Research Highlights

Federal University of Rio Grande do Sul (UFRGS), Brazil

The geotechnical and geo-environmental research group (LEGG) from Federal University of Rio Grande do Sul in Brazil aims at conducting investigations related to the characterization of natural deposits and the development of new geomaterials, the development of ground improvement techniques, the study of sustainability applied to geotechnical engineering and the study of soil structure interaction systems. Our research interests include both the fundamental behaviour of geomaterials and the application of practical solutions to current challenges from the engineering industry.

The group includes 6 staff members and about 50 research members (post-doctorates, PhDs and MSc students). University academic staff is formed by:

- Fernando Schnaid, Professor of Civil Engineering
- Nilo Cesar Consoli, Professor of Civil Engineering
- Samir Maghous, Associate Professor
- Marcelo Maia Rocha, Associate Professor
- Karla Salvagni Heineck, Associate Professor
- Lucas Festugato, Assistant Professor
Research Highlights (Con’t)
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Our research consists of the following research highlights:

a) **In situ testing in geomechanics:**
20 years undergoing research in this area comprises the main site characterization techniques with focus on the interpretation of soil parameters, rate effects, drainage conditions for both natural deposits and man-made materials.

b) **Development of new geomaterials:**
A general index (porosity/binder ratio) that controls mechanical and hydraulic behaviour of artificially cemented materials (all kinds of soils treated with Portland cement, lime, pozzolans-lime, any other binder) was developed and successfully checked through advanced laboratory testing focused on new geomaterials mechanical behaviour. Dosage methodologies have been developed for unreinforced and fibre-reinforced cemented granular composites. Prediction of materials’ compressive and tensile strengths, stiffness, failure envelope parameters, hydraulic conductivity and cyclic response.

c) **Foundation analysis and design:**
Ongoing research on both onshore and offshore conditions: The Araquari experimental testing site is a joint industry research project that includes 6 large diameter fully instrumented pile load tests. The oil and gas industry is sponsoring work in deep-water foundation systems with focus on anchors and load attenuation on offshore platforms.

d) **Foundation on residual soils:**
Ongoing research on shallow and deep foundations behaviour on lightly bonded residual soils.

e) **Ground improvement:**
Field-testing focused on enhanced geomaterials behavior. Shallow and deep foundations embedded in unreinforced and fibre-reinforced cemented (and uncemented) granular composites are tested under tension, compression and lateral loading.

f) **Geotechnical sustainability:**
Advanced studies focused on the use of industrial by-products in the enhancement of geomaterials mechanical behavior. Impacts of low binder content/high density or high binder content/low density to get to a specific artificially cemented soil strength. The use of alkali activated geopolymers as a geotechnical material.

g) **Micro and macro modelling in poromechanics:**
Micromechanics-based reasoning is applied to constitutive and computational modelling in geomechanics, with particular emphasis on geophysics and petroleum engineering fields. At material level, the poromechanical behaviour at large strains with account for multiple couplings is formulated combining micromechanics and macroscopic arguments. At a structural level, finite element tools specifically devised to deal with geo-structure in a highly non-linear context are developed.
In situ testing in geomechanics

In situ testing in geomechanics has been a subject of research at UFRGS for the past 2 decades (see Fig. 1). Attempts are made to provide engineers with the information and data necessary for assessment of constitutive parameters for the proper design of geotechnical structures. Assessment of the stress-strain-time and strength characteristics of geomaterials comprises interpretation methods using the most commonly encountered in situ tests.

Current research activities focus on new methods for interpretation of tests in clay and rate effects in silts.

Interpretation of piezocone dissipation test in clays

Contributors: Fernando Schnaid (Coordinator), Edgar Odebrecht, Fernando Mantaras

Recent research efforts include the estimation of the undrained shear strength and the coefficient of consolidation from CPT dissipation tests. Determining the consolidation coefficient in clay was conducted in collaboration with Professor DeJong from Davis University, USA.

Recently a method was developed to link the measured piezocone dissipation excess pore-water pressure (\(\Delta u\)) to the soil undrained shear strength (\(S_u\)). In cohesive soils both \(\Delta u\) and \(S_u\) are dependent on the same variables (stress state, stress history, soil stiffness), which allows them to be related by the theoretical cavity expansion-critical state framework. A mathematical derivation is presented to demonstrate that the ratio of normalized maximum excess pore pressure and the normalized undrained shear strength fluctuates around a mean value, being affected by soil strength and stiffness and are independent of stress history. The predicted \(S_u\) values obtained from the proposed approach are calibrated against field vane shear strength in both normally consolidated (monotonic dissipation tests) and overconsolidated soils (dilatary dissipation tests). Reported results are consistent and encourage the use of the method in engineering practice.

The core of the method is a mathematical expression derived from the principles of cavity expansion and critical state framework that can be simplified to the following equation:

\[
S_u \Delta u_{max} = \frac{\Delta u_{max}}{4.2(\pm 0.2)\log(I_r)}
\]

where \(S_u\) is the undrained shear strength, \(\Delta u_{max}\) the maximum pore pressure recorded during dissipation and \(I_r\) is the rigidity index.

The variation of undrained shear strength with depth for the Tubarão testing site is shown in Fig. 2 and includes \(S_u\) estimated from field vane tests and dilatometer tests (note that the cone factor \(N_{tk}\) was determined by calibrating tip resistance directly against the \(S_{uv}\)). A general good agreement is observed over the whole profile indicating that the prediction method using \(\Delta u_{max}\) is suitable for evaluating the undrained shear strength of clay.
A comparison between the undrained shear strength obtained by Vane Test $S_u(FV)$ and from dissipation tests $S_u(\Delta u_{\text{max}})$ for a number of well-documented sites is presented in Fig. 3. Equation (1) provides a reasonable approximation to the field vane undrained shear strength for all case studies and supports the recommendation of using an $I_r=100$ for Quaternary clays. The error defined as $(S_u(\Delta u_{\text{max}}) - S_u(FV))/S_u(FV) \times 100\%$ is shown to remain within the $\pm20\%$ range, which is considered acceptable given the fact that comparisons between different tests depend on the mode of failure, rate of shearing, soil anisotropy and stress history.

**Key recent publications**


Rate effects on in-situ tests
Contributors: Samir Maghous (Coordinator), Fernando Schnaid, Gracieli Dienstmann, Edgar Odebrecht

Rate effects on piezocone and vane tests is a subject of research at UFRGS since 2006. Special attention has been given to the interpretation of drained conditions in tailings deposits, comprising database in gold, bauxite and zinc, geo-materials that often exhibit coefficients of hydraulic conductivity in the range of transitional soils. Recent work aims at developing a structured theoretical framework to predict the drained conditions in silts based on the rotation and expansion of a cylinder embedded into an infinite nonlinear poroelastic medium. The understanding of the transient behavior on this simplified model provides insights into the interpretation of in-situ tests (piezocone, vane, pressuremeter), pile foundations and geotechnical structures (shafts, wells) constructed in transient geo-materials.

The conceptual geometries adopted for the analysis of the rotating and expanding cylinder are shown in Fig. 4. The derived solutions are based on the theory of poroelasticity, which is a well-established engineering framework for studying the fluid flow process through porous materials. An approach based on the local equivalence between the response of a perfectly plastic behavior to monotonic loading and an appropriate fictitious non-linear poroelastic response is adopted in both problems’ analysis. Closed-form solutions for pore pressures, stresses and displacements were derived for the rotation problem within a simplified poroelastic framework. The expansion problem was solved considering a simplified framework for the diffusion equation to derive a closed-form expression for pore pressure distribution, while stresses and displacements were computed numerically. The results are discretised and critically compared to finite element solutions showing good agreement in terms of radial stresses and pore pressure distributions.

Results analysed in the space of degree of drainage (U) versus normalized velocity (V) show considerable sensitivity to the soil rigidity, which is usually correlated to the zone of influence. The latter parameter characterizes the extension of the zone of influence (the distance beyond which the initial poromechanic state of the medium is no longer affected by cylinder expansion or rotation). The shape and position of the characteristic curve in the VxU space change considerably with the area of influence, expressed by the a/R ratio, where R is the cylinder radius. This approach has been used to interpret the behavior of tailings for separating drained, from partially drained, and undrained responses. The characteristic curve for piezocone tests in gold tailings is shown in Fig. 5, in which measured field data are compared to analytical and numerical predictions. Partially drained behavior occurs for normalized velocities typically in the range of 0.1 to 100. Class A model predictions are offset in respect to measured values, but can be adjusted accordingly by changing soil stiffness.
Figure 4. Conceptual geometries (a) transversal section of the infinite rotating cylinder (b) finite element mesh for the rotation problem (c) transversal section of the infinite expanding cylinder (d) finite element mesh for the expansion problem

Figure 5. Results of the cylinder expansion problem compared to piezocone file data
Evaluation of rate effects in the DMT from pore pressure measurements
Contributors: Fernando Schnaid (Coordinator), Edgar Odebrecht, Jonatas Sosnoski

The evaluation of rate effects on the flat dilatometer test (DMT) can best be developed with some knowledge of the excess pore pressures generated during penetration, dissipation and subsequent membrane expansion. While research that includes pore pressure measurements in the DMT have documented drainage conditions in clean sand and soft clay, further studies are required to determine the drainage conditions during the DMT in intermediate permeability soils, such as silts. For that purpose, a simple and inexpensive research device has been developed for monitoring pore pressures at the center of the DMT blade. Data using both a standard DMT and the modified research DMT from various tests in sand, silt and clay have been compared in a space that correlates dimensionless velocity to degree of drainage. In this space it is possible to evaluate whether partial drainage is taking place. Measurements indicate that the DMT is essentially undrained in soft clay and dominated by penetration pore pressures. However, it is drained in clean sand and is partially drained in intermediate permeability soils, such as silt. A method is suggested to identify soils where partial drainage may influence the standard DMT results.

The research conducted in collaboration with Professor Peter Robertson includes the development of an instrumented flat dilatometer that allows pore pressures to be recorded at the centre of the blade during penetration and with time during any dissipation from the end of penetration. The instrumented device used a modified Marchetti flat dilatometer blade where the circular steel membrane was replaced by a fixed porous element connected to a pressure transducer, as shown in Fig. 6.

Results indicate that within the 60s required for the DMT readings the test is essentially undrained in clay, drained in sand and partially drained in silt (see Fig. 7). A challenge for the standard DMT is how to produce a unified interpretation criterion that allows drainage conditions to be identified or (even better) to be controlled.

Figure 6. Pore pressure instrumented DMT (a) instrumented blade compared to a standard Marchetti blade, (b) details of instrumented blade and (c) saturation of pore pressure element
Rate effects are evaluated in the normalized dissipation pore pressure ($U$) versus normalized velocity ($V_h$) space to interpret drainage effects during pore pressure dissipation, after stopping penetration, corresponding to the time required for $p_0$ and $p_1$ readings. However, in this space, $u_{max}$ is the maximum pore pressure generated during penetration and $u_i$ is the pore pressure at either 15s ($u_{15}$) or 30s ($u_{30}$) during dissipation. Fig. 8 shows data using the modified DMT at three testing sites, as well as previous published data. The drained response is attained in less than 30s for $V_h$ less than about 8s. Partial drainage is characterized by an intermediate region where the rate of consolidation is relatively fast producing considerable scatter in pore pressure measurements, until the onset of undrained response for $V_h$ greater than about 100s.

The potential for partial drainage in some silts can influence the subsequent interpretation that can result in incorrect interpretation of geotechnical parameters. Very low $K_D$ values ($K_D < 2.0$) maybe an indicator of possible partial drainage effect or, alternatively, CPTUs can be performed simultaneously and compare the DMT and CPT results for consistency.

Key recent publications
The porosity/cement ratio, $\eta/C_{iv}$

Contributors: Nilo Cesar Consoli (Coordinator), Lucas Festugato, Karla Salvagni Heineck, Cecília Gravina da Rocha, Diego Foppa, Luizmar da Silva Lopes Junior, Daniel Winter, Carina Silvani, Amanda Dalla Rosa Johann, Rodrigo Beck Saldanha, Rafael Rizzati de Moraes, Rodrigo Caberlon Cruz, Pedro Domingos Marques Prietto, Sério Filipe Veloso Marques, Márcio Felipe Floss, Anderson Fonini, Rubén Alejandro Quiñonez Samaniego, Néstor Masamune Kanazawa Villalba

The porosity/cement ratio, $\eta/C_{iv}$, has been extensively studied and has shown to be an extremely effective factor for prediction of cemented soil mixtures mechanical strength and stiffness. A wide range of soils (from clayey to coarse particles), additions (fibres and industrial by-products) and bonding agents (different types of Portland cements, lime, fly ash-lime, etc.) mixtures have been tested. Results of unconfined compression and split tensile tests are presented in Fig. 9 for artificially cemented sand. Fig. 10 shows results of shear modulus measurements $G_0$, for uniform sand-Portland cement and very well graded silty sand-Portland cement mixtures.

Figure 9. Variation of both splitting tensile ($q_t$) and unconfined compressive strengths ($q_u$) with porosity/cement ratio for sand-cement mixtures

Figure 10. Variation of $G_0/q_u$ with adjusted porosity/cement ratio for uniform sand-Portland cement and very well graded silty sand-Portland cement mixtures
Key recent publications

Araquari pile load testing site in sand
Contributors: Fernando Schnaid (Coordinator), Alexander C.M. Kormann, Edgar Odebrecht, Jarbas Milititsky, Luiz Guilherme de Mello, Débora F. Alves, Fabiano Nienov, Liamara P. Sestrem

The ARAQUARI Pile Load Testing Site is a joint industry research project that has been launched under the auspices of the ISSMGE. The main scope of this research is that of investigating the complex pile-soil interaction at pile shaft and pile base in a well known subsoil condition (saturated sandy soil), hence hopefully contributing to extending knowledge.

Attention will be particularly focused on the effects due to concrete curing, the development of shaft friction during pile loading, scale effects and different pile loading conditions (static, Osterberg, cyclic and dynamic).

Six large diameter, fully instrumented piles have been installed at the site and are currently being tested. Three piles are non-displacement (ND) bored type: one is installed under bentonite slurry and three under polymer slurry. Two piles are ND CFA type. All piles are cast in situ and concrete properties (stress-strain curves) have been carefully determined by usual tests on concrete specimens.

A general view of the site is shown in Fig. 11 and a summary of the characteristics of the piles is presented in Table 1.

Figure 11. General view of the Araquari Testing Site
All the piles are fully instrumented along the depth by means of Vibrating Wire (VW) strain gauges carefully connected to the reinforcement cage. The choice of VW gauges is due to their robustness and stability over the time. It is indeed not excluded that load tests should be repeated after some weeks and months to check if pile capacity changes occur due to creep effects.

Table 1. Test Piles

<table>
<thead>
<tr>
<th>Pile type</th>
<th>Details</th>
<th>( \phi [\text{m}] )</th>
<th>( L [\text{m}] )</th>
<th>Load Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bored piles</td>
<td>Bentonite</td>
<td>1.0</td>
<td>24</td>
<td>Conventional static</td>
</tr>
<tr>
<td></td>
<td>Polymer</td>
<td>1.0</td>
<td>24</td>
<td>Conventional static</td>
</tr>
<tr>
<td></td>
<td>Polymer</td>
<td>1.0</td>
<td>24</td>
<td>Conventional static</td>
</tr>
<tr>
<td></td>
<td>Polymer</td>
<td>0.7</td>
<td>12</td>
<td>Osterberg + Conventional static</td>
</tr>
<tr>
<td>Continuous Hollow Auger</td>
<td>CFA</td>
<td>1.0</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CFA</td>
<td>0.7</td>
<td>12</td>
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</tr>
</tbody>
</table>

A comprehensive in situ investigation was undertaken at the Experimental Testing Site, comprising several geotechnical and geophysical techniques. A total amount of 13 CPTUs, 3 SPTs and 2 SDMTs were performed. A CPTU was carried out at the axis of every tested pile. Additional laboratory tests have been performed on disturbed and undisturbed samples and results are available at [http://www.ufrgs.br/araquari-ets/?page_id=20](http://www.ufrgs.br/araquari-ets/?page_id=20).

Results from a polymer-base bored pile tested at Araquari is shown in Fig. 12, showing the load-settlement curve to a bearing capacity of about 8000 kN. Ongoing research is being carried out in the interpretation of Araquari testing data.
Laterally loaded piles associated with top treated soils
Contributors: Nilo Cesar Consoli (Coordinator), Fernando Schnaid, Vitor Pereira Faro, Ricardo Bergan Born, Luizmar da Silva Lopes Junior, Antônio Thomé

Prediction of lateral capacity of pile foundations is a frequently encountered design problem evolving from forces such as wind, waves, earthquakes and equipment acting on structures such as buildings, bridges, harbors, transmission lines, onshore and offshore wind turbines, among others. There are several methods reported in the literature for determining the ultimate lateral resistance of pile-soil systems in homogeneous ground, and for assessing the pile stress-deflection behavior based on either ground reaction or stress-deflection concepts. However, procedures for evaluating the resistance response of a pile with cement treated soil subjected to lateral loads are not well established.

A series of laterally loaded pile tests carried out both in natural ground and in cement treated soil was carried out in a residual soil site. The length to diameter ratio L/D of the piles was selected as 5, representing the behaviour of a free-headed, short pile that will move as a rigid body in the direction of the applied load without structural damage. The extent of the treated soil layer around the piles ranged from 2-4 times the pile diameter and 0.1-0.3 times the pile length. The treated layer was a mixture of Osorio sand and early strength Portland cement.

Field tests are being analysed using 3D Finite Element numerical simulations in order to achieve a better understanding of the behavior of laterally loaded piles in both the natural and reinforced ground. A typical comparison between measured and predicted load-displacement response of a pile stabilized with cement sand backfill is shown in Fig. 13. The conclusion is that the use of a superficial treated layer, radial to piles, considerably improves the system performance, increasing the lateral load capacity and decreasing their deformation, showing that this technique could be a promising solution to deep foundations subjected to horizontal loads (see Fig. 14).

Several geometrical and mechanical parameters are involved in the interpretation of this problem, emphasizing the need to formulate test results in terms of dimensionless variables. This is achieved by expressing results in terms of normalized applied lateral pressure versus top horizontal displacement-to-pile diameter ratio. In this space, the effect of the size of the acting laterally loaded area on horizontal bearing capacity is captured for this residual soil site. A general based framework for test interpretation of lateral load pile capacity is being formulated, thus allowing for future analysis and interpretation of field observations in light of dimensional reasoning.

Figure 13. Comparison between numerical predictions versus field test results
Figure 14. Horizontal displacement ($\delta_H$) versus horizontal resistance for piles on both natural and reinforced soil

Key recent publications
Uplift performance of plates embedded in stabilized backfill

Contributors: Nilo Cesar Consoli (Coordinator), Fernando Schnaid, Lucas Festugato, Cesar Alberto Ruver, Antônio Thomé, Vinicius Girardello

Pullout tests have been carried out and used to identify the kinematics of failure and the uplift response of circular anchor plates embedded in sand-cement stabilized layers at distinct normalized embedment depths (H/D), where H is the thickness of the treated layer and D is the diameter of the anchor plates. The uplift test layout is presented in Fig. 15. Experimental results show that the uplift capacity of anchor plates embedded in sand backfill layers increases considerably after mixing 3% cement with the backfill material. Distinct failure mechanisms observed for anchor plates embedded in both sand and cement-stabilized backfills are shown to be a function of H/D. Fig. 16 summarizes the results. The addition of cement to the sand backfill leads to an increase in uplift capacity of 9 times for an H/D ratio of 1.0 and of 13 times for an H/D ratio of 2.0. For sand backfill with H/D = 1.0, the failure surface had a truncated cone shape, whereas for H/D of 1.5 and 2.0, radial cracking was observed. Pullout of anchor plates in cement-stabilized backfills at H/D ratios ranging from 1.0 to 2.0 exhibit two distinct characteristics: (a) a linear elastic deformation response at small pullout displacements and (b) a later stage where radial fracturing of the stabilized backfill leads to hardening just prior to failure. Radial cracks starting at the top of the layer near the centre of the anchor plates start to propagate only at about 90% of the final uplift failure load, irrespective of H/D.

Key recent publications
Foundations on lightly bonded residual soils
Contributors: Nilo Cesar Consoli (Coordinator), Fernando Schnaid, Samir Maghous, Vitor Pereira Faro, Ricardo Bergan Born

Unlike transported soils with similar grain size distribution, the residual soil is the product of in situ weathering, which decreases unit weight, increases porosity and hydraulic conductivity and exhibit parent rock features such as interparticle bonding, characteristic of cohesive-frictional materials. Data are presented (see Fig. 17) comparing lateral load-top horizontal displacement response measured from tests carried out using cylindrical reinforced concrete piles ranging from 0.10 to 0.40 m diameter and 5.0 to 8.0 m long. Several geometrical and mechanical parameters are involved in the interpretation of this problem, emphasizing the need to formulate test results in terms of dimensionless variables.

Key recent publications

Inverse catenary load attenuation along embedded ground chain of mooring lines
Contributors: Marcelo Maia Rocha (Coordinator), Armando Miguel Awruch, Samir Maghous, Fernando schnaid, Alexandre Brown, Cinthia C. Morais, Naloan Coutinho Sampa, André Bruch

This research project sponsored by PETROBRAS presents an experimental and numerical investigation of the static and dynamic load attenuation emerging from the soil frictional forces acting on the embedded part of an anchor chain. Mooring line tension makes the embedded chain segment to develop an inverse catenary shape between the deep down point (DDP) and the anchor link. Both the shape of the catenary and the mobilized frictional forces have significant influence on the total loading capacity of the anchoring system. The experimental work is based on laboratory tests using a scale-reduced model with Froude number similarity, designed to evaluate the catenary development and the load attenuation with respect to the installation depth, nominal chain angle and soil mechanical properties. As the experiments comprehend both loading and unloading cycles, the results provide a substantial database for confrontation of constitutive models for soil-chain interaction. The main conclusions are:

- Mean attenuation levels of 22% to 44% were observed in laboratory tested soil models. These reductions in the load reaching the anchor link are important enough to influence present design criteria and further motivate the research towards larger scale models.
- The mean ratio of frictional and transversal forces F/Q cannot be represented by a direct proportionality, exhibiting considerable dependence on the undrained soil shear resistance, $s_u$. 

Figure 17. Lateral load versus horizontal displacement curves of identical symmetrical piles (right and left) of 0.4 m diameter and 8.0 m length
The computational investigation is based upon the formulation of a finite element model aiming to provide a reliable and accurate approach to structural analysis of media with embedded curvilinear inclusions. These are assumed to take only tensile-compressive forces, disregarding shear forces and bending moments. Owing to the diameter of embedded inclusions being significantly smaller than the typical size of the structure, the so-called “embedded element concept” is adopted to model at macroscopic level the behaviour of the two medium components in mutual interaction along contact interface. In the context of mixed 3D-1D formulations, special emphasis is given to properly adapt the Mohr-Coulomb interface model relating the bond-stress and bond-slip. Unlike matrix and inclusion that may undergo large strains, those associated with bond-slip are assumed to remain infinitesimal along matrix/inclusion interface. At the structure level, the finite element implementation for nonlinear analysis is based on a correlational kinematics description introduced in the context of embedded approach. Application of the computational model to simulate the problem of load transfer in mooring anchor systems has demonstrated its aptitude to deal and macroscopically capture essential features of deformation in a complex structure. A series of simulations are performed to understand the role of some key parameters in controlling the mechanical response of this kind of geo-structure, demonstrating the aptitude of the numerical modelling to deal and macroscopically capture essential feature of deformation in such a complex structure. The numerical predictions have corroborated the results obtained from the experimental investigations: Dynamic effects may be disregarded when analysing the structural response of the mechanical system defined soil, embedded catenary and associated interface.
Figure 20. Example of finite element model referring to the anchoring: computational domain.

Figure 21. Contours of von Mises equivalent stress around the embedded mooring line.

Key recent publication
Experimental study of the installation and load capacity of fluidized model piles

Contributors: Fernando Schnaid (Coordinator), Larissa de Brum Passini, David Lourenço, Fernanda Stracke, Jonathan Jung

The fluidization process gives emphasis to the potential application to offshore foundations where the exploration frontier moves fast to deep-water depths and requires development of new technologies for the installation and anchoring of offshore structures. The work concentrates on the Torpedo anchor developed by PETROBRAS in Brazil, embedded into the seabed by free fall, with its own weight and velocity at the point of entry in the soil providing the driving energy. A technique that may increase the depth to which the torpedo pile can be installed in sandy soil is fluidization by vertical water jets, which could be applied during pile penetration under free fall.

The research program was conceived to examine the mechanism of pile installation by vertical jet fluidization in saturated sand and clay deposits in order to define the constitutive parameters that control installation geometry and pile depth of embedment. A series of laboratory model tests representative of offshore torpedo piles was carried out using downwardly-directed vertical water jets in both medium and dense sands and soft clay. In sand, measurements from model tests at three different scales indicate that the geometry of fluidized cavities is not influenced by the initial density of the sand and that the perturbed zone is constrained to a distance of about 2 piles diameters from the pile centreline during pile installation. Following the laws of dimensional analysis, an expression for the embedment of fluidized piles is derived and shows that penetration depth is a function of pile weight and geometry, fluidized water jet flow rate and velocity, as well as the soil and fluid properties. Penetration is shown to increase with increasing flow rate and pile weight and decreasing soil relative density. Although the results have to be validated by tests at larger scales to prove compatibility with the full-scale behaviour, model tests indicate maximum embedment depth of the order of 50 times the pile diameter.

The testing program was carried out at 1G conditions. The key design questions in connection with torpedo piles are how far they penetrate into the ocean floor and what their pullout capacities are. Pullout tests were performed on the model piles in fluidized and non-fluidized saturated sandy soils prepared at two initial relative densities, at four different times after installation. The technology provides a technically feasible and commercially efficient solution for torpedo pile installation.

Results from the laboratory tests indicate that shaft uplift capacity of fluidized piles is independent on the sand initial relative density and that the design of shaft friction should be made in terms of the sand critical state soil conditions. The measured values of the coefficient of lateral earth pressure $K_s$ derived from the fluidized model tests are lower than those reported by other methods of pile installation, in some cases lower than $K_0$. Consequences are that piles installed by fluidization have their bearing capacity reduced considerably compared with piles installed in non-fluidized soil. Finally, fluidized piles require a sufficient time after installation in order to allow pore pressure dissipation and particle rearrangement setup for full shaft mobilization.

Figure 22. Schematic representation of the experiment with installation and pullout equipment
Figure 23. Mechanism and Installation depth according to the model weight and flow rate applied in sand

Figure 24. Pile shaft uplift capacity ($Q_f$) versus pile length ($L$) in fluidized soil (a) immediately and 4 hours after installation and (b) 24 and 48 hours after installation

**Key recent publications**


Cyclic shear behaviour of fibre-reinforced materials

Contributors: Lucas Festugato (Coordinator), Nilo Cesar Consoli, Jorge Florez, Rubén Alejandro Quiñonez Samaniego, Rubén Alcides Lopez Santacruz, Antonio Aquino, Guilherme Venson

In order to investigate techniques to improve tailings backfill stability in stopes and the mechanical behaviour of mine tailings, studies on the cyclic shear response of fibre-reinforced mine tailings and fibre-reinforced cemented paste backfill have been developed. Cyclic simple shear tests have been conducted on fibre-reinforced and non-reinforced, cemented and uncemented, mine tailings. Figs. 25 and 26 show, respectively, the effect of fibre addition on shear response of uncemented and cemented material. Under shear stress-controlled cyclic conditions, fibres improved the material shear response and produced a stiffer material. Under shear strain controlled cyclic conditions, fibres increased the shear stress values of the cemented samples after successive load cycles.

![Figure 25](image1.png) ![Figure 26](image2.png)

Figure 25. Shear stress versus shear strain curves of (a) non-reinforced uncemented mine tailings and (b) fibre-reinforced uncemented mine tailings under stress-controlled cyclic conditions with a ratio of maximum cyclic stress and initial vertical effective stress, $\tau_{\text{cyc max}} / \sigma'_v$ initial of 0.2

![Figure 26](image3.png)

Figure 26. Ratio of cyclic maximum shear stress to initial effective vertical stress $\tau_{\text{cyc max}} / \sigma'_v$ initial versus number of cycles of strain controlled tests under 100 kPa of initial effective vertical stress for (a) non-reinforced cemented mine tailings and (b) fibre-reinforced cemented mine tailings

Key recent publications


Prediction of strength parameters
Contributors: Nilo Cesar Consoli (Coordinator), Lucas Festugato, Luizmar da Silva Lopes Junior, Bernardo Scapini Consoli

Studies have been developed to estimate the Mohr-Coulomb failure envelope of fibre-reinforced and non-reinforced artificially cemented sands based on splitting tensile strength ($\sigma_t$) and unconfined compressive strength ($\sigma_c$) of such materials, without the necessity of carrying out triaxial testing. Based on the concept previously established that the $\sigma_t/\sigma_c$ relationship is unique for each mixture, results have shown that the effective angle of shearing resistance of a given mixture ($\phi'$) is dependent of the $\sigma_t/\sigma_c$ ratio and that effective cohesion intercept ($c'$) is a direct function of the unconfined compressive strength ($\sigma_c$) [or splitting tensile strength ($\sigma_t$)] and $\sigma_t/\sigma_c$ ratio. Figure 27 presents the Mohr-Coulomb envelope based on Mohr circles from splitting tensile and unconfined compression tests. In Figure 28, as an example of the efficiency of the proposed methodology, Portland cement treated silty sand Mohr-Coulomb failure envelope (using methodology developed) in $\tau - \sigma$ stress space for three triaxial specimens are presented.

Figure 27. Mohr-Coulomb envelope based on Mohr circles from splitting tensile and unconfined compression tests

Figure 28. Portland cement treated silty sand Mohr-Coulomb failure envelope (using methodology developed) in $\tau - \sigma$ stress space for three triaxial specimens considering 5% Portland cement content, void ratio of 0.51 and 7 days of curing

Key recent publications
The use of alkali activated geopolymers in geotechnical engineering
Contributors: Nilo Cesar Consoli (Coordinator), Cecília Gravina da Rocha, Rodrigo Beck Saldanha, Eduardo Mallmann, Carina Silvani, Amanda Dalla Rosa Johann

Increasingly it is necessary to search for alternative materials to the construction industry in order to make it more sustainable. In this regard, fly ash and carbide lime - residues from production processes - are targets of this study due to their applicability in the stabilization of slopes, base of pavements and manufacture of artefacts for building construction. Therefore, this work aims at the development of method (technique) that enables the prediction of the compressive strength for long curing time periods at standard laboratory curing temperature (23°C) through prediction equivalence with accelerated curing (using temperatures of 40°C and 60°C). The porosity/carbide lime (\(\eta/L_{iv}\)) ratio (corresponding to porosity divided by the volumetric carbide lime content) can be used to predict compressive strength (\(q_u\)). The results show that a power function predicts better the relation \(q_u\) versus \(\eta/L_{iv}\), in which \(L_{iv}\) is adjusted by an exponent (in this case 0.11) for all coal fly ash - carbide lime mixtures studied (see Figs. 29 and 30). This correlation allowed the comparison of the unconfined compression strength between 1, 3 and 7 days in steam curing at 40°C and 60°C with 7, 14, 28, 180 and 360 days at standard laboratory curing temperature (23°C) for different proportions of porosity and carbide lime content. The comparison of standard laboratory curing temperature and accelerated curing allowed generating equations which determine the time required for fast steam cure (40°C and 60°C) to provide the same resistance for extended periods under standard laboratory curing temperature (23°C).

![Figure 29. Normalized unconfined compressive strength (divided by adjusted porosity/volumetric content of carbide lime) versus curing temperature for 1, 3 and 7 days of curing](image-url)
Figure 30. Empirical $q_u$ vs. $\eta/(L_u)^{0.11}$ curves and their normalized $q_u$ vs. curing time (days) period for (a) 40°C, (b) 60°C and (c) 23°C

**Key recent publications**


Impacts of binder content and porosity in the sustainability of improved geomaterials

Contributors: Nilo Cesar Consoli (Coordinator), Cecilia Gravina da Rocha, Rubén Alejandro Quiñónez Samaniego, Néstor Masamune Kanazawa Villalba, Ana Carolina Passuello

Geotechnical engineering can account for a considerable portion of the environmental impact in infrastructure and construction projects. As a result, sustainability is increasingly becoming a key research topic in this area. This paper assesses the environmental impact of lean clay-lime blends for road sub base in the Paraguayan Chaco region. More specifically, it compares distinct dosages to attain a target strength (unconfined compressive strength and splitting tensile strength) and stiffness (initial shear modulus) using life cycle analysis (LCA). Eight impact categories were considered: acidification, eutrophication, photochemical oxidation, depletion of natural resources, ozone depletion, global warming, and embodied energy. For all target values of strength and stiffness examined, low-binder/high-density dosages have a lower impact across all categories compared to high-binder/low-density dosages (see Fig. 31). More specifically, minimal impact across all categories is attained when the smallest binder content (required to attain a target strength or stiffness) is used. Changes in binder content and density produce major increases in two categories (energy consumption and global warming). Lime production accounts for more than 80% of the total energy and CO₂ emission for all blends. This supports previous research, which show that materials account for a considerable part of energy consumption in geotechnical works. As a result, minimizing binder content and maximizing compaction are main strategies to create more sustainable dosages for ground improvement works.

![Figure 31: Impacts of F3, F5 and F7](image-url)

Key recent publications
The First Kazakhstan-USA Geotechnical Engineering Workshop was held in Astana and Almaty from July 13th - 16th, 2015. For context, during the 18th International Conference for Soil Mechanics and Geotechnical Engineering, which was held in Paris, France in 2013, bilateral agreements (Memoranda of Understanding) between the Kazakhstan Geotechnical Society (KGS) and the ASCE Geo-Institute were signed. The agreements outlined prospects for cooperation between societies, exchange of experience and knowledge, exchange of scientific and normative documents, training of specialists in the field of geotechnical engineering, and organization of joint geotechnical conferences, seminars, workshops, and webinars. This workshop represented the first formal interaction in this regard. The workshop was co-chaired by Prof. Askar Zhussupbekov and Prof. Jim Hanson. The workshop had 70 total participants including a delegation of 10 participants from the USA. The participants included also practitioners, university faculty, and researchers from Kazakhstan, Japan, Poland, Russia, Turkey, UAE and Ukraine (Photo 1).

Photo 1. The participants of the First Kazakhstan-American Geotechnical Workshop

The theme of the workshop was transportation and energy geotechnics, inclusive of highways, railways, tunneling, bridges, wind energy, geosynthetics, and geothermal energy systems. The format of the workshop included white paper presentations, keynote presentations, technical presentations, and breakout working sessions. Breakout working sessions were conducted on the following themes: practice, research, education, and commercialization to promote establishing plans for future collaborations amongst the geoprofessionals of the two countries. In particular, the participants identified opportunities for interface between geotechnical practitioners and researchers as well as between industry and classrooms, including contributing to development of activity TC 305 “Geotechnical Infrastructure for Megacities and New Capitals”.

Breakout working sessions generated a series of suggestions for further collaboration between the members of the two geotechnical societies (Photo 2). In the area of education, exchanges at all levels (faculty and students) and effective use of on-line services (e.g., webinars, short courses, synchronous international classroom interactions) were highlighted. Financial support from geo construction companies can be sought. Learning each other’s system is a first important step. In the area of research, it was suggested to have deeper exchanges beyond conferences such as face-to-face meetings (could be done online). There seems to be a fertile area of cooperation in geoenvironmental issues with numerous environmental problems in both countries. It was suggested to establish a Center for Sustainable Construction (CSC) in a university in Kazakhstan (e.g. Eurasian National) in collaboration with Road Research Institute. Recycled Materials Resource Center in the USA can provide technology transfer to develop standards, specifications, material characterization methods, and outreach activities relevant to Kazakhstan.
Four keynote lectures and two special reports from the USA and Kazakhstan were presented:

- **Keynote Lecture 1.** Prof. Tuncer Edil (University of Wisconsin, USA): Sustainable Construction and Maintenance of Transportation Facilities and Reuse of Wastes;
- **Keynote Lecture 2.** Prof. Tanatkan Abakanov (Director of National Center of Seismological Observations and Research, Kazakhstan): Seismic Safety State and Prospects in Kazakhstan;
- **Keynote Lecture 3.** Prof. Victor Kaliakin (University of Delaware, USA): Constitutive Models for Cohesive Soils - Synthesis and Expansion;
- **Keynote Lecture 4.** Prof. Askar Zhussupbekov (Eurasian National University, Kazakhstan): Geotechnical and Construction Considerations of Pile Foundations in Problematical Soils;
- **Special Report 1.** Prof. Michal Topolnicki (Director of Large Project, Vremya/Keller Holding GmbH, Kazakhstan): Complex Ground Improvement and Excavation Support Projects - Design and Building Approach (Photo 3);
- **Special Report 2.** Mr. Tsunenobu Nozaki (Construction Design & Pl.gr., Giken Ltd., USA): Press-in Piling Method for Road/Railway Retaining Walls (Photo 4).
Having the workshop held in two cities such as Astana and Almaty, was a unique format that allowed an opportunity to explore different parts of Kazakhstan and for the participants to be introduced to a variety of geotechnical engineering challenges. Technical field visits were conducted to the Astana EXPO 2017 (Photo 5) and Abu-Dhabi Plaza construction sites in Astana. The Almaty visits included Road research Institute Laboratories (KazDorNII Laboratories) (Photo 6) where the Institute President Dr. Bagdat Teltayev presented Prof. Tuncer Edil and Prof. Yoshinori Iwasaki the medals for significant contributions to road science. Koktobe, Chimbulak, Medeo at Tien Shan Mountains was the highlight of the Almaty visits.

At the Closing Ceremony of the workshop, Prof. Hoe Ling was awarded an Honorary Medal by Eurasian National University for extensive work in advising of Ph.D. Students in Eurasian National University as a scientific foreign consultant. Prof. Tuncer Edil also was awarded Kazakhstan Geotechnical Society’s Medal of Academic Sh. M. Aitalyev for his significant contributions in promoting international collaborations within the geo-profession, and specifically establishing the bridge between the ASCE-GI and KGS. Dr. Gennady Sultanov was awarded the International Geotechnical Medal of Academic T. Zh. Zhunusov for his exceptional work in geotechnical engineering.

The organizers are confident that this workshop established a foundation for developing meaningful future collaborations between the two countries including increased interactions between Kazakhstan Geotechnical Society and ASCE Geo-Institute. The workshop had a strong industry related component to highlight geotechnical and construction opportunities in Kazakhstan. The organizers are grateful to the sponsors of this event, including the Kazakhstan Geotechnical Society, the ASCE Geo-Institute, the L.N. Gumilyov Eurasian National University; Vremya, LLP (Keller); Giken, Ltd.; Geo-Research Institute, KGS-Astana, LLP.; PI Bazis, LLP.; KazDorNII, KazNII5A, MG Build, LLP.; Sembol, LLP.; KaragandaGIIIZ, LLP.; CCC, LLP and Arabtec, LLP and others. A proceedings is planned to be published after the workshop. Future interactions, including a second workshop, are already in discussion.
Young Members’ Arena

Technical review: Experimental mechanics at the grain-scale in sand: Recent work from the geo-mechanics lab of Grenoble

About the Young Member
Dr. Edward Andò is a young researcher applying in-situ x-ray tomography to the study of soil mechanics with the hope of elucidating the grain-scale mechanisms responsible for macroscopic behavior. He defended his PhD -- supervised by Jacques Desrues, Gioacchino (Cino) Viggiani and Stephen Hall -- in 2013 on this subject in Laboratoire 3SR, Grenoble and has stayed on in Laboratoire 3SR as a CNRS Research Engineer. The data coming from Dr. Andò's work has been studied and shared with a number of groups including most notably Jose Andrade's in Caltech and Antoinette Tordesillas' in Melbourne University. Current projects continue in this vein, trying to extract a fabric tensor from existing granular experiments, as well as applying x-ray tomography to the study of particle breakage, to three-phase problems (unsaturated soil mechanics), as well as more exotic problems such as fibre-reinforced soil.

Abstract
This paper presents some recent x-ray tomography work from Grenoble, illustrated with existing measurements of sand grain kinematics under triaxial compression, allowing full 3D kinematics to be measured for each grain over 18 scanned increments. Future challenges for the application of x-ray tomography in revealing other grain-scale processes in sand are also discussed.

Keywords: x-ray tomography; granular media; shear banding; discrete analysis

1. Introduction
Continuum models of soil behaviour have long been used to describe the deformation characteristics of these materials, and with a good degree of success. Continuum models are easy to use directly within a Finite Element Model (FEM), allowing complex engineering problems to be simulated. The tendency of granular materials to undergo strain localization is difficult to capture with such models since the hypothesis of a continuum breaks down, as deformation structures emerge within the soil. Many experimental observations indicate that such structures (shear bands for example) have a characteristic size (width) of only a few grain diameters (regardless of grain size) - which indicates that this is a grain scale phenomenon. The modelling of such structures is understandably a fine art: continuum models need sophisticated techniques (such as enriched continua) to overcome Finite Element mesh dependency, whereas particle-based simulations such as the Discrete Element Method or Contact Dynamics require careful calibration. In any case, in order to be able to capture the behaviour of a granular medium undergoing localisation with a model, experimental observations at this scale are required.

This paper presents ongoing work from Laboratoire 3SR (Grenoble) on this very subject, where granular assemblies are deformed “in-situ” (i.e., inside an x-ray tomography machine), allowing multiple states to be imaged in 3D. This is a technique which is getting increasing attention in materials science, and in the subject of the study of granular materials, the work of Alshibli (e.g., Alshibli and Hasan, 2008) and the group at ANU (e.g., Saadatfar et al., 2013) must be mentioned. The paper shows existing work on the grain-scale study of shear banding, with results from triaxial testing, and a short discussion about future challenges.

2. Experimental setup

2.1 Materials and in-situ triaxial testing
This paper presents results obtained on an unusual material: Caicos ooids, a very rounded carbonate sand from the Turks and Caicos islands in the British West Indies, $D_{50} = 420\mu m$. These materials (along with others tested), are detailed fully in Andò (2013), Caicos ooids have been chosen in this case since their rounded shape helps the automatic identification of grains.
The triaxial tests used in this work differ significantly from standard ones to allow x-ray scanning of the specimen in various stages of deformation - to this end experiments are entirely performed within the Laboratoire 3SR x-ray micro-tomograph. Given that the $D_{50}$ of the grains studied is in the order of 300µm, the pixel size necessary for sufficient information for grain has been set to 15.56 µm/px, meaning that an average particle will have around 20 pixels across a diameter\textsuperscript{1}. This choice limits the field of view and consequently the size of the specimen is reduced to 22mm height and 11mm diameter. Despite this extreme miniaturisation, the specimen is composed of more than 50,000 grains of sand.

Furthermore, since x-ray tomography requires the rotation of the specimen, the steel tie bars that usually take the return force from the compression of the specimen would severely degrade the scan - to avoid this the pressure cell (which is made in x-ray transparent plexiglas or polycarbonate) takes this extra load. Specimens are prepared dense (through dry pluviation through a 1m tube), and are tested dry. This would normally mean that no volume changes can be measured, however these are obtained from the different 3D images. Triaxial testing is done under strain control at a strain rate of 0.1%/min, however loading is interrupted at various points during the test to scan the specimen (acquiring around a thousand radiographs as the specimen rotates through 360°). When loading is stopped the specimen relaxes - the majority of the relaxation happens in a few minutes after loading is stopped. Axial force and imposed displacement are measured externally.

2.2 Image-based measurements

The 3D images coming from each scan contain around 1000×1000×1600 voxels, each voxel representing a reconstructed value of x-ray attenuation (which is roughly related to density, meaning that grains have “high” and pores have “low” grey values). From such an image, a local field of porosity can easily be defined, either by defining the grey values represent pore and grain, and measuring the average grey value in a suitably defined sub-volume. However the preferred technique for the low-pressure tests where grains do not break, is to define a threshold greyscale value, above which voxels are considered to be grain and below which they are considered to be pore - the value is chosen to obtain the solid volume of grains measured by weighing at the end of the test. Porosity is then easy to define in a sub-volume in such an image: the volume of voids and solids are simply counted.

Binary images where the solid and void phases are defined are the starting point for the definition of individual grains: the solid phase is split into individual grains using a watershed as described in Andò et al. (2012a). Each grain (i.e., all the voxels making up an individual grain) is then given a unique number, and properties of these 3D sets of voxels (position, volume) can be measured. The splitting and labelling procedure is repeated for each imaged state, and since grains will not have the same unique number, labels are reconciled by tracking grains from increment to increment using a specifically developed technique called ID-Track (Andò et al., 2012a). Following the change in the centre-of-mass of each grain over an increment gives a very precise evaluation of the displacement of the particle (with an error less than 0.1 pixels).

The measurement of rotations is more challenging: at this resolution the grain shapes are not detailed enough for the long and short axes of the moment of inertia tensor to be stable. To overcome this problem, a discrete DIC (digital image correlation) technique has been proposed in Andò et al. (2012b), where tracked grains are matched based on their images - this combined with ID-Track gives the full rigid body motion of the grains.

3. Results

The measurements that can be obtained with the combination of tools detailed above are shown, for an example test, in Figure 1. In the top of the figure, a schematic of the in-situ setup is shown, along with the macroscopic results obtained from the force and displacement measurements.

\textsuperscript{1} An average particle will therefore be composed of around 4200 3D pixels, known as voxels
Figure 1. Illustration of the procedure for the analysis of in-situ experiments, with some highlighted results.
Figure 1 shows schematically the steps of image processing required to reconstruct a 3D image, and then to define and follow grains between imaged states, allowing measurement of their kinematics. The series of vertical slices presented at the bottom of the figure shows vertical slices taken through the specimen at points during the test, where all grains are coloured by their incremental rotations. Above these maps of discrete quantities, is a map of a continuum mechanics quantity of shear strain, measured on tetrahedra defined by tesselating grain centres.

It is clear that this kind of discrete 3D information available all the way through a mechanical test represents an experimental revolution in geomechanics - recent publications such as Desrues and Andò (2015) show how, for example, the residual state of stress in specimens with different angularities is easy to relate to the grain-scale kinematics at play in the shear band.

4. Challenges

Future work will focus on two areas: solving current measurement challenges for the subject presented above, as well as elucidating new phenomena using 3D images and data processing tools similar in spirit as those presented.

4.1 Current measurement challenges for grain kinematics

The rotations of grains, as well as the shear strain maps derived from grain displacements highlight some interesting phenomena. Especially before the macro-peak, there are some interesting chains of rotating grains that can even be seen in the vertical section shown (in 3D the chains are clear to see, but unfortunately analysing this structure in 3D as well as showing it in print also remains an open challenge). The emergence of a wide band of rotating grains that concentrates into a final shear band is also very interesting, and the grain-scale reasons for this collective behaviour are doubtlessly to be found in the way that forces are transmitted from grain to grain. Looking at the grain maps, we can see that a specimen with significantly fewer grains would not have had the degrees of granular freedom in order to exhibit such a shear band. Unfortunately, having sufficient resolution to study grain kinematics does not appear, using standard tools, to offer enough to study grain-to-grain contacts, as shown in Andò et al. (2013) and illustrated in Figure 2 - the number of voxels describing the contact between the two objects is simply insufficient. Problems appear both in the counting of contacts (they are systematically overestimated - see Wiebicke et al., 2015), as well as the extremely poor definition of their orientation. 

Figure 2. A collection of 31 Caicos ooids grains, shown with a zoom on two grains in contact.
Some work in collaboration with discrete mathematicians has allowed this measurement to be made in some idealised cases using a Random Walker (see Viggiani et al., 2013, the base of this algorithm is now implemented in the python toolkit skimage - see Van Der Walt et al., 2014), and the application of this sort of tool is part of the ongoing PhD work of M. Wiebicke, with the objective of obtaining a fabric tensor from such measurements. Another approach to the scarcity of information is to use geometrical models to capture grain shapes, either in the style of level sets (see Andrade et al., 2012 and upcoming work), or in the style of spherical harmonics (see Zhao et al., 2015). Work on all fronts is extremely important to get further in the characterisation of the complex phenomenon of shear banding.

4.2 Highlighting any grain-scale phenomena with tomography
The ability to non-destructively image multiple states of a granular medium in 3D offers tremendous possibilities in the quantification of many phenomena in granular materials. In Grenoble, a number of different phenomena are being investigated at the time of writing. The three-phase interaction of soil-water-air mix with a focus on the water-retention behaviour of soil is an important area of focus (Kadhour et al., 2013, with important work also done by other groups such as Sheel et al., 2008 and Higo et al., 2011. Kim et al., 2011 uses neutrons instead of x-rays to pick out the water), the study is currently being extended to the triaxial behaviour of partially saturated sand with a new triaxial setup. One of the main challenges here is the “trinarisation” of such a volume to distinguish all three phases without errors, this is a particular challenge in the case of water, since its density is low compared to sand grains.

Furthermore, the quantification of cement is also an important area of research work, be it “bio-cemented” materials such as those produced in U.C. Davis (DeJong et al., 2006) which have been studied with x-ray tomography (Tagliaferri et al., 2011), or artificially cemented material (see Das et al., 2013 as well as Tengattini et al., 2015). Challenges here include the difficult quantification of cement and its evolution between grains (since both can be of similar grey-scale values).

Figure 3. Some observations of grain breakage from Andò et al., 2013
One last major area of work is grain breakage (as illustrated in Figure 3), where the challenge is to quantify the process of breakage, even when particle shapes are evolving, and particle sizes are becoming small. When particles fall below the resolution of the measurement, only their average mass can be followed, and taking this into account in an algorithm is certainly a big challenge. Observations of breakage in triaxial compression (Alikarami et al., 2014) show that this is a rich field for exploration, and the ongoing PhD thesis of Z. Karatza is in this direction. Results of compression tests on a few particles (Cil and Alshibli, 2012) also highlight some interesting particle-level mechanisms.

5. Conclusions

X-ray tomography, and its application to geomaterials is becoming a very powerful tool in this field. The ability to acquire images with a resolution of tens of microns allows the grain-scale to be accessed in sand, and phenomena to be characterised at this scale. This kind of measurement opens many doors: to treat particles discretely and analyse their collective behaviour with complex networks (see Tordesillas et al., 2015), as well as discrete particle-by-particle simulations (Andrade et al., 2012). Many open measurement questions remain, since the development of accurate and well-characterised image analysis tools require careful procedures, however the tempting prospect of answering long-standing macro-questions at the micro-scale makes the challenge worth facing.

Acknowledgements

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References


Young Members’ Arena (Con’t)

Technical review: Experimental mechanics at the grain-scale in sand:
Recent work from the geo-mechanics lab of Grenoble


Conference Report

The XVI European Conference of Soil Mechanics and Geotechnical Engineering 2015

The XVI European Conference on Soil Mechanics and Geotechnical Engineering (XVI ECSMGE) was held in Edinburgh, United Kingdom, from 13th to 17th September 2015. The conference was held at the magnificent Edinburgh International Conference Centre, and organized by the British Geotechnical Association (BGA), with the support of ISSMGE, under the overarching theme of Geotechnical Engineering for Infrastructure and Development.

The Edinburgh International Conference Centre (Figure 1) provided excellent conditions for the event, with comfortable, ample and very well-equipped auditoriums and session rooms.

![Figure 1 - Edinburgh International Conference Centre](image)

The conference was very well attended by engineers, professionals, scientists, researchers and equipment or solution providers operating in the field of soil mechanics and geotechnical engineering, allowing interesting discussion and a platform for exchange of experience and knowledge. A provisional total number of 992 delegates, 1154 attendees (including exhibitors), 71 accompanying persons, and 61 exhibitors and sponsors occupying 74 stands contributed to the largest European geotechnical conference in the already long history of the events.

The event started on Saturday 12th September, with the ISSMGE Board meeting and continued on Sunday 13th with the ISSMGE Council meeting and the first of the 37 Technical Committee meetings held in Edinburgh.

At the end of the Sunday traditional Scottish entertainment was provided, with the brilliant performance of the groups Clann and Drumma (Figure 2), and highland dancers (Figure 3) and Bagpiper (Figure 4). The session was followed by the official Opening of the Exhibition and a welcome Reception.
The opening session of the event occurred on Monday 14th of September, with the intervention of Prof. Mike Winter, Chair of the Conference Organising Committee, Prof. Antonio Gens, ISSMGE Vice president for Europe, Prof. Roger Frank, ISSMGE President, Dr. Chris Menkiti, BGA Chair, and the Minister for Transport & Islands of Scotland, Derek Mackay MSP, who put emphasis on the importance of geotechnical engineering in sustainable development of a modern world. The Minister also mentioned the importance of the United Kingdom in the development of the Geotechnical Engineering, evoking also the role of two distinguished citizens of Edinburgh, William Rankine as one of the earliest contributors to the Soil Mechanics science, and James Hutton, the founder of modern geology.

The end of the first day was marked by a whisky tasting session, in several of the stands of the technical exhibition, which allowed the delegates to experience the differences between the several whisky zones of Scotland, providing a fun and cheerful end of first day of the conference.

The social program also included the Gala dinner on Wednesday evening in the National Museum of Scotland and delegates were again entertained by a bagpiper and also by a team of aerialists (Figure 5).
From a scientific point of view the conference was the largest ECSMGE ever, with a total number of 686 papers published, including three keynote lectures and six invited lectures, totaling 4,784 pages in the seven volumes of the proceedings (Figure 6). Ninety of the papers were from outside Europe, which demonstrates the enormous interest the conference sparked in the geotechnical community. The removal of the national allocation limits on papers undoubtedly contributed to this success as along with the quality of scientific program and the attractiveness of Edinburgh. The division of the papers by theme was as follows:

<table>
<thead>
<tr>
<th>Theme</th>
<th>Number of Papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory, keynote and invited papers</td>
<td>10</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>108</td>
</tr>
<tr>
<td>Development</td>
<td>103</td>
</tr>
<tr>
<td>Slopes, Geohazards and Problematic Materials</td>
<td>156</td>
</tr>
<tr>
<td>Environment, Water and Energy Investigation</td>
<td>66</td>
</tr>
<tr>
<td>Investigation, Classification, Testing and Forensics</td>
<td>127</td>
</tr>
<tr>
<td>Parameter Selection and Modelling</td>
<td>93</td>
</tr>
<tr>
<td>Developments in Education and Practice</td>
<td>23</td>
</tr>
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The first keynote lecture was delivered by Kenichi Soga from the University of Cambridge, United Kingdom, and coauthored by V. Kwan, L. Pelecanos, Y. Rui, T. Schwamb, H. Seo and M. Wilcock, entitled “The Role of Distributed Sensing in Understanding the Engineering Performance of Geotechnical Structures”. The keynote presented an innovative distributed fibre optic strain measurement system, allowing having thousands of “strain gauges” along a single cable connected to structures, complemented with four case studies that utilized distributed strain sensing to understand the engineering performance of piles, thermal piles, diaphragm walls and concrete tunnel linings.

Prof. Gomes Correia, from University of Minho, Portugal, gave the second keynote lecture entitled “Geotechnical Engineering for Sustainable Transportation Infrastructure”. The lecture highlighted how transportation geotechnics can interact with transportation infrastructures and how through the planning, design, construction and maintenance may contribute to ensure solutions more safe, reliable and resilient in the future and, in this way, contribute to preserving natural resources and assuring socio-economic and environmental benefits for the society.

The third keynote lecture was delivered by Prof. Giulia Viggiani from the Università di Roma Tor Vergata, Italy, and coauthored by F. Casini, with the title “Artificial Ground Freezing: from applications and case studies to fundamental research”. The lecture presented the excavation of some of the stations of Line 1 of Napoli Underground through loose granular soils and a fractured soft rock, as a recent example of an extensive and successful application of Artificial Ground Freezing. The presentation also included some recent work conducted in the framework of an international co-operative research project, which included a preliminary experimental investigation of the behaviour of pyroclastic soils on freezing/thawing cycles, the calibration of a fully coupled thermo-hydro-mechanical constitutive model against available experimental data, and its application to the back analyses of one of the stations of the Napoli Underground.
There were also 6 invited lectures, as follows:

- “Ground improvement versus hybrid foundation and deep foundation: three case histories of European significance” - D. Adam, Institute of Geotechnics, Vienna University of Technology, Austria
- “Developments in the use of geophysics in geotechnical engineering in soft ground” - M. Long, University College Dublin (UCD), Ireland
- “Vulnerability assessment of buildings exposed to co-seismic permanent slope displacements” - K.D. Pitilakis and S.D. Fotopoulou, Aristotle University, Greece
- “Thermo-hydro-mechanical issues in claystones: application to radioactive waste storage at great depth” - P. Delage, Ecole des Ponts ParisTech, Navier/CERMES, France
- “Reassessment of geotechnical conditions after an offshore well incident” - J. Peuchen, B. Meijninger, T. Drummen, Fugro, Netherlands
- “On the merits of using advanced models in geotechnical engineering” - H.F. Schweiger, Graz University of Technology, Austria

The official closure of the conference was held at the end of Thursday morning, with the participation of Prof. M. Winter, Chair of the XVI ECSMGE, Prof. Dong-Soo Kim, Chair of the 19th ICSMGE Seoul Organising Committee XVII ECSMGE 2019, Dr Haraldur Sigurssteinsson chair of the XVII ECSMGE that will be held in Reykjavik, Iceland, Prof. A Gens, ISSMGE VP for Europe, and Dr. C. Menkiti, BGA Chair.

Prof. Dong-Soo Kim presented the 19th ICSMGE, with the theme “Unearth the future, connect beyond”, while Dr Sigurssteinsson gave the first sketches of the XVII ECSMGE, in Reykjavik, Iceland under the theme of “Geotechnical Engineering, foundation of the future”. Both the orators created high expectations for the delegates regarding the quality of the forthcoming conferences.

Finally, Prof. Mike Winter closed with heartfelt thanks to all who contributed to the enormous success of the conference.

During the afternoon the technical tours took place as follows:

- Firth of Forth: Queensferry Crossing;
- The Railway Research Centre;
- Antonine (Roman) Wall;
- Haymarket Rail Tunnel Upgrade;
- Edinburgh Geological Tour;
- Falkirk Wheel (Figure 7).

![Figure 7 - Technical Tour - Falkirk wheel](image)
The International Workshop on Geotechnology for Natural Hazards was held in the city of Kitakyushu, Japan from July 12th to 14th, 2014. It was held under the auspices of Asian Technical Committee No. 3 (ATC3) of ISSMGE with support from Japanese Geotechnical Society, Taiwan Geotechnical Society, Kitakyushu City, Kitakyushu City Convention Center, and Department of Civil Engineering, Kyushu University.

ATC3 on Geotechnology for Natural Hazards under ISSMGE was established in 1993 to deal with the geotechnical aspects concerning earthquake triggered and rainfall induced natural hazards in Asian region. Since its inception, ATC3 has always been very active in organizing academic events and research activities between Japan and Taiwan, since these two countries share many common problems in geotechnical and natural hazards related issues such as earthquakes, tsunamis, earthquake- and rainfall-induced debris flows, landslides, etc. Being aware of those common interests, both the Japanese Geotechnical Society (JGS) and Taiwan Geotechnical Society (TGS) had been giving importance on regularly exchanging knowledge and information on geotechnical natural hazards, and also promoting technology in mitigating natural disasters. Five workshops were successfully held alternately in Japan and Taiwan every two years. This workshop was sixth in the series of Japan-Taiwan joint workshops on Geotechnical Hazards from Large Earthquakes and Heavy Rainfall. More than 100 participants not only from Taiwan and Japan, but also from four other Asian countries attended the workshop. (Photo 1)

The workshop began with the opening speeches given by ATC3 Chairman Prof. Motoki Kazama (Photo 2), Prof. Kenji Ishihara (Founding chairman of ATC3), Prof. Takaji Kokusho (Past chairman of ATC3), Prof. Susumu Yasuda (past chairman of ATC3), Prof. Cheng-Hsing Chen (National Taiwan University, Taiwan), and Prof. San-Shyan Lin (National Taiwan Ocean University, Taiwan), and Prof. Noriyuki Yasufuku (Head of Civil Engineering Department, Kyushu University). Total of 67 technical papers were presented and discussed during the workshop.

(Photos Not Shown)
In addition to the general presentations, two keynote lectures and two special lectures were presented in the workshop (Photo 3).

The keynote lectures were delivered as follows:
- **Prof. Akihiko Wakai**, Japan: *Initial trigger for slope failures in volcanic ash layer of hillside surface in Izu-Oshima Island in Japan due to a typhoon rainfall in 2013*
- **Prof. Tzou-Shin Ueng**, Taiwan: *Some observations in experiments on liquefaction of sand*

The special lectures were delivered as follows:
- **Dr. Hidenori Takahashi**, Japan: *Bearing capacity of breakwater mound under tsunami-induced seepage flow*
- **Dr. Wei F. Lee**, Taiwan: *A case study on silty sand liquefaction*

In the general presentations, three plenary sessions of 8 minute oral presentations were scheduled. A special feature of this workshop was the “student and young researcher session” with 2-minute oral presentations combined with poster presentations. A luncheon poster session was also arranged during lunch time.

The workshop program came to an end with the speeches delivered (Photo 4) by Prof. Yang-Show Fang (President, Taiwan Geotechnical Society), Prof. Ikuo Tawhata (President, Japanese Geotechnical Society) and Prof. Hemanta Hazarika (Secretary of ATC 3 and Co-Chairman of the Workshop). A farewell banquet was held at Brillansa Mojiko (the harbor area of Kitakyushu) before which the delegates visited the Memorial Hall of Albert Einstein. During the banquet, the best poster presentation award was presented to Ms. Zih-Fang Wang of the National Taiwan University in order to encourage the young researchers.
A pre-workshop technical tour was organized on July 12 to the reconstruction sites of the damaged area due to the 2012 Northern Kyushu Torrential Rainfall. As a part of the technical tour, the delegates visited one of the reconstruction projects (Sakanashi Check dam) under the jurisdiction of Aso Regional Promotion Bureau, Kumamoto Prefecture (Photo 5). Director general of the Bureau, Mr. Matsunaga briefed on Sakanashi check dam project and Toi River check dam project, two ongoing projects as a part of the reconstruction of the area damaged by the 2012 Northern Kyushu Torrential Rainfall.

The workshop was financially supported by the Kitakyushu city and Kitakyushu City Convention Association, Kitakyushu, Japan. On behalf of the organizing committee the author would like to express his heartfelt gratitude for this financial support.

The post workshop proceedings of the workshop will be published in November, 2015 by Springer Japan. All the papers of this post-workshop volume were rigorously reviewed by at least two reviewers from the ATC3 technical committee members from Japan and Taiwan. Title of the volume is: “Geotechnical Hazards from Large Earthquakes and Heavy Rainfalls”. The next workshop of this series will be held in Pingtung University of Science and Technology, Pingtung, Taiwan in September 2016.

Hemanta Hazarika  
Professor, Department of Civil Engineering  
Kyushu University  
Fukuoka, Japan
Participating at the XVI ECSMGE 2015 Geotechnical Conference has been really exciting and this is not only from a professional point of view. What makes this activity more beautiful is the fact that for me, and for most of Albanians, visiting a city like Edinburgh was just a beautiful dream. This conference was a big event in my career as a young geotechnical engineer. I had the opportunity to meet colleagues from almost every country and it was great to share our knowledge and to discuss topics regarding geotechnical engineering in our countries. It is amazing to realize that countries really far from each other despite many distinctions can face very similar realities. It was a good feeling to me to understand that my geotechnical knowledge can be applicable all around the world. The most interesting feature of the conference was discussing each paper with the authors and with the professors that were present. Since the conference covered a large number of geotechnical topics, I had a comprehensive understanding on what issues are the participants, and also universities and research institutions, dealing with current topics nowadays. The organising committee did an excellent job in providing every necessary information and facility, all this accompanied with an unbelievable courtesy. Finally, I would like to thank all the people that helped me to attend the XVI European Conference on Soil Mechanics and Geotechnical Engineering. I wish also to thank and congratulate ISSMGE and all member societies for the excellent and hard work in coordinating and supporting such activities.

A special thank to the Conference Organizing Committee (COC) for Fee Waiver award and to ISSMGE foundation because without your help I would never be part of this big event!

Ani Kosho
Sweco Branch office Albania
The conference was organized by the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) in association with the British Geotechnical Association (BGA). The conference theme “Geotechnical Engineering for Infrastructure and Development”, was broad and inclusive which provided a multitude of opportunities for all parts of researchers and the industry (including consultants, contractors and materials manufacturers and academics) and at all career stages to attend and to present papers.

The conference was started on 13th September, 2015 with warm welcome reception and registration. However, the opening ceremony was started on 14th September and followed by a “Skempton Lecture” delivered by Prof. Kenichi Soga, University of Cambridge, UK. It was followed by various outstanding and inspiring parallel, main and discussion sessions including keynote lectures and invited lectures by well renowned researchers in the field of geotechnical engineering (3 keynote lectures by Prof. Kenichi Soga, Prof. António Gomes Correia and Prof. Giulia Viggiani, 6 invited lectures by Prof. Dietmar Adam, Dr. Mike Long, Prof. Kyriazis Pitilakis, Prof. Pierre Delage, Prof. Joek Peuchen, Prof. Helmut F. Schweiger). All the keynote and invited lectures were very informative and educational. Various parallel discussion sessions were arranged after the lunch all day of the conference. Also, poster presentations were organized during coffee and lunch breaks. The poster presentations provided an opportunity to interact and discuss directly with researchers and share ideas with them. Apart from paper presentations, this conference gave an opportunity to know various industrial organizations, software developers and companies working in the field of geotechnical engineering. Furthermore, the whisky tasting and dinner at national museum of Edinburgh organized by the organizing committee were quite interesting. Various technical tours were organized after completing of presentation session and lunch on 17th September by the conference committee.

Also, this conference gave me an extra opportunity to visit various beautiful and attractive areas of Edinburgh and Newcastle. I also visited the University of Edinburgh and interact with students. These visits provided me with a chance to know the socio-culture of Scotland which was amazing.

In the last but not least, the conference gave me a right platform to learn and understand the different aspects of geotechnical engineering and also provided me an opportunity to extend knowledge in my area of research. I would like to express my sincere thanks to ISSMGE foundation for providing financial support for participating and presenting my work in the conference.
Reports from ISSMGE Foundations Recipient (Con’t)

Photo 3. During Opening Ceremony at Pentland hall, EICC

Photo 4. Visited National Museum of Edinburgh

Arvind Kumar Jha
Indian Institute of Science
Press release: Geomodels in Engineering Geology – an introduction

Peter Fookes, Geoff Pettifer, Tony Waltham

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- Profusely illustrated with over 400 photographs and diagrams
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**Contents:** Introduction. **Part 1:** The Underlying Factors - Climate and Geology. **Part 2:** Near-surface Ground Changes. **Part 3:** Some Basic Geological Environments for Engineering. **Part 4:** Ground Investigation (GI). **Part 5:** Case Histories and Some Basic Ground Characteristics and Properties. **Appendix:** Geotechnical Problems Associated with Different Types of Engineering Soils. References. Bibliography. Index

**Readership:** the book will provide instant access to a store of information for engineering geologists, geotechnical/ground engineers whether as an aide mémoire for experienced professionals in a new or novel location, or as a basic guide for those learning about or starting in the profession.

ISBN 978-184995-139-5  297 × 210mm (landscape)  208pp  colour throughout  41 block models and maps  over 370 photographs  softback  £35  October, 2015

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Event Diary

ISSMGE EVENTS

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

2015

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

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

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

Geo-Environment and Construction European Conference
Date: Thursday 26 November 2015 - Saturday 28 November 2015
Location: Polis University, Tirana, Albania
Language: Albanian, English
Organizer: Polis University, Albanian Geotechnical Society and Co-PLAN
Contact person: Msc. Eng. Erion Bukaçi
Address: Polytechnic University of Tirana, Faculty of Civil Engineering,1001, Tirana, Albania
E-mail: erion.bukaci@gmail.com, Correspondence and information, MSc. Eng. Erdi Myftaraga (erdi.myftaraga@hotmail.com), Prof. Dr. Luljeta Bozo (lulibozo@gmail.com)
Event Diary (Con’t)

2015

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

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

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

2016

First South African Geotechnical Conference 5 - 6 May 2016
Date: Thursday 05 May 2016 - Friday 06 May 2016
Location: Sun City,25.3403° S, 27.0908° E, South Africa
Language: English
Organizer: Geotechnical Division of the South African Institution of Civil Engineering (SAICE)
E-mail: info@geotechnicaldivision.co.za
Website: www.geotechnicaldivision.co.za
Event Diary (Con’t)

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

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

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

SEAGC2016
Date: Tuesday 31 May 2016 - Friday 03 June 2016
Location: Dorsett Grand Subang, Subang Jaya, Selangor, Malaysia
Language: English
Organizer: Malaysian Geotechnical Society and Institution of Engineers, Malaysia
Contact person: SEAGC2016 Secretariat
Address: c/o IEM Training Centre Sdn Bhd, No.33-1A (1st Floor) Jalan 52/18, PO Box 224 (Jalan Sultan), 46720, Petaling Jaya, Selangor, Malaysia
Phone: +(603) 7958 6851
Fax: +(603) 7958 2851
E-mail: seagc2016@gmail.com/ choy.iemtc@gmail.com
Website: www.mygeosociety.org/SEAGC2016
12th International Symposium on Landslides
Date: Sunday 12 June 2016 - Sunday 19 June 2016
Location: Naples, Italy
Language: English
Contact person: Italian Geotechnical Association (AGI)
Address: Viale dell’Università, 11 - 00185, Roma, Italy
Phone: +39 064465569 - 0644704349
E-mail: agi@associazionegeotecnica.it
Website: http://www.isl2016.it/

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

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

Fifth International Conference on Geotechnical and Geophysical Site Characterisation (ISC’5)
Date: Monday 05 September 2016 - Friday 09 September 2016
Location: QT Hotel, Gold Coast, QLD, Australia
Language: English
Organizer: Leishman Associates
Address: 113 Harrington St, 7000, Hobart, TAS, Australia
Phone: 03 6234 7844
E-mail: hannah@laevents.com.au
Website: http://www.isc5.com.au
Event Diary (Con’t)

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

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

2017

ICSMGE 2017 - 19th International Conference on Soil Mechanics and Geotechnical Engineering, Seoul
Date: Sunday 17 September 2017 - Thursday 21 September 2017
Location: Coex Convention Center, Seoul, Korea
Language: English and French
Organizer: Organising Committee of ICSMGE 2017
Contact person: Ms. Soi LEE
Address: 4F, SUNGJI Building, 192, Bangbae-ro, Seocho-gu, 137-835, Seoul, Republic of Korea
Phone: +82-2-6288-6347
Fax: +82-2-6288-6399
E-mail: secretariat@icsmge2017.org
Website: http://www.icsmge2017.org
Event Diary (Con’t)

2018

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 person: Prof. Charles 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

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GERMANY

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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.

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   www.bbri.be/go/tc211

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