Landslides
Date: Sunday 12 June 2016 - Sunday 19 June 2016
Location: Naples, Italy
Language: English
Contact person: Italian Geotechnical Association (AGI)
Address: Viale dell'Università, 11 - 00185, Roma, Italy
Phone: +39 064465569 - 0644704349
E-mail: agi@associazionegeotecnica.it
Website: http://www.isl2016.it/

GeoChina 2016
Date: Monday 25 July 2016 - Wednesday 27 July 2016
Location: Shandong, China
Language: English
Organizer: Shandong University in Cooperation with Shandong Department of Transportation and University of Oklahoma
Contact person: Antony Warden
Address: Shanghai, China
Phone: +86-021-54721773
E-mail: geochina.sec@gmail.com
Website: http://geochina2016.geoconf.org/

Event Diary (Con't)

2016

3rd ICTG International Conference on Transportation Geotechnics
Date: Sunday 04 September 2016 - Wednesday 07 September 2016
Location: Vila Flor Cultural Centre and University of Minho, Guimaraes, Portugal
Language: English
Organizer: Portuguese Geotechnical Society and University of Minho
Contact person: Prof. A. Gomes Correia (Chair)
Address: University of Minho, School of Engineering, 4800-058, Guimarães, Portugal
Phone: +351253510200
Fax: +351253510217
E-mail: agc@civil.uminho.pt
Website: http://www.webforum.com/tc3

13 Baltic States Geotechnical Conference
Date: Thursday 15 September 2016 - Saturday 17 September 2016
Location: Vilnius University, Vilnius, Lithuania
Language: English
Organizer: Baltic Sea states Geotechnical Societies / Main organizer Lithuanian Geotechnical Society
Contact person: Danutė Sližytė
Address: Saulėtekio ave. 15-510, LT-10224,Vilnius, Lithuania
Phone: +37068690044
Fax: +37052500604
E-mail: danute.slizyte@vgtu.lt
Website: http://www.13bsgc.lt

2017

ICSMGE 2017 - 19th International Conference on Soil Mechanics and Geotechnical Engineering, Seoul
Date: Sunday 17 September 2017 - Thursday 21 September 2017
Location: Coex Convention Center, Seoul, Korea
Language: English and French
Organizer: Organising Committee of ICSMGE 2017
Contact person: Ms. Soi LEE
Address: 4F, SUNGJI Building, 192, Bangbae-ro, Seocho-gu, 137-835, Seoul ,Republic of Korea
Phone: +82-2-6288-6347
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E-mail: secretariat@icsmge2017.org
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2015

International Conference in Geotechnical Engineering - ICGE-Colombo 2015
Date: Monday 10 August 2015 - Tuesday 11 August 2015
Location: Colombo, Colombo, Sri Lanka
Language: English
Organizer: Sri Lankan Geotechnical Society
Contact person: Eng. K. L. S. Sahabandu
Address: Central Engineering Consultancy Bureau, 415, Bauddhaloka Mawatha, Colombo 7, Sri Lanka
Phone: +94 11 2668803
Fax: +94 11 2687369
E-mail: gm@cecbsl.com ; sahabandukls@gmail.com
Website: www.slgs.lk

The 2nd International Symposium on Transportation Soil Engineering in Cold Regions (TranSoilCold2015)
Date: Thursday 24 September 2015 - Saturday 26 September 2015
Location: Siberian State University of Railway Engineering, Novosibirsk, Russia
Language: English, Russian
Organizer: Universities of Russia, China, USA
Contact person: Yury Moryachkov
Address: Novosibirsk, Russia
E-mail: transoilcold@inbox.ru
Website: http://transoilcold2015.stu.ru/

5th International Symposium on Geotechnical Safety and Risk (ISGSR 2015)
Date: Tuesday 13 October 2015 - Friday 16 October 2015
Location: WTC, Rotterdam, The Netherlands
Language: English
Organizer: KIVI, GEOSnet, Geo Impuls
Contact person: Maarten Profittlich
Address: Zekeringstraat 41A, 1014BV, Amsterdam, The Netherlands
Phone: +31206510800
E-mail: nssmge@kivi.nl
Website: www.isgsr2015.org

FOR FURTHER DETAILS, PLEASE REFER TO THE WEBSITE OF THE SPECIFIC CONFERENCE

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Seoul 138-200
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    - **d.** The Chinese Institution of Soil Mechanics and Geotechnical Engineering – CCES
      www.geochina-cces.cn/en
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f. Chinese Taipei Geotechnical Society www.tgs.org.tw

g. Prof. Zuyu Chen
http://www.iwhr.com/zswwenglish/index.htm

h. East China Architectural Design and Research Institutehttp://www.ecadi.com/en/ ECADI

i. TC 211 of ISSMGE for Ground Improvement
www.bbri.be/go/tc211

j. Prof. Askar Zhussupbekov www.enu.kz/en, www.kgs-astana.kz

k. TC302 of ISSMGE for Forensic Geotechnical Engineering
http://www.issmge.org/en/technical-committees/impact-on-society/163-forensic-geotechnical-engineering

l. Prof. Yoshinori Iwasaki yoshi-iw@geor.or.jpwww.geor.or.jp

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