



International Society for Soil Mechanics and Geotechnical Engineering

If the quality of the distributed file is not satisfactory for you, please access the ISSMGE website and download an electronic version.

www.issmge.org

TABLE OF CONTENTS

Select all items below

- 1 [President's message](#)
- 3 [Board Members' Corner: Sharing by Professor Vlasta Szavits-Nossan](#)
- 4 [Research Highlights](#)
 - [Georgia Institute of Technology, USA](#)
- 35 [Conference Reports](#)
 - [The 8th Asian Young Geotechnical Engineers Conference](#)
 - [The 2nd Youth Russian Geotechnical Engineer Conference & the 2nd Geo Games](#)
 - [The 3rd European Conference on Unsaturated Soils](#)
- 53 [Young Members' Arena](#)
- 63 [ISSMGE Foundation Reports](#)
- 67 [Hot News](#)
 - [Book review: Reliability of Geotechnical Structures in ISO2394](#)
- 68 [Event Diary](#)
- 75 [Corporate Associates](#)
- 77 [Foundation Donors](#)

EDITORIAL BOARD

Frank, Roger (Ex-officio)
 Gomes, Antonio Topa (Editor for Europe)
 Gonzalez, Marcelo (Editor for South America)
 Leung, Anthony Kwan (Editor for Europe)
 Ng, Charles Wang Wai (Editor-in-Chief)
 Ooi, Teik Aun (Editor for Asia)
 Rujikiatkamjorn, Cholachat (Editor for Australasia)
 Sanchez, Marcelo (Editor for North America)
 Sfriso, Alejo O (Editor for South America)
 Shahien, Marawan (Editor for Africa)
 Take, Andy (Editor for North America)
 Taylor, Neil (Ex-officio)

President's message

Dear colleagues,

It is a pleasure to announce the launch of the new ISSMGE website: <http://www.issmge.org>.

The new website is a major development that thrusts ISSMGE deeper into the digital era. It is an initiative nurtured by the Innovation and Development Committee, that was supported by many other committees throughout the ISSMGE.

The new website has a more appealing modern layout, more valuable content and an improved website design architecture that provides enhanced functionality. The navigation bar has been updated so that it can better communicate the many activities of our organization. Just to highlight some of them:

- Under "Publications", the "[Online Library](#)" includes a collection of 3,450 papers that are all available directly for download and include a number of conference proceedings, including the Osaka (16th), Alexandria (17th) and Paris (18th) International Conferences on Soil Mechanics and Geotechnical Engineering. This database is expected to significantly grow in future years. It has been one of the main reasons for designing this new website. It is perceived as the tool needed in order to implement the open access policy of the ISSMGE!

- Under "[Media](#)", a truly unique collection of 28 webinars and honour lectures are immediately available for you to view online.

- There are also sub-websites for [each of the TCs](#), the [Young Members Presidential Group \(YMPG\)](#), and the [Corporate Associates Presidential Group \(CAPG\)](#). These websites will now be operated directly by the Committees and Groups themselves, and news from these committees and groups will be automatically promoted through the main page of the ISSMGE website.

President's message (Con't)

We hope you find the new website, informative, useful... and fun! We encourage you to send us any feedback you wish to provide about the current website as well as ideas about future initiatives.

On behalf of the ISSMGE,

Roger Frank, President of ISSMGE



Dimitrios Zekkos, Chair of Innovation and Development Committee (IDC)



Board Members' Corner: Sharing by Professor Vlasta Szavits-Nossan

Report on the 13th Baltic Sea Region Geotechnical Conference, 22nd - 24th Sep 2016, Vilnius, Lithuania

The President of ISSMGE, Professor Roger Frank, and the Vice-President of ISSMGE for Europe, Professor Antonio Gens, asked me to participate at the 13th Baltic Sea Region Geotechnical Conference on behalf of the ISSMGE Board. The Conference was held from 22nd - 24th September 2016 in Vilnius, Lithuania, at over Vilnius University (more than 400 years old), under the title "Historical experience and challenges of geotechnical problems in Baltic Sea region". The President of the Organising Committee was Dr. Vytautas Kuliesius, who is also the President of the Lithuanian Geotechnical Society.

There was a Welcome reception on 21st September. The Opening ceremony was held in the beautiful church of St. John's on 22nd September (see Plate 1). The first Invited lecture was held by S. Gadeikis from Lithuania. Two Sessions followed on the same day. Each Session started with an Invited lecture, and then there were presentations from authors of papers and discussion. The Invited lecture for Session 1 was delivered by H. Brandl from Austria, and for Session 2 by P. Seco e Pinto from Portugal (see Plate 2). In the evening an excellent concert by the University orchestra was organised in St. John's church.



Plate. 1. Welcoming greetings at the Opening ceremony Plate. 2. Invited lecture by Prof. P. Seco e Pinto in Session 2

On 23rd September there were four Sessions. The Invited lecture for Session 3 was delivered by J. S. Steinfeldt from Denmark, for Session 4 by Charles W. W. Ng from Hong Kong, for Session 5 by I. Vanicek from Czechia, and for Session 6 by G. Kacprzak and A. Stanczak from Poland. It is interesting to note that the Invited lecture from Poland was delivered by two contractors. The Gala dinner was organised in the evening.

Session 7, the Closing ceremony and two technical tours were organised on 24th September. The Invited lecture for this Session was delivered by P. Benetis from Lithuania.

The conference was very well organised. It represented a mixture of academic and practical views, as well as views of contractors, which is what ISSMGE is striving for. There were 97 participants from 18 countries.

The Finnish Geotechnical Society volunteered to organise the 14th BSGC in Helsinki in 2020, which was unanimously accepted at the meeting of representatives from Baltic Sea region geotechnical societies. The president of the Finnish Geotechnical Society announced that the organisers of this conference will try also to host the next Nordic Meeting at the same time and venue, which was accepted with acclamation.

I addressed the audience with greetings on behalf of ISSMGE, the President, Vice-President for Europe and Secretary General at the Opening ceremony (see Plate 2), and with congratulations at the Closing ceremony. I had a presentation with information on ISSMGE activities after the Invited lecture during Session 1. I attended the whole conference programme, all social events and a technical tour after the conference. I enjoyed the great hospitality of the conference organisers, Vilnius and Lithuanians.





Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA

Introduction

Geosystems Engineering at the Georgia Institute of Technology provides broad and in-depth educational and research opportunities in geo-related engineering fields. Geosystems engineering includes geotechnics, geomechanics, geomaterials, geophysics, geochemistry, geology, and bio-geoengineering. This approach allows students to comprehend the behavior of natural and man-made materials to analyze, design and construct engineered systems. Research encompasses both traditional and emerging topics, with a focus on the fields of bio-mediated and bio-inspired geotechnics, energy geotechnology, geotechnical analysis and design, natural hazards, engineered geomaterials, sustainable subsurface engineering, and rock mechanics and engineering. Research is supported by federal and state agencies including the National Science Foundation, the U.S. Geological Survey, the Federal Highway Administration, the U.S. Department of Energy, the Nuclear Regulatory Commission, and the Georgia Department of Transportation, as well as private consulting, manufacturing and testing companies, with interests in the mining, petroleum, energy and infrastructure sectors. Graduate students may select from almost 25 geotechnical graduate courses, engage in research, and participate in a wide range of professional development and social activities coordinated by the Georgia Tech Geotechnical Society.

Faculty

	<p>CHLOÉ F. ARSON, Ph.D. Associate Professor</p> <p>Research interests: Modeling of damage in porous and granular materials, thermodynamics, micro-mechanics, FEM and DEM numerical simulations. Applications: deep geological storage, fluid injection and withdrawal in rock, particle crushing, self-healing materials.</p>
	<p>RUDY BONAPARTE, Ph.D., P.E., F.ASCE, N.A.E. Professor of the Practice and President Emeritus & CEO, Geosyntec Consultants</p> <p>Research interests: Solid, hazardous and radioactive waste disposal facility design; waste facility permitting and performance evaluation; design methods for earth retention and ground improvement systems; engineering leadership.</p>
	<p>SUSAN E. BURNS, Ph.D., P.E., F.ASCE Georgia Power Distinguished Professor and Associate Chair, Undergraduate Programs</p> <p>Research interests: Geo-environmental engineering; engineered materials; physical and chemical behavior of soils; physical remediation of contaminated soil and groundwater; and productive reuse of waste materials.</p>
	<p>G. WAYNE CLOUGH, PhD, P.E., DIST. M. ASCE., N.A.E. Professor and President Emeritus, Georgia Tech</p> <p>Research interests: Tunneling, excavation, large construction; finite elements; strength anisotropy; earthquake engineering; climate change; nature and man-made hazards; engineering leadership.</p>

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

	<p>SHENG DAI, Ph.D. Assistant Professor</p> <p>Research interests: Energy geotechnics (gas hydrate, geothermal system and carbon storage); HTCMB-coupled subsurface processes; characterization of geomaterial at high pressure-temperature conditions.</p>
	<p>J. DAVID FROST, Ph.D., P.E., P.Eng., F.ASCE Elizabeth and Bill Higginbotham Professor and Geosystems Engineering Group Leader</p> <p>Research interests: Multi-scale geomaterial characterization; interface mechanisms; spatial hazard analysis; analysis of earth structures; sustainable subsurface infrastructure; bio-inspired geotechnics.</p>
	<p>LEONID N. GERMANOVICH, Ph.D. Professor</p> <p>Research interests: rock mechanics, fracture mechanics; hydraulic fracturing; petroleum engineering; mining engineering; micro-mechanical modeling; geophysics; applied mathematical methods; tsunamigenic landslides and methane hydrates; biomechanics; Earth and extraterrestrial materials.</p>
	<p>HAIYING HUANG, Ph.D. Associate Professor</p> <p>Research interests: Rock mechanics; fracture mechanics; coupled processes; flow in porous media; fluid injection into granular media; hydraulic fracturing; rock cutting and indentation.</p>
	<p>PAUL W. MAYNE, Ph.D, P.E., M.ASCE Professor</p> <p>Research interests: In-situ testing; site characterization; foundation systems; soil properties determination; geostatic stress state; ground improvement; cone and in-situ penetrometers.</p>

Facilities

The Geosystems Engineering research and instruction laboratories occupy about 1,000 square meters of custom space within the Mason Building. The program is home to numerous state-of-the-art facilities, including:

- Damage Poromechanics Laboratory
- Geoenvironmental Engineering Laboratory
- Sustainable Geotechnical Systems Laboratory
- In-Situ Research Laboratory
- Rock and Fracture Mechanics Laboratory
- Subsurface Processes Research Laboratory
- NSF Engineering Research Center on Bio-mediated and Bio-inspired Geotechnics (CBBG)

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

Research Areas

Specific topics of research within the Geosystems group include: in situ testing and site characterization using cone penetrometers and wave-based process monitoring and inverse problems; geomaterial characterization, including 2-D and 3-D micro-structure quantification, interface mechanisms, physical and chemical behavior of engineered soils, and particle and pore-scale behavior of particulate materials; foundation systems including dynamic soil-foundation structure interaction; geotechnical processes with applications to gas hydrates, geothermal energy and carbon sequestration; geomechanics in geological processes and engineering applications, including modeling of damage in porous and granular materials; petroleum geomechanics and hydraulic fracturing including environmental aspects; hydro-mechanical well testing; geo-environmental engineering; natural hazards and strong motion site response analysis and impact on geotechnical systems; nature-inspired and biologically-based geotechnical infrastructure systems; subsea geothermal heat and submarine landslides.

Research Activities

1. Geomaterial Characterization, Modeling and Simulation

1.1 Automated shear wave generator for in-situ testing

The roto-autoseis is a portable electro-mechanical device that generates repeatable shear waves for downhole testing. A set of GT autoseis units are shown in Figure 1. Licenses have been issued to commercial firms for manufacturing the GT autoseis and units are located in many countries. As strikes can be delivered as fast as once per second, the unit permits continuous-interval V_s type profiling.

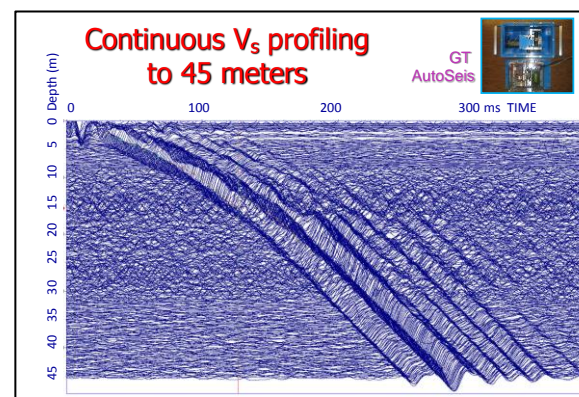
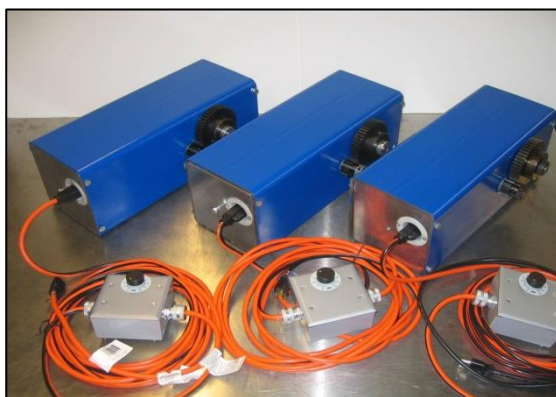


Fig. 1. Autoseis units and resulting continuous shear wave velocity measurements 45m

1.2 CPT-DMT interrelationships in soft clays

A first-order relationship uses cavity expansion theory, to establish a link between piezocone resistances and flat dilatometer pressures in soft to firm intact clays. The nexus allows for the extended post-processing of CPT and DMT data. For instance, an existing undrained limit plasticity solution for evaluating the effective stress friction angle of clays (ϕ') from CPT results that was developed at NTNU Trondheim can now be utilized for evaluating ϕ' from the DMT pressures p_0 and p_1 (Figure 2).

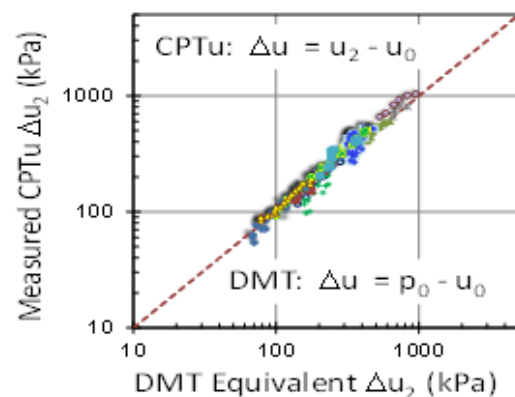


Fig. 2. Verification of CPTu-DMT link for soft-firm clays using spherical cavity expansion solution.

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

1.3 X-ray CT for porous media characterization

High energy electromagnetic waves like X-ray can penetrate through objects. Meanwhile, the X-ray attenuates with increasing material density and travel length, resulting 2D radiographs. The 2D X-ray radiographs obtained at many different angular positions can furtherly be used to reconstruct 3D tomography to show the spatial structures of geomaterials nondestructively. X-ray tomographic imaging has provided the possibility of studying geomaterials and processes at elevated pressure and temperature conditions. Studied materials vary from soils and rocks to membranes and hydrates (Figure 3).

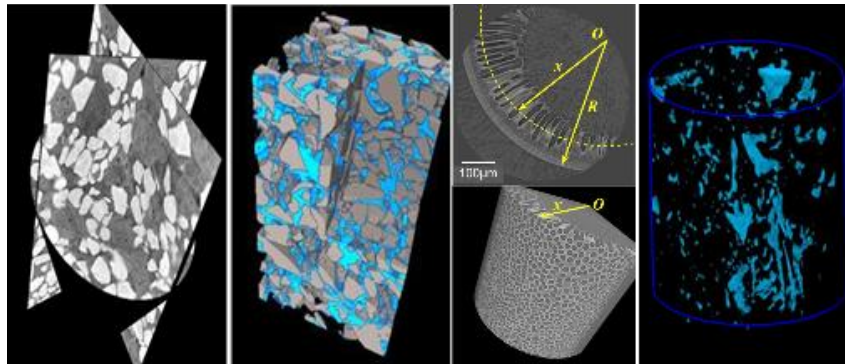


Fig. 3. Material characterization using microfocus X-ray computed tomography. From left to right: sands with spherical porous polymers; unsaturated fine sands; fiber membranes for CO capture; and hydrate lens in kaolinite

1.4 Monitoring creep in sands using coda waves

The determination of very small changes in travel time limits our ability to resolve changes in soil stiffness caused by tiny internal processes like creep. The first-arrival reflects the fastest path between the source and receiver of the propagating wave field; later arrivals in the coda correspond to longer paths after multiple boundary reflections and internal scattering. Thus, any tiny changes that may not be picked up by the first arrivals will be accumulated and amplified in the wave codas. Therefore, time shifts between the codas of two consecutive signals are longer and easier to detect than between the signals' first arrivals (Figure 4). The coda wave analysis can detect changes in wave velocity on the order of $\Delta V/V < 0.1\%$. The experimental result of dry quartzitic sands under constant confinement shows that its stiffness creeps with time in a power law.

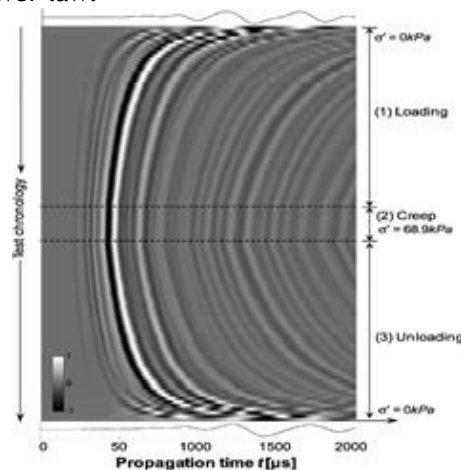


Fig. 4. Cascade of wave signals collected for clean quartzitic sands during the loading, creep at constant stress, and unloading processes

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

1.5 Modeling salt stiffness and permeability evolution during damage and healing

The very low permeability of salt rock is its principal advantage for nuclear waste disposal and high-pressure gas storage. Creep tests on granular salt assemblies were carried out under constant temperature and humidity conditions. Probability distributions of crack radius, void areas and crack spacing were determined based on microscope imaging and micro-CT scanning. Statistical moments of these descriptors were used to formulate a fabric-enriched Continuum Damage Mechanics model that couples damage and healing effects on the mechanical and transport properties of salt rock. A stress path comprising a tensile loading, a compressive unloading, a creep-healing stage, and a reloading was simulated. As expected, stiffness decreases (respectively increases) and permeability increases (respectively decreases) upon damage (respectively healing). Results also highlight the increased efficiency of healing with temperature. The micro-macro relationships established by statistical image analysis also provide the evolution of microstructure descriptors during the test. Simulations show that porosity changes have less influence on permeability changes than changes in crack connectivity.

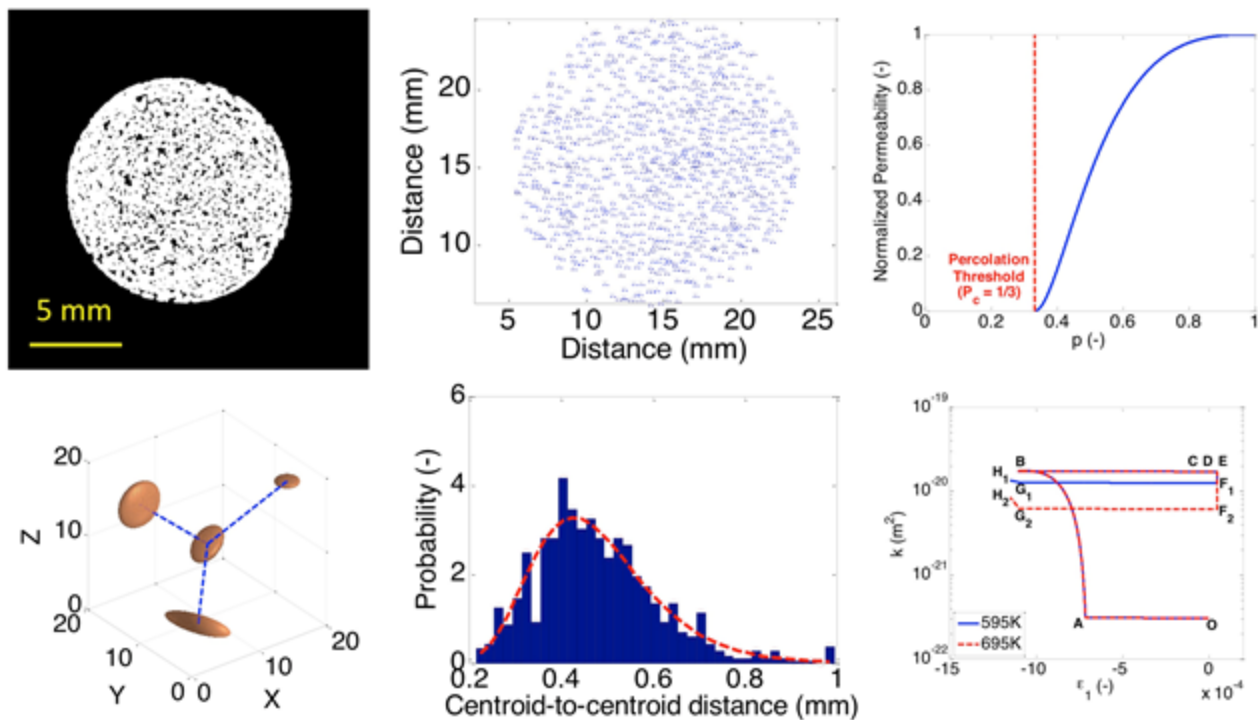


Fig. 5. Principle of the fabric-enriched damage and healing mechanics model formulated for predicting salt stiffness and permeability: micro-CT scans of granular salt samples (top left), image processing (top center), statistical analysis of pore connectivity (bottom left and center), evolution of permeability with pore pressure (top right) and axial deformation (bottom right)

1.6 Modeling salt crust formation on soil surfaces

Salt precipitation plugs pores and generates crystallization pressure that can damage stone, concrete, and ceramics, affect roads and underground structures, and diminish farming land. The salt concentration gradually increases at the soil free surface when the evaporation rate exceeds the diffusive counter transport (Figure 6). Eventually, salt precipitates and crystals form a porous sodium chloride crust with a porosity of 0.43 ± 0.14 . After detaching from soils, the salt crust still experiences water condensation and salt deliquescence at the bottom, brine transport across the crust driven by the humidity gradient, and continued air-side precipitation. This transport mechanism allows salt crust migration away from the soil surface forming salt domes above soil surfaces.

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

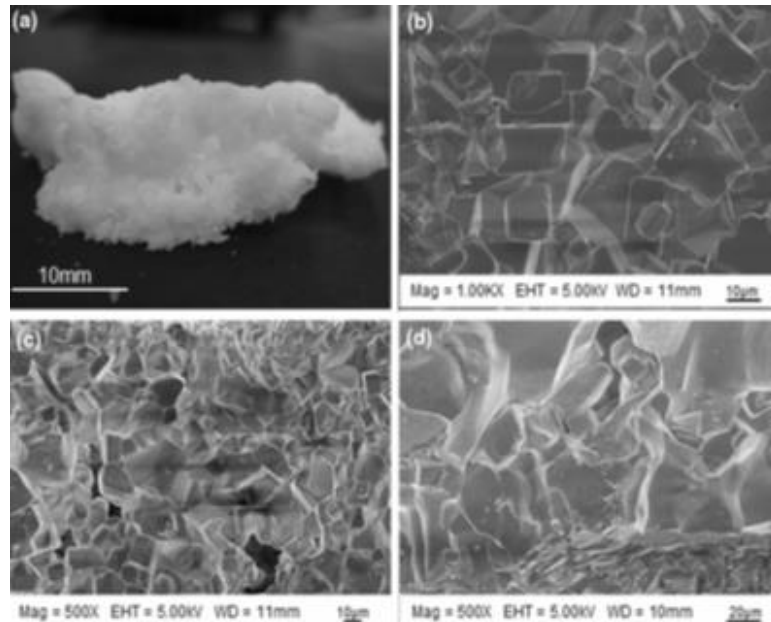


Fig. 6. Porous nature of salt crust formed on soil surfaces

1.7 Characterization of fly-ash

In recent decades, advances in low NO_x coal combustion and increasingly strict CO_2 reduction mandates have changed power plant boiler operations significantly. As a result, the characteristics of fly ash generated at many power plants have also changed. In particular, increases in unburned carbon content (Figure 7) have been observed with detrimental implications on the utility of these fly ashes in concrete applications. Over the same period, the combustion of biomass for energy generation has received increased attention due to the potential benefits of reducing emissions (CO_2) and improved sustainability when compared to fossil fuel combustion. Results from physical and chemical characterization of ash samples show no significant differences between pure coal ash and coal co-fired with biomass ash samples from the same power plant. However, there are significant morphological, chemical, and mineralogical differences between coal ash and pure biomass ash.

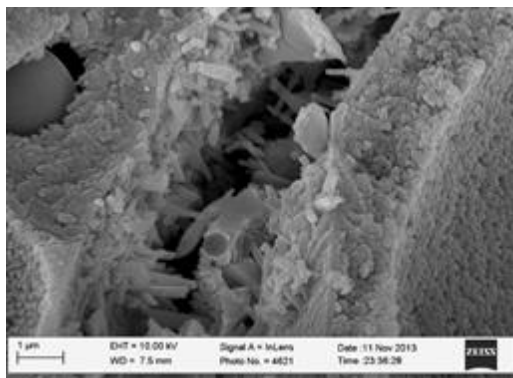


Fig. 7. SEM image of fly-ash

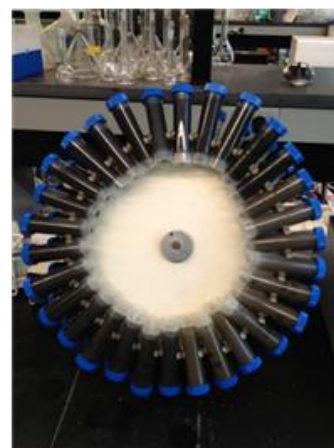


Fig. 8. Rotation shaker for contaminant adsorption equilibrium and kinetic testing

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

2. Environmental Geotechnics

2.1 Storm-water runoff from highway construction sites

Most highway and construction site storm-water runoff originates from non-point or diffused sources. This runoff contains environmental pollutants, which when transferred to sensitive receiving waters, can result in deterioration of water quality and downstream aquatic habitat. The work being performed in this study characterized storm-water runoff from an interstate highway in Georgia for comparison of conditions before, during, and after construction of a highway culvert. A statistical wavelet analysis technique (MODWT) was used to analyze the high-resolution water quality data collected during the construction period. Results demonstrated the method was useful for analysis of transient signals, as in the case of storm-water monitoring data. It yielded insight into the behavior of parameters at several temporal scales; for example, the diurnal behavior of parameters was clearly evident in the results. Also, the transient events which impacted water quality. Most significantly, the effect of short term events such as concrete pours and storm events was observed.

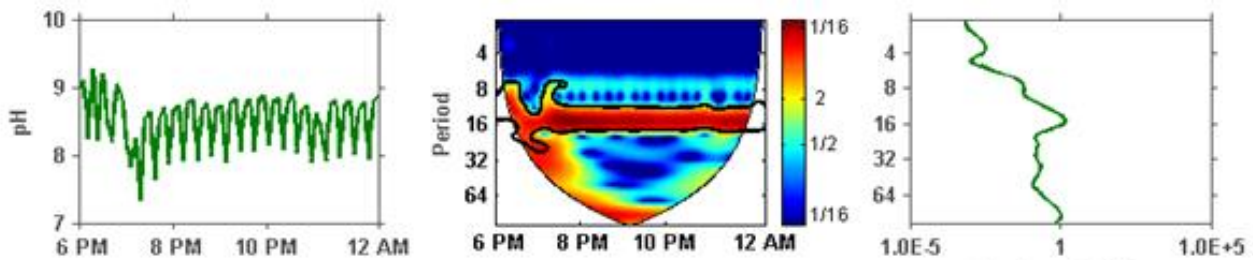


Fig. 9. Wavelet analysis of storm-water runoff data

2.2 Chemical weathering effects on particle surface roughness

Chemical weathering significantly impacts the nature of soil deposits, especially in warm, humid climates, resulting in alteration of soil fabric, composition, and soil grain characteristics. Iron-bearing (Fe^{II} ferrous) minerals are of significant interest due to their abundance in nature, and to their susceptibility to dissolution under typically encountered geochemical groundwater conditions. This work studied the effect of adsorbed iron oxides on the shear strength of laboratory-prepared iron oxide-coated sands. Goethite- and hematite-coated Ottawa sands were synthesized in the laboratory via a heterogeneous geochemical suspension reaction method. The critical state friction angle of coated sands increased more than 5% iron oxide coatings also increased dilatancy and decreased contractiveness. The experimental findings resulted from changes in the relative roughness and contact area of the coated sands.

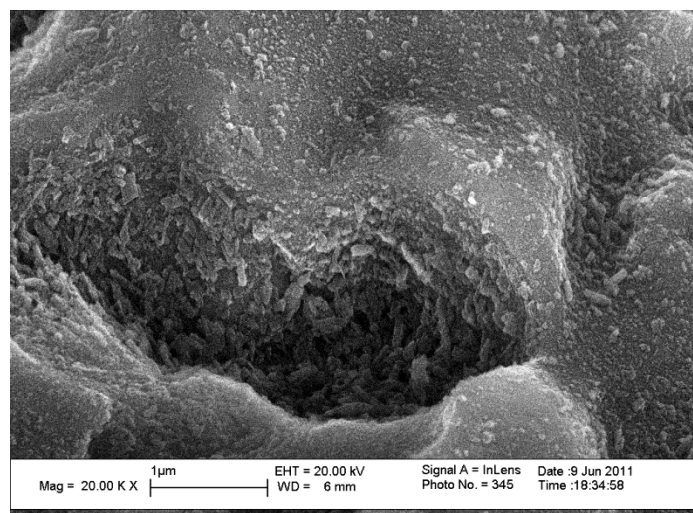


Fig. 10. SEM image of iron oxide coated sand particles

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

2.3 Molecular dynamics simulations of clays with controlled coatings

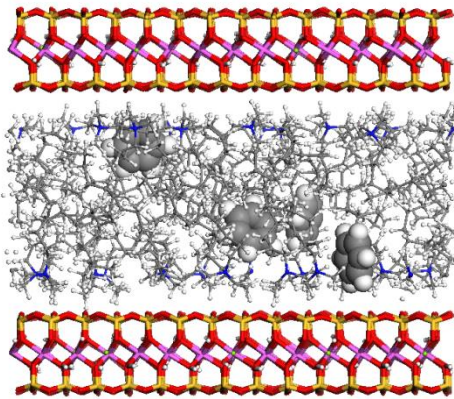


Fig. 11. Molecular dynamic simulations of clay interlayer

Engineered organoclays are 2:1 phyllosilicate clay minerals synthesized with a controlled organic coating to provide enhanced mechanical and chemical properties when compared to unmodified naturally occurring clays. Organoclays synthesized with montmorillonite as the base clay have demonstrated increased frictional strength, decreased compressibility, and enhanced sorption compared to the unmodified clay. The work performed in this investigation studied the behaviors of montmorillonite modified by quaternary ammonium cations (QAC clays), chosen with controlled structure and density of loading. The geochemical processes were modeled in the QAC clay interlayer using molecular dynamics simulations, and included organic cation structure and arrangement, organic compound sorption and mass transport, and surface electrokinetics of suspended QAC clay particles, and yielded insight into strength, deformability, sorption, and electrokinetic properties of the modified clays.

2.4 Waste containment

Municipal solid waste is most commonly land disposed, within a containment system designed to reduce the advective transport of contaminants. Engineered barriers are designed with composite liners and redundancy in the system to minimize the rate of leakage into the surrounding environment.

Additional containment measures can be included within these systems in order to further retard the movement of contaminants into the environment. Ongoing research at Georgia Tech has focused on investigation of the fundamental properties and behavior of soils that have been engineered to retard the transport of organic contaminants through earthen barriers. Organobentonites, which are clay based soils that have had their inorganic cations replaced with organic cations, have demonstrated enhanced sorption capacity for a wide variety of volatile organic compounds (VOCs). The sorption capacity of these engineered materials, which can be incorporated into earthen barriers and geosynthetic clay liners, is substantially enhanced when compared to unmodified bentonite, with enhanced strength and stiffness behavior.



Fig. 12. Characterization of MSW for optimization of organobentonites in earthen barriers

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

2.5 *In situ* treatment of highway storm-water runoff

Highway storm-water runoff contains a number of contaminants including nutrients and heavy metals that can be detrimental to the health of lakes, rivers, and streams. Bio-filtration is a common storm-water treatment mechanism that can reduce nutrients and heavy metals through physical, chemical, and biological processes. The presence of vegetation and a permanent saturated layer underneath the surface of a bio-filter can sorb and retard contaminants, as well as enhance denitrification (nitrogen removal). Ongoing work has studied six native Georgia grasses, as well as one turf grass, for their ability to remove contaminants through bio-filtration. Results indicated that Big Bluestem, Indian-grass, and Switchgrass, when paired with a permanent saturated zone, removed the highest percentage of total nitrogen in all experimental conditions. Phosphorus, copper, lead, and zinc removal was not correlated with plant species; however, a permanent saturated zone increased removal of phosphorus, copper, and zinc (removal of lead was >97% in all cases making differences in removal insignificant). These results support the impact of specific vegetation types on the removal extent of total nitrogen.



Fig. 13. Bio-filtration system

2.6 Performance of debris flow mitigation systems

Post-earthquake debris flows in the Sichuan Province, China after the 2008 Wenchuan earthquake led to the exposure of the shortcomings in the design of the conventional debris flow mitigation system and resulted in significant damage to downstream communities. The poorly sorted loose soil particles deposited by the co-seismic landslide in the Wenchuan event provided abundant source material for debris flows under the saturation and agitation of water. As a result, a holistic design solution for the debris flow mitigation system was proposed and constructed in the Wenjia Gully, which has exhibited superior performance and resilience during subsequent debris flows. The two-fold solution reduces the energy of debris flows by combining various mitigation measures, while minimizing the potential hazard by event forecasting and rapid public information sharing. The design of the mitigation system was governed by a three-part philosophy of water control, debris control, and erosion control. As part of the solution, an Early Warning System (EWS) for debris flow was developed to leverage real-time field data. The EWS issues alerts based on the rainfall thresholds associated with different possibilities of debris flow events. The increase of the rainfall ID threshold, peak minimum rainfall intensity threshold, and the intensity-antecedent precipitation threshold in the past three years indicate high efficiency of the mitigation system. The susceptibility of debris flow in Wenjia Gully is lower than what it was before the Wenchuan earthquake. Studies conducted in conjunction with researchers from the State Key Laboratory for Geohazard Prevention and Geo-environmental Protection at Chengdu University of Technology have evaluated the characteristics of



Fig. 14. The stepped flexible drainage channel in the midstream of the Wenjia Gully

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

rainfall and debris flow events that occurred before and after the implementation of the new mitigation system. The aim is to evaluate the effectiveness of one of the most advanced debris flow mitigation system in China.

3. Petroleum Geomechanics and Rock Engineering

3.1 Fracturing mechanisms in tool-rock interaction

Fracturing mechanisms involved in the interaction of a tool with rock are critical to improving the efficiency of mechanical excavation in tunneling for infrastructure development as well as mining and drilling for energy and resources extraction from the subsurface. Numerical analyses based on FEM and DEM are conducted to better understand the fracturing mechanisms beyond the primary crack systems, in particular, how the material properties, tool geometry and field conditions such as the in situ stresses and the loading-unloading actions, affect the development of the lateral crack systems, which are primarily responsible for rock chipping and fragmentation.

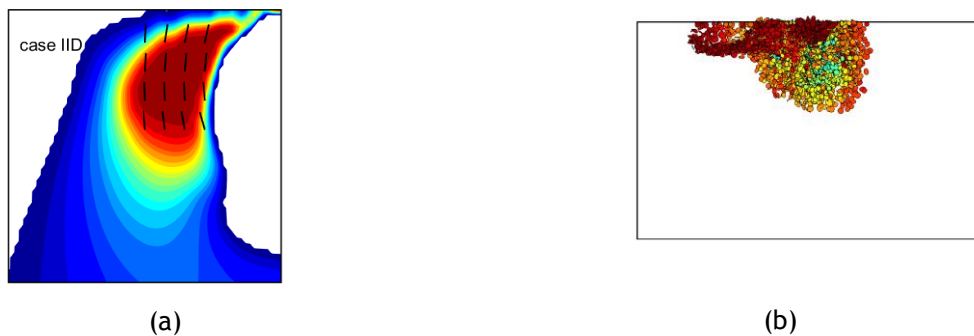


Fig. 15. Evidence of lateral crack development after a rigid tool is pressed down against the rock surface and then removed; (a) contours of the in-plane principal tensile stress in a vertical cross section from a FEM simulation, (b) side view of micro-crack accumulations from a DEM simulation

3.2 Drilling mud loss prediction

Severe circulation loss is a common contributor to the nonproductive time in drilling and could cause significant issues in subsequent well completion and reservoir production. Quantitative prediction of the drilling mud loss is crucial for selecting prevention and remedial strategies to control lost circulation. Numerical tools based on hydraulic fracturing geometry models are developed to predict the transient mud loss for the particular cases when the wellbore intersects the natural fracture either vertically or horizontally. Meanwhile, based on a worst case scenario, a theoretical model is developed to predict the total mud loss volume and the mud invasion profile when an inclined wellbore intersects an arbitrary oriented natural fracture. Such a model could also be used for predicting the grout placement in a rock joint for rock mass improvement.

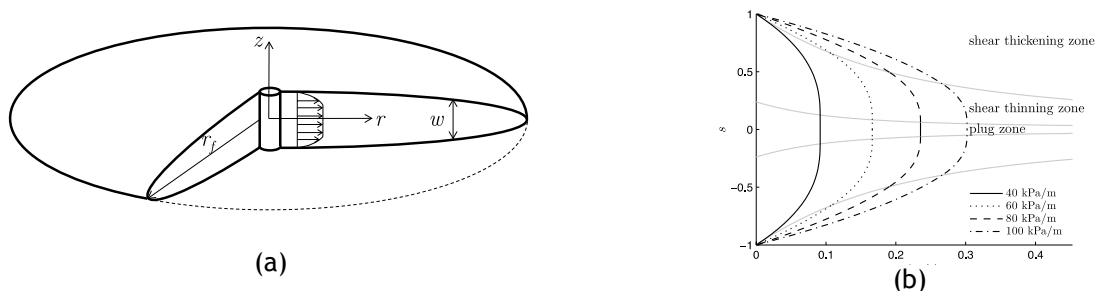


Fig. 16. A mud loss model based on radial fracture growth, considering complex non-Newtonian rheology

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

3.3 Damage localization and multi-scale fracture propagation in rocks

A numerical method was developed to couple a Cohesive Zone Model (CZM) and a Finite Element - based damage model that can capture the flow of energy that takes place between the bulk material that forms the matrix and the macroscopic fracture surfaces. As an example, the shear energy release rate of the CZM was fitted in order to match to the post-peak stress/strain curves obtained during experimental tests performed on Bakken shale. The calibrated shale rheology was used to simulate the propagation of a meter-scale mode II fracture. Under low confining pressure, the macroscopic crack (CZM) and its damaged zone propagate simultaneously (i.e. during the same loading increments). Under high confining pressure, the fracture propagates in slip-friction, i.e. the de-bonding of the cohesive zone alternates with the propagation of continuum damage. The computational method is applicable to a range of geological injection problems including hydraulic fracturing and fluid storage, and should be further enhanced by the addition of mode I and mixed mode (I+II+III) propagation.

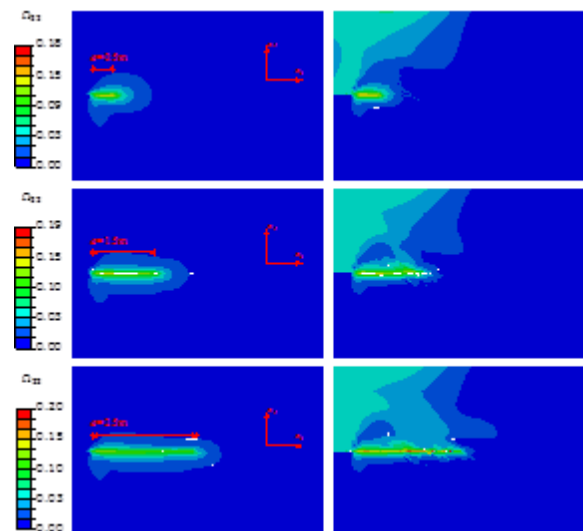


Fig. 17. Vertical damage (i.e. distribution of horizontal micro-cracks) around the cohesive zone when the material crack tip reaches $a = 0.5$ m, $a = 1.5$ m and $a = 2.5$ m for $p_c = 5$ MPa (left) and $p_c = 25$ MPa (right)

3.4 Measuring strains due to geologic storage in-situ

Geologic storage of carbon dioxide is a promising way to limit the increase of greenhouse gases in the atmosphere. Injecting CO_2 or other fluids into a well deforms the enveloping rocks in a complex pattern that increases in magnitude and expands outward with time. This evolving strain field holds important information that can be interpreted to improve understanding of geomechanical processes, such as fault slip, which could hinder the injection process. On the other hand, this information can be used to evaluate formation properties and pressures, which will reduce risks and costs associated with injection. The in-situ strain field is a tensor with six independent components, and while all of them provide useful information only the tilt component is currently used for monitoring injection. The strain signal is affected by CO_2 injection in ways that vary strongly in space and time. Results of initial analyses suggest that measurements of multiple components of strain could be used to characterize pressure distribution, leaks, and phase distribution, among other processes. The strain signal at near-surface depths is particularly significant because it suggests that relatively shallow strain measurements in the confining unit could be used to characterize pressures and properties in the underlying reservoir.



Fig. 18. Bartlesville Formation exposed in road-cut west of Avant Field

The strain signal at near-surface depths is particularly significant because it suggests that relatively shallow strain measurements in the confining unit could be used to characterize pressures and properties in the underlying reservoir.

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

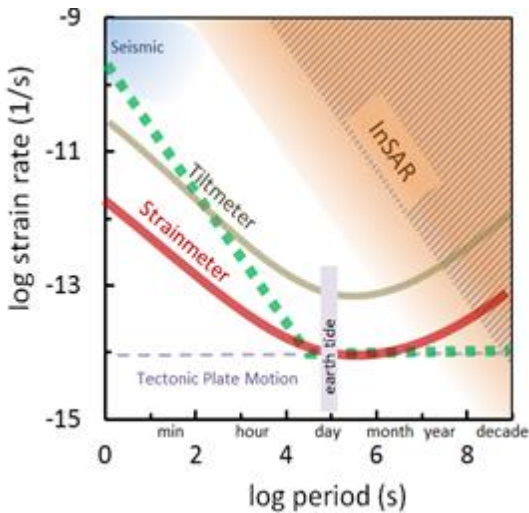


Fig. 19. Deformation monitoring methods.

Region above green line of interest for characterizing and monitoring CO₂ storage. Revised from Plate Boundary Observatory Report (1999)

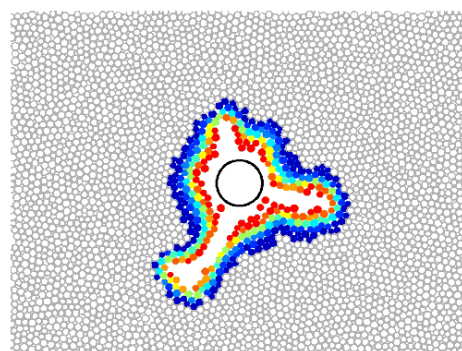
Measuring strain in the field includes techniques deployed at both the ground surface and in-situ. Surface methods such as Interferometric Synthetic Aperture Radar (InSAR) and Global Positioning System (GPS) receiver networks have been used to evaluate deformation associated with subsurface injection, including deformations associated with CO₂ storage. Strain meters bridge the gap between the very long period, relatively low resolution measurements provided by InSAR and GPS, and the high frequency seismic sensors (Figure 19). A field demonstration to monitor strains in the vicinity of a water injection well used to increase oil recovery from the Bartlesville Formation, a 100-ft-thick Pennsylvanian sandstone at a depth of 1700 ft in the Avant Field in Osage County, Oklahoma is being planned. This will serve as an analog to CO₂ injection. The effects of ambient signals will be evaluated by monitoring in the vicinity of a gas cap. The geology of the Avant Field is similar to conditions proposed for CO₂ storage, and the presence of other on-going injection and production activities in neighboring locations is also similar. The research is ongoing in collaboration with Clemson University.

3.5 Fluid injection in dense granular media

Experimental and theoretical analyses are performed to investigate how a dense granular medium behaves in response to fluid injection in the subsurface. This is a subject of fundamental and applied research interests to better understand subsurface processes such as fluid or gas migration and formation of intrusive features as well as engineering applications such as hydraulic fracturing and geological storage in unconsolidated formations. A novel experimental setup similar to the Hele-Shaw cell is developed to allow direct visualization of the fluid injection process. Depending on the injection rate and the granular medium and fluid properties, distinct fluid-grain displacement regimes are identified. DEM based analyses are employed to investigate the growth mechanisms of the fluid channels as well as the effect of the parameters governing the injection process.



(a)



(b)

Fig. 20. Laboratory experiments (a) and DEM simulations (b) of fluid injection into a dense granular medium

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

4. Energy Geotechnics

4.1 Geological carbon sequestration

Continued carbon emissions into the atmosphere are anticipated in the coming decades as fossil fuels will remain as the dominant energy resource. A prospective method to alleviate carbon emission is geological carbon sequestration with the potential to reduce the amount of CO₂ into the atmosphere by Giga-tons annually. The competence of geological carbon sequestration relies, to a large extent, on the short-term injection efficiency and the long-term capillary trapping and geological stability. Experimental and numerical studies have been conducted to enhance the understanding of the impacts of pore characteristics on the efficiencies of scCO₂ injection and trapping (Figure 21).

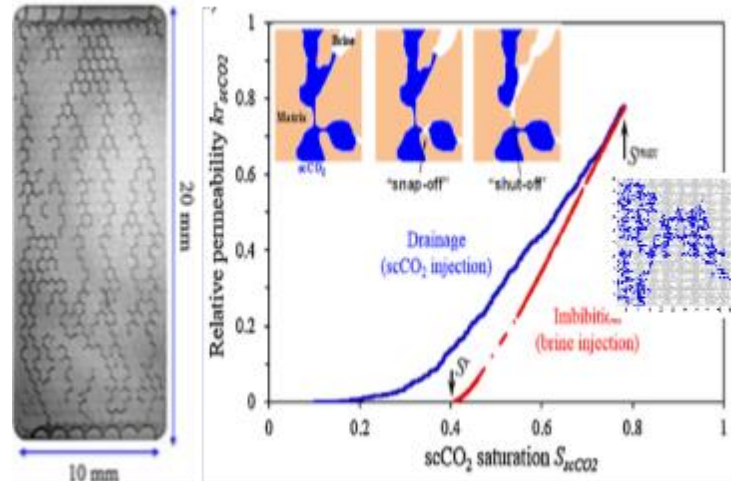


Fig. 21. Supercritical CO₂ injection into brine-saturated porous media

4.2 Characterizing faults and leaks during CO₂ storage

Fault slip occurs when stresses caused by injection reach a critical value. Maintaining stresses below a critical stress state is important for limiting the risk of faulting and subsequent leakage. This scenario can be evaluated by considering CO₂ leakage up a permeable, blind, modest-sized fault of approximately 800 m in maximum dimension, which dipped 60° (Figure 22). The model fault is shaped like a dipping ellipse, 150 m from the well, with the upper edge approximately 500 m from the ground surface (Figure 22a). Strain is monitored at the colored points, which are 100 m deep and 200 m from the well. Reservoir is 1 km deep. Wellbore pressure is 1.5 MPa = 220 psi, fault pressure is <70 psi. The permeability of the fault was assumed to be much greater than that of the confining unit so it became pressurized during a 12-day-long injection test (Figure 22b). Strain was measured at monitoring locations 200 m from the injection well and at 100 m depth, approximately 400 m above the fault (colored points in Figure 22a). The analysis shows that the pressurized fault caused a significant change in the strain field. The horizontal strain in the dip direction at the monitoring points increases compared to the baseline strain calculated for the same injection scenario without the fault (Figure 22c). Moreover, the magnitude of the strain at the monitoring locations is significantly different, even though they are the same distance from the injection well (Figure 22d). The analysis indicates that the effects of this fault would become apparent as the strains at the symmetric monitoring points differed after one to two days of injection. This is much faster than could be detected using methods of strain measurement at the ground surface, like GPS and InSAR.

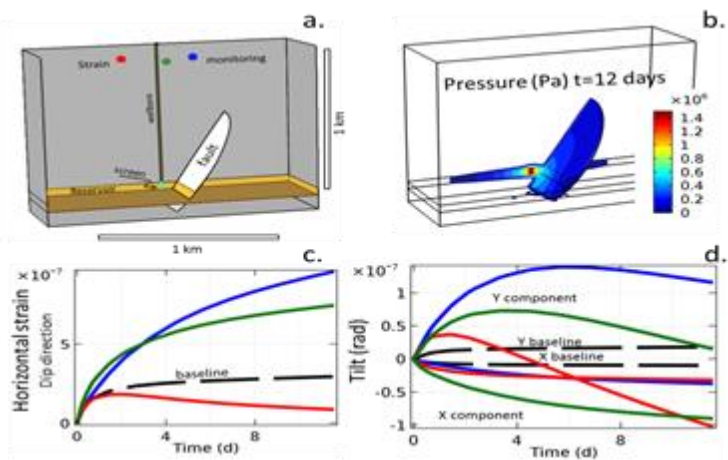


Fig. 22. Effects of a leaky fault on the strain field during injection. (a) Configuration of the finite element analysis. (b) Pressure field after 12 days of injection in Pa. (c) Horizontal strain in Y direction, parallel to dip of fault, at measurement points (colored). Strain with intact confining unit shown as dashed baseline. (d) Tilts in X (along strike) and Y (dip) directions at monitoring points (colored), and baseline (dashed)

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

4.3 Modeling in-situ pressures during CO₂ storage

Pressure changes in subsurface formations during injection also result in distinctive strain patterns in the subsurface. We conducted a baseline analysis to illustrate this effect where an elliptical region 400 m across and 20 m thick at a depth of 1 km was pressurized by 1 kPa (0.15 psi). The elastic modulus of the enveloping rock was 10 GPa. The results indicate the highest strains occur in the vicinity of the pressurized zone (Figure 23). The different components of strain form different patterns, and they all are greater than 1 nanostrain within broad regions in the vicinity of the pressurized zone.

There are two important insights from this analysis. One is that the strain patterns are distinctive and form a characteristic signature from the pressurized geometry. This is the reason why multiple components of strain are more effective than single components, or pressure signals, at constraining pressurized geometries. The analysis also shows a variable strain field near the ground surface, suggesting that shallow sensors could detect the signal. The other insight is that a remarkably small pressure, 1 kPa, produces a strain field that is greater than the resolution of available strainmeters, and the instruments we have developed. The magnitude of the strain scales with the pressure, so increasing the pressure by several orders of magnitude to the range of a CO₂ storage project would cause a strong signal that could be clearly seen by the instruments. It also means that subtle changes in pressure, like what could occur in a leak, could result in strains that could be detected, even when measurements are made close to the ground surface. The caveat, of course, is that the signal from this effect must be distinguished from other background strains, spotlighting the importance of signal processing for these applications.

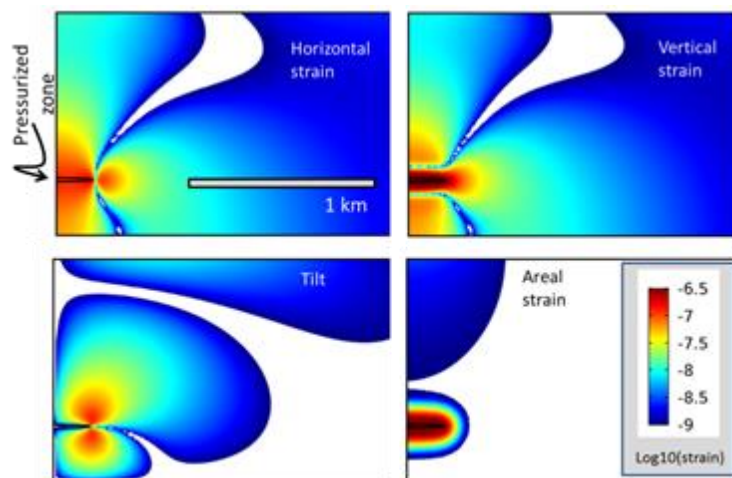


Fig. 23. Strain field (scale is $\log(\text{strain magnitude})$) in the vicinity of an elliptical zone pressurized by 1 kPa (~ 0.2 psi) at 1 km depth in rock with $E = 10$ GPa. Elliptical region is 400 m by 20 m thick. All colored region is greater than 1 nanostrain. Strain magnitude increases in proportion to the pressure in the elliptical zone

4.4 Using ambient signals to monitor performance of CO₂ storage systems.

Monitoring and characterization using background seismicity has been used for a wide range of applications, including geothermal exploration. Broadband strain sensing can extend the use of natural signals into the frequency range of 10^{-4} to 10^{-7} Hz. This enables the use of Earth tides and barometric pressure changes as natural sources of large scale load perturbations resulting in a small, but measurable strain response.

To test this idea we conducted an analysis of a hypothetical gas lens at a depth of 1 km. The lens is 200 m long and 10 m thick and it resides along the top of an aquifer or reservoir (Figure 24a). The gas causes the compressibility of the lens to be greater than that of the enveloping region. Similar results would occur if pores were filled with supercritical CO₂. The results show that the strain in the subsurface varies spatially as a result of the presence of the gas lens at depth. It is particularly encouraging to see that strain variations occur at shallow depths (<100 m) where they could be detected by sensors in shallow borings (dots in Figure 24a). The horizontal strain signal is periodic (Figure 24a), in response to the periodic load, but the magnitude and phase of the strain vary with location (Figures 24b, c and d). The Lissajous plot in Figure 24a shows how the strain and barometric pressure form distinctive patterns whose size and shape depend on the magnitude and phase of the periodic signal, as well as on the location of the sensor.

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

It seems likely that these signals could be inverted to estimate the characteristics of the gas lens that caused them.

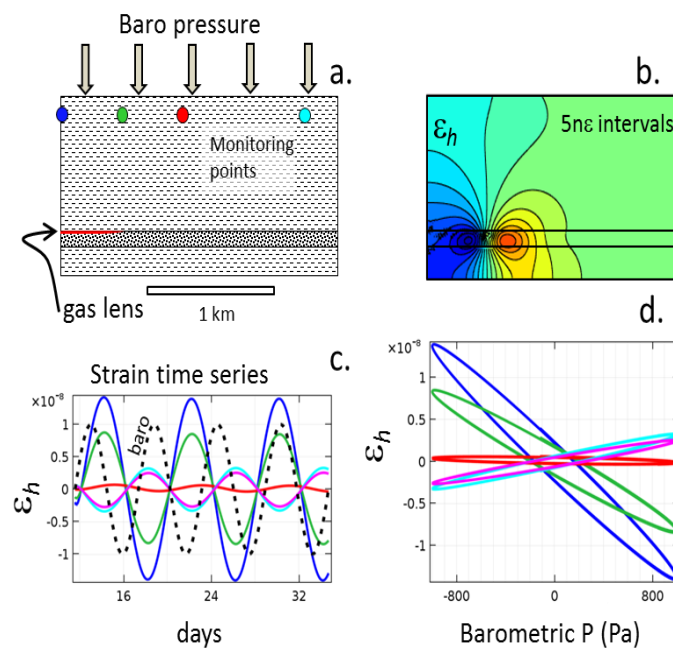


Fig. 24. Strain caused by barometric loading of a compressible CO_2 lens at depth. (a) Configuration, CO_2 lens at 1 km depth (red) is loaded by periodic variations in barometric pressure. (b) Cross section of horizontal normal strain in $5 n_\epsilon$ contour intervals; (c) Time series of strain and barometric pressure. Colored lines are from monitoring points with similar color in (a); (d) Lissajous plot of strain and pressure from monitoring points shown in (a). The gas lens affects the magnitude and phase of the strain, which creates a distinctive signal for inversion

4.5 High pressure sampling and recovery of hydrate-bearing sediments

Gas hydrates are clathrate compound of natural gas (methane) and water. Massive amounts of hydrates can be found beneath permafrost and within continental marine sediments, playing a critical role in potential energy resource, global carbon budget, and submarine seafloor instability. Characterization of natural hydrate-bearing sediments faces experimental difficulties of maintaining high pressure throughout the experimental time to prevent hydrate dissociation. An array of unprecedented high-pressure devices have been developed to allow transferring, sub-sampling, and testing natural specimens without depressurizing or causing hydrate dissociation, i.e., the pressure core technology (Figure 25).



Fig. 25. High pressure core tool

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

4.6 Viscous damage and fatigue in salt formations used for geological storage

A self-consistent homogenization scheme was used to upscale the viscoplastic and damage behavior of halite polycrystals from mono-crystal viscous glide and associated breakage mechanisms. A failure criterion was introduced at the mono-crystal scale in order to predict grain breakage and the subsequent evolution of salt damaged elastic moduli. The model provided micro-mechanical interpretations to important aspects of salt rock visco-plastic and fatigue behavior, which had not been explained so far, such as strain hardening, creep recovery, as well as damage and accelerated creep due to grain breakage. Moreover, incremental visco-plastic strains decreased over the cycles, which is in agreement with the phenomenon of “shakedown” observed in elasto-plastic media (Figure 26).

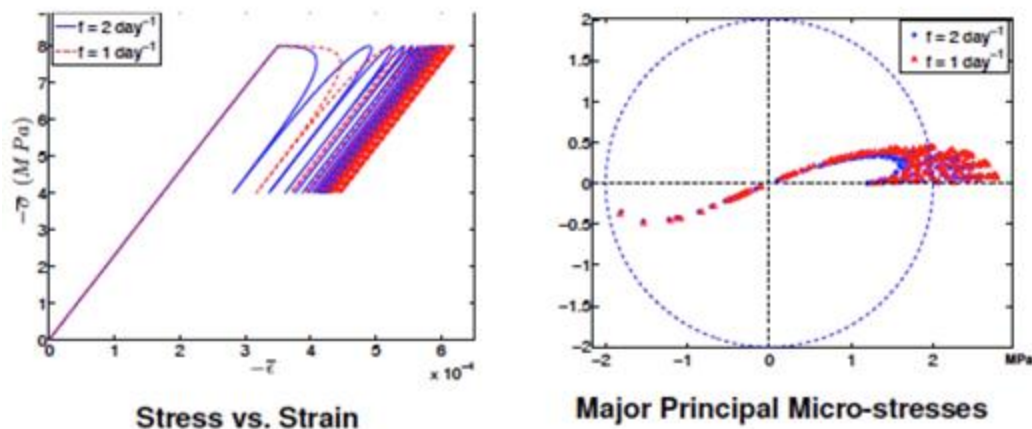


Fig. 26. Simulation of a cyclic axial compression test performed on a salt polycrystal in typical CAES conditions. Prediction of the stress/strain behavior (left) and of microscopic (grain scale) stresses (right)

The critical visco-plastic deformation was set as a yield criterion to control the transition between secondary and tertiary creep in a phenomenological visco-plastic model. The formation of a damaged zone around a Compressed Air Energy Storage (CAES) facility subject to depressurization was simulated with the Finite Element Method (Figure 27).

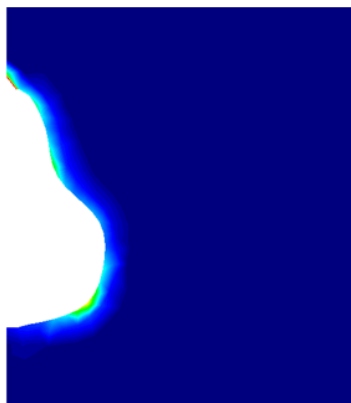


Fig. 27. Simulation of damage subsequent to the depressurization of a salt cavern

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

4.7 Engineered Transition Zone Energy Piles

Thermal characteristics and performance of energy piles and other energy foundations have received relatively little attention in comparison to the hydro-mechanical behavior of these systems. In this regard, the concept of an engineered “transition zone” is currently being investigated. The transition zone consists of a thermally optimized material that not only reduces the contrast between the thermal properties of the pile element, but can also be used to decouple the structural component of the pile from the thermal component and provide more freedom in the number and configuration of circulation pipes to enhance heat transfer. Numerical simulations to date, performed using a multi-physics COMSOL model, indicate that the introduction of a transition zone can considerably increase power extracted from the system in comparison to an energy pile without a transition zone. A laboratory scale model is currently under development to study the transition zone behavior under a controlled environment and further validate the numerical model.

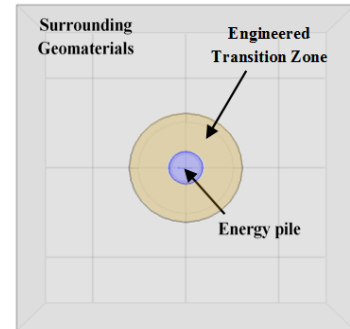


Fig. 28. Plan view of engineered transition zone energy pile

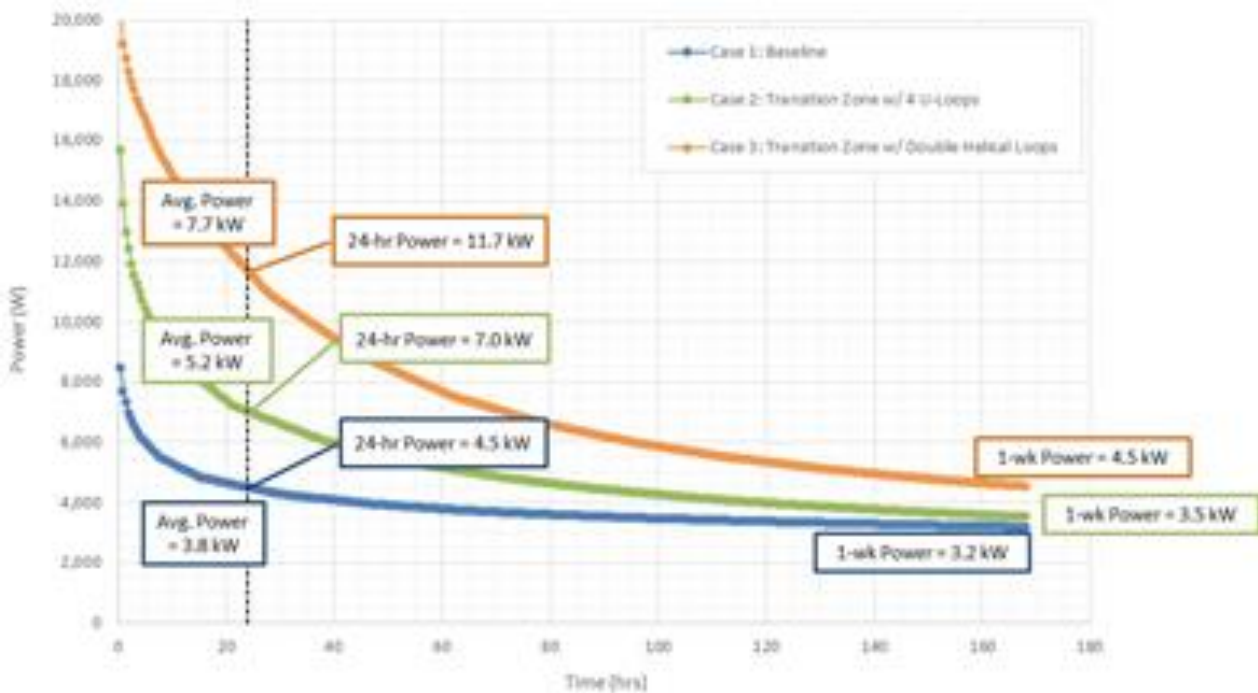


Fig. 29. Results of COMSOL simulations of conventional and transition zone energy piles

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

5. Bio-geotechnics

5.1 Bio-inspired optimization of flow networks

According to constructal theory, a flow network of finite volume, embedded in a finite porous matrix of constant flow rate, is optimal for fluid withdrawal from a sink point when its topology is fractal. To verify this optimum, slime mold was placed on spots forming a regular grid in agar, and used to create a fractal nutrient pathways (Figure 30). The area occupied by the slime mold over time was determined using image analysis. Preliminary results showed that slime mold propagates faster on fractal nutrient pathways, in agreement with the constructal theory.

By providing a water source, sinks and geometric constraints, studies to optimize the topology of a water line network were performed. Fluid injection in a porous medium represented by continuum Finite Elements surrounded by Cohesive Zones (CZ's) was simulated. A Root System Architecture (RSA) model will be calibrated against observations made by growing stems in a 3D printed chip. Root growth around obstacles will be simulated for various plant species, while analog simulations will be conducted with the CZ model and compared to the networks topology, performance and resilience.

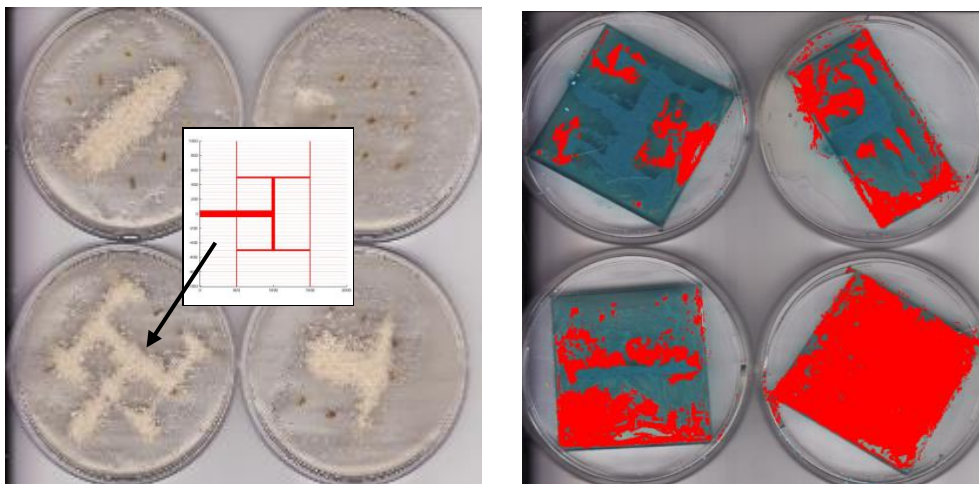


Fig. 30. Left: Fractal nutrient pathways (yellow) used to study the propagation of slime mold (dark dots) in agar (white). Right: After three days, area occupied by slime mold (red) vs. agar (dyed in blue)

5.2 Bio-inspired insights from ant nest topology

It has been estimated that ants use less than 0.1% of the energy that the most advanced human tunnelling machines do to excavate the same volume of soil. It is believed that ants are able to do so since they perform their tunnelling activities using a variety of approaches which seem to minimize the amount of energy expended at each step including tunnelling around obstacles, not removing particles that are deemed critical to supporting the surrounding soil particles (particles that are part of primary force chains) and creating clumps of several smaller particles as appropriate before removing them from the tunnel. These insights have been gleaned from both observing their behaviour while tunnelling as well as studying the characteristics of castings of the ant hill structures they create. An image with a "harvester-ant" nest casting is shown in Figure 31.



Fig. 31. Harvester ant nest casting after removal of soil

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

On-going studies are investigating the topology of the structure using DEM simulations and in particular, the geometrical configuration of the larger open structures which appear to be spaced apart by equal distances. Initial indications from the DEM simulations are that the presence of multiple cavities reduces the size of force chains in the vicinity of the openings and that more stable structures exist when multiple large cavities are present. A comparison of force chain plots for a single versus double cavity is shown in Figure 32.

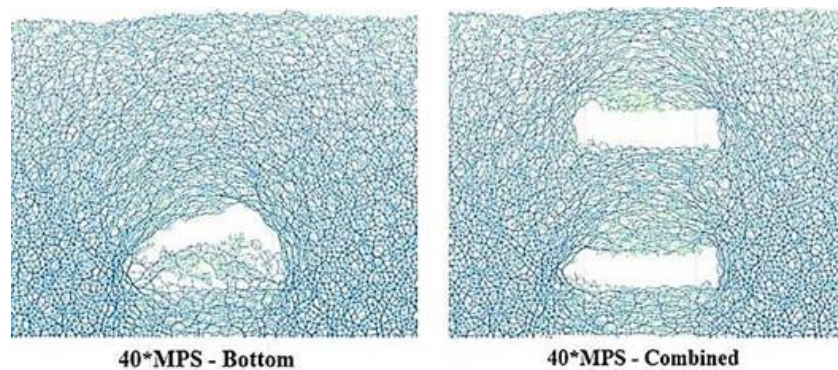


Fig. 32. DEM simulation force chains for single and double cavities

5.3 Characterization of multi-functional root systems

Plant roots accomplish multiple functions including provision of water (hydraulic function) and nutrients (chemical function) as well as providing anchorage (uplift and download) against external forces (wind). As such, roots may be one of the most evolved multi-function systems in that all these functions are nominally accommodated in a single root system, albeit with different portions of the root system contributing to different degrees to these various functions. To better understand the relationship between tree roots and the structural capacity of the roots as a foundation system, on-going studies are undertaking both experimental and numerical simulations using root analogues. The analogues being used included un-branched and branched wire cables that incorporate many of the characteristics of tap roots as well as 3D printed roots that incorporate many of the characteristics of fibrous roots. A selection of root analogues are shown in Figure 33. Results from experimental pull-out tests conducted on un-branched and branched tap roots with and without friction (achieved by coating outside of root fibres with sand) show significant differences in terms of both peak and large displacement root resistance. Typical results are shown in Figure 34 and indicate that branched tap roots reach a larger peak than un-branched ones and also exhibit significantly less post-peak reduction in resistance. Further, roots with textured surfaces (higher friction) typically indicate higher pull-out resistance compared to their smooth-surfaced (lower friction) counterparts as seen in Figure 34.



Fig. 33. Selection of root analogues

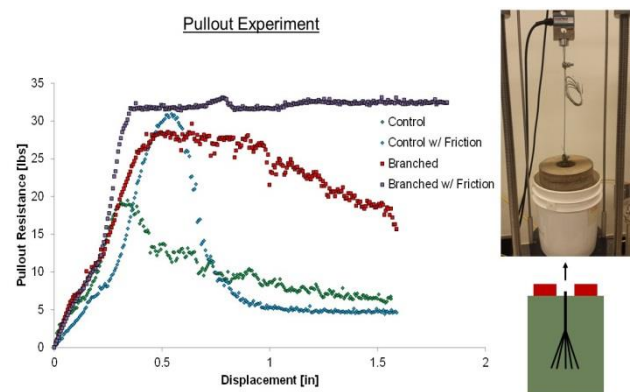


Fig. 34. Relative pullout capacity of root analogues

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

5.4 Evaluation of root analogue and particulate interactions using DEM

To further evaluate the structural capacity of root systems, DEM simulations were performed. Results from DEM numerical simulations of compression loading of fibrous root analogues further demonstrated differences between typical human-constructed and nature-constructed foundation systems. Figure 35 shows the force versus displacement response for different root analogues (straight, zig-zag, 15 degree splay and 30 degree splay). It can be seen that the common human implemented approach of using a straight shaft pile yields the lowest resistance while the large splay pile yields the largest resistance.

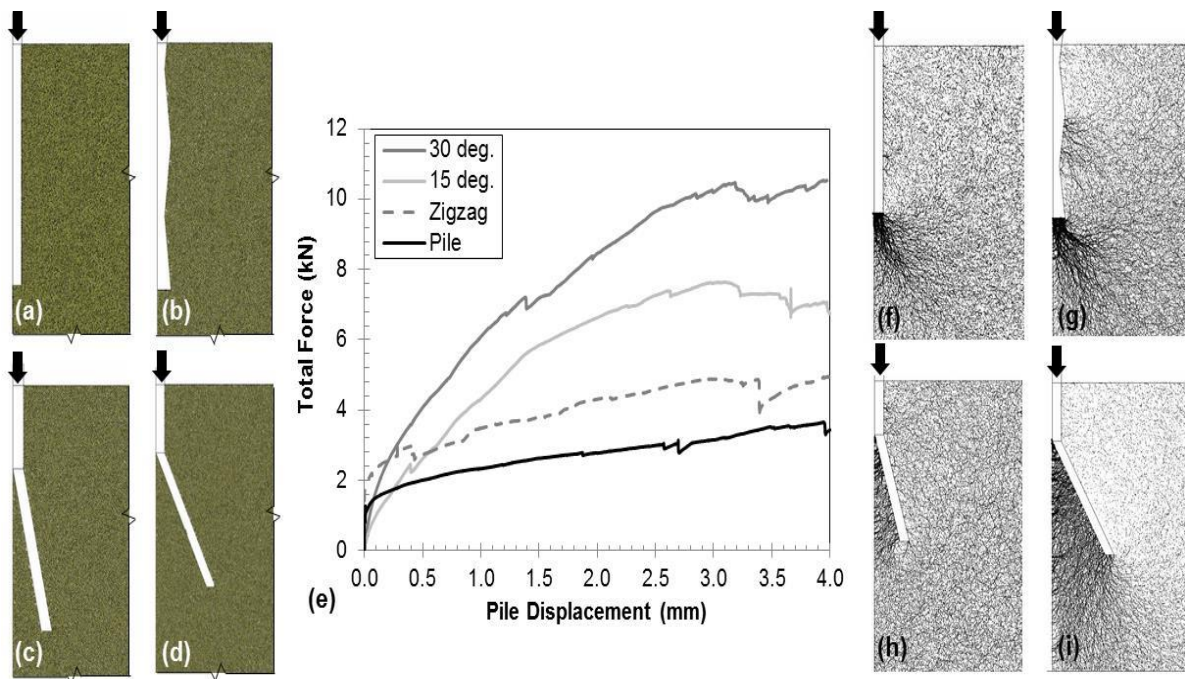


Fig. 35. DEM simulations of compressive loading of different root analogue systems.

5.5 Evaluation of root analogue and particulate interactions using X-ray CT

To further evaluate the structural capacity of root systems, X-ray CT observations have been made during pull-out testing. The test program involves a range of sands of different particle sizes and shapes from rounded to sub-angular and different root analogue systems. Some of the root analogues were fabricated using 3-D printing while others were created by unravelling wire cables to one or two levels of hierarchy to simulate more fibrous roots. The roots were placed in a chamber mounted on a turn-table in an X-ray CT. As pullout tests were performed, the soil-root systems were periodically scanned at pre-determined intervals so the soil-root interaction could be quantified. Vertical and horizontal 2-D images from the 3-D scans are shown in Figure 36. The shear zones can clearly be seen in the images. Depending on the number of root elements in the analogue and their inclination as well as the soil type, the location as well as number of shear zones can be clearly seen. The full 3-D scans will be compared with 3-D DEM simulations of root-soil systems.

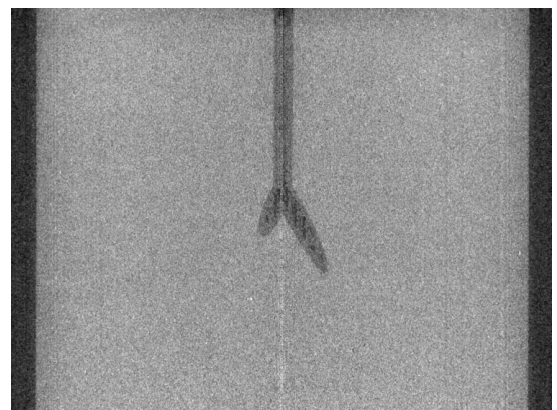


Fig. 36. Vertical (L) and horizontal (R) X-ray CT scans of root-sand interactions

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

5.6 Microbial effects on mechanical and geochemical properties of porous media

The overall goals of this project are to characterize the diversity/metabolic potential of indigenous microbial communities present in the subsurface using metagenomics and to develop a cultivation system for the testing the bio-mediated transformation of fluids and gases exposed to high pressure in the subsurface. The objective is to determine the contribution of microorganisms to the thermo-hydro-chemo-bio-mechanical (THCBM) properties of subsurface environments that contain important hydrocarbon and metal resources. In particular, the impacts of pressure and temperature on the structure and function of microbial communities is critical to engineering strategies for hydrocarbon resource/recovery, remediation of hydrocarbon contamination, and modeling of flow paths in porous media. Existing subsurface science generally does not include the impacts of pressure on microbial communities that are critical to the integrity of subsurface porous media. Modeling of reactive-transport of contaminants or flow in porous media often includes limited information about microbial communities and that information is limited to process rates from pure bacterial cultures.

Through research cruises supported by GoMRI, we obtained subsurface samples from the Gulf of Mexico in environments exposed to ~ 10 MPa. From these sediment samples, we isolated hydrocarbon-degrading bacteria and performed experiments with the sediments. Replicate sediment slurries were incubated at 10 MPa as well as at atmospheric pressure with and without the addition of crude oil. Oxygen consumption was used as a proxy for biodegradation. After incubation, DNA was extracted from the sediments and microbial communities were characterized using next generation sequencing of SSU rRNA genes. Several iterations of experiments were performed using the high pressure cultivation system. Rates of hydrocarbon biodegradation were shown to be elevated at high pressure in subsurface sediments collected from high pressure environments, indicating that microbial communities are well adapted to high pressure conditions. In sediments collected from shallow environments exposed to much lower natural pressures, biodegradation rates were not substantially impacted by exposure to high pressure. Analysis of microbial communities showed an enrichment of microbial groups known to carry out hydrocarbon degradation including members of the Colwelliaceae and Oceanospirillaceae taxa (Figure 37).

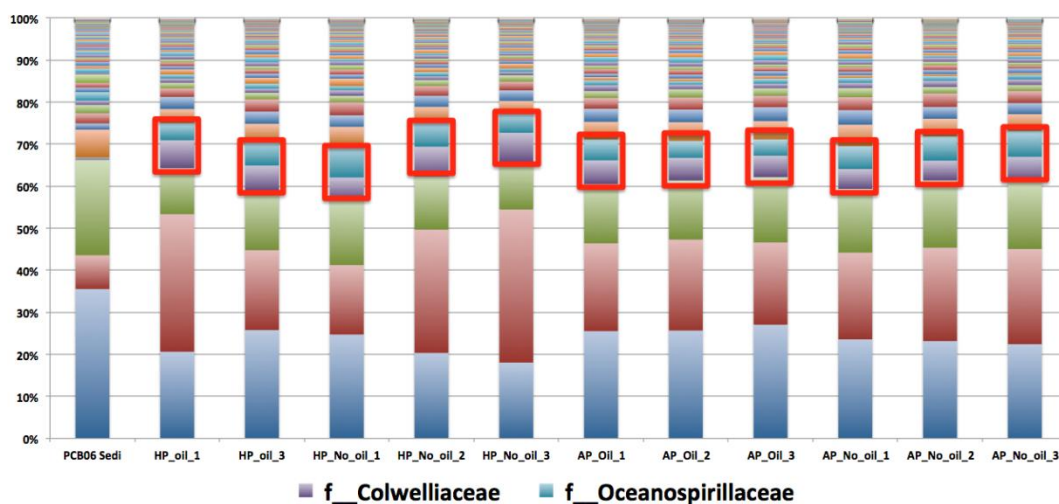


Fig. 37. Characterization of microbial communities at class level from the high pressure incubation system. Samples were collected from subsurface sediments exposed to > 10 MPa

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

6. Micro-geomechanics

6.1 Physical nature of heat conduction in granular medium

Heat conduction in a granular medium is phononic in nature. Atomic scale phonon vibration at low temperatures can be equivalently described to wave propagation in solids. Wave propagation in granular materials inherently captures the stiffness of the packing. With increase in confinement of dry granular media (i.e., Ottawa sand, table salt, and lead beads), the measured thermal conductivity increases linearly with P-wave velocity (Figure 38). Both thermal conduction and p-wave propagation in dry granular media are inherently dominated by contact properties. Hence, p-wave velocity measurements can be used to estimate the thermal conductivity of granular media and vice versa. This allows to determine the skeleton stiffness through the measurements of thermal properties even at high temperatures while piezocrystals for wave measurement are not functioning.

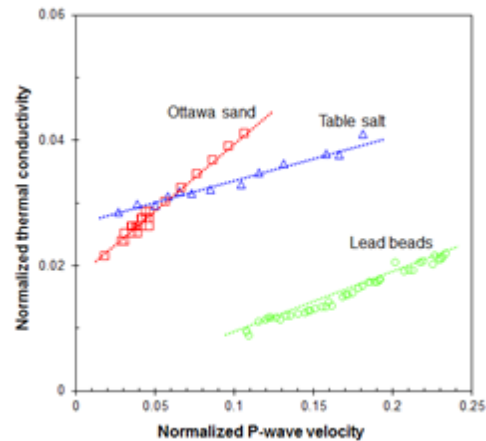


Fig. 38. Relationship between thermal conductivity and P-wave velocity as confinement increases for different dry granular materials

6.2 Prediction of size and shielding effects during single grain crushing

The goal of this research work is to better understand the microstructure parameters that control the triggering of fragmentation. Size and shielding effects respectively refer to the decrease of particle strength with increasing particle size, and to the increase of particle strength with the redistribution of stress towards hydrostatic stress conditions upon crushing of neighboring particles. Parameters of a Discrete Element Method (DEM) cluster model of crushable particle were calibrated so as to match the displacement and axial force obtained experimentally at the first particle fragmentation. The mechanical confinement effect of neighboring particles was simulated by placing rigid walls around the DEM cluster. Size effects on the crushing process were studied for clusters with and without internal flaws. Results show that: (1) For clusters with a porosity ranging between 0% and 30%, tensile strength only depends on the porosity and not on flaw size; (2) Particle strength depends linearly on particle coordination number; (3) Particle strength depends on particle porosity.

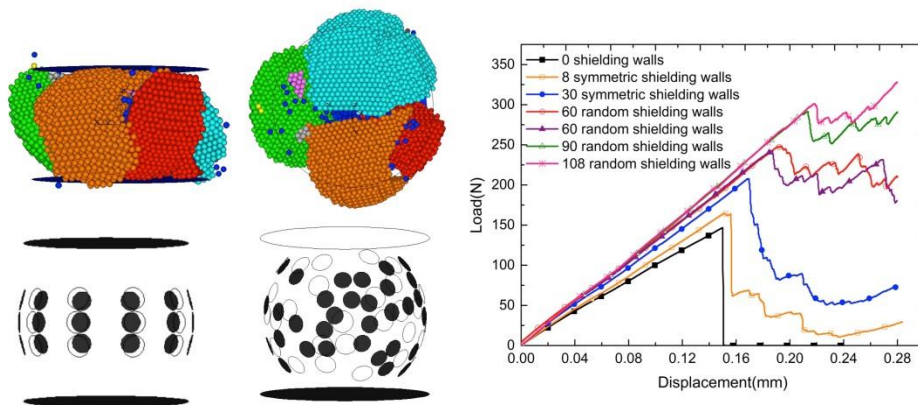


Fig. 39. Simulation of shielding effects at the grain scale with a DEM cluster with different distributions of walls that represent the presence of neighboring particles (left). Numerical prediction of the axial force reached at the first fragmentation (right)

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

6.3 Aggregate-geogrid interactions

Many applications in geotechnical engineering use a composite material system to achieve the desired objectives. An example of this approach is illustrated for the interaction of aggregate particles and geogrids for pavement applications. Two different aggregate-geogrid combinations are shown in Figure 40. The image on the left shows an aggregate with nominal size 10% of the geogrid rib length while that on the right has nominal size 80% of the geogrid rib length. Of interest is what size aggregate within this range can yield optimal interaction and thus performance with the geogrid. To evaluate this issue, a research study involving micro-scale tools and techniques is being conducted using 3-D printing and DEM simulations.

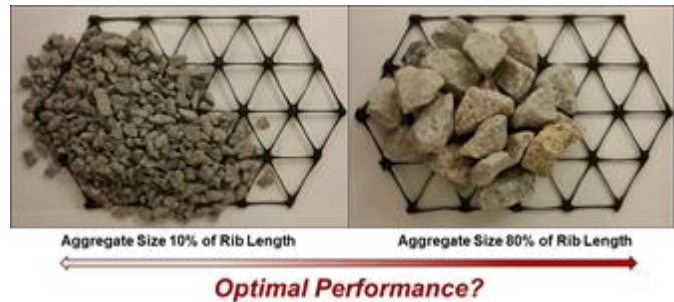


Fig. 40. Aggregate-geogrid combinations

The micro-scale tensile testing of geogrid ribs are used to determine the geogrid tensile strength properties. The geogrid ribs are modelled using DEM with particle clumps. Particles with pre-determined angularity indices are generated using a 3D printer (Figure 41) and then verified using an optical aggregate image analyzer. Binary mixtures of 3D particles were generated for DEM simulations which included a subgrade layer, aggregate layers with a geogrid embedded in middle and a loading particle clump. Preliminary results from this study are enabling the relative contributions of particle interlocking, as measured by particle rotations and displacements in the simulations, to be determined. Numerical models with and without geogrids present show the beneficial contributions of this man-made material on the overall system behavior (Peralta et al., 2016).

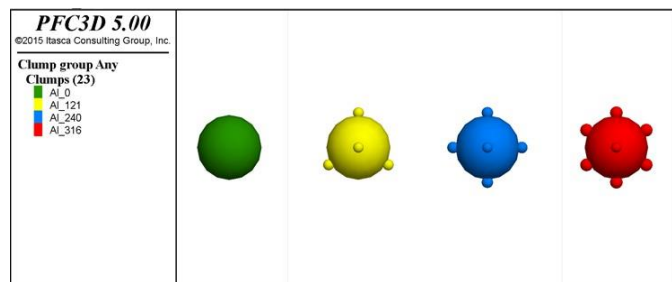


Fig. 41. Sketches of aggregate particles with different angularities

6.4 Micro-geomechanics of axial and torsional shearing

This study is part of a broader investigation that aims to characterize the mechanical response of geomaterial interfaces and the factors governing their response during axial and torsional shear. The ultimate objective of these investigations is to develop technologies that will help expand the current understanding of interface soil behavior, improve the efficiency and reliability of geotechnical investigation methods, and improve the performance of constructed systems. Applications of these technologies include more robust site characterization methods, and improved interface system capacity and performance prediction accuracy. The first of these technologies is a series of multi-sleeve modules for site investigation that use the understanding of soil-steel interface behavior to directly measure soil properties.

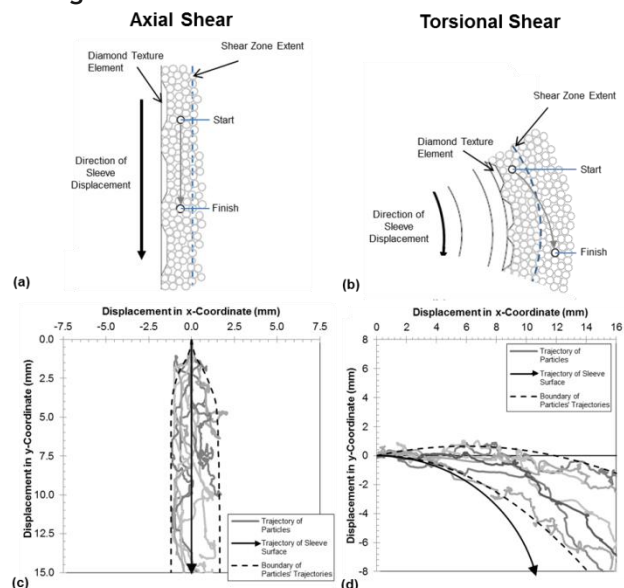


Fig. 42. Particle displacements under axial and torsional shearing

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

6.5 Laboratory evaluation of slushing as a densification process

The placement and densification of the unbound aggregate base layer in an IBP incorporates a technique called “slushing”. In contrast to conventional approaches for densification of aggregate layers which involve static or vibratory compaction of the placed material, the South African slushing technique involves sequences of over-watering, low impact smooth drum and rubber-tired compaction to increase the packing density in the unbound aggregate layer by removal of excess fines to achieve an optimum fine to coarse aggregate matrix. Water migrating to the surface by capillary action under the sequential compaction process carries excess fines to the surface where they are removed (Figure 43).

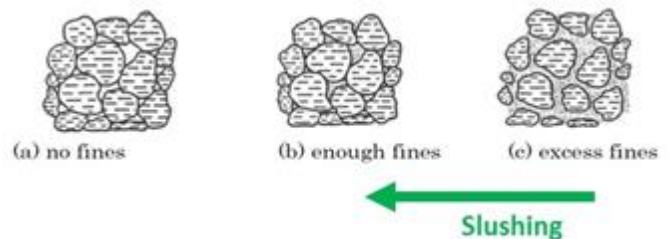


Fig. 43. Slushing technique to remove excess fines during compaction

To better understand the micro-mechanics of the slushing compaction technique, a bench scale device has been developed to allow for simulation of the field compaction process and then the subsequent recovery of samples at different numbers of slushing cycles to quantify the evolution of the microstructure using automated imaging technique. A photo of the apparatus is shown in Figure 44.



Fig. 44. Bench-scale slushing compaction simulator

6.6 Simulating flow in porous media

Flows are ubiquitous in geosystems engineering for hydrocarbon recovery, geothermal energy harvest, geological carbon sequestration, sediment and debris transport, wetting and drying in vadose zones, and so on. Pore network model simulations have been performed to investigate the impacts of mineral precipitation or dissolution on flow tortuosity, hysteresis during drainage and imbibition (or wetting and drying) processes for two phase flows in porous media, and gas percolation simulations based on 3D X-ray computed tomography images (Figure 45). These results are mainly applied for increasing storage capacity of supercritical CO₂ into brine-saturated sandstones, efficient gas recovery from hydrate-bearing sediments, and enhanced geothermal energy recovery from hot rock reservoirs.

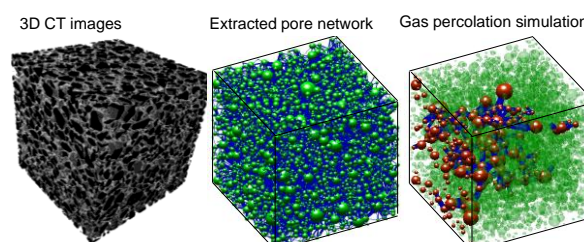


Fig. 45. Flows in porous media: combined X-ray CT scanning and pore network model simulation

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

6.7 DEM simulations of penetrometer insertion

Discrete Element Method (DEM) modelling provides a valuable technique to compare various in-situ testing devices and the manner in which they interact with the surrounding soil either during insertion or in subsequent test phases as relevant. For example, in contrast to Cone Penetration Test (CPT) soundings where, in general, soil-instrument interaction is predominantly measured during actual device insertion using load and pressure sensors, other test techniques including the Dilatometer Test (DMT) and the K_0 Stepped Blade (KSB) rely on the measurement of soil-device interactions that occur at sequential stationary steps during insertion with pressure or displacement transducers. Disturbance effects due to the insertion of the devices into the ground are unavoidable but can be accounted for to varying degrees either through the incorporation of empirical correction factors based on experimental observations or numerical simulations. These simulations to date have largely used continuum based approaches. The DEM method is now being increasingly used to evaluate soil-device interactions and in particular to assess how a range of factors including device geometry, soil characteristics and test methodology can be accounted for in test interpretation.

A study in which a model to evaluate the insertion of various devices was built and enabled the relative responses of the soil to the various devices to be evaluated. The model consisted of a chamber whose boundaries were made of rigid walls containing circular particles. The simulations involved inserting the testing devices vertically from the top of the chamber. During the insertion of each device, the contact forces (Figure 46) between particles at any testing stage was recorded as well as the local stress responses of soil at some locations. The total vertical forces required to insert the devices were also recorded.

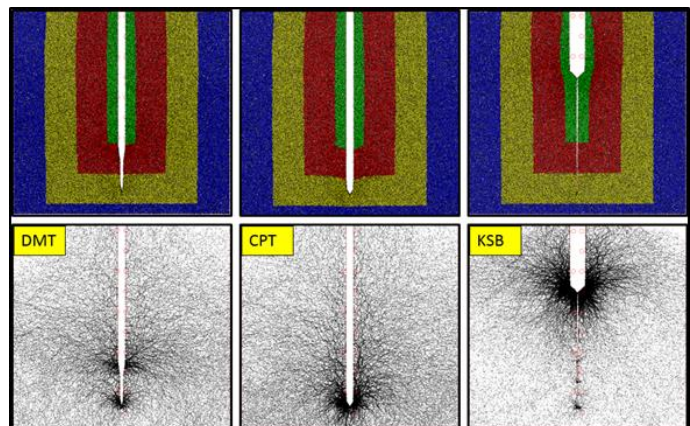


Fig. 46. Sample deformation and contact force chains during insertion of DMT (L), CPT (M) and KSB (R)

6.8 Simulating shearing between sands and surfaces of varying roughness

In order to better simulate the real environment, the two dimensional simulations presented in a previous section were extended to a corresponding three dimensional model using the PFC3D software. The computational requirements of the 3D model increase significantly because the number of particles in 3D increases more rapidly than for the corresponding 2D simulations. Certain simplifications such as scaling up particle size are a viable approach to reduce the number of particles (Butlanska et al. 2013).

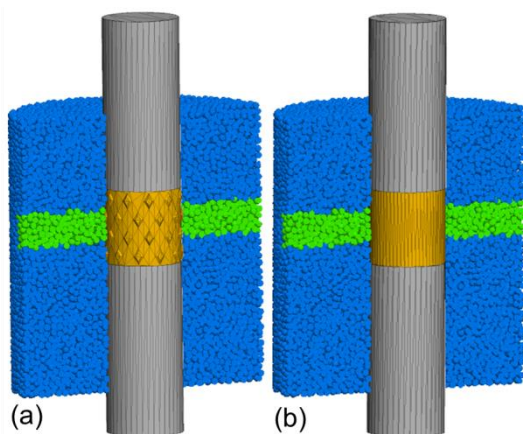


Fig. 47. 3D DEM models with textured (L) and smooth (R) sleeves

For simplicity, the soil particles were simulated as spherical particles, although more complex particle shapes are being evaluated in ongoing studies. In the current model (shown in Figure 47), the soil parameters and testing environment were similar to the previous 2D simulations, with the exception that the mean particle size was chosen as six times larger than the 2D particle size in order to keep the relative roughness as well as the total number of particles in an acceptable range. The sleeve length and chamber height in the model were also shortened to further decrease the computational demands. Even with these simplifications, the number of particles in the model is about five times that in the 2D model.

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

The induced particle displacements observed in the 3D simulations shown in Figure 48 confirm the different particle-sleeve interaction mechanisms that occur during shearing against textured and smooth sleeves. The force at the rough interface is transferred into the soil mass and more particles are mobilized. For smooth interfaces, only negligible shearing occurs at the interface. The limited soil displacements agree with the pure sliding mechanism previously noted by Frost & DeJong (2005).

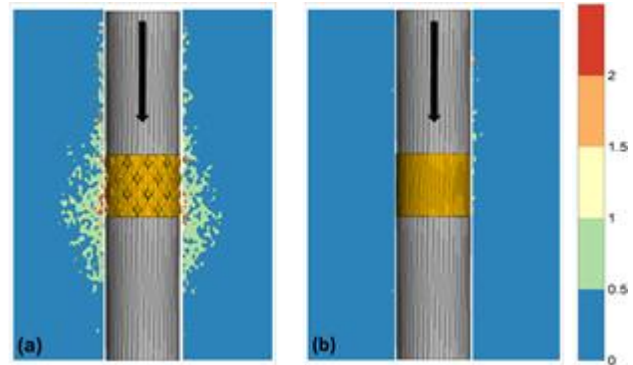


Fig. 48. Particle displacements after shear for textured (L) and smooth (R) sleeves

7. Ocean Science and Engineering

7.1 Evaluation of undrained shear strength from piezocone tests in offshore clays

Funded by Fugro, a methodology for evaluating the N_{kt} factor based on piezocone porewater pressure parameter (B_q) was developed using a large high-quality database derived from undrained shear strengths (s_{uc}) measured by CAUC triaxial tests on 61 different clays. The clays ranged from normally-consolidated offshore and onshore deposits to over-consolidated and fissured clays.

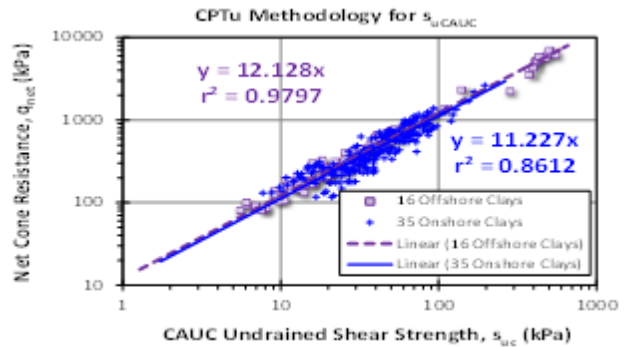


Fig. 49. Lab-in situ strength correlations

7.2 Cone-based marine sediment testing

Laboratory testing of natural sediments faces unavoidable sampling effects, which is aggravated for marine sediments that undergo several fabric destructureations due to gas exsolution by a pressure decrease and temperature increase. Originally led by Dr. Carlos Santamarina (now at KAUST), a new borehole tool has been developed for comprehensive characterization of hydrate-bearing marine sediments in situ (Figure 50). This tool offers direct measurement of sediment properties in situ to avoid sampling disturbance, robust determination of reliable in situ characteristics of hydrate-bearing sediments, and critical information needed in reservoir simulators and analysis tools used for resource recovery, seafloor stability, and environmental evaluations.

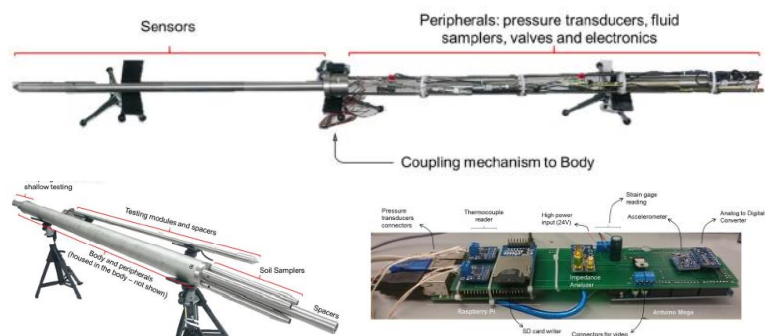


Fig. 50. Comprehensive cone-based in situ tools for marine sediment characterization. Measured properties include temperature, pressure, electrical conductivity, hydraulic conductivity, strength, visual port, pore fluids and soil sampling

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

7.3 Subsea hydrothermal heat output

The discovery of low temperature hydrothermal discharge at the Galapagos Spreading Center in 1977 and high-temperature “black smoker” vents a year later on the East Pacific Rise (EPR), together with their associated biological ecosystems [Corliss *et al.*, 1979], ushered in a new era of marine geophysical exploration at oceanic spreading centers. Further studies showed that seafloor hydrothermal systems were responsible for approximately 25% of the Earth’s total heat flux, 10% of which may be due to high-

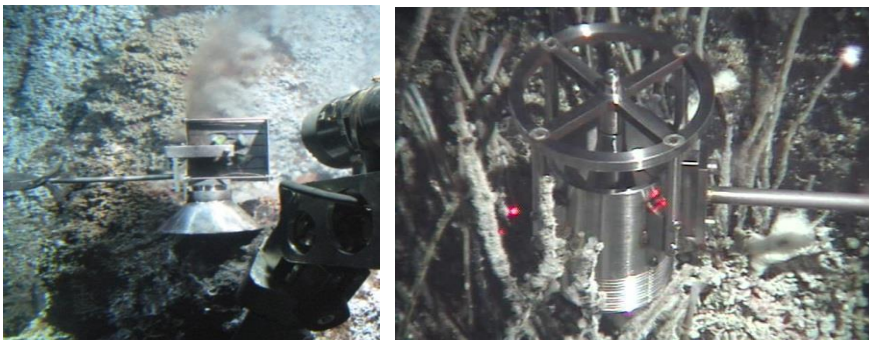


Fig. 51. Deployment of the cup anemometer flow meter over a black smoker orifice (right) on *Alvin* dive 4414 to the Dante Hydrothermal vent field. The black smoker flow is affected by cross flow upon exiting the device. Turbine flow meter deployed at a diffuse flow site (left) at the Hulk vent structure (Main Endeavour vent field, JdF, *Alvin* dive 4627)

temperature venting alone. It was also shown to have a great impact on the geochemical budget of oceans and submarine ore deposits (e.g., of nickel, copper, cobalt, manganese, zinc, lead, cobalt, vanadium, molybdenum, and platinum, gold, and silver). Since these discoveries, many attempts have been made to estimate heat flow from both high-temperature and low-temperature discharge zones. None of these attempts have been truly successful due to the harsh seafloor environment. In this study a series of devices, such as those shown in Figure

51, have been designed, built, calibrated, and tested. They allow for measuring fluid velocity at high and low temperature, focused and diffuse discharge sites, at oceanic spreading centers [Germanovich *et al.*, 2016].

The devices perform at ocean floor depths and black smoker temperatures (~350°C) and can be used to measure flow rates ranging over 2 orders of magnitude. Flow velocity is determined from either the rotation rate of the rotor blades or the paddle assembly. These devices have an open bearing design that eliminates clogging by particles or chemical precipitates as the fluid passes by the rotors. The devices have been tested on 30 *Alvin* dives on the Juan de Fuca Ridge and 3 *Jason* dives on the East Pacific Rise (EPR).

7.4 Submarine landslides

The term ‘landslide’ refers to a broad range of processes that result in gravity-assisted, downslope movement of slope-forming materials. The largest landslides known on Earth occurred in the submarine environment and involved ~10³ - 10⁴ km³ of sediment. Dimensions of the region excavated by a landslide range from less than 1 km to more than 102 km (e.g., 120-km Brunei slide, Northwest Borneo Margin, South China Sea). Submarine landslides (Figure 52) are particularly abundant on continental slopes and represent a major mechanism of sediment transfer across continental margins to deep ocean sites.

This study considers landslides caused by the shear band (Figure 53) that emerges along the potential slip (rupture) surface [Germanovich *et al.*, 2016]. The material above the band slides downwards, causing the band to grow along the slope. This growth may first be stable (progressive), but eventually becomes dynamic (catastrophic). The landslide body acquires a finite velocity before it separates from the substrata.

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

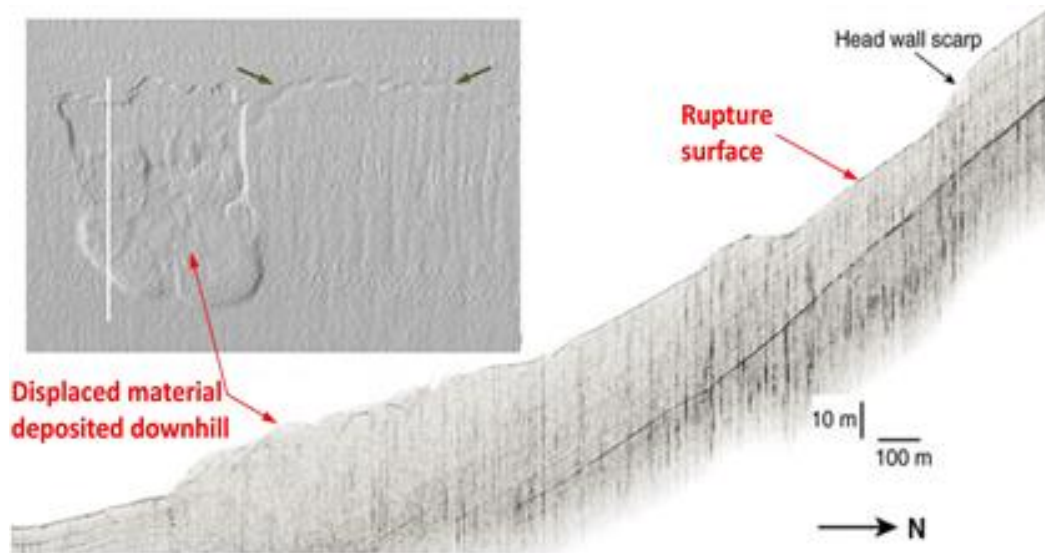


Fig. 52. Gaviota slide (34° 22'N, 120° 06'W) on the northern slope of the Santa Barbara basin. Seismic profile image along the white, solid line in the inset, shows bathymetry in the vicinity of the Gaviota slide. The sub-horizontal, 'headscarp' fracture (indicated by arrows, spaced by ≈ 2.5 km) [modified after Blum *et al.*, 2010]

The corresponding initial-boundary value problem for a dynamic shear band was formulated within the classic framework of the Palmer and Rice approach, which was generalized to the dynamic case. The exact, closed-form solution for the band velocity, sediment deformation, and slip rate was obtained [Germanovich *et al.*, 2016]. This solution assesses when the slope fails owing to a limiting condition near the propagating tip of the shear band. The results are applicable to both submarine and subaerial landslides of this type. It was shown that in the case of submarine slides, the effect of water resistance on the shear band dynamics may frequently be limited during the slope failure stage. For a varying slope angle, a condition of slide cessation can be formulated. It appears that neglecting dynamic (inertia) effects can lead to a significant underestimation of the slide size, and that the volumes of catastrophic slides can exceed the volumes of progressive slides by a factor of two. Underestimating the displaced volume and initial velocity of the slide body could, in turn, result in underestimating the slide damage and tsunamigenic potentials.

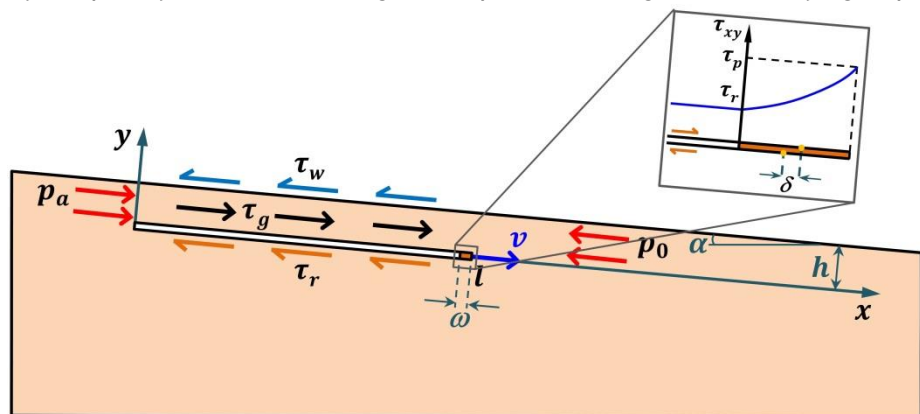


Fig. 53. The corresponding model based on the shear band in an infinite slope. The slab above the slip surface is already deformed during the stable (progressive) stage of the band growth, while the sliding velocity appears in the dynamic stage that begins at the initial moment

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

7.5 Coastal resilience evaluation and modeling

This study will develop a location independent scalable framework for Community based Sustainable Coastal Area Resilience Planning (C-SCARP). The data-driven framework is thus adaptable to other locations and/or scales in the future. Working with Golder Associates, the C-SCARP framework will make use of an adapted and expanded version of the GoldSET suite of decision support tools that incorporates multi-criteria analysis in a sustainability evaluation framework. Three distinct uses of GoldSET are anticipated:

- **Resilience Baseline Mapping:** They will be used to evaluate the current state of resilience.
- **Resilience Forecasting:** They will be used to incorporate and evaluate the results of forecasting models researched and produced in this project.
- **Resilience Scenario Planning:** Based on the current and future resilience mapping exercises, the spatial expression of and benchmarking of the effectiveness of mitigation measures will be simulated.

Key inputs into the C-SCARP framework will come from existing models developed by NOAA and its partners and include elevated water levels from long-term sea level rise, tides and storm surge, combined with changes in the frequency and intensity of storms, all of which increase the risk of devastating impacts and pose threats to natural/human coastal systems. To effectively demonstrate the applicability and scalability of the proposed approach, a number of “Use Cases” will be conducted for communities with different scales and attributes in Coastal Georgia. A community is considered herein as a complex dynamic system that has interdependencies between the infrastructure systems and includes diverse elements such as the “transportation”, “electrical”, “communications”, “social” and “economic” systems. In many cases, the impacted community (i.e. the area directly impacted) is not the same as the influenced community (i.e. the area affected). The “Use Cases” will allow for a comprehensive evaluation of the proposed framework and tools and provide insight into a range of critical factors including: how overlapping governmental entities can complement each other; how the core of logistics centered operations can influence a geographically distributed industry; and how “resilience equity” can be a critical component of public/private funding and investment decisions.

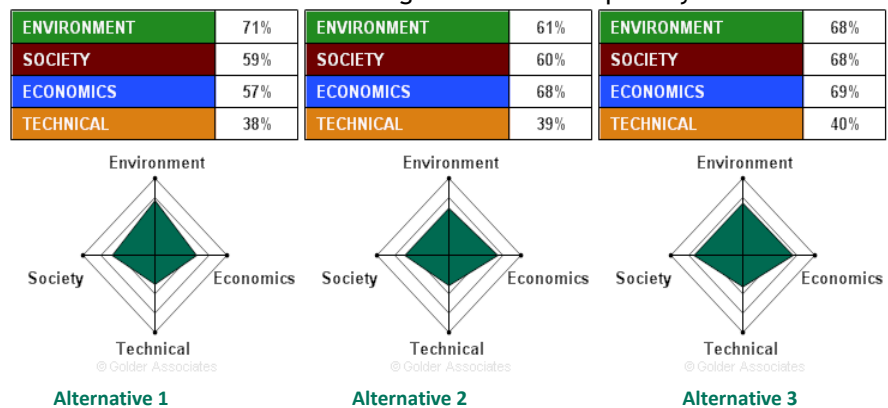


Fig. 54. Example GoldSET scenario evaluation

Selected References:

- Arson, 2016. Bio-inspired Subsurface Networks, Army Research Office Workshop on Geo-surface materials dynamics, Chicago, August 17th, 2016.
- Cao, S.C., Dai, S. and Jung, J., 2016. Supercritical CO₂ and brine displacement in geological carbon sequestration: Micromodel and pore network simulation studies. *International Journal of Greenhouse Gas Control*, 44, pp.104-114.
- Choo, H., Larrahondo, J., and Burns, S. 2014. Coating Effects of Nano-Sized Particles onto Sand Surfaces: Small Strain Stiffness and Contact Mode of Iron Oxide-Coated Sands. *Journal of Geotechnical and Geoenvironmental Engineering*, [10.1061/\(ASCE\)GT.1943-5606.0001188](https://doi.org/10.1061/(ASCE)GT.1943-5606.0001188) , 04014077.
- Dai, S., Shin, H. and Santamarina, J.C., 2016. Formation and development of salt crusts on soil surfaces. *Acta Geotechnica*, pp.1-7.

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

- Dai, S., Seol, Y., Wickramanayake, S. and Hopkinson, D., 2015. Characterization of hollow fiber supported Ionic liquid membranes using microfocus X-ray computed tomography. *Journal of Membrane Science*, 492, pp.497-504.
- Dai, S. and Seol, Y., 2014. Water permeability in hydrate-bearing sediments: A pore-scale study. *Geophysical Research Letters*, 41(12), pp.4176-4184.
- Dai, S., Wuttke, F. and Santamarina, J.C., 2012. Coda wave analysis to monitor processes in soils. *Journal of Geotechnical and Geoenvironmental engineering*, 139(9), pp.1504-1511.
- DeJong, J.T., Burrall, M., Wilson, D.W., and Frost, J.D. 2017. A Bio-Inspired Perspective for Geotechnical Engineering Innovation, in review for possible publication in Proceedings of ASCE Geo-Institute Geotechnical Frontiers Conference 2017.
- Frost, J.D., 2016. The Evolving Role of Materials in Infrastructure Systems, Proceedings of Civil Engineering Research Association Conference, Galway, Ireland, pp. 31-36.
- Frost, J.D., Martinez, A., Mallett, S.D., Roozbahani, M.M., and DeJong, J.T. 2017. The Intersection of Modern Soil Mechanics with Ants and Roots, in press for publication in Proceedings of ASCE Geo-Institute Geotechnical Frontiers Conference 2017.
- Frost, J.D., Martinez, A., Su, J., and Xu, T., 2016. DEM Modeling Studies of the Interactions between Soils and in-Situ Testing Devices, Proceedings of ISC 5 Conference, Gold Coast, Australia, CD-ROM.
- Garagash, D., and Germanovich, L.N., 2012. Nucleation and arrest of dynamic slip on a pressurized fault, *Journal of Geophysical Research: Solid Earth*, Volume 117, Issue B10, October 2012, DOI: 10.1029/2012JB009209.
- Germanovich L. N. and Murdoch L. C., 2010. Injection of Solids to Lift Ground Surface in Coastal Areas, Proceedings of the Royal Society A: Mathematical, Physical, and Engineering Sciences, Vol. 466, pp. 3225-3252, doi: 10.1098/rspa.2010.0033.
- Germanovich, L.N., Hurt, R.S., J.E. Smith, Gence, G., Lowell, R.P., 2015. Measuring fluid flow in seafloor hydrothermal environments, *J. of Geoph. Research*, 120, doi:10.1002/2015JB012245, 25 pages.
- Germanovich L.N., Kim S., Puzrin A.M., 2016. Dynamic growth of slip surfaces in catastrophic landslides, *Proc. of the Royal Society: A - Math., Phys. and Eng. Sciences*, Vol. 472 (2185): 20150758, <http://dx.doi.org/10.1098/rspa.2015.0758>, pages 1-28.
- Gray, C., Burns, S., and Griffith, J. 2012. The Use of Natural Zeolites As a Sorbent for Treatment of Dissolved Heavy Metals in Stormwater Runoff. *GeoCongress 2012*: pp. 3978-3987.
- Hisz, D.B., Murdoch L.C., Germanovich, L.N. 2013. A portable borehole extensometer and tiltmeter for characterizing aquifers, *Water Resources Research*, Vol. 49, Issue 7, DOI: 10.1002/wrcr.20500.
- Jin, W., Xu, H., Arson, C., and Busetti, S. 2016. A Multi-Scale Computation Tool Coupling Mode II Fracture Propagation and Damage Zone Evolution, *International Journal of Numerical and Analytical Methods in Geomechanics*, DOI: 10.1002/nag.2553
- Ku, T., Weemees, I., Cargill, E., Mayne, P.W. and Woeller, D.J. 2013. Post-processing continuous shear wave signals taken during cone penetrometer testing. *ASTM Geotechnical Testing Journal* 36 (4): 543-552.
- Liu, F.Z., Xu, Q., Dong, X.J., Yu, B., and Frost, J.D. 2016. Performance review of novel multi-function debris flow mitigation system in the Wenjia Gully, Sichuan", submitted to *Landslides*, *Journal of International Consortium of Landslides*, under review.
- Liu, M. and H. Huang, 2016. Sphere indentation - the Hertzian stress field and the effect of far-field confining stress, In Proceedings of the 49th U.S. Rock Mechanics Symposium, Houston, TX.
- Mahabadi, N., Dai, S., Seol, Y., Sup Yun, T. and Jang, J. 2016. The water retention curve and relative permeability for gas production from hydrate-bearing sediments: pore-network model simulation. *Geochemistry, Geophysics, Geosystems*.
- Mayne, P.W. 2016. Invited keynote: Evaluating effective stress parameters and undrained shear strengths of soft-firm clays from CPT and DMT. In Pursuit of Best Practices - Proc. 5th Intl. Conf. on Geotechnical & Geophysical Site Characterization (ISC-5), Jupiters Gold Coast Australia.
- Murdoch, L.C., Freeman, C.E., Germanovich, L.N., Thrash, C. and DeWolf, S., 2015. Using in situ vertical displacements to characterize changes in moisture load, *Water Resources Research*, 51(8), pp. 5998-6016.

Research Highlights

Geosystems Engineering at the Georgia Institute of Technology, USA (Con't)

- Murdoch, L. C., Germanovich, L. N., Wang, H., Onstott, T. C., Elsworth, D., Stetler, L., Boutt, D., 2012. Hydrogeology of the vicinity of Homestake mine, South Dakota, USA, *Hydrogeology Journal*, Vol. 20, Issue 1, pp. 27-43, DOI: 10.1007/s10040-011-0773-7.
- Murdoch, L.C., and L.N. Germanovich, 2012. Storage change in a flat-lying fracture during well tests, *Water Resources Research*, 48, W12528, doi:10.1029/2011WR011571, December 2012, 14 pages, 8 figures, 2 tables.
- Nasirian, A., Cortes, D. and Dai, S., 2015. The physical nature of thermal conduction in dry granular media. *Géotech. Lett*, 5, pp.1-5.
- Pouya, C. Zhu, C. Arson, 2015. Micro-Macro Approach of Salt Viscous Fatigue under Cyclic Loading, *Mechanics of Materials*, DOI: 10.1016/j.mechmat.2015.10.009
- Puzrin, A. M., L. N. Germanovich, and B. Friedli, 2016. Shear band propagation analysis of submarine slope stability, *Géotechnique*, Vol. 66, Issue 3, pages 188-201, DOI: 10.1680/jgeot.15.LM.002.
- Santamarina, J.C., Dai, S., Terzariol, M., Jang, J., Waite, W.F., Winters, W.J., Nagao, J., Yoneda, J., Konno, Y., Fujii, T. and Suzuki, K., 2015. Hydro-bio-geomechanical properties of hydrate-bearing sediments from Nankai Trough. *Marine and Petroleum Geology*, 66, pp.434-450.
- Sun, Y. and H. Huang, 2015. Effect of rheology on drilling mud loss in a natural fracture, In *Proceedings of the 49th U.S. Rock Mechanics Symposium*, San Francisco, CA.
- Wang, P., Arson, C. 2016. Discrete Element Modeling of shielding and size effects during single particle crushing, *Computers and Geotechnics*, DOI: 10.1016/j.compgeo.2016.04.003
- Wankel, S. D., Germanovich, L. N., Lilley, M. D., Gence, G., DiPerna, C. J., Bradley, A. S., Olson, E. J., and P. R. Girguis, 2011. Influence of subsurface biosphere on geochemical fluxes from diffuse hydrothermal fluids, *Nature Geosciences*, Vol. 4, pages 461-467, doi: 10.1038/ngeo1183.
- Yeboah, N.N. and Burns, S.E. 2011. Geological Disposal of Energy-Related Waste, *KSCE Journal of Civil Engineering*, Vol. 15, No. 4, pp. 697-705.
- Yeboah, N.N.N., Shearer, C.R., Burns, S.E., and Kurtis, K.E. 2014. Characterization of biomass and high carbon content coal ash for productive reuse applications, *Fuel*, Volume 116, Pages 438-447, ISSN 0016-2361, <http://dx.doi.org/10.1016/j.fuel.2013.08.030>.
- Zhao, Q. and Burns, S.E. 2013. Modeling Sorption and Diffusion of Organic Sorbate in Hexadecyltrimethylammonium-Modified Clay Nanopores- a Molecular Dynamics Simulation Study, *Environmental Science and Technology*, 47(6), pp 2769-2776, 10.1021/es3045482.
- Zhu C., Arson C., 2014. A model of damage and healing coupling halite thermo-mechanical behavior to microstructure evolution, *Geotechnical and Geological Engineering*, Special Issue: Thermo-hydro-mechanical behavior of soils and energy geostructures, DOI: 10.1007/s10706-014-9797-9
- Zhang, F., B. Damjanac and H. Huang, 2013. Coupled discrete element modeling of fluid injection into dense granular media, *J. Geophys. Res. - Solid Earth*, 118(6), 2703-2722.

Conference Reports

The 8th Asian Young Geotechnical Engineers Conference (8AYGEC) 5th – 7th August, 2016, Astana, Kazakhstan

The Kazakhstan Geotechnical Society is pleased to report on the Eighth Asian Young Geotechnical Engineers' Conference (8AYGEC) which was split between Nazarbayev University and Eurasian National University named after L.N. Gumilyov (Astana, Kazakhstan) with the support of ISSMGE, KGS and ISSMGE TC305 "Geotechnical infrastructures for megacities and new capitals".

The theme of 8AYGEC was "**Challenges and Innovations in Geotechnics**". There were 7 (seven) Technical Sessions of oral presentations. Technical sessions were organized as follows: *Laboratory and Field Testing* (TS1), *Foundation and Underground Structure* (TS2), *Ground Improvement* (TS3), *Earthquake and Environment* (TS4), *Numerical and Analytical Modeling* (TS5), *Advanced Soil Mechanics* (TS6) and *Historical Sites* (TS7).

Throughout its span, the Conference took place in Bangkok, 1991; Singapore, 1994 and 1997; Seoul, 2001; Taipei, 2004; Bangalore, 2008; Tokushima, 2012; and finally in Astana on August 5-7, 2016. Astana is the new capital of Kazakhstan. It is located on the Ishim River in the north portion of Kazakhstan, within Akmola Region, though administrated separately from the region as the city with special status. The 2014 census reported a population of 835,153 within the city, making it the second-largest city in Kazakhstan. Astana is a planned city, such as Canberra in Australia, Washington, D.C. in the United States and Brasilia in Brazil. The Master Plan of Astana was designed by a Japanese architect Dr. Kisho Kurokawa. As the seat of the Government of Kazakhstan, Astana is the site of the Parliament House, the Supreme Court, the Ak Orda Presidential Palace, and numerous government departments and agencies. Home to many futuristic buildings, hotels, and skyscrapers, Astana is the center for sport, healthcare, and education, and it will host Expo 2017.

The main goals of the conference were to provide interactive platform for the young geotechnical engineers across Asia, to contribute strengthening interaction between foreign and Kazakhstani specialists in the field of geotechnical innovations, to promote the exchange of experience and know-hows, as well as to identify possible ways for future cooperation in the fields of construction, education, and science.

Geotechnical engineers and researchers below the age of 35 years from Asian countries were invited to participate at the conference. Each of the National Geotechnical Societies in Asia was invited to nominate two participants from their countries and research fields to submit written contributions and to present their researches at the conference.

Participants from 21 countries had opportunities to exchange innovative ideas and developments in the field of geotechnics during their time at the conference in a warm and friendly environment.

Eighth Asian Young Geotechnical Engineers Conference was full of geotechnical engineering spirit. 100 participants including Professors, Students, and young professionals attended the conference and the countries where they participated from are as follows:

Belarus	Japan	Russia	Thailand
China	Kyrgyzstan	Saudi Arabia	Turkey
Chinese Taipei	Nepal	Singapore	UK
Germany	Pakistan	South Korea	USA
India	Poland	Syria	Uzbekistan

Conference Reports

The 8th Asian Young Geotechnical Engineers Conference (8AYGEC) 5th – 7th August, 2016, Astana, Kazakhstan (Con't)

Among all participants it is important to mention Lecturers of the conference:

Two Special Lecturers:

- Prof. Ikuo Towhata, Vice President of ISSMGE for Asia, Japan
- Dr. Sondermann Wolfgang, Member of the Board of Keller Group, UK, President of the German Geotechnical Society, Germany

Four Keynote Lecturers:

- Prof. Eun-Chul Shin, Incheon National University, South Korea
- Dr. Talal Awwad, Damascus University, Syria
- Prof. Jong R. Kim, Nazarbayev University, Kazakhstan
- Prof. Askar Zhussupbekov, Eurasian National University, Kazakhstan

The half of the first day of the conference and opening ceremony were held at Nazarbayev University. The attendees were greeted with welcoming speeches by Dr. Loretta O'Donnell, Provost for Academic Affairs, Nazarbayev University; Assemgul Moldazhanova, Vice-Rector of L.N. Gumilyov ENU; Prof. Ikuo Towhata, Vice President of ISSMGE for Asia and President of the Japanese Geotechnical Society; and Prof. Askar Zhussupbekov, President of the Kazakhstan Geotechnical Society, the head of Civil and Structural Engineering Department of L.N. Gumilyov ENU. The ceremony was moderated by Prof. Jong R Kim, Nazarbayev University. Each speaker while greeting the participants touched upon important aspects.

Dr. Loretta O'Donnell (Fig. 1) accentuated audience's attention to the importance of progress, interactive technologies and live communication: *"Despite all the challenges in geotechnics and in the modern world, I guess we'd still not want to trade places with our parents and grandparents. Unlike them, we have access to interactive technologies, professional opportunities to travel and professional dreams. And yet, despite the presence of all kinds of interactive technologies, we decided to get together - in real time, in real life"*.

"It has been said about non-feminine nature of geotechnical science, though it happened so that women are the first ones to greet the conference guests on Kazakhstani land", said Prof. Assemgul Moldazhanova (Fig. 2) while giving the audience warm wishes in Kazakhstani land. She also sent her sincere welcome to the representatives of Incheon National University whose hospitality was appreciated by Kazakhstani students who were sent to study at this university.



Fig. 1. Opening Address by Dr. Loretta O'Donnell, Provost of Nazarbayev University



Fig. 2. Welcome Address by Prof. Assemgul Moldazhanova, Vice Rector of Eurasian National University

Conference Reports

The 8th Asian Young Geotechnical Engineers Conference (8AYGEC) 5th – 7th August, 2016, Astana, Kazakhstan (Con't)

"Being different - you have the opportunity to learn here something different, something new about the world, to develop friendships," - speech was the appeal of Prof. Ikuo Towhata to multinational compound of the conference: *"For us, engineers, peace is very important. Only under peaceful conditions engineers can concentrate on their work, can develop infrastructure, build a good peaceful community and make people happy"*.

Prof. Askar Zhussupbekov thanked sponsors and organizers of the conference at the end of the opening ceremony, calling the event *"a bridge between the L.N. Gumilyov Eurasian and Nazarbayev University"*, since both universities joined forces in such an organization for the first time.

"The main idea behind the conference is an opportunity to exchange ideas in the field of geotechnical engineering with the representatives of younger generation from different parts of the world", - said the professor. In addition, Professor Zhussupbekov, while addressing the participants of the Conference, referred to the strong connection between Kazakhstan and Syrian Geotechnical Society. He expressed his hopes for Syria for a better, strong, and peaceful country, *"Kazakhstan will be the first one to come and help to rebuild the country, trust me"* said Prof. Askar Zhussupbekov to the representatives of Syria.

Overall every single speaker emphasized the importance of dialogue and exchanging information between the societies for the sake of development of geotechnical engineering and they all wished the participants a fruitful work.

The Opening Ceremony was followed by a series of special, keynote lectures and technical sessions.

Dr. Wolfgang Sondermann, President of German Geotechnical Society gave a special lecture on "Future challenges for geotechnical engineers (a more contractor orientated perspective)". After this lecture, Prof. E. C. Shin presented a keynote lecture titled "Application of Geosynthetics in Civil Engineering Projects".



Fig. 3. Group photo of participants at Nazarbayev University

Conference Reports

The 8th Asian Young Geotechnical Engineers Conference (8AYGEC) 5th – 7th August, 2016, Astana, Kazakhstan (Con't)

Overall, one could observe nice discussions between the participants, exchanging business cards, smiles, and laughter. After lunch the second technical session was held, following with a group photo at Nazarbayev University. In the afternoon, participants arrived at L.N. Gumilyov Eurasian National University, where the second half of the event took place.



Fig. 4. Group photo of participants at Eurasian National University

Guests had a tour at the Eurasian National University whose history is slightly shorter than the history of the conference.

Historical culture heritages such as Museum of Turkic writing, Kultegin's Monument, paintings of Tleuzhan Batanov were an interest to the guests.

One of the first main results from the 8AYGEC conference was that the memorandum was signed between the Far Eastern State Transport University and L.N. Gumilyov Eurasian National University about exchange programs for Bachelor, Master, and PhD Students in Geotechnical Engineering.

Professor Ikuo Towhata presented a special lecture titled "Reconnaissance in and findings from the 2016 Kumamoto earthquake in Japan". Dr Talal Awwad who is a professor at Damascus University gave a keynote lecture on the topic of "Problems of Syrian Historical Monuments, Destroyed by Military Action: Diagnostics, Strengthening and Reconstruction".

Concluding the official part of the first day, the scientists were awarded with signs of gratitude and recognition: Professor Ikuo Towhata received "Kultegin" Medal for his great contribution in research of geotechnical and earthquake engineering on historical sites. Prof. Eun Chul Shin was awarded with "Lev Gumilyov" Medal for his meaningful contribution in development of PhD programs at Eurasian National University.

At the end of the long fruitful day, guests headed to a dinner where they were entertained with Kazakh folk songs and music. Most participants have never been in Kazakhstan before. Foreign guests noted high level of organization provided by the team from Kazakhstan.

Conference Reports

The 8th Asian Young Geotechnical Engineers Conference (8AYGEC) 5th – 7th August, 2016, Astana, Kazakhstan (Con't)



Fig. 5. Hostess in National Kazakh Costume meets key participants of 8AYGEC at Eurasian National University

The second day of the conference began at Nazarbayev University and consisted of technical sessions filled with presentations. That day was also marked by two keynote lectures: “Geotechnical and construction consideration of pile foundation on problematic soils” by Prof. Askar Zhussupbekov and “On interim results of sand production research in weak sandstone formations in Kazakhstan” by Prof. Jong R. Kim.

The official part of the conference ended with a closing ceremony at Nazarbayev University.



Fig. 6. PhD Candidate Tugce Baser, University of California San Diego, USA, President CalGeo at UCSD, ASCE GI GSO at UCSD (Presentation titled “Role of considering non-constant soil thermal parameters in the simulation of geothermal heat storage systems in the vadose zone”)

Conference Reports

The 8th Asian Young Geotechnical Engineers Conference (8AYGEC) 5th – 7th August, 2016, Astana, Kazakhstan (Con't)

Words of farewell and gratitude to participants for presentations along with wishes for a safe journey back were expressed by Prof. Dong Soo Kim from Korean Advanced Institute of Science and Technology (South Korea), Dr. Loretta O'Donnell, Prof. Ikuo Towhata and Prof. Askar Zhussupbekov.

The second outcome from the conference is that there were 4 winners in three categories selected out of the Conference participants.

1. Dr. Atsushi Takai (Japan) and Kunsulu Bekish (Kazakhstan) won the Best Oral Presentation awards.
2. Dong Kwan Ham (South Korea) was the winner of "Best Report of Poster Session".
3. The winner of "Best Paper" was Dr. Prashanth Vangla (India)

Prof. Dong Soo Kim invited the young participants to take part in the Sixth International Conference of Young Geotechnical Engineers which will take place on September 16 - 17, 2017 in Seoul, South Korea. Acquiring valuable experience from other geotechnical researchers is equally important.

Xiang-Yun WANG, East China Research Institute of Architectural Design, China:

"This is the first time for me to represent my country in Kazakhstan. Undoubtedly, one of the main goals of the Conference is to exchange of international know-hows. In connection with the development of various technologies, I believe that this conference is particularly relevant today. Transfer of the precious experience will make it clear the direction to move forward, what needs to be done to achieve set goals. We can plan together and we can be prepared for risks and consequences, we can learn from each other".

A farewell dinner was organized for all the participants of the conference. At the dinner all the Sponsors of the Conference were awarded with plaques of appreciation by Kazakhstan Geotechnical Society.

The final day of the Conference was dedicated to a technical tour which participants visited Baiterek monument and Expo 2017 construction site. Many of the guests noted beauty of Kazakhstan's capital and its rapid pace of construction. At the "EXPO-2017" construction site, participants familiarized themselves with the construction process of the Sphere building Complex, on the ground floor of which will be located Pavilion of the Republic of Kazakhstan. Young geotechnical engineers asked technical questions about the construction process of the complex.



Fig. 7. The EXPO 2017 construction site

Conference Reports

The 8th Asian Young Geotechnical Engineers Conference (8AYGEC) 5th – 7th August, 2016, Astana, Kazakhstan (Con't)

Before leaving the conference, young geotechnical engineers exchanged contacts, hoping to be in touch, despite the difference of cultures, kilometers, and time zones. Communication established in real time and in real place, the exchange of ideas and experiences - all of these will continue, thanks to the technology which is available to the fortunate young generation.

We can also proudly say that the conference was a tool to build new bridges and new ideas were raised; old frames destroyed and new horizons have been set.

Moreover, last but not least, all participants' papers of the 8AYGEC conference has been published by CRC Press/Balkema, The Netherlands, and all papers are included in the SCOPUS data base.

“Today it can be said with confidence that the goal of the Eighth Young Asian Geotechnical Engineers Conference has been achieved. Immeasurable contribution towards the achievement of this goal belongs to - Prof. Askar Zhussupbekov”, said at the Closing Ceremony Dr. Loretta O'Donnell.

The Closing Ceremony has been also summarized with the Astana Manifesto by Dr. Rauan Lukpanov (Eurasian National University).



Fig. 8. The Proceedings of 8AYGEC “Challenges and innovations in geotechnics”

Conference Reports

The 8th Asian Young Geotechnical Engineers Conference (8AYGEC) 5th – 7th August, 2016, Astana, Kazakhstan (Con't)



Fig. 9. International geotechnical friendship activity of young geotechnical engineers with the Board member of Syrian Geotechnical Society Dr. Talal Awwad (in green T-shirt)



Fig. 10. Group Photo of participants at the Baiterek Monument (Symbol of Astana)

Conference Reports

The 8th Asian Young Geotechnical Engineers Conference (8AYGEC) 5th – 7th August, 2016, Astana, Kazakhstan (Con't)

This international event was not ended with Technical Tour in Astana, it was continued with the Joint Kazakhstan - Korea Geotechnical Workshop (satellite geotechnical event of 8AYGEC), which took place at the JSC “Kazakhstan Highway Research Institute” in Almaty on August 10th.

The Workshop started with the lecture and presentation of Prof. Teltayev B.B., President of the JSC “Kazakhstan Highway Research Institute” and was followed by lectures from Prof. Eun Chul Shin, Prof. Askar Zhussupbekov, Dr. Park Bong-Geun (BKGNC Ltd., South Korea), Dr. Tattygul Seidmarova (Eurasian National University) and researchers of KHRI Nugmanova A. with Tileu K.

Young but very active Bachelor Students of the Incheon National University presented their wonderful oral and poster presentations sharing it with their compassionate ideas about geo-environmental issues.

At the Opening Ceremony of this joint workshop Prof. Eun Chul Shin was awarded with the Kazakhstan Governmental Medal by the President of “KazdorNII” Prof. Bagdat Teltayev for his outstanding activities during of scientific consultation of Megaproject “Highway: West China - West Europe throw of the territory of Kazakhstan (3 000 km)”. During these two events in Kazakhstan (in Astana and Almaty) Prof. Eun Chul Shin has received two honorary medals.

The Workshop ended with the tour to laboratories of the Research Institute “KazdorNII”.



Fig. 11. Awarding Ceremony by the Kazakhstan Governmental Medal for Prof. Eun Chul Shin by the President of «KazDorNII» JSC Prof. Bagdat Teltayev

Conference Reports

The 8th Asian Young Geotechnical Engineers Conference (8AYGEC)
5th – 7th August, 2016, Astana, Kazakhstan (Con't)



Fig. 12. Group Photo with Korean Young Delegation at the Kazakhstan Highway Research Institute “KazdorNII” in Almaty

The official website of 8AYGEC including a final report, all photos and videos will be available until the next Asian Young Geotechnical Engineers’ Conference by the following link :

<http://kgs-astana.wixsite.com/8aygec>

All supported sponsors and donors were thanked were thanked.



Conference Reports

The 2nd Youth Russian Geotechnical Engineer Conference & the 2nd GeoGames)

The 2nd Youth Russian Geotechnical Engineer Conference (YRGEC) was successfully held on 30 June - 1 July 2016 in Gersevanov Research Institute of Bases and Underground Structures (NIIOSP a structural subdivision of JSC Research Center of Construction) at Moscow in Russia. It was organized by the Young Bureau of the Russian Society on Soil Mechanics and Geotechnical Engineering (RSSMGE), NIIOSP and the Moscow State University of Civil Engineering.



The philosophy of such events is to provide a favorable atmosphere for a friendly dialogue between young geotechnical researchers or engineers and senior colleagues or distinguished professors, which could be a start of professional cooperation. Another challenge is to give a nature of the educational process through the conference.

The Organizing Committee did an excellent job to bring together advanced academics and best-known practitioners to give 5 Keynote Lectures which opened each technical blocks and covering the history of geotechnical engineering areas and up-to-date trends, namely Prof. Z.G. Ter-Martirosyan (Moscow) on “The history of theoretical soil mechanics”, PhD O.A. Shulyatyev (Moscow) “Features of foundation design of high-rise buildings”, PhD Ya.A. Pronozin (Tumen) “Experimental studies experience of stress-strain state of soil bases under laboratory and field conditions”, Prof. V.E. Merkin (Moscow) “Current status and the development of domestic tunnel construction”, Prof. B.V. Bakholdin (Moscow) “History and development of the Code and Regulation (SNiP) on pile foundations”. The Open Lecture was dedicated to outstanding geotechnical teachers and prepared by young geo-engineers: “Karl Terzhagi - father of soil mechanics” (A. Chepurnova) and “A mentor in science and a teacher in life. Memoirs of Prof. A. Bartolomey” (D. Sursanov).

This year the 2-day conference was attended by over 80 young participants from different part of the Russian Federation including a young geo-engineer from Kazakhstan. All participants had an opportunity to take a part in the Geotechnical Games (GeoGames) - the major complex professional competition on various field of geotechnical engineering, organized for the second time. The idea came up from the Olympic Games but in GeoGames ‘athletes’ compete on the knowledge in the field of geotechnics rather than on physical ability. Members did tasks and earned points. Participants with the highest number of points were allowed to the Quiz (quick round of questions).

A highlight of the meeting was the delivery a series of awards for the best presentation (one recipient from each block) and the winners in GeoGames (four champions).

Everyone can check the knowledge of the basic geomechanics laws by working out on one of the task from 2nd GeoGames which is given below. Answer to the task can be found on the YMPG page on LinkedIn <https://www.linkedin.com/groups/7056027>. If you have any questions, you can contact a member of the Organizing Committee - Aleksandra Chepurnova via alexa.chepurnova@gmail.com.

The Organizing Committee is pleased to present a scientific paper by one of the recipients of the award at the YRGEC, Danil D. Sabirzyanov “ANALYTICAL DEPENDENCE FOR CALCULATING OF FOUNDATION BASE SETTLEMENT AT THE REGIME FOR A LONG-STATIC AND CYCLIC LOADING” in this ISSMGE Bulletin issue.

The Organizing Committee wishes to express its gratitude and appreciation to the following partners:



Conference Reports

The 2nd Youth Russian Geotechnical Engineer Conference & the 2nd GeoGames) (Con't)

Task from the 2nd GeoGames: Fill in the table, which shows the daily events, their scientific explanation of their respective adopted laws and their authors. You must choose answers from the second table below.

Everyday event	The scientific explanation	Scientific law	Author
From fifth floor of a building a brick and a plastic helmet fall	The falling velocity of the body independent of its mass, the motion occurs with constant acceleration	_____	_____
_____	_____	The law of universal gravitation	Isaac Newton
Passengers in the subway during the train braking hard	_____	The law of inertia	Isaac Newton
_____	The acceleration is directly proportional to the applied force and inversely proportional to the body mass	_____	Isaac Newton
Collision of a car and a truck	_____	Newton's Third Law	_____
_____	Time in different parts of the universe is different. It depends on the speed: the faster you move, the slower time passes for you	The theory of relativity	_____
_____	The buoyancy force effect on the body immersed in a liquid, equal to the weight of fluid in the body volume	_____	Archimedes
Loss of pressure at a water filtration	_____	_____	Henri Darcy
_____	_____	The law of elasticity	Robert Hook
Settlements of railroad ties, elastic beam on deformable foundation	Liner relationship between the load and a foundation deflection	_____	_____

Use the table below to fill in the gaps:

1	Albert Einstein	2	Deformation occurs in an elastic body is proportional to the force applied to that body	3	Nikolay Fuss	4	The water velocity in the soil is directly proportional to the hydraulic gradient
5	Emil Winkler	6	A heavy ocean liner does not sink in the sea	7	Archimedes' principle	8	A hockey player slaps a puck
9	Isaac Newton	10	Theory of groundwater flow	11	Galilei's law	12	The Moon moves around the Earth
13	A normal spring, a helical clock spring and a brass wire have different resilience	14	Galileo Galilei	15	The second law of motion	16	Returning from Space twin younger brothers left on earth
17	Fuss-Winkler model	18	For every action there is an equal and opposite reaction.	19	Gravity affects all objects in the Universe	20	An object is at rest or continues to move at a constant velocity, unless acted upon by a net force.

Conference Reports

The 2nd Youth Russian Geotechnical Engineer Conference & the 2nd GeoGames) (Con't)



Fig. 1. Group photo of the 2nd YRGE in Moscow in front of the NIIOSP main entrance



Fig. 2. President of the RSSMGE Prof. Ilyichev V.A. delivers his speech on the Open Ceremony



Fig. 3. The Board of the conference Open Ceremony. From left to right: Prof. Z.G. Ter-Martirosyan, PhD I.V. Kolybin, A.V Kuzmin, Prof. V.A. Ilyichev

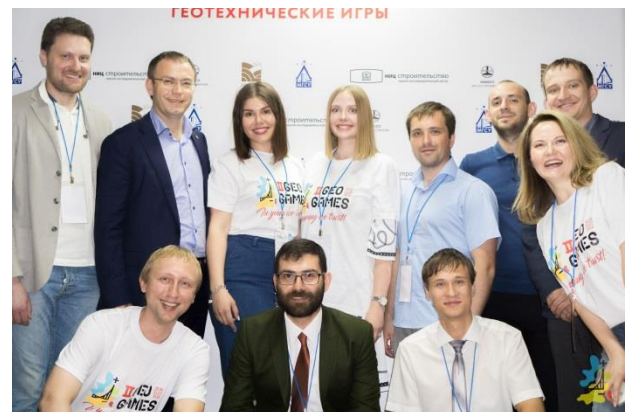


Fig. 4. Participants of the 2nd YRGE with the Organizing Committee



Fig. 5. Partial view of the audience at the 2nd YRGE



Fig. 6. A young geotechnical engineer giving his 8 minute presentation at the 2nd YRGE

Conference Reports

The 2nd Youth Russian Geotechnical Engineer Conference & the 2nd GeoGames) (Con't)



Fig. 7. The final part of GeoGames - the Quiz



Fig. 8. Awarding the best presenters of the 2nd YRGECC



Fig. 9. Participants of the 2nd YRGECC during the Technical Visit Tour to the Dynamo Central Stadium which is being built for the World Cup 2018 in Russia



Fig. 10. #geogames_2016 on Instagram

Aleksandra Chepurnova (alexa.chepurnova@gmail.com)
Organizing Committee

Conference Reports

The 3rd European Conference on Unsaturated Soils (E-UNSAT 2016)



3rd European Conference on Unsaturated Soils

E-UNSAT 2016

Frontiers in Unsaturated Soils

12-14 September 2016
Paris, France



With 201 delegates (including around 60 PhD students) and 167 papers from 28 countries from all over the world, quite large figures for a regional Unsaturated Soil Conference, the E-UNSAT2016 Paris Conference has been quite successful with excellent scientific presentations and very friendly exchanges and social events. All registered authors presented their work and 18 Distinguished Lecturers provided insights into the more advanced achievements in the field, playing an important role in generating interest and facilitating scientific outcomes of the conference.



Photo 1. Group photo of delegates, participants, organizers and helpers of E-UNSAT 2016

The Conference was opened by the first European distinguished lecture (selected by TC106), delivered by Prof. Yu-Jun Cui (Ecole des ponts Paris Tech, France) entitled “*Unsaturated railway track-bed materials*”. Two other keynote lectures were given by Prof. Weimin Ye (Tong-Ji University, China) on “*Investigation on chemical effects on GMZ bentonite as buffer material*” and Majid Hassanizadeh (University of Utrecht, the Netherlands) on “*Advances in experimental and computational studies of flow in unsaturated porous media*”. Six plenary lectures were also delivered, together with nine invited lectures given at the beginning of the parallel sessions.

Conference Reports

The 3rd European Conference on Unsaturated Soils (E-UNSAT 2016) (Con't)

Plenary lectures

- Dr. Gilles Armand (Andra, Bure, France): *Inputs from in situ experiments to the understanding of unsaturated behaviour of the Callovo-Oxfordian claystone*
- Prof. Charles Augarde (Durham University, UK): *Challenges in treating earthen construction materials as unsaturated soils*
- Prof. Giuseppe Buscarnera (Northwestern University USA): *Pore pressure instabilities in soils: modeling the role of saturation conditions*
- Prof. Nasser Khalili (University of New South Wales, Sydney, Australia): *Effective stress and Energetics of Unsaturated Soils*
- Prof. Alberto Ledesma (Universitat Politècnica de Catalunya, Barcelona, Spain): *Cracking in desiccating soils*
- Prof. Tom Schanz (Ruhr Universiteit Bochum, Germany): *Transient boundary conditions in the frame of THM-processes in nuclear waste repositories*

Invited Lectures

- Prof. Francesca Casini (University of Rome Tor Vergata, Rome, Italy): *Infiltration-induced Slope Instability: a multi scale approach*
- Prof. Frédéric Collin (University of Liège, Belgium): *Modelling an in-situ ventilation test in the ANDRA Underground Research Facilities*
- Prof. Philippe Cosenza (University of Poitiers, France): *Geophysical determination of soil water content*
- Dr. Paul Hughes (Durham University, UK): *Challenges in monitoring and managing engineered slope stability in a changing climate*
- Prof. Cristina Jommi (TU Delft, The Netherlands): *Fabric and clay activity in soil water retention behaviour*
- Dr. Nadia Mokni (IRSN, France): *SEALEX In-Situ Experiments-Performance Tests of Repository Seals: Experimental observations and modelling*
- Prof. Giacomo Russo (Università di Cassino e del Lazio Meridionale, Italia): *Chemo-physical evolution and microstructure features of lime treated soils*
- Prof. Alessandro Tarantino (University of Strathclyde, UK): *Advances in the monitoring of geo-structure subjected to climate loading*
- Dr. Victor Vilarrasa (EPFL, Switzerland): *Two-phase flow effects on the CO₂ injection pressure evolution and implication for the caprock geomechanical stability*

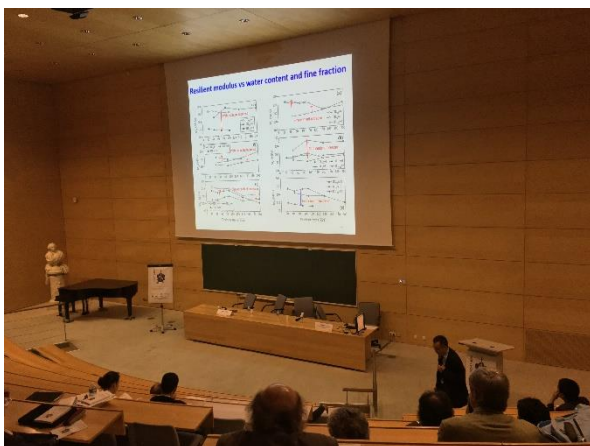


Photo 2. First European Distinguished Lecture:
Prof. Yu-Jun Cui



Photo 3. Keynote Lecture:
Prof. Weimin Ye

Conference Reports

The 3rd European Conference on Unsaturated Soils (E-UNSAT 2016) (Con't)

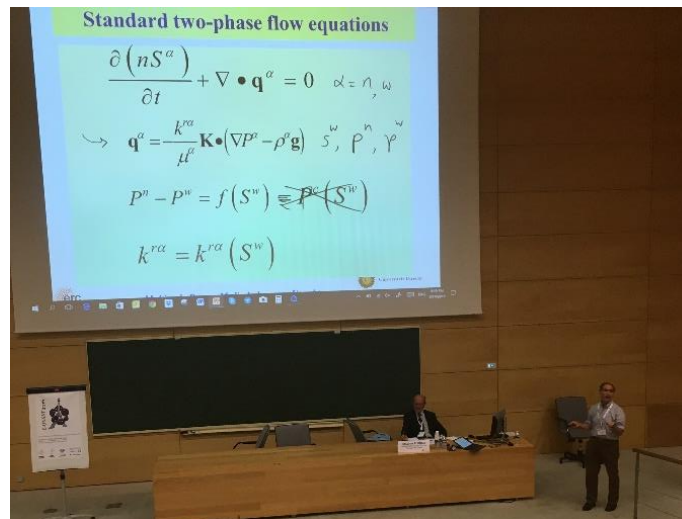


Photo 4. Keynote Lecture: Prof. Majid Hassanizadeh

General programme: the topics that drew particular interest are *Advances in experimental methods*, *Water retention and transport properties* and *Mechanical behaviour*, with also significant contributions on *Numerical and Constitutive modelling*. The practical applications that have been dealt with are *Dams and dykes*, *Soil-Vegetation-Atmosphere interaction*, *Slope stability*, *Geo-environmental applications* (a session organised together with the ISSMGE TC215) and *Nuclear waste disposal*. The conference proceedings are available as open-access (see link below) and their insertion in major databases (Web of Science, Scopus) is being processed.

Open Access

<http://www.e3s-conferences.org/articles/e3sconf/abs/2016/04/contents/contents.html>

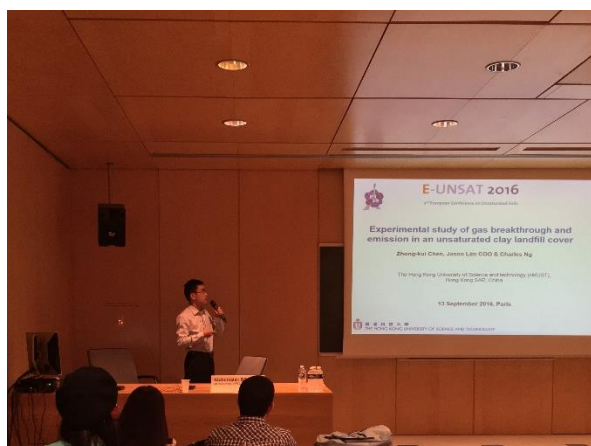


Photo 5. An author gives his presentation in the session "Geo-environmental applications"

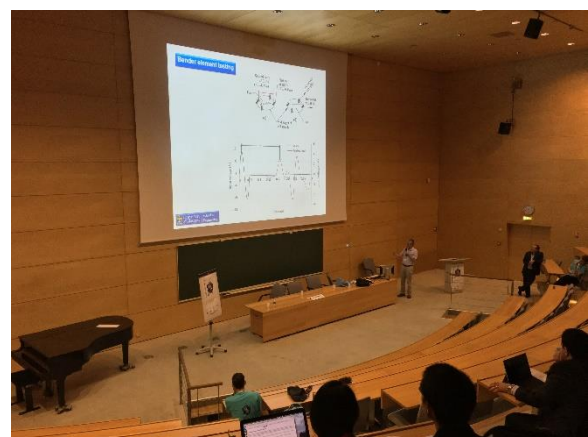


Photo 6. Prof. Wheeler gives his presentation in the session "Advances in experimental methods"

Conference Reports

The 3rd European Conference on Unsaturated Soils (E-UNSAT 2016) (Con't)



Photo 7. Gala dinner at "Le Train Bleu"

As expected and confirmed by the large number and the high quality of the papers received, the E-UNSAT2016 Paris Conference fostered fruitful presentations and discussions on up to date ideas, concepts and achievements in Unsaturated Soils, from many researchers from Europe and other continents.

Prof. Pierre Delage
Chair of the organizing committee

Young Members' Arena

Analytical dependence for calculating of foundation base settlement at the regime for a long-static and cyclic loading

Young Member Author

Danil D. Sabirzyanov, Kazan State University of Architecture and Engineering (Kazan, Russia)
email: danil198900@mail.ru

Co-author(s)

Ilizar T. Mirsayapov, Kazan State University of Architecture and Engineering (Kazan, Russia)
email: mirsayapov1@mail.ru

Irina V. Koroleva, Kazan State University of Architecture and Engineering (Kazan, Russia)
email: prepod-irina@ya.ru

About the Young Member:

Danil was born in the Republic of Tatarstan (Russia). In 2007 year, he entered the Faculty of Civil Engineering KSUAE, in 2011 graduated from the Kazan State University of Architecture and Engineering (KSUAE) with "Bachelor of engineering and technology."

From 2011 to 2013, Danil studied at the Department of "Groundbases, foundations, structural dynamics and engineering geology" of KSUAE, in 2013 with honour defended master's dissertation on the topic "*Long-term strength and deformability of clay soils under regime triaxial compression*".

In 2013, Danil enrolled in the postgraduate study in KSUAE and appointed as assistant at the Department of groundbases, foundations, structural dynamics and engineering geology. He is engaged in scientific work on the theme: "*Bearing capacity and deformation clay soils ground bases at alternating long static and cyclic loadings*".

Danil is also engaged in teaching activities and has a teaching load of 900 hours per year. He supervises five graduate students per year. During his career, he participated in:

- Examination of more than 10 different subjects;
- The organization of the XIV International Symposium on the rheology of soils, Kazan (2014)

Danil is an author of 15 scientific published works. He also took part in Russian and international scientific - practical conferences.

Abstract

This article describes the initial and transformed the clay soil deformation diagram for long-static, cyclic and regime long- static and cyclic loading. The test results are processed and are plotted and used for comparison with theoretical studies. Based on the analysis of the transformed strain diagrams developed engineering method for calculating ground settlement, based on the method of layering summation taking into account spatial changes of stress - strain state of the ground in the process of regime static and cyclic loading. Comparisons with the results of triaxial tests with long trough-static, cyclic and long-modal static and cyclic deformation of the clay base slab foundation.

Keywords: Clay soils, triaxial compression, static loading, cyclic loading, regime static and cyclic loading, transformed diagram.

Young Members' Arena (Con't)

Introduction

One of the specific problems at designing of installations, it is necessary to consider that during the construction and operation of the load on the foundation soil is applied in stages as construction of buildings and structures. At this stage of the active loading during the construction stage transformed into stages sequential alternation of long static and cyclic loading, if the building or construction equipment is installed, which create a dynamic impact on the ground base. The maximum and minimum values of cyclic loading and prolonged static load depends on the technology and mode of equipment operation. However, existing methods of calculation cannot to take into account the particular strain of foundations under such loadings.

Based on that, there is a need to develop a method for calculating bases at regime-static cyclic loading. This is particularly relevant for the grounds composed of clay grounds, as in this case, the stress - strain state varies with time and depends on the previous history of the loading. Scheme strained substrate conditions and calculation mode shown (Mirsayapov and Koroleva (2011)).

Experimental researches

In connection with the foregoing at the Department "Bases and foundations, dynamics of structure and engineering geology" in KSUAE were carried out experimental studies of the clay ground under triaxial static, cyclic and regime loading. Were tested clay ground samples with the following characteristics: $W=23\%$; $W_p=22.8\%$; $WL=40.1\%$; $\rho=1.94 \text{ g/cm}^3$; $I_p=17.3\%$; $IL=33\%$. Samples twins were prepared in accordance with GOST 30416-96.

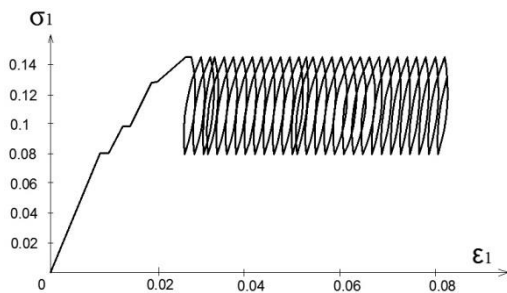


Fig. 1. Dependence of vertical stress from vertical deformation under triaxial short-term cyclic loading

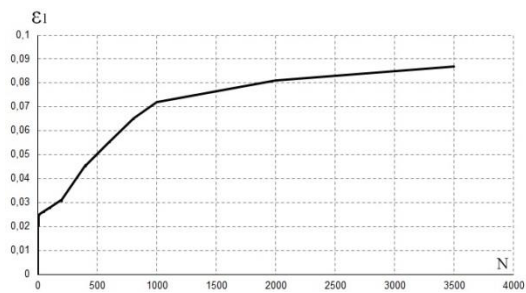


Fig. 2. Dependence of vertical deformation from number of cycles under triaxial cyclic loading

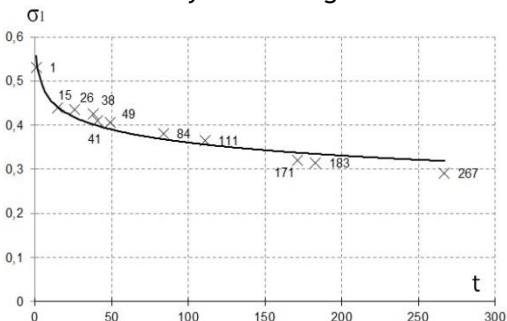


Fig. 3. Dependence of vertical stress from triaxial prolonged static loading

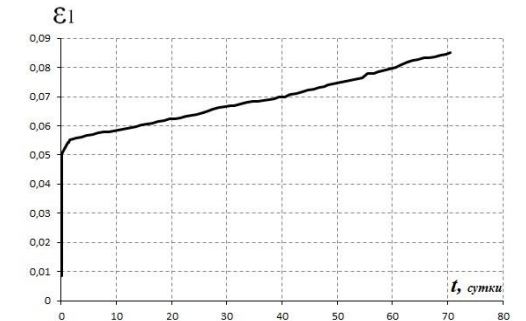


Fig. 4. Dependence of vertical stress from time under triaxial prolonged static loading

Young Members' Arena (Con't)

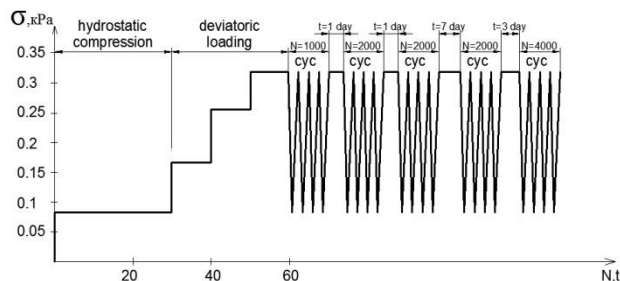


Fig. 5. Loading mode under triaxial regime prolonged static and cyclic loadings

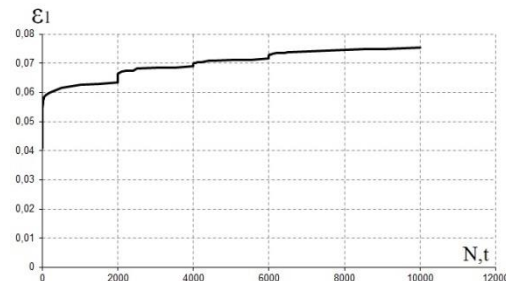


Fig. 6. Dependence of vertical deformation under triaxial prolonged static loading

According to the results of experimental studies obtained graphic dependences between the intensity of tangential stresses τ_i and the intensity of shear strain γ_i , between the axial stress σ_z and axial strain ε_z , between the bulk stresses σ_m and volume deformations ε_v ; changes of linear module E_{0Z} , bulk modulus K_v and the shear modulus G with time (Mirsayapov and Koroleva (2009), Mirsayapov and Koroleva (2010), Mirsayapov et al. (2013), Mirsayapov et al. (2014)).

Figure 7 shows the change in strength at various lateral pressures of 0.08 MPa and 0.16 MPa. Graphs show changes in the short-term strength of triaxial static, long static, short-term cyclic loading points and showed the values strength at the regime long triaxial static and cyclic loadings. The graphs show that the strength of the clay samples at regime-static cyclic loading is significantly different from the strength of the long-term static and cyclic loading.

As can be seen from the graphs at viewed regimes take place changing of all bases parameters, characterizing the stress and strain state of the ground in time, which allows to conclude about necessity to develop a new parameter characterizing the mechanical condition and about necessity to create calculation models. As this parameter is accepted analytical diagram of ground deformation in the coordinates (σ_1 - ε_1) for triaxial (where σ_1 , ε_1 vertical stress (deviator) and linear deformation under triaxial compression).

Analytical diagram of ground deformation under triaxial compression

Based on the graphs (Figs. 1-7) were built initial diagrams (phase diagram) of ground deformation at short triaxial static loading. As a limit point to the coordinates (σ) takes the value of ground tensile strength $\sigma_1=R_{gr,u}$ (deviator) under triaxial short-term static compression. Limit point on the y-axis (ε) takes the value of linear deformation $\varepsilon_{u1}=0.0869$. View of diagram shown in Figure 8.

At clay ground state diagrams under triaxial long static loading as initial used stress-strain diagram « σ_1 - ε_1 » for the case of short-term triaxial static loading. Transforming the initial phase diagram under triaxial short-term static loading, obtain analytical dependences for the description diagrams of the clay ground deformation under triaxial prolonged static loading.

Young Members' Arena (Con't)

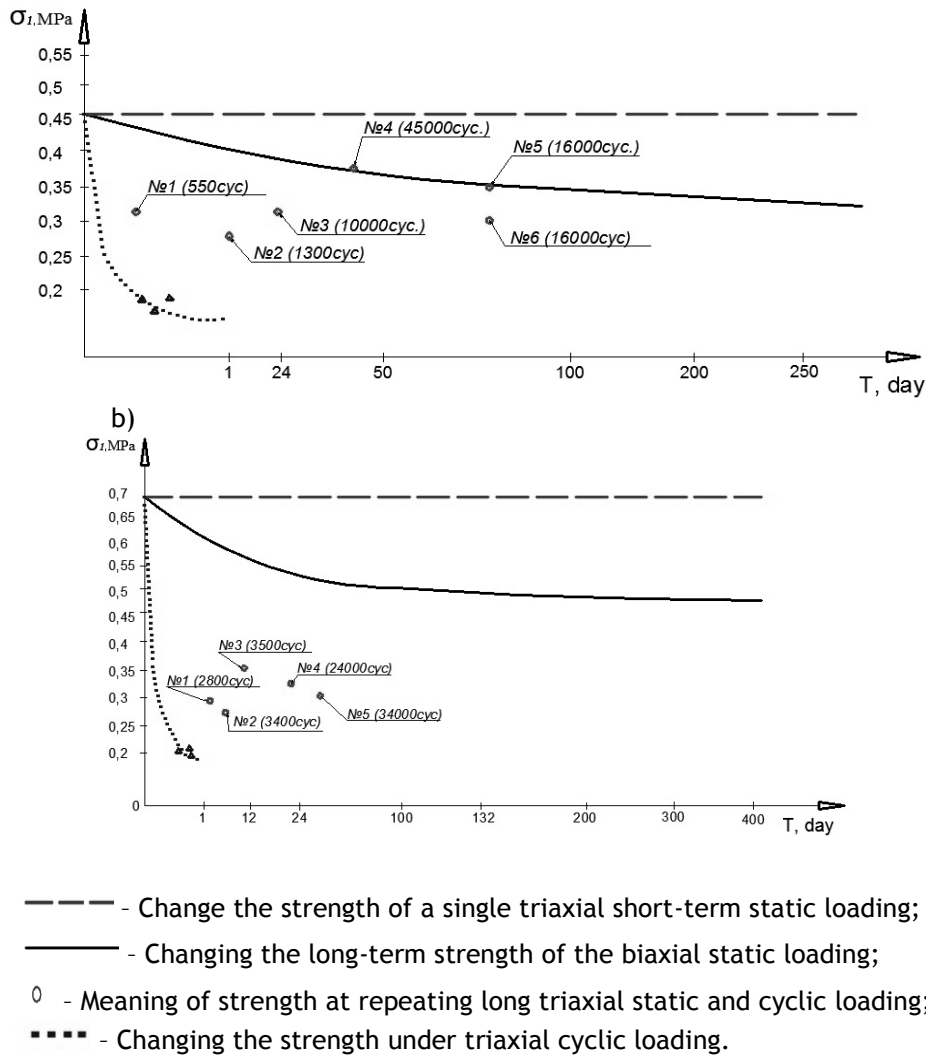


Fig. 7. Change the regime of loading strength: a) for the lateral pressure of 0.08 MPa; b) for the lateral pressure of 0.16 MPa

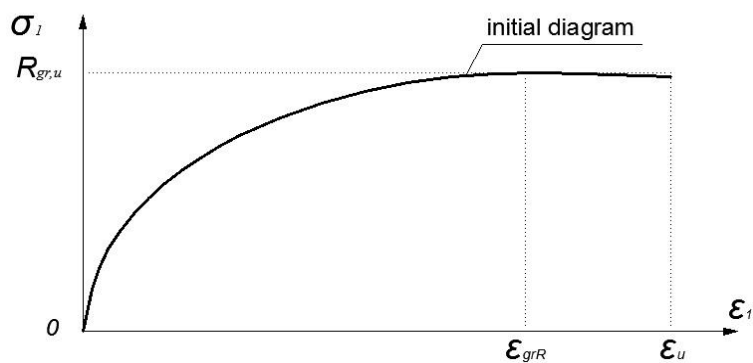


Fig. 8. Initial ground deformation diagram with short-term static triaxial loading

Young Members' Arena (Con't)

By the form of transformed diagram taken similar initial phase diagram based on the following provisions (Fig. 9):

- Limit point of the vertical pressure at the top of diagram accept stress in the ground, which is equal to the limit prolonged resistance under triaxial load action $R_{gr,long}(t,\tau)$ and deformation, answer to deformations at the top of the state diagram under triaxial short-term static loading $\epsilon_{gr,u,red}=\epsilon_{gr,u}$;
- To limit point, define the limits of state diagrams on the y-axis, deformations equal to limit deformations under triaxial short-term static loading $\epsilon_{gr,red}=\epsilon_{gr,R}$, and on major dependencies calculate by (1) stresses in the ground;
- The origins of diagrams taken offset to value, equal to the creep deformation at the viewing moment of time: $\epsilon_{pl}(t)$ - at long static loading;
- Obtained tilt angles deformation diagrams taken in view of the changes of the clay ground module deformation under triaxial long static loading.

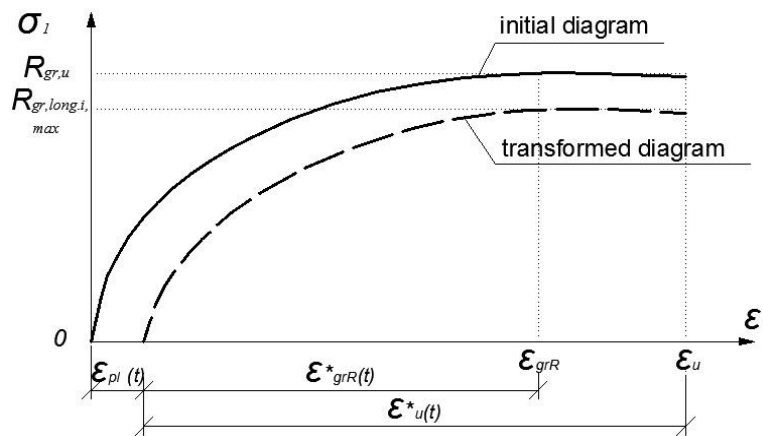


Fig. 9. Original and transformed ground deformation diagram long triaxial static loading

The dependence of vertical pressure (deviator) limiting point at the top of diagram and the loading time under triaxial long static loading takes the form:

$$\sigma(t_1 t_0) = R_{gr,long} = -\alpha \ln(t) + R_{gr,u} \tag{1}$$

where a is values obtained by experiments. Ground creep deformation at given moment of time at long static loading are determined by the formula:

$$\epsilon_{pl}(t_1 t_0) = c_{\infty}(t_1 \tau) \cdot \sigma(t_1 t_0) \cdot f(t_1 t_0) \tag{2}$$

where $f(t_1 t_0) = 1 - e^{-\gamma(t-t_0)}$ is the growth creep deformation function; and γ is ground creep parameter.

$$c_{\infty}(t_1 \tau) = \frac{\epsilon_{pl}(t_1 \tau)}{R_{gr,u}(t_1 \tau)} \tag{3}$$

where $c_{\infty}(t_1 \tau)$ is ground creep limit measure at time t .

Young Members' Arena (Con't)

At viewing the clay ground state diagrams under triaxial cyclic loading as initial were used stress-strain diagram « $\sigma_1-\epsilon_1$ » for the case of short-term triaxial static loading.

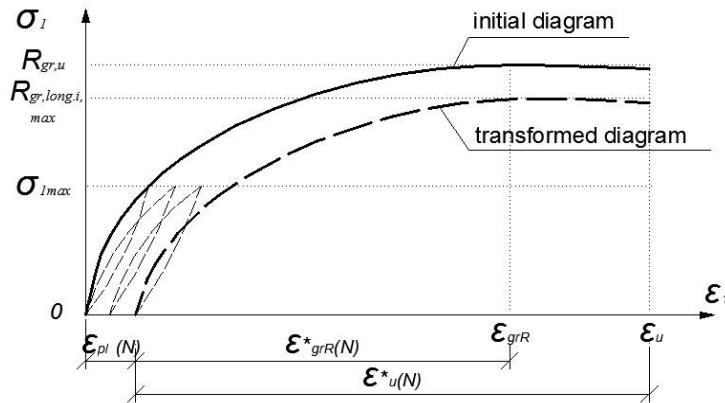


Fig. 10. Initial and transformed ground deformation diagram under triaxial cyclic loading

By transforming the initial state diagram under triaxial short-term static loading, obtain analytical dependences for the description of clay ground deformation diagrams under triaxial short-term cyclic loading. Transformed diagram form taken similar to initial state diagram based on the following provisions (Fig. 10):

- Vertical pressure limit point takes from the top of ground stress diagram, which is equal to the limit of endurance under triaxial cyclic loading $R_{gr,long}(t,\tau)$ and deformation answering to deformation at the top of state diagram under triaxial cyclic loading $\epsilon_{gr,u,red}=\epsilon_{gr,u}$;
- For limit point, which define the state diagram limits at the Y-axis, deformation equal to limit deformation under short-term triaxial cyclic loading $\epsilon_{gr,red}=\epsilon_{gr,R}$, and stress in the ground calculate by the major dependencies (4);
- Diagram start coordinates taken offset to value, which equal to vibrocreep deformations at viewing loading cycle: $\epsilon_{pl}(N)$ - at short-term cyclic loading;
- Obtained deformation diagram tilt angles, which taken with changes of the clay ground deformation module under triaxial short-term cyclic loading.

The dependence between the limiting point of the vertical pressure at the top of the state diagram and the loading cycles number under cyclic loading takes the form:

$$\sigma(t_1\tau) = R_{gr,long}(N) = R_{gr,u} \cdot e^{-\beta N} \tag{4}$$

where β is values obtained by experiment; and N is number of cyclic loadings. Ground creep deformation in viewing cycle at short cyclic loading determine by the formula:

$$\epsilon_{pl}(N) = c_\infty(t_1\tau) \cdot \sigma^{\max}(t_1\tau) \cdot f(N) \tag{5}$$

where $f(N) = 1 - e^{-\gamma(N-N_0)}$ is growth creep function; and γ is ground creep parameter under cyclic loading;

Young Members' Arena (Con't)

$$c_{\infty}(t_1\tau) = \frac{\varepsilon_{pl}(t_1\tau)}{R_{gr,u}(t_1\tau)} \tag{6}$$

where $c_{\infty}(t_1\tau)$ is limit ground creep measure.

Analytical dependences for describing ground deformation diagrams at regime triaxial loading are obtained by transforming dependencies (1-6) for triaxial long static and cyclic loading (Fig. 11).

In the ground deformation regime description under triaxial loading is necessary to consider the influence from vertical pressure (σ_1) of the previous block for strength, modulus and relative deformation at the top of the diagram in the subsequent loading after the regime change. Within each block, in which develops regime loading, changing deformation diagrams described by the same formulas as for cycling or long - static loading, but appropriate for each block σ_i , N_i or T_i and taking into account the change in the strength and deformability of the previous blocks.

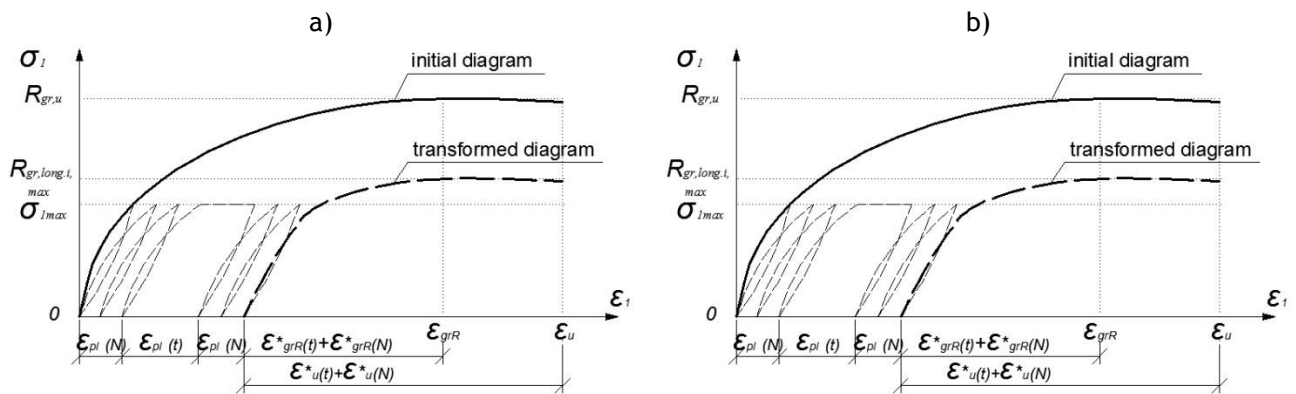


Fig. 11. Initial and transformed ground deformation diagrams at regime alternating static and cyclic loading

It is necessary to take into account two specific case when:

- at first acting the long - static loading $\sigma_1(t)$, and then cyclic loading;
- at first acting cyclic loading $\sigma_1(N)$, and then prolonged static loading.

In the first case, the overall durability increases as compared with that, when cyclic loading is being with the stress value $\sigma_1(N)$. This is due to with increasing the effective destruction of the ground surface energy on the first stage load due to recovery and the increasing of coagulation bonds (Mirsayapov and Koroleva 2016).

In the second case, strength reduction at the transition to the block with prolonged static load will be extremely slow. This is explained by "delay effect" of fatigue cracks in the equilibrium limit planes in the calculated ground volume (Mirsayapov and Koroleva 2016).

Thus, at transforming the initial diagram for the case of regime loading must be taken into account the influence of alternation long-term static and cyclic loads.

Young Members' Arena (Con't)

Based on the analysis of the transformed strain diagrams developed the engineering method for calculating ground base settlement, which based on the method of layering summation with taking into account changes in the spatial stress - strain state of ground in the process of triaxial long-static, cyclic and regime static - cyclic loading.

Accepted volumetric stress state of foundation base ground presented in figure 12. Breaking base compressible thickness to the layers, for each layer based on (Fig. 12) for the stress deviator (σ_1) determine the deformation $\varepsilon_{z,i}$ appropriate to value of vertical pressure, and then the deformation values at the limits of the compressible thickness summed up.

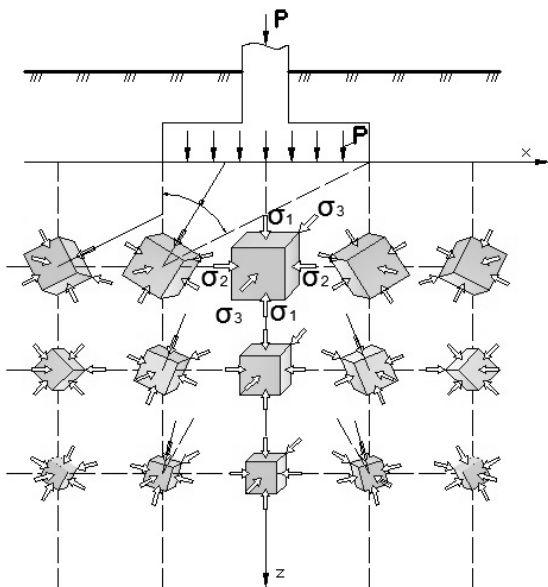


Fig. 12. Stress state scheme of the foundation base during the regime loading

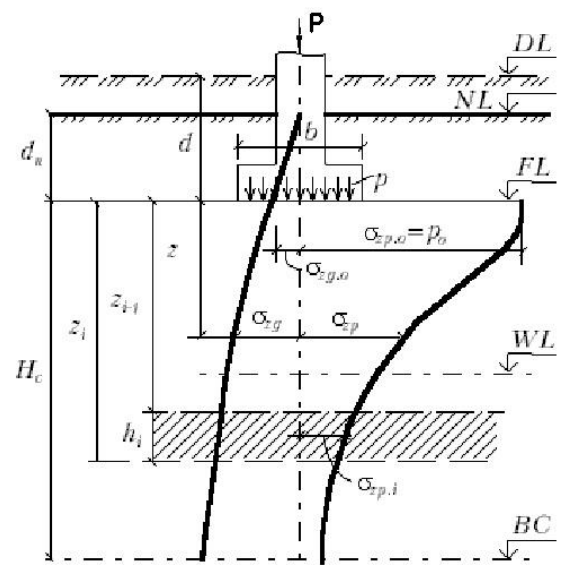


Fig. 13. Calculation scheme for determining ground base settlement during the regime loading

Thus, the base settlement calculate according to the formulas:

- with triaxial prolonged static loading:

$$S = \sum_{i=1}^n [\varepsilon_{z,i}(t, \tau)] \cdot h_i \tag{7}$$

where n is the number of layers in which divide compressible base thickness; h_i is the thickness of the i -th layer; $\varepsilon_{z,i}(t, \tau)$ is axial strain increment of i -th layer under the static load action; t is time appropriate to the moment of observation; t_0 is application time of the load.

- -at triaxial cyclic loading:

$$S = \sum_{i=1}^n [\varepsilon_{z,i}(N)] \cdot h_i \tag{8}$$

where $\varepsilon_{z,i}(N)$ is axial strain increment of i -th layer under cyclic loading action;

Young Members' Arena (Con't)

- under triaxial regime prolonged static and cyclic loading:

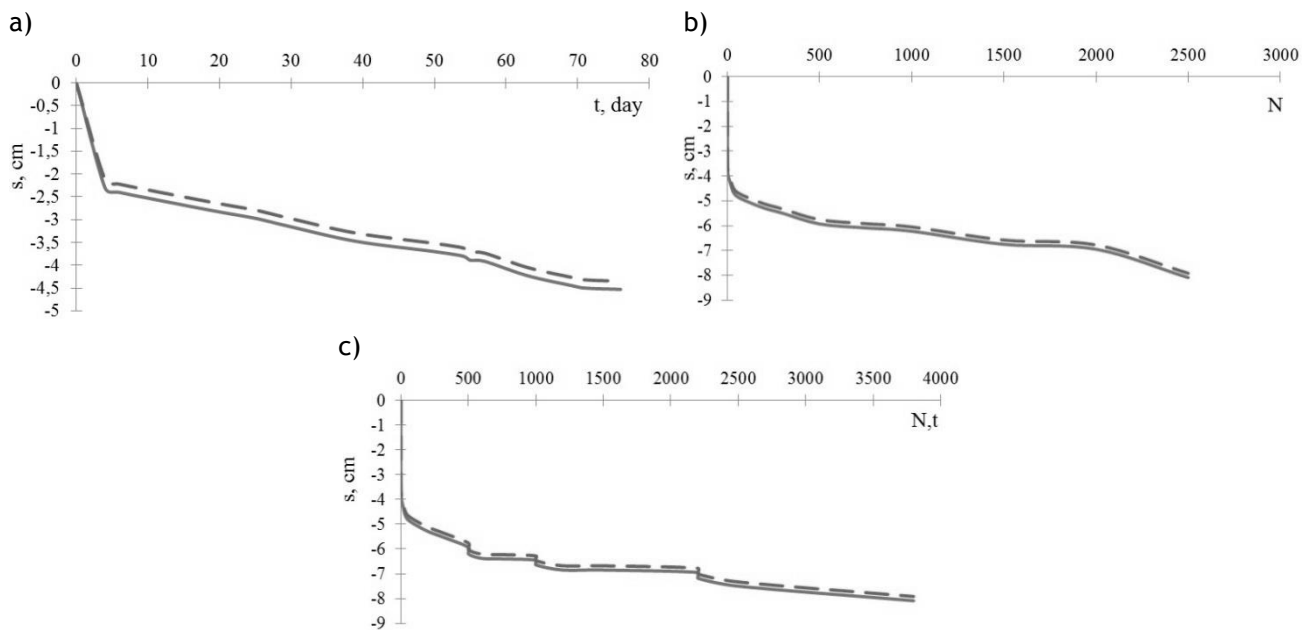
$$S = \sum_{i=1}^n \left[\sum_{j=1}^m \varepsilon_{z,j}(N) + \sum_{j=1}^k \varepsilon_{z,j}(t, \tau) \right] \cdot h_i \quad (9)$$

where m is the number of cyclic loading blocks; k is the number of long-term static loading blocks.

Comparing theoretical and experimental researches results graph of raft foundation model settlement (with dimensions of 0.4x0.4 m) on clay ground base in a laboratory tray (tray with the size of 1x1m) the ground characteristics that defined above, for the triaxial loading conditions are shown in figure 14.

In the limits of starting block, independently from sequence from loading block, transformed diagrams obtain similarly to not regime long-static and cyclic loading. In each subsequent block take place further deformation diagram transforming, but the initial diagram for each of them is an transformed diagram at the end of the previous block.

Top coordinates of transformed diagrams at the beginning of each subsequent block depends from the level of stress in the preceding block and the sequence alternation of blocks with different types of loading.



——— - raft foundation model settlement graph; - - - - - calculated data.

Fig. 14. Raft foundation comparing settlements graphs: a) at long static loading; b) under cyclic loading; c) at the regime-static-cyclic loading

Young Members' Arena (Con't)

Conclusions

Based on the analysis of the transformed strain diagrams developed the engineering method for calculating ground base settlement, which based on the method of layering summation with taking into account changes in the spatial stress - strain state of ground in the process of triaxial long-static, cyclic and regime static-cyclic loading.

As seen from figure 14, comparing the results of triaxial with a trough tests at long-static, cyclic and static and modal prolonged cyclic deformation of the clay base raft foundation shows a good agreement between the calculated and experimental settlement data.

References

- Mirsayapov I.T., Koroleva I.V. 2011. Bearing capacity of foundations and rainfall with prolonged loading. Integration, partnership and innovation in building science and education: the International Collection of papers. Scien. Conf. 2 t. Vol.2, 342-347.
- Mirsayapov I.T., Koroleva I.V. 2009. Research strength and deformability of clay soils with prolonged triaxial compression. Proceedings of the Kazan State Architectural University. № 2 (12), 167-172.
- Mirsayapov I.T., Koroleva I.V. 2010. Features deformation of clayey soils under cyclic triaxial compression. International Journal of Geotechnical. № 6, 64-67.
- Mirsayapov I.T., Koroleva I.V., Sabizyanov D.D. 2013. Strength and deformation of clayey soils under triaxial modal alternating static and cyclic loading. Geotechnics Belarus: Science and Practice, 297-304.
- Mirsayapov I.T., Koroleva I.V., Sabizyanov D.D. 2014. Warp clay soils combined with the regime and the long-term cyclic loading. Perspective directions of development of the theory and practice of rheology and soil mechanics. Proceedings of the XIV International Symposium on rheology, 130-135.
- Mirsayapov I.T., Koroleva I.V. 2016. The strength and deformability of clay soils under the regime spatial stress state in view of cracking. Grounds, foundations and soil mechanics, No. 1, 16-23.
- Voznesensky E. A . 1997. The behavior of soils under dynamic loads.MGU, 286.
- Zaretsky Yu.K. 1989. Lectures on modern soil mechanics. Rostov-na-Donu: Publ growth. University Press, 607.

ISSMGE Foundation Reports

The conference, Geo-Chicago 2016: Sustainability, Energy and the Geo-environment, was organized by the Geo-environmental Engineering Committee of the Geo-Institute (G-I) of the American Society of Civil Engineers (ASCE). The conference was aimed at providing a unique opportunity to explore recent advances, new directions and opportunities for sustainable and resilient approaches to design and protect infrastructure and the environment. The conference theme, “Sustainability, Energy, and the Geo-environment”, was delivered in six tracks (1. Sustainability and Resiliency, 2. Energy, 3. Geo-environmental Systems, 4. Materials and Resource Conservation, 5. Waste Management and Remediation and 6. Policy and Regulations) which were broad enough to encompass the spectrum of sustainable geoenvironmental engineering practice and research.

On 14th August, prior to the main conference, a short course was held on the topic “Vertical Barriers for Geo-environmental Applications” by Prof. Jeffrey C. Evans and Daniel G. Ruffing. The conference got underway on 15th August with welcome speech by the Conference Chair Prof. Krishna R. Reddy which was followed by two Keynote Lectures by Prof. Craig H. Benson and Prof. Mario E. Manassero. After a short coffee break, there were five parallel sessions. All the sessions were observed by a good gathering of people who had come there to explore new ideas and innovation in the field of geo-environmental engineering. After lunch, there was a session for honouring Prof. David E. Daniel along with other four parallel sessions which was followed by a short break. Then was the session for honouring Prof. Robert M. Koerner, also with other four parallel sessions. The end of the day was marked with the Award Ceremony.

Next day, on 16th August, the day started with two keynote lectures by Nathan J. Snorteland (P.E.) and Prof. John L. Daniels respectively. After the short break, there were 5 concurrent sessions; followed by lunch. The lunch was followed by other set of 5 concurrent sessions, a short coffee break and another 5 concurrent sessions. The end of the day was marked by fun event at the ballpark (Cubs vs. Brewers at Wrigley Field).

The third day of the conference (17th August) started with two keynote lectures by Prof. Michel Aubertin and Marc Tuchman. Each day of the conference was divided into three parts with each part having five concurrent sessions. The lunch on the final day was dedicated towards discussion among the researchers and practising engineers about what would be the possible ways forward to bridge the gap between academics and applications followed by comments and suggestions by front-runners of the field. All the days, the breaks were dedicated exploring the exhibitors and posters presented.

Finally, on 18th August, to bring the researchers from different parts of the world together, Indo-US Bilateral Workshop was held with an objective of establishing linkage between Geo-environmental Practices and Sustainability.



Fig. 1. Photo with Prof. Mario Manassero



Fig. 2. Photo with Prof. Sivakumar Babu, Prof. John Daniels and Prof. Jeffery Evans (from left to right)

ISSMGE Foundation Reports (Con't)

The Schofield centre at the University of Cambridge, England was visited from the 30th of June 2016 to the 31st of August 2016. The purpose of the visit was twofold: to conduct centrifuge modelling of clay liners spanning cavities with me Talia da Silva and to discuss the results of the centrifuge modelling and material tests conducted at the University of Pretoria. This was done to complement and improve my Master's dissertation on the optimal geogrid reinforcement of piggyback landfill liners.

In the first week of the visit I attended a conference on expanding skills, hosted by the Department of Engineering's Division. The workshops on negotiation and entrepreneurship were valuable learning experiences.

In the subsequent weeks the preparation for centrifuge tests were completed. Three tests were conducted: a clay liner spanning a narrow void, a liner spanning a wide void and finally a liner spanning a wide void, subject to overburden pressure. These tests simulated landfill liners, in various stages of commissioning, subject to local voids.

From each of the clay liners tested, samples were extracted for bending beam flexural tests. An additional set of samples were prepared at a higher consolidation pressure. The test conducted at the University of Cambridge, together with those conducted at the University of Pretoria, investigated the flexural behaviour of kaolin clay beams for: three and four point bending tests; 500 kPa, 610 kPa and 700 kPa consolidation pressures; very slow (0.0167 mm/min), slow (1 mm/min), medium (3 mm/min) and fast loading rates (10 mm/min); notched and unnotched beams. These results will be reported in a future publication.

I am grateful to the ISSMGE Foundation for helping to realise my visit to the University of Cambridge's Schofield centre. I gained valuable experience on working with clays in the centrifuge and centrifuge modelling in general. Perhaps more valuable were the people I have met and the influence they may have on my career as a geotechnical engineer. It was a privilege to work and live in a country so different from my own. The quality of my Master's dissertation will surely benefit from the visit.



Fig. 1. Photo with delegates who attend the conference dinner at Trinity College

David H Marx
The University of Pretoria, South Africa

ISSMGE Foundation Reports (Con't)

The 3rd International Conference on Transportation Geotechnics was held in Guimarães, Portugal. The conference was divided in Honour, Keynote, Theme and Special Lectures and Poster Sessions. The conference included 182 papers from 50 countries. All of them focused in a better understanding and improvement of geotechnics of roads, railways, airports, harbours and other ground transportation infrastructure.

It was clear during the conference that the geotechnical community is working hard to find better solutions to use construction and recycled materials in several infrastructures, combining several factors such as safety, economical and sustainability, in order to fit the growing requirements of infrastructure around the world. Sustainability and environment are getting more and more important day after day due to the well-known consequences of climate changes and others related. Considering this, I think it is evident that these points will represent the future challenges of the young engineers around the globe.

I would like to highlight some presentations which, among many others, I especially liked. The paper presented by Doctor Rasouli, from Japan, about *Controlled Curved Drilling Technique in the Permeation Grouting Method for Improvement Works of an Airport in Operation* was for me very impressive once they had to improve the soil against liquefaction, which is not an easy task. The methodology, permeation grouting of chemicals to the liquefiable ground, was accompanied by a detailed monitoring system.

Another paper which I really appreciated was presented by Dr. Pinto, from Portugal, and it was about *Ground Improvement with Jet Grouting Solutions at the New Cruise Terminal in Lisbon, Portugal*. The presentation was really engaging since the goal was to build an embankment on a soft muddy alluvium layer with an average thickness of 20m. All studies, analyses and designs performed were a real big challenge which ended magnificently.

The last presentation that I would like to highlight was presented by Doctor Soungyu, from China, about *A New Combined Vacuum Preloading with Pneumatic Fracturing Method for Soft Ground Improvement*. The technology presented consists in combining vacuum pumps, PVDs, horizontal drain pipes with a pneumatic fracturing system which will increase the permeability and consequently accelerate the consolidation. The author also presented a successful case study.

Last, but not the least, I would like to thank the ISSMGE Foundation Awards Committee and Mota-Engil Central Europe S.A. for giving me the opportunity to attend this conference, which was assuredly very enriching from the professional point of view.



Fig. 1. Opening Ceremony and speech by Prof. António Gomes Correia

Diana Martins Marques
Mota-Engil Central Europe S.A.

ISSMGE Foundation Reports (Con't)

The 1st International Conference on Energy Geotechnics, ICEGT 2016, provided a platform for interaction and communication among academic and non-academic parties to exchange ideas, innovations and future practices in the area of energy geotechnics.

One of the technical sessions at the 1st International Conference on Energy Geotechnics ICEGT 2016 was *Thermo-active Foundations, Tunnels and Earth-coupled Structures*, which is the current research focus of my PhD, and a research area I hope to pursue as a future faculty member. I presented a talk on the thermo-mechanical behavior of the soil-energy pile interface entitled “*Cyclic Thermal Loading Effects on Soil-Energy Pile Interaction*” based on my test results from thermal-modified borehole shear tests (Thermal-mBSTs) performed at the Lehigh University.

I attended the two site tours organized by the committee of ICEGT 2016. One is the GEOMAR/Helmholtz Centre. Dr. Haeckel delivered a lecture about marine gas hydrates. In the lecture, he presented the current conditions and difficulties in exploitation of the gas hydrate. The other one is the CO₂ Pilot storage site in Ketzin, Dr. Lüth gave us a lecture about the CO₂ storage research of their team.

My career goal is to find an academic position where I can make full use of my experiences and specialties in geotechnical engineering. The feedback and comments during my presentation and, throughout the conference, will help me to further develop my research ideas during my doctoral period and future career in academia. The presentation, also, helped me develop my communication skills with scientists in my area of research. Moreover, the connections I developed by networking with the speakers and attendees will be an invaluable resource for my development of research collaborations and the search for a faculty position.

Other technical topics at the conference included carbon sequestration, gas hydrate sediments, shallow & deep subsurface geo-thermal systems, nuclear waste deposits, etc. This cross-disciplinary conference will benefit my future research career. Exposure to such a broad range of topics accelerated my learning and helped me stay up-to-date on the latest developments in our field. I was excited to learn from the presentations of other speakers.



Fig. 1. Photo with Prof. Carlos Santamarina at the GEOMAR/Helmholtz Centre



Fig. 2. Site visit at the CO₂ Pilot storage site, Ketzin

Hot News

Book review: Reliability of Geotechnical Structures in ISO2394

Publication: Reliability of Geotechnical Structures in ISO2394

Publisher: CRC Press/Balkema

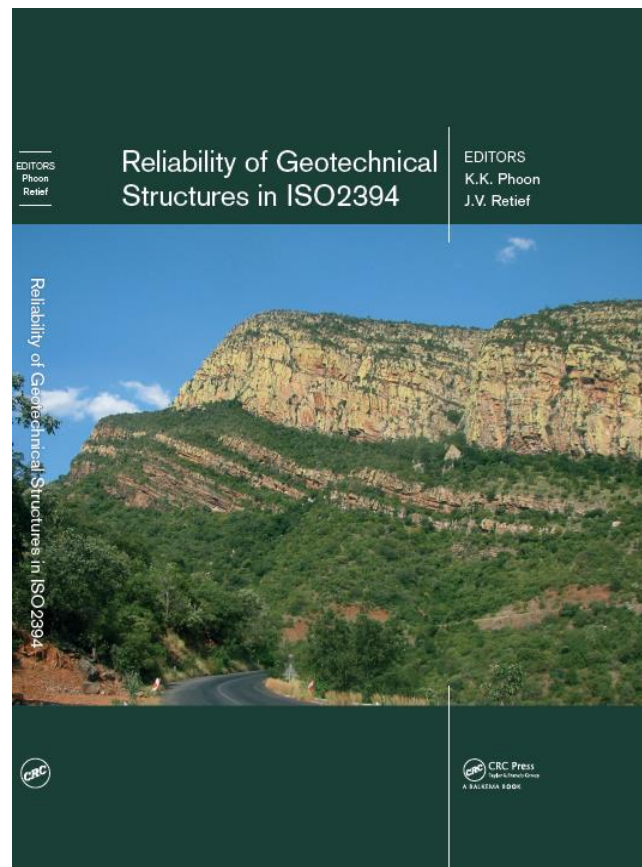
Editors: K. K. Phoon and J. V. Retief

Overview:

The key departure of the current ISO2394:2015 from previous versions is the introduction of risk and risk-informed decision making as the fundamental basis for the regulation and standardization of safety and reliability of structures. From a geotechnical perspective, the key departure of the current ISO2394:2015 from previous versions is the introduction of a new informative Annex D on “Reliability of Geotechnical Structures”. The need to achieve consistency between geotechnical and structural reliability-based design is explicitly recognized for the first time in ISO2394 with the inclusion of Annex D. The emphasis in Annex D is to identify and characterize critical elements of the geotechnical reliability-based design process. This book provides data, methods and examples that can be used for probabilistic design of geotechnical structures in line with the topics covered in Annex D (uncertainty representation of geotechnical design parameters, statistical characterization of multivariate geotechnical data and model factors, and implementation issues in geotechnical reliability-based design). The book unlocks the general principles of reliability as presented in this 4th edition of ISO 2394 for extended application in geotechnical practice effectively. The resulting systematic application of reliability based geotechnical design will consequently be soundly founded on the reputable international standard. It is a must-read for designing geotechnical structures in compliance with ISO2394.

Key Features:

- provides interpretation and application of general principles of ISO 2394 to geotechnical design
- serves as an informative supplement to ISO2394 Annex D Reliability of geotechnical structures
- provides valuable authoritative statistical data and reliability models needed for any code calibration
- provides efficient methods for reliability analysis and design
- provides a systematic process for deriving reliability based design procedures whilst fully taking account of the unique character of geotechnical design
- resulting overall in a significant advancement in reliability based geotechnical design practice



Event Diary

ISSMGE EVENTS

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

2016

9th All-Ukrainian Scientific-Technical Conference “Soil mechanics, geotechnics and foundation engineering”: “Geotechnical innovations and implementation of Eurocodes in Ukraine”

Date: Tuesday 11 October 2016 - Thursday 13 October 2016

Location: Dnieper state academy of construction and architecture, Dnipropetrovsk, Ukraine

Language: English, Ukrainian, Russia

Organizer: Ukrainian society of soil mechanics, geotechnics and foundation engineering

Address: SE NDIBK, 5/2 Preobrazhenska street, 03037, Kiev-37, Ukraine

Phone: (056) 247-08-88

E-mail: iepi@pgasa.dp.ua

Website: www.niisc.com (section: Conferences)

XVIII Brazilian Conference on Soil Mechanics and Geotechnical Engineering - COBRAMSEG 2016

Date: Wednesday 19 October 2016 - Saturday 22 October 2016

Location: Minascentro, Belo Horizonte, MG, Brazil

Language: Portuguese and English

Organizer: ABMS - Brazilian Society for Soils Mechanics and Geotechnical Engineering

E-mail: contato@cobramseg2016.com.br

Website: <http://www.cobramseg2016.com.br/>

SFGE 2016 - Shaping the Future of Geotechnical Education - International Conference on Geo-Engineering Education

Date: Thursday 20 October 2016 - Saturday 22 October 2016

Location: Minascentro, Belo Horizonte, MG, Brazil

Language: English

Organizer: ISSMGE TC306 and ABMS - Brazilian Society for Soil Mechanics and Geotechnical Engineering

Contact person: Michele Calvello

E-mail: sfge2016@cobramseg2016.com.br / michele.calvello@gmail.com

Website: <http://cobramseg2016.com.br/index.php/sfge-sobre/?lang=en>

V South American Young Geotechnical Engineers Conference - SAYGEC/GEOJOVEM 2016

Date: Thursday 20 October 2016 - Saturday 22 October 2016

Location: Minascentro, Belo Horizonte, MG, Brazil

Language: Portuguese, Spanish, English

Organizer: ABMS - Brazilian Society for Soil Mechanics and Geotechnical Engineering

Contact person: Prof A. Terezinha Esposito

E-mail: geojovem@cobramseg2016.com.br

Website: <http://www.cobramseg2016.com.br>

11th ANZ Young Geotechnical Professionals Conference (11YGPC)

Date: Tuesday 25 October 2016 - Friday 28 October 2016

Location: Queenstown, New Zealand

Language: English

Organizer: NZGS

Contact person: Frances Neeson

E-mail: 11ygpc@gmail.com

Website: http://www.nzgs.org/resources/pdfs/YGP_11Queens2016formsv1.pdf

Event Diary (Con't)

5ème Congrès Maghrébin en Ingénierie Géotechnique - 5CMIG

Date: 26 - 28 October 2016

Location: Hotel Kenzi Farah, Morocco, Marrakech

Language: Français

Organiser: Comité Marocain de mécanique des Sols et de Géotechnique - CMMSG

Contact person: Mtrane Hasna

Phone: 212 5 22 54 75 81

Fax: 212 5 22 54 75 12

Email: lpee.dts@lpee.ma

Website: <http://www.5CMIG.lpee.ma>

XXIII CAMSIG - Argentinian Congress on Soil Mechanics and Geotechnical Engineering

Date: Wednesday 09 November 2016 - Friday 11 November 2016

Location: Paraninfo de la Universidad Nacional del Litoral, Santa Fé, Argentina

Language: Spanish

Organizer: SAIG

Contact person: Paraninfo UNL Bv

Address: Pellegrini 2750, Santa Fe, Argentina

Phone: +54 (0342) 4602390 / 4601579, interno 2200 (16 a 20 h)

E-mail: camsig2016@frsf.utn.edu.ar

Website: <http://fich.unl.edu.ar/camsig2016>

5th International Conference on Geotechnical Engineering and Soil Mechanics

Date: Monday 14 November 2016 - Wednesday 16 November 2016

Location: Tehran, Iran

Organizer: International Conference on Geotechnical Engineering and Soil Mechanics

Address: Unit2, No 14, Eftekharnia Alley, Larestan St, Motahari Ave, 1595914911 Tehran, Iran

Phone: 9888931507

Fax: 9888931275

E-mail: info@igs.ir

Website: www.igs.ir

Geotec Hanoi 2016

Date: Thursday 24 November 2016 - Friday 25 November 2016

Location: JW Marriott Hotel Hanoi, No 8 Do Duc Duc Road, Me Tri Ward, South Tu Liem District, Hanoi, Vietnam

Language: English

Organizer: FECON, VSSMGE, and JGS

Contact person: GEOTEC HANOI 2016 Secretariat

Address: FECON Corp, 15th Floor, CEO Tower, Lot HH2-1 Urban Me Tri Ha, Pham Hung Street, Ward Me Tri, Nam Tu Liem District, Hanoi, Vietnam

Phone: +84 4 6269.0481 / 82

Fax: +84 4 6269 0484

E-mail: secretariat@geotechn.vn

Website: www.geotechn.vn

Event Diary (Con't)**IX Chilean Congress of Geotechnics**

Date: Monday 05 December 2016 - Wednesday 07 December 2016
Location: Universidad Austral de Chile, Valdivia, XIV Región de Los Ríos, Chile
Language: Spanish - English
Organizer: SOCHIGE
Contact person: Macarena Tugas
Address: San Isidro 53, Santiago, Santiago, Chile
Phone: +56994253193
E-mail: directorio@sochige.cl
Website: <http://www.congresosochige.cl>

International Conference on Forensic Geotechnical Engineering

Date: Thursday 08 December 2016 - Saturday 10 December 2016
Location: Satish Dhawan Auditorium, Bangalore, Karnataka, India
Language: English
Organizer: ISSMGE TC 302
Contact person: Dr. Anbazhagan
Address: Indian Institute of Science, 560012, Bangalore, Karnataka, India
Phone: 00918022932467
E-mail: anbu@civil.iisc.ernet.in

2017**Advances in Laboratory Testing and Modelling of Soils and Shales**

Date: Wednesday 18 January 2017 - Friday 20 January 2017
Location: Swiss Alps, Switzerland
Language: English
Organizer: Prof. Lyesse Laloui and Prof. Alessio Ferrari
Contact person: Ms Valentina Favero
Address: EPFL-ENAC-IIC-LMS, Station 18, CH-1015, Lausanne, Switzerland
Phone: +41 (0)21 693 23 13
E-mail: valentina.favero@epfl.ch
Website: <http://atmss.epfl.ch>

International Conference on New Challenges In Geotechnical Engineering, ICNCGE-2017

Date: Monday 23 January 2017
Location: FAST National University, Lahore, Punjab, Pakistan
Language: English
Organizer: Pakistan Geotechnical Engineering Society - PGES
Contact person: Syed Badar Ul Hussnain
Address: NESPAK House, 1-C, Block N, Model Town Lahore-Pakistan, 54700, Lahore, Punjab, Pakistan
Phone: +92 42 99090325
Fax: +92 42 99231950
E-mail: icncge2017@gmail.com
Website: <http://www.pges-pak.org/home/icncge-2017>

Event Diary (Con't)**International Conference on Advances in structural and geotechnical engineering ICASGE17**

Date: 27- 30 March 2017

Location: Titanic Palace Resort, Egypt , Hurghada

Language: English

Organiser: Structural Engineering Department, Tanta University, Supported by Egyptian Geotechnical Society

Contact person: Professor Marawan Shahien

Address: Faculty of Engineering,31733,Tanta,Gharbeia Governorate, Egypt

Phone: +201005117064

Email: marawan.shahin@f-eng.tanta.edu.eg

Website: <http://www.icasge.com> (select 2017)

9th International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground, IS - São Paulo 2017

Date: Tuesday 04 April 2017 - Thursday 06 April 2017

Location: Centro de Convenções Rebouças, São Paulo, SP, Brazil

Language: English

Organizer: Brazilian Association for Soil Mechanics and Geotechnical Engineering (ABMS) and the Brazilian Tunnelling Committee (CBT)

Contact person: MCI São Paulo

Address: Rua George Ohm, 230 - Torre A, 19º Andar, 04576-020, São Paulo, SP, Brazil

Phone: 55 11 3056-6000

Fax: 55 11 3056-6000

E-mail: atendimento@mci-group.com

Website: <http://www.is-saopaulo.com>

3rd Bolivian International Conference on Deep Foundations, Santa Cruz de la Sierra, Bolivia

Date: 27-29 April 2017

Location: Universidad Privada de Santa Cruz de la Sierra

Language: English

Organiser: INCOTEC SA, ISSMGE TC 212, the Society of Engineers of Bolivia, the Bolivian Society of Soil Mechanics and Geotechnical Engineering

Contact person: Eng. Fabiana Viscarra

Address: 5to. Anillo entre Av. Cristo Redentor y radial 27

Phone: +591 3 3429522

Fax: +591 - 3 3429525

Email: fabiana.viscarra@incotec.cc

Website: <http://www.cfpbolivia.com/>

BCRRA 2017 - Tenth International Conference on the Bearing Capacity of Roads, Railways and Airfields.

Date: Wednesday 28 June 2017 - Friday 30 June 2017

Location: ATHENS, Greece

Language: English

Local Organizer: National Technical University of Athens (NTUA)

Contact person: Prof. Andreas Loizos

Address: 5, Iroon Polytechniou str.,15773, ATHENS, Greece

Phone: + 30 210 7721279

Fax: + 30 210 7724254

E-mail: aloizos@central.ntua.gr

Website: <http://www.bcrra2017.com/>

Event Diary (Con't)

GeoMEast 2017

Date: Saturday 15 July 2017 - Wednesday 19 July 2017

Location: Sharm El-Sheikh, Egypt

Language: English

Organizer: The Egyptian Housing and Building Research Center (HBRC) in cooperation with the Soil-Structure Interaction Group in Egypt (SSIGE)

Contact person: Hany Farouk Shehata

Address: Tower C, Maamora Towers, 7th District, Nasr City, 11727 ,Cairo, Egypt

Phone: +201110666775

E-mail: hanyfarouk808@gmail.com

Website: <http://www.geomeast2017.org/>

PBD-III Vancouver 2017 - The 3rd International Conference on Performance Based Design in Earthquake Geotechnical Engineering

Date: Sunday 16 July 2017 - Wednesday 19 July 2017

Location: Westin Bayshore Hotel (<http://www.westinbayshore.com/>) Vancouver, British Columbia, Canada

Language: English

Organizer: TC203 (Earthquakes)

Website: <http://pbdiivancouver.com/>

2nd International Symposium on Coupled Phenomena in Environmental Geotechnics (CPEG2)

Date: Wednesday 06 September 2017 - Friday 08 September 2017

Location: Faculty of Engineering, University of Leeds, Leeds, W. Yorks, United Kingdom

Language: English

Organizer: CPD, Conference & Events Unit, Faculty of Engineering, University of Leeds, LEEDS, LS2 9JT, UK

Contact person CPD, Conference & Events Unit

Address: Faculty of Engineering, University of Leeds, LS2 9JT, Leeds, W.Yorks, United Kingdom

Phone: +44 (0)113 343 2494 / 8104

E-mail: CPEG2@leeds.ac.uk

Website: <http://tinyurl.com/cpeg2017>

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

Fax: +82-2-6288-6399

E-mail: secretariat@icsmge2017.org

Website: <http://www.icsmge2017.org>

Event Diary (Con't)**2018****4th International Symposium on Cone Penetration Testing (CPT'18)**

Date: Thursday 21 June 2018 - Friday 22 June 2018

Location: Delft University of Technology (TUD), Delft, Netherlands,

Language: English

Organizer: Delft University of Technology (endorsed by TC102)

Contact person: Prof. Michael Hicks, Dr. Federico Pisanò and Ir. Joek Peuchen

Address: Faculty of Civil Engineering and Geosciences, Section of Geo-Engineering, Building 23, Stevinweg 1, 2628 CN Delft, The Netherlands

Phone: +31 70 31 11299

E-mail: info@cpt18.org

Website: <http://www.cpt18.org>

The 7th International Conference on Unsaturated Soils (UNSAT2018)

Date: Friday 03 August 2018 - Sunday 05 August 2018

Location: The Hong Kong University of Science and Technology (HKUST), Hong Kong, China

Language: English

Organizer: The Hong Kong University of Science and Technology (HKUST)

Contact persons: Prof. Charles W. W. Ng (Chair), Miss Shirley Tse (Administrative Secretary) or Dr Anthony Leung (Technical Secretary)

Address: Geotechnical Centrifuge Facility, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, HKSAR, China

Phone: (852) 2358-0216

Fax: (852) 2243-0040

E-mail: unsat2018@ust.hk

Website: <http://www.unsat2018.org>

2019**7 ICEGE 2019 - International Conference on Earthquake Geotechnical Engineering**

Date: Monday 17 June 2019 - Thursday 20 June 2019

Location: Rome, Italy

Language: English

Organizer: TC203 and AGI (Italian Geotechnical Society)

Contact person: Susanna Antonielli

Address: AGI - Viale dell' Università 11, 00185, Roma, Italy

Phone: +39 06 4465569

Fax: +39 06 44361035

E-mail: agi@associazionegeotecnica.it

ISDCG 2019 - 7th International Symposium on Deformation Characteristics of Geomaterials

Date: Wednesday 26 June 2019 - Friday 28 June 2019

Location: Technology and Innovation Centre (TIC) of the University of Strathclyde, Scotland, UK,

Language: English

Organizer: TC101

Website: *in construction*

Event Diary (Con't)**ECSMGE 2019 - XVII European Conference on Soil Mechanics and Geotechnical Engineering**

Date: Sunday 01 September 2019 - Friday 06 September 2019

Location: Harpa 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

E-mail: has@road.is

Website: <http://www.ecsmge-2019.com>

XVI Asian Regional Conference on Soil Mechanics and Geotechnical Engineering

Date: Monday 21 October 2019 - Friday 25 October 2019

Location: Taipei, China

XVI Panamerican Conference on Soil Mechanics and Geotechnical Engineering

Date: Monday 18 November 2019 - Friday 22 November 2019

Location: Cancun, Quintana Roo, Mexico

Organizer: SMIG

Phone: +(52) 1 55 5677-3730, +(52) 1 55 5679 3676

E-mail: support@panamerican2019mexico.com

Website: <http://panamerican2019mexico.com>

NON-ISSMGE SPONSORED EVENTS**2016****Advancing Experimental Geomechanics**

Date: Monday 31 October 2016 - Wednesday 02 November 2016

Location: Mercure Resort Hunter Valley Gardens, Pokolbin, NSW, Australia

Language: English

Organizer: Benjy Marks

Contact person: Benjy Marks

Address: Civil Engineering Building, J05, 2006, The University of Sydney, NSW, Australia

Phone: +61 02 9351 2146

E-mail: benjy.marks@sydney.edu.au

Website: <http://sydney.edu.au/engineering/civil/research/scigem/workshops/aeg2016.shtml>

International Seminar on Roads, Bridges and Tunnels

Date: Friday 18 November 2016 - Thursday 24 November 2016

Location: Aristotle University of Thessaloniki (AUTH), Thessaloniki, Greece

Language: English

Organizer: School of Civil Engineering along with the Highway Engineering Laboratory of the Aristotle University of Thessaloniki (AUTH)

Contact person Mrs. D. Gatoula: and Dr. E. Mantho

Address: Highway Engineering Laboratory (for the ISRBT2016 Seminar) School of Civil Engineering Aristotle University of Thessaloniki, 541 24, Thessaloniki, Greece

Phone: +30 2310 994385 and +30 2310 995804

E-mail: isrbt@civil.auth.gr

Website: <http://isrbt2016.civil.auth.gr/>

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

Corporate Associates



S.N. Apageo S.A.S.
ZA de Gomberville
BP 35 - 78114 MAGNY LES HAMEAUX
FRANCE



Deltares
PO Box 177
2600 AB Delft,
THE NETHERLANDS



Fugro N.V.
PO Box 41
2260 AA Leidschendam
THE NETHERLANDS



Golder Associates Inc
1000, 940-6th Avenue S.W.
Calgary, Alberta
CANADA T2P 3T1



Jan de Nul N.V.
Tragel 60,
B-9308 Hofstade-Aalst
BELGIUM



NAUE GmbH Co KG
Gewerbstrasse 2
32339 Espelkamp-Fiestel
GERMANY



Norwegian Geotechnical Institute
P.O. Box 3930 Ullevaal Stadion
N-0806 OSLO
NORWAY



SOLETANCHE BACHY

SOLETANCHE BACHY SA
133 boulevard National, 92500 Rueil-
Malmaison,
FRANCE



Tensar International Ltd
Cunningham Court
Shadsworth Business Park
Blackburn, BB1 2QX,
UNITED KINGDOM



Terre Armée
280, avenue Napoléon Bonaparte
92506 Rueil Malmaison Cedex
France



Zetas Zemin Teknolojisi AS
Merkez Mah. Resadiye Cad. No. 69/A
Alemdag, Umraniye
Istanbul, 34794
TURKEY



Siemens Energy
Kaiserleistrasse 10
63067 Offenbach
GERMANY



International I.G.M. s.a.r.l.
P.O.Box: 166129 Achrafieh
Beirut
LEBANON



TenCate Geosynthetics
9, rue Marcel Paul
B.P. 40080
95873 Bezons Cedex
FRANCE



RCF Ltd
4C Ologun Agbeje
Victoria Island
Lagos,
Nigeria



Coffey Geotechnics
8/12 Mars Road
Lane Cove West
NSW, 2066
AUSTRALIA



A.P. van den Berg
IJzerweg 4
8445 PK Heerenveen
THE NETHERLANDS



Pagani Geotechnical Equipment
Localita Campogrande 26
29010 Calendasco (PC)
Italy
www.pagani-geotechnical.com

Corporate Associates (Con't)



Huesker Synthetic GmbH
Fabrikstrasse 13-15
48712 Gescher
GERMANY



LLC GEOIZOL
Bolshoy PR PS h.25//2 lits E.
197198 Saint Petersburg



AECOM Asia Company Ltd
8/F, Tower 2, Grand Central Plaza
138 Shatin Rural Committee Road
Shatin, NT
HONG KONG



Novosibirsk Engineering Center Ltd.
Televizionnaya Street, 15
Novosibirsk 630048
RUSSIA



Ove Arup & Partners Ltd.
13 Fitzroy Street
London W1T 4BQ
UNITED KINGDOM



Maccaferri
Via Kennedy 10
40069 Zola Predosa (Bologna)
ITALY



GHD Pty, Ltd.
57-63 Herbert Street
Artarmon NSW 2064
AUSTRALIA



Hayward Baker Inc.
1130 Annapolis Road, Suite 202
Odenton, MD 21113
UNITED STATES



Terrasol
42/52 Quai de la Rapée - CS7123075583
Paris CEDEX 12
FRANCE

Foundation Donors

The Foundation of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) was created to provide financial help to geo-engineers throughout the world who wish to further their geo-engineering knowledge and enhance their practice through various activities which they could not otherwise afford. These activities include attending conferences, participating in continuing education events, purchasing geotechnical reference books and manuals.

- **Diamond: \$50,000 and above**

- a. ISSMGE-2010 <http://www.issmge.org/>



- b. Prof. Jean-Louis and Mrs. Janet Briaud

<https://www.briaud.com> and
<http://ceprofs.tamu.edu/briaud/>



- **Platinum: \$25,000 to \$49,999**

- **Gold: \$10,000 to \$24,999**

- a. International I-G-M
<http://www.i-igm.net/>



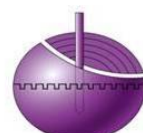
- b. Geo-Institute of ASCE
<http://content.geoinstitute.org/>



- c. Japanese Geotechnical Society
<http://www.jiban.or.jp/>



- d. The Chinese Institution of Soil Mechanics and Geotechnical Engineering - CCES
www.geochina-cces.cn/en



CISMGE-CCES

- e. Korean Geotechnical Society
www.kgshome.or.kr



- f. Comité Français de Mécanique des Sols et de Géotechnique
www.cfms-sols.org



CFMS

- **Silver: \$1,000 to \$9,999**

- a. Prof. John Schmertmann

- b. Deep Foundation Institute
www.dfi.org



- c. Yonsei University
<http://civil.yonsei.ac.kr>



Foundation Donors (Con't)

- d. CalGeo - The California Geotechnical Engineering Association

www.calgeo.org



- e. Prof. Ikuo Towhata
towhata.ikuo.ikuo@gmail.com
<http://geotle.t.u-tokyo.ac.jp/>



- f. Chinese Taipei Geotechnical Society www.tgs.org.tw

- g. Prof. Zuyu Chen
<http://www.iwhr.com/zswenglish/index.htm>



- h. East China Architectural Design and Research Institute **ECADI**
<http://www.ecadi.com/en/>

- 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.jp www.geor.or.jp



Yoshi IWASAKI

- m. Mr. Clyde N. Baker, Jr.

- n. Prof. Hideki Ohta



- o. Prof. Eun Chul Shin www.incheo@incheon.ac.kr n.ac.krcschin



Eun Chul Shin

- p. Prof. Tadatsugu Tanaka

• Bronze: up to \$999

- a. Prof. Mehmet T. Tümay http://www.coe.lsu.edu/administration_tumay.html
mtumay@eng.lsu.edu

- b. Nagadi Consultants (P) Ltd



www.nagadi.co.in

- c. Professor Anand J. Puppala
University of Texas Arlington
<http://www.uta.edu/ce/index.php>



- d. ARGO-E (Geoengineer.org)
<http://www.argo-e.com>