# IS-Glasgow 2019

## 7<sup>th</sup> International Symposium on Deformation Characteristics of Geomaterials

26<sup>th</sup> – 28<sup>th</sup> June 2019 Technology & Innovation Centre, University of Strathclyde, Glasgow, UK



# Programme

www.is-glasgow2019.org.uk



# Welcome

Under the auspices of the Technical Committee Laboratory Stress Strain Strength Testing of Geomaterials (TC101) of the International Society for Soil Mechanics and Geotechnical Engineering, we are delighted to welcome you to the 7<sup>th</sup> International Symposium on Deformation Characteristics of Geomaterials, IS-Glasgow 2019.

The key aim of IS-Glasgow 2019 is to engage with the full spectrum of geotechnical specialists, from early career engineers and researchers through to world-leading experts in academia and industry. The outstanding response from the Geotechnical community has helped move us towards this goal, with 200 papers submitted and accepted for publication in the Symposium Proceedings from participants from 40 countries world-wide. Through our 10 Keynote Lectures, the fifth Bishop Lecture, 17 Theme Lectures, our presenting authors and our exhibitors, IS-Glasgow 2019 will act as a true forum, bringing together researchers and practitioners to explore new directions in geomaterial testing.

Glasgow is a city known as much for its warm hospitality as its innovation. We hope your time here brings many new ideas and collaborations, whether through an insightful Q&A, or over a dram of whisky. Fàilte!

Professor Alessandro Tarantino Chair, University of Strathclyde

> Dr Erdin Ibraim Chair, University of Bristol

Professor Richard Jardine Chair, Imperial College London

Katharine Houston Coordinator, Organising Committee





# Table of Contents

Committees	3
Acknowledgements	7
Sponsors and Exhibitors	8
Conference Themes & Topics	9
Conference Venue (TIC)	.10
Bishop Lecture	.11
Keynote Speakers	.12
Theme Lectures	. 22
Programme at a Glance	. 24
Parallel Sessions	. 27
Poster Presentations	. 38
Laboratory Tour	. 39
Accessibility	. 39
Social Programme	. 40
City of Glasgow	.41
Travel in Glasgow	. 42
Useful Information	. 44

# Committees

## Organised by



Technical Committee Laboratory Stress Strain Strength Testing of Geomaterials (TC101) of the International Society for Soil Mechanics and Geotechnical Engineering



University of Strathclyde



University of Bristol

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# Acknowledgements

The Organising Committee would like to extend its thanks to the following partner organisations which have supported the development of IS-Glasgow 2019.



Glasgow Marketing Bureau



Presented in partnership with the Lord Provost and Glasgow City Council



# **Sponsors and Exhibitors**

We are particularly grateful to the support of our Sponsors and Exhibitors.

#### Sponsors:



Sponsors and Exhibitors:





# **Conference Themes & Topics**

The conference is designed to bring together established practitioners and academics with young researchers in the field of geomaterials, encouraging the application of advanced laboratory testing in research, in integrated site characterisation studies, and in ground modelling.

#### **Technical Core Themes**

#### Advanced laboratory and field testing of geomaterials in saturated and unsaturated states

- Novel sensors for laboratory testing
- Advances in laboratory testing technique
- Digital image and PIV analysis
- Advances in ground investigation and field monitoring
- Geophysical methods
- Advanced sampling
- Particle-scale experimental observation
- Behaviour at geotechnical interfaces

#### From laboratory testing to constitutive and numerical modelling

- Constitutive modelling of geomaterials
- Numerical modelling of boundary value problems
- Physical modelling
- Anisotropy and localisation
- Time dependent responses (ageing, creep)
- Cyclic and dynamic behaviour
- Soil stabilisation (lime, cement, geopolymers, biopolymers, alkaline activation)
- Soil improvement via biological and chemical processes
- Thermal behaviour
- Frozen soils including hydrates
- Mixtures (soils with inclusions)
- Soil-plant interaction

#### Application of advanced testing to practical geotechnical engineering

- Integrated site characterisation
- Performance evaluation of geotechnical structures
- Field monitoring and observational method

# Conference Venue (TIC)

The Technology and Innovation Centre (TIC) was opened in 2015 and houses purpose-built conference and events spaces.

IS-Glasgow 2019 will be taking place across two levels of the building, Level 2 (ground floor) and Level 3. Access to the building is from George Street. All of the Symposium areas are fully accessible. If you need more information, or any assistance, please contact us. Accessibility information can be found on page 39.

Many of our sessions will be held in the Main Auditorium, which incorporates three spaces (A/B/C), see plan below. The Plenary Sessions will be taking place in B/C (combined), with B/C divided for the Parallel Sessions. Make a note of the correct entrances for B&C on Levels 2 and 3, when you are attending the relevant Parallel Sessions.



#### Wifi

Free Wifi is available throughout the building. Passwords will be made available to all delegates on arrival.

#### Page | 10

# **Invited Speakers**

## Bishop Lecture (Thursday 27<sup>th</sup> June, 14.00 – 15.00)

## Introduction to Bishop Lecture (13.45 – 14.00)

Established in honour of Professor Alan W. Bishop with the 1st Bishop Lecture at IS-Seoul 2011, we are delighted that the 5th Bishop Lecture will be hosted here, at IS-Glasgow 2019. "Several challenges in advanced laboratory testing of geomaterials with emphasis on unconventional types of liquefaction tests", will be presented by our invited Speaker, Prof. Junichi Koseki, from the University of Tokyo, Japan.

The 5th Bishop Lecture will be introduced by Dr Laurence D. Wesley from the University of Auckland, New Zealand. IS-Glasgow 2019 will also host the launch of Dr Wesley's new book on Professor Bishop. "THE BISHOP METHOD: The Life and Achievements of Professor Alan W. Bishop, soil mechanics pioneer".



#### Prof. Junichi Koseki, University of Tokyo, Japan

"Several challenges in advanced laboratory testing of geomaterials with emphasis on unconventional types of liquefaction tests"

#### Abstract

On advanced laboratory testing of geomaterials with emphasis on unconventional types of liquefaction tests, it is attempted to report some of the recent challenges in developing/improving laboratory stress-strain soil testing apparatuses and relevant control/measurement techniques.

They include a) local measurements in triaxial tests on prismatic/cylindrical specimens and torsional shear/triaxial tests on hollow cylindrical specimens, b) nondestructive evaluation of particle crushing and inter-particle sliding based on AE measurements, c) special types of liquefaction tests using motor-driven loading devices on specimens with thin sandy layer as well as those consisting of segregated layers with direct/indirect evaluation of local deformation, and d) other special types such as large deformation tests, direct tension tests and long-term tests.

The general lessons learned from these challenges are as follow. Some of the "element" test results need to be analyzed and interpreted as boundary value problems in terms of the stress/strain non-uniformities and the specimen heterogeneity. Possible effects of system compliance should be properly considered as well. Each of the variety of laboratory stress-strain test methods has its specific advantages and limitations. By developing an original way of application, the limitation may turn into an advantage.

# **Keynote Speakers**

## Keynote Lecture 1 (Wednesday 26th June, 09.00-09.45)



#### Torsten Wichtmann, Ruhr-University Bochum, Germany

"Soil behaviour under low- and high-cycle loading – element tests vs. constitutive models"

#### Abstract

In the first part an extensive experimental data base with numerous undrained cyclic triaxial tests performed on Karlsruhe fine sand is presented. In these tests failure was reached after a rather low number of cycles (low-cycle loading). The combined influence of stress or strain amplitude, initial effective stress (isotropic or anisotropic), relative density and sample preparation method (air pluviation vs. moist tamping) is discussed. The influence of particle size, grading and particle shape is quantified based on another test series on natural sands, glass beads and crushed sand mixed with predefined grain size distribution curves. In order to establish a database for a fine-grained soil, a kaolin was tested. The tests with a variation of initial stress and stress or strain amplitude were supplemented by investigations on the influence of the loading frequency, degree of over-consolidation and anisotropy. The influence of plasticity is addressed based on a comparison of cyclic tests on different clays. Both, the data sets for Karlsruhe fine sand and kaolin are freely available in the internet. They may serve as the basis for the development, calibration and inspection of constitutive models dedicated to a low-cycle loading, e.g. for applications in Geotechnical Earthquake Engineering. As an example, some experimental results for Karlsruhe fine sand are compared to the predictions of three advanced constitutive models (hypoplasticity, Sanisand, ISA).

The second part will concentrate on a high-cycle loading, that means a loading with many cycles (N > 103) and relatively small strain amplitudes ( $\epsilon^{ampl} < 10^{-3}$ ). Numerous drained cyclic triaxial tests and some hollow cylinder triaxial tests have been performed, most of them on Karlsruhe fine sand. The effects of the stress or strain amplitude, average stress, relative density, grain size distribution curve, particle shape, a content of non-plastic or plastic fines and a content of shell fragments on the cumulative deformations are discussed. The important role of initial fabric (sample preparation method) is demonstrated, while the geometry and dimensions of the samples are of secondary importance. The effect of multiple changes of the polarization (i.e. direction) of the cycles was found less important than previously thought. Recently, an interesting effect has been observed in tests with bundles of cycles interrupted by monotonic loading phases: The monotonic loading leads to a loss of the cyclic preloading memory, and thus to an increase of the rate of strain accumulation in the next bundle of cycles. The results from tests with 1D, 2D, 3D and 4D cycles are presented, which confirm the amplitude definition for multi-dimensional strain loops incorporated into a high-cycle accumulation (HCA) model. The description of the cumulative strains in the HCA model based on the various test series is discussed.



## Keynote Lecture 2 (Wednesday 26th June, 09.45-10.30)



#### Lidija Zdravkovic, Imperial College, UK

"Integrating laboratory and field testing into advanced geotechnical design"

#### Abstract

The complexities of contemporary geotechnical problems often require application of advanced calculation tools as part of the design process. Developments in congested urban environments, resilience and lifecycle assessment of infrastructure, thermo-hydro-mechanical coupling of soil phases in geothermal energy explorations or in the development of lasting solutions for nuclear waste disposal, are just some of the challenges that can be reasonably confronted only by application of advanced numerical analysis. Examples of practical geotechnical problems are utilised here to demonstrate the process of integrating the numerical input, based on design requirements and ground investigation, to produce accurate and robust numerical models and enable efficient design. Particular focus is placed on the treatment of soil behaviour and the process of integrating laboratory and field experimental evidence to characterise the soil and ground conditions, in conjunction with appropriate constitutive models.

## Keynote Lecture 3 (Wednesday 26th June, 14.00-14.45)



Gioacchino Viggiani, Université Grenoble Alpes, France

"X-Ray and Neutron Tomography for Geomaterials"

#### Abstract

This talk presents a review of some recent technical developments and scientific accomplishments in laboratory experimental testing of geomaterials – with a special focus on imaging, i.e., x-ray and neutron tomography. For each of these two imaging techniques, the basic physics is outlined, an historical review of their use in geomechanics is given, and finally some selected examples are presented, with particular emphasis to the more recent and promising applications. X-rays and neutrons interact differently with the atomic structure of materials, which means that they are highly complementary, in that they can provide different information about the same material. For instance, neutrons interact with hydrogen-rich substances more readily than x-rays, simplifying therefore the identification of water and hydrocarbons. The talk concludes by showing the results of a few very recent studies successfully combining x-ray and neutron tomography.



## Keynote Lecture 4 (Wednesday 26<sup>th</sup> June, 14.45-15.30)



#### Pierre Delage, École des Ponts ParisTech, France

"Macroscopic effects of nano- and microscopic phenomena in clay, soils, and rocks"

#### Abstract

Clay soils and rocks contain a significant proportion of clay minerals that have significant influence of their macroscopic response through the effects of clay-water interactions that, in turn, depends on their plasticity properties. As a consequence, a distinction has to be made between free water, with the same physical properties as that a bulk water, and adsorbed water, resulting from various adsorption mechanisms along the surface of clay minerals. After recalling some bases of clay mineralogy, some mechanisms governing clay-water interactions and their macroscopic hydro-mechanical consequences are described for various typical soils, from soft compressible soils to claystones, also including swelling soils. Besides the diffuse double layer that develops along clay surfaces when enough pore volume is available, the step and progressive placement of consecutive water layers along the surface of clay minerals during hydration are commented, together with their macroscopic effects in both swelling materials and claystones. In the claystones that are considered as possible host rocks for deep geological disposal of radioactive waste, the competition between these mechanisms and the bonding that results from long term diagenesis and calcite re-precipitation provides some explanation on their swelling and self-sealing properties. These mechanisms also help better understand the response of compacted bentonites used as engineered barriers to isolate the wastes.

## Keynote Lecture 5 (Thursday 27th June, 09.00-09.45)



Lyesse Laloui, École Polytechnique Fédérale de Lausanne, Switzerland

"Geothermal structures: from experimental investigation to engineering design"

#### Abstract

Geothermal operation of energy geostructures involves an interplay between the multiphysical phenomena governing the behaviour of soils, geostructures and the interaction between them, mainly characterized by the associated temperature variations. The goal of this lecture is to bring together details regarding in-situ and laboratory tests performed in the framework of energy geostructures, as well as to compile an observational framework in attaining a thorough understanding of the mechanics of soils, structures and the interaction between them in consequence of thermal actions. In this lecture, the outcomes of full-scale in-situ tests focusing on the response of single and group of energy piles to monotonic and cyclic temperature variations are presented. Moreover, the results from laboratory tests are introduced, revealing the related volumetric response and changes in shear strength experienced by the soils at the vicinity of the energy geostructures, as well as the thermal and mechanical interactions at the soil-concrete interfaces. The design and development of the laboratory testing devices, as well as the experimental setup for the in-situ tests are also detailed in the lecture, preceding the corresponding outcomes.



## Keynote Lecture 6 (Thursday 27<sup>th</sup> June, 09.45-10.15)



#### Emmanouil M Tentzeris, Georgia Institute of Technology, USA

"Inkjet-/3D-/4D-Printed mmW Wireless Ultrabroadband Sensor Modules for IoT, Smart Skin and Smart City Applications"

#### Abstract

In this talk, inkjet-/3D-printed antennas, interconnects, "smart" encapsulation and packages, RF electronics, microfluidics and sensors fabricated on glass, PET, paper and other flexible substrates are introduced as a system-level solution for ultra-lowcost mass production of Millimeter-Wave Modules for Communication, Energy Harvesting and Sensing applications. Prof. Tentzeris will touch up the state-of-the-art area of fully-integrated printable broadband wireless modules covering characterization of 3D printed materials up to E-band, novel printable "ramp" interconnects and cavities for IC embedding as well as printable structures for selfdiagnostic and anti-counterfeiting packages. The presented approach could potentially set the foundation for the truly convergent wireless sensor ad-hoc networks of the future with enhanced cognitive intelligence and "rugged" packaging. Prof. Tentzeris will discuss issues concerning the power sources of "nearperpetual" RF modules, including flexible miniaturized batteries as well as powerscavenging approaches involving thermal, EM, vibration and solar energy forms. The final step of the presentation will involve examples from shape-changing 4D-printed (origami) packages, reflectarrays and mmW wearable (e.g. biomonitoring) antennas and RF modules. Special attention will be paid on the integration of ultrabroadband (Gb/sec) inkjet-printed nanotechnology-based backscattering communication modules as well as miniaturized printable wireless (e.g.CNT) sensors for Internet of Things (IoT), 5G and smart strain sensing applications. It has to be noted that the talk will review and present challenges for inkjet-printed organic active and nonlinear devices as well as future directions in the area of environmentally-friendly ("green") RF electronics and "smart-skin' conformal sensors.

## Keynote Lecture 7 (Friday 28th June, 09.00-09.45)



#### Reiko Kuwano, University of Tokyo, Japan

"Experimental investigation of mechanism of internal erosion and development of underground cavities"

#### Abstract

Internal erosion can be a cause of failure in hydraulic structures such as levees, dikes and embankment dams. Sinkholes or cave-in's of the ground are also caused by subsurface cavities forming as a result of internal erosion of soil. The mechanism of two types of internal erosion, suffosion and suffusion, were experimentally investigated. Suffosion, a process to form a sinkhole, was simulated in a series of model tests to clarify key parameters for the growth and properties of subsurface cavity. Suffusion is a type of internal erosion in which the fine particles migrate through the voids between the coarse particles under seepage flow, leaving behind the coarse skeleton. Impacts of suffusion on the mechanical properties of gap graded soil in triaxial compression and torsional shear are presented. Elastic wave measurement was also conducted on the soil subjected to internal erosion, which gives an insight of the role of coarse and fine particles in the mechanical behaviour.



## Keynote Lecture 8 (Friday 28<sup>th</sup> June, 09.45-10.30)



#### Jonathan Chambers, British Geological Survey, UK

"Electrical imaging methods in geotechnical applications: From site investigation to near-real-time monitoring and decision support"

#### Abstract

Electrical imaging methods first came to prominence in the 1990s with the advent of both suitable measurement instrumentation and 2D forward modelling and inversion [imaging] code. In subsequent decades the state-of-the-art has rapidly developed with the emergence of 3D and 4D geoelectrical imaging approaches – enabling electrical imaging to be used for site investigation (2D and 3D) and subsurface monitoring (4D). However, geoelectrical monitoring has largely remained the preserve of the research community due to the lack of appropriate low-cost low-power measurement and data processing systems.

Here the development of a novel geoelectrical characterisation and monitoring approach for near surface geotechnical applications is described. The system, called PRIME (Proactive Infrastructure Monitoring and Evaluation), is based on timelapse electrical resistivity tomography (ERT), which is an electrical geophysical technique used to non-invasively generate images of subsurface resistivity to depths of tens of metres below the ground surface. Resistivity is a useful property to consider as it is sensitive to compositional variations, changes in moisture content, and also ground movement.

PRIME is designed for remote operation, so that ERT images can be captured automatically and streamed in near-real-time via a web interface. The PRIME system comprises four key elements: (1) low-cost, low-power field measurement instrumentation; (2) data telemetry and storage; (3) automated data processing; (4) information delivery via a web dashboard. These elements form the basis of an asset condition and slope stability monitoring approach that provides near-real-time spatial information on both subsurface processes and surface responses.

The use of this approach is illustrated with reference to a series of case studies relating to geotechnical asset monitoring in the road, rail, canal and water utilities sectors. These studies demonstrate that the user-friendly and accessible spatial subsurface monitoring information provided by PRIME strongly complements surface-based observations (e.g. remote sensing or walk over surveys) and discrete sampling (e.g. boreholes and point sensors). Crucially, it provides a means of spatially tracking complex subsurface moisture driven processes at the site scale that would be very difficult to characterise using other approaches.

## Keynote Lecture 9 (Friday 28th June, 14.00-14.45)



Cristina Jommi, Delft University of Technology, the Netherlands & Politecnico di Milano, Italy

"Developing constitutive models of soft soils from laboratory data"

#### Abstract

"Element testing" for the development of constitutive models requires experimental protocols assuring homogenous load and deformation patterns, so that externally measured quantities can be assumed to be representative measures of the soil element stress and strain states. A number of experimental procedures have been suggested to reduce the influence of inhomogeneous deformation due to soil sample - experimental equipment interaction. However, for soft soils including organic material, which typically characterise deltaic environment, recommendations from "good practice" may not be sufficient to guarantee straightforward use of the experimental data in the development of constitutive models. This is due to the unusual combination of low stiffness and high friction angle, which amplifies the effects of the soil sample - experimental equipment interaction, and typically biases the interpretation of both the pre-failure and the at failure experimental information. This difficulty can be circumvented by abandoning the concept of pure "element testing" in favour of a "physical replica" approach, in which the results of laboratory tests are used in a numerical back-analysis, able to account for and separate out the interference of the testing protocol with the measurements. The difference between the "element testing" assumption and the "physical replica" approach is discussed and demonstrated on different ingredients of constitutive models of soft organic soils.



## Keynote Lecture 10 (Friday 28th June, 14.45-15.30)



#### Andrew Ridley, Geotechnical Observations, UK

"Assessing the deformation of geomaterials through field measurements"

#### Abstract

Field measurements are an essential part of nearly all construction projects. Field monitoring is the repeated measurement of a particular parameter over a period of time and is used to evaluate designs, assess the effectiveness of construction methods, control construction progress to avoid unwanted damage, provide warnings of unacceptable performance and prevent failures. Field monitoring is also an effective way of maintaining existing geotechnical assets such as embankments and slopes. When it is done well field monitoring improves stakeholder confidence. This paper discusses the methods used to measure deformations in ground and geotechnical assets (e.g. slopes and retaining structures). It covers nomenclature of the instruments used to measure deformation, the measurement errors associated with them and the techniques used to obtain high quality measurements.

# **Theme Lectures**

## Wednesday 26th June 11.00 – 13.00

Presenter	Theme Lecture Title	Parallel Session	Location
Edward Andò, Laboratoire 3SR, Grenoble, France	Timeseries tomography measurements on granular materials at the grain scale: Capabilities, significance, and future	PS1.1: Laboratory Experimental Techniques: Particle Scale and Fabric	Auditorium A
Beatrice Baudet, University College London, UK	Rate effects on the small strain stiffness of clay	PS 1.2: Geomaterial Behaviour: Compressibility and Time- dependency	Auditorium B
Giovanna Biscontin, Cambridge University, UK	Performance of biochar-enhanced cement stabilised peat	PS 1.3: Geomaterial Behaviour: Coupled Effects	Auditorium C
Lucas Festugato, UFRGS, Brazil	Multiaxial response of reinforced materials	PS 1.4: Treated Geomaterials: Mechanical stabilisation	Conference Room 6&7

## Wednesday 26th June 16.00 – 18.00

Presenter	Theme Lecture Title	Parallel Session	Location
Catherine O'Sullivan, Imperial College London, UK	The particle-scale mechanics of internal erosion by suffusion	PS 1.5: Geomaterial Behaviour: Fabric and Fabric Evolution	Auditorium A
Anna d'Onofrio, University of Naples, Italy	Factors affecting the cyclic behaviour of a pyroclastic silty sand	PS 1.6: Geomaterial behaviour: cyclic and dynamic	Auditorium B
Matteo Pedrotti, University of Strathclyde, Glasgow, UK	Colloidal silica nanoparticle-hydrogel as grouting material for hydraulic barrier and soil stabilization: TEM and X-CT analysis on desiccation behaviour	PS 1.8: Treated Geomaterials: Chemical Stabilisation	Conference Room 6&7

## Thursday 27th June 10.45 – 12.45

Presenter	Theme Lecture Title	Parallel Session	Location
Satoshi Nishimura, Hokkaido University, Japan	Small-strain characterisation – new tools and multi-dimensional perspective	PS 2.1: Geomaterial Behaviour: Small Strains	Auditorium A
Adrian Russell, UNSW, Australia	Uniqueness of pore geometry	PS 2.2: Discrete Element Modelling	Auditorium B
Hans Henning Stutz, Department of Engineering, Aarhus University, Denmark	Recent research in soil-structure interface behavior with emphasis on fine and coarse grained soils	PS 2.4: Behaviour at Geotechnical Interfaces I	Conference Room 6&7



## Thursday 27th June 15.30 – 18.00

Duccoutou	The week leaderse Title	Densellel Constant	Leenken
Presenter	Ineme Lecture Ilfie	Parallel Session	Location
Andrea Diambra, University of Bristol, UK	Modelling long-term cyclic response and ratcheting of soils	PS 2.5: Constitutive Modelling	Auditorium A
Dr Nebojsa Kovacevic Geotechnical Consulting Group, UK	Some practical applications of advanced laboratory testing to aid the analysis of slopes and embankments	PS 2.7: Laboratory/Site investigations, Geophysical Methods	Auditorium C
Bernardo Caicedo, University of Los Andes, Colombia	Innovative devices to measure the dynamic response of unsaturated compacted materials	PS 2.9: Behaviour of Unsaturated Geomaterials	Conference Room 7

## Friday 28th June 11.00 – 13.00

Presenter	Theme Lecture Title	Parallel Session	Location
Marcelo Sanchez, Texas A&M University, USA	Coupled THM modeling of evolving fractures in geo-materials	PS 3.1: Numerical Modelling: THCM Coupling, Localisation, Boundary Value Problems	Auditorium A
Gráinne El Mountassir, University of Strathclyde, Glasgow, UK	Engineering Fungal networks for ground improvement	PS 3.2: Treated Geomaterials: Chemical, Microbial	Auditorium B
Jelke Dijkstra, Chalmers University of Technology, Göteborg, Sweden	Challenges in adopting materials science technologies to study fine- grained geo-materials	PS 3.3: Fine grained soils: numerical and experimental investigations	Auditorium C
Jonathan Knappett, University of Dundee, UK	Multi-scale physical modelling of vegetated slopes	PS 3.4: Physical Modelling	Conference Room 6&7

Tuesday 25<sup>th</sup> June

18.15 – 19.30 Registration - Level 2 Foyer

	Wednesday 26 <sup>th</sup> June						
08.00 - 08.45	08.00 – 08.45 Registration - Level 2 Foyer						
		Plenary Session – Auditori	um B&C				
08.45 - 09.00	Opening: A. Tarantino (Chair Organisi	ng Committee), M. Coop (Chair TC101)					
09.00 - 09.45	Keynote Lecture 1: Soil behaviour und	er low- and high-cycle loading – eleme	ent tests vs. constitutive models		Chairs:		
	Torsten Wichtmann, Ruhr-University Boo	chum, Germany			Matthew Coop		
09.45 – 10.30	Keynote Lecture 2: Integrating laborat Lidija Zdravkovic, Imperial College, Uk	tory and field testing into advanced geo	otechnical design		Minna Karstunen		
10.30 - 11.00		Coffee break – Level 2	2 Foyer				
		Parallel Sessions (P	S)				
11.00 - 13.00	0       PS 1.1       Auditorium A       PS 1.2       Auditorium B       PS 1.3       Auditorium C       PS 1.4         Laboratory Experimental       Techniques: Particle Scale and       Geomaterial Behaviour:       Geomaterial Behaviour:       Geomaterial Behaviour:       Geomaterial Behaviour:       Figure 1       Treat         Fabric       dependency       Chair: A. di Donna       Chair: A. di Donna       Chair: A. di Donna       Compressibility and Time-				Conference Room 6&7 comaterials: Mechanical stabilisation Chair: H. H. Stutz		
	Chair: D. Barreto	Chair: A. Ferrari		<b>T</b> I I			
	Laboratoire 3SR, Grenoble, France	University College London, UK	Cambridge University, UK	UFRGS, Braz	rure: Lucas Festugato zil		
13.00 - 14.00		Lunch – Level 2 Foyer					
		Plenary Session – Auditori	um B&C				
14.00 - 14.45	Keynote lecture 3: X-Ray and Neutron Gioacchino Viggiani, Université Grenc	Tomography for Geomaterials bble Alpes, France			<b>Chairs:</b> Catherine O'Sullivan		
14.45 - 15.30	Keynote lecture 4: Macroscopic effects of nano- and microscopic phenomena in clay, soils, and rocks         Simon Wheeler           Pierre Delage, École des Ponts ParisTech, France         Simon Wheeler						
15.30 – 16.00 Coffee break – Level 2 Foyer							
Parallel Sessions (PS)							
16.00 – 18.00	PS 1.5 Auditorium A Geomaterial Behaviour: Fabric and Fabric Evolution Chair: J. Dijkstra	PS1.7 Auditorium C Geomaterial Behaviour: Particle Crushing, Strength, Critical state	PS 1.8 Treated G	Conference Room 6&7 Geomaterials: Chemical Stabilisation hair: R. Cardoso			
	Theme Lecture: Catherine O'SullivanTheme Lecture: Anna d'OnofrioImperial College London, UKUniversity of Naples, Italy		Chair: Y. Nakata	Theme Lec University of	ture: Matteo Pedrotti Strathclyde, Glasgow, UK		

19.00

Welcome Drinks – Glasgow City Chambers

Page | 24

# Programme at a Glance

	Thursday 27 <sup>th</sup> June						
	Plenary Session – Auditorium B&C						
09.00 - 09.45	Keynote Lecture 5: Geothermal strue Lyesse Laloui, École Polytechnique I	<b>ctures: from experimental</b> Fédérale de Lausanne, Sv	l investigation to witzerland	engineering de	sign		Chairs: Alessandro Flora
09.45 – 10.15	Keynote Lecture 6: Inkjet-/3D-/4D- Applications. Emmanouil M Tentzeris, Georgia Inst	Printed mmW Wireless U	Itrabroadband 3	Sensor Modules	for IoT, Smart Skin and	l Smart City	Beatrice Baudet
10.15 - 10.45		Coffee	e break – Level 2	2 Foyer			
		Po	arallel Sessions (P	(S)		_	
10.45 – 12.45	5     PS 2.1     Auditorium A     PS2.2     Auditorium B     PS 2.3     Auditorium C     PS 2.4     Co       Geomaterial Behaviour: Small     Discrete Element Modelling     Discrete Element Modelling     Numerical Modelling of Boundary     Behaviour of Interview       Chair: C. Ferreira     Chair: E. Andò     Value Problems     Chair					Conference Room 6&7 iour at Geotechnical Interfaces I Chair: G. Miller	
	Theme Lecture: Satoshi Nishimura Hokkaido University, Japan	Theme Lecture: Satoshi NishimuraTheme Lecture: Adrian RussellChair: P. GerardTheme LecHokkaido University, JapanUNSW, AustraliaDepartmenUniversity, I			ture: Hans Henning Stutz ht of Engineering, Aarhus Denmark		
12.45 - 13.45		Lunch – Lev	vel 2 Foyer				
		Plenary S	ession – Auditori	ium B&C			
13.45 - 14.00	Introduction to Bishop Lecture: Laurence D Wesley, University of Aug	ckland, New Zealand					<b>Chairs:</b> Hervé Di Benedetto
14.00 - 15.00	5th Bishop Lecture: Several challenges in advanced laboratory testing of geomaterials with emphasis on unconventional types       Richard Jardine         of liquefaction tests       Junichi Koseki, University of Tokyo, Japan						
15.00 - 15.30		Coffee	break – Level 2 F	oyer			
Parallel Sessions (PS)							
15.30 - 18.00	0       PS 2.5       Auditorium A       PS 2.6       Auditorium B       PS 2.7       Auditorium C       PS 2.8       Conference Room 6       PS 2.9       Conference Room 6       Behaviour of         Constitutive Modelling       Laboratory Experimental       Geophysical Methods       Behaviour at Geotechnical       Behaviour at Geotechnical       Geometric         Chair: M. Sanchez       Techniques: Element Scale       Chair: W. W. Moinet       Interfaces II       Chair: A					2.9 Conference Room 7 Sehaviour of Unsaturated Geomaterials Chair: A. Russell	
	Theme Lecture: Andrea Diambra, University of Bristol, UK	Chair: L. Festugato	Theme Lecture Kovacevic, Ge Consulting Gro	: Nebojsa otechnical up, UK	Chair: A. Martinez V	'ela The Cai Anc	me Lecture: Bernardo cedo, University of Los des, Colombia

18.30 - 23.00

Gala Dinner, Kelvingrove Art Gallery and Museum



Friday 28 <sup>th</sup> June							
Plenary Session – Auditorium B&C							
09.00 - 09.45	Keynote lecture 7: Experimental invest Reiko Kuwano, University of Tokyo, Jap	t <b>igation of mechanism of internal erosic</b> Dan	on and development of underground co	avities	<b>Chairs:</b> David Airey		
09.45 – 10.30	Keynote lecture 8: Electrical imaging methods in geotechnical applications: From site investigation to near-real-time Anna d'Onofrio monitoring and decision support Jonathan Chambers, British Geological Survey, UK						
10.30 - 11.00		Coffee break – Level 2	2 Foyer				
		Parallel Sessions (P	S)				
11.00 – 13.00	PS 3.1       Auditorium A       PS 3.2       Auditorium B       PS 3.3       Auditorium C       PS 3.4         Numerical Modelling: THCM       Treated Geomaterials: Chemical,       Fine grained soils: numerical and       Fine grained soils: numerical and       PS 3.4         Coupling, Localisation, BVP       Microbial       Chair E Damara       Chair M Dedretti			PS 3.4 Ph C	Conference Room 6&7 ysical Modelling hair: B. Caicedo		
	Theme Lecture: Marcelo Sanchez       Theme Lecture: Gráinne El Mountassir,       Theme Lecture: Jelke Dijkstra       Theme Lecture         Texas A&M University, USA       University of Strathclyde, Glasgow, UK       Chalmers University of Technology,       University of				ture: Jonathan Knappett f Dundee, UK		
13.00 - 14.00		Lunch – Level 2 Foyer					
		Plenary Session – Auditori	um B&C				
14.00 - 14.45	Keynote lecture 9: Developing constitutive models of soft soils from laboratory data       Chairs:         Cristing Jommi, Delft University of Technology, the Netherlands & Politecnico di Milano, Italy       Ivo Herle						
14.45 – 15.30	Keynote lecture 10: Assessing the deformation of geomaterials through field measurementsGráinne El MountassirAndrew Ridley, Geotechnical Observations, UKGráinne El Mountassir						
15.30 - 16.00	Coffee break – Level 2 Foyer						
16.00 - 16.30	Closing remarks and Announcement of IS-2023 – Auditorium B&C						
16 30 - 18 00		Guided Tour of Geomechanics Labo	pratory - TIC Reception				

#### Wednesday 26<sup>th</sup> June - Morning

PS 1.1: Laboratory Experimental Techniques: Particle Scale and Fabric	P\$ 1.2: Geomaterial Behaviour: Compressibility and Time-dependency
11.00-13.00 Auditorium A	11.00-13.00 Auditorium B
Chair: D. Barreto	Chair: A. Ferrari
Theme Lecture: Timeseries tomography measurements on granular materials at the	Theme Lecture: Rate effects on the small strain stiffness of clay
grain scale: Capabilities, significance, and future Edward Andò Laboratoire 3SR, Grenoble, France	Beatrice Baudet, University College London, UK
01001 Grain Kinematics During Stress Relaxation in Sand: Not a Problem for X-Ray	05001 Genuine and False Pre-Consolidation and Yield Pressures
Imaging	Laurence D Wesley
Jelke Dijkstra, Edward Andò and Christophe Dano	05002 On the Evaluation of Yield Stress of Soils for Debris Flow Analysis
01002 Sand Grains Versus Tiny Glass Granules – Comparative Study on Stress-	Carlos Besso and Tácio Mauro Pereira de Campos
Deformation Characteristics	05003 Influence of Structure on the Compression Behaviour of Two Very Stiff Fissured
<u>Danuta Leśniewska</u> , Iwona Radosz and Magdalena Pietrzak	High Plasticity Eocene Clays
01003 Characterizing Fabric Anisotropy of Air-Pluviated Sands	Kenny Kataoka Sorensen and Maryam Rezaei
Quan Sun, Junxing Zheng, Hantao He and Zhaochao Li	05004 Stress Dependency and Unloading-Induced Swelling Behaviour of a High
01004 An X-Ray CT Study of Miniature Clay Sample Preparation Techniques	Plasticity Overconsolidated Clay of Paleogene Origin
<u>Christopher Ibeh</u> , Matteo Pedrotti, Alessandro Tarantino and Rebecca Lunn	Emil Mejlhede Kinslev, Ole Hededal, Irene Rocchi and Varvara Zania
03008 Investigation of Fabric Evolution Using Bidirectional Shear Wave Velocity	05005 How to Interpret Consolidation and Creep in Yoldia Clay
Measurements	Elena Peri, Lars Bo Ibsen and Benjaminn Nordahl Nielsen
<u>Kazem Fakharian</u> , Farzad Kaviani Hamedani, Iman Parandian and Morfeza	05006 Creep Behaviour of Undisturbed London Clay in Triaxial Stress Space
Jabbarpour Agnaam	Iruong Le, David Airey and Jamie Standing
Mixtures	Volume Change Zone in Engineered Silty Sand
Kevin Vin Anne Laure Fauchille, Khaoula Othmani, Giulio Sciarra, Panagio	Young Hoop Jung Taesun Lee, Ka-Hyun Park and Choopa Ki Chung
Kotronis Vannick Benoit Francois Bertrand and Samuel Branchu	05008 Effects of Loading Rate on Strength and Deformation Characteristics of Gynsum
06005 Study on the Shear Band of Sand with Various Particle Characteristics Using PIV	Mixed Sand
Analysis	Zain Maasood Junichi Koseki and Hirovuki Kvokawa
Shintaro Kajivama, Yukio Nakata, Rvota Mivamoto and Masato Taue	
01006 An Experimental Microstructural Characterization of High-Quality. Load-	
Preserved Fabric 1-D Consolidated Kaolinite Samples	
Jun Kang Chow, Zhaofeng Li and Yu-Hsing Wang	



PS 1.3:	Geomaterial Behaviour: Coupled Effects	PS 1.4:	Treated Geomaterials: Mechanical stabilisation
11.00-1	3.00 Auditorium C	11.00-1	3.00 Conference Room 6&7
Chair: /	A. di Donna	Chair:	H. H. Stutz
Theme	Lecture: Performance of biochar-enhanced cement stabilised peat	Theme	Lecture: Multiaxial response of reinforced materials
	Giovanna Biscontin, Cambridge University, UK		Lucas Festugato, Federal University of Rio Grande do Sul, Brazil
10001	Coupled Thermo-Hydro-Mechanical Behaviour of a Deep Clay	12001	Drained Volumetric Behaviour and Static Liquefaction of Very Loose Sand
	<u>Núria Sau</u> , Enrique Romero and Hervé Van Baelen		Reinforced with Synthetic Fibres
10003	Thermally Induced Pore Water Pressure of Reconstituted London Clay		<u>Xidong Zhang</u> and Adrian R Russell
	<u>Sihua Chen</u> , Lidija Zdravkovic and J. Antonio H. Carraro	12004	Vane Shear Strength of Bio-Improved Sand Reinforced with Natural Fibre
10004	Study of the Mechanical Behaviour of Reclaimed Asphalt Aggregates Without		Mohsin Usman Qureshi, Abdulsalam Al-Hilly, Ola Al-Zeidi, Ashwaq Al-Barrami and
	Binder Addition		Ahed Al-Jabri
	Laura Gaillard, Cyrille Chazallon, Pierre Hornych and Juan Carlos Quezada	12008	Measuring Mechanical Anisotropy on Geogrid Reinforced Soil Using a Cubical
10005	Effect of Heavy Metal Contamination on the Plasticity of Kaolin-Bentonite Clay		Triaxial Apparatus
	Mixtures and an Illite-Smectite Rich Natural Clay		Pedro A. Covassi and <u>Víctor A. Rinaldi</u>
	<u>Abdulla Muththalib</u> and Béatrice A. Baudet	12009	Understanding the Mechanisms of Root-Reinforcement in Soils: Soil Shear Tests
10006	Experimental and Analytical Investigations of Volume Change Behaviour of		Using X-Ray Computed Tomography and Digital Volume Correlation
	Saturated Expansive Soils in Oedometer Test		<u>Daniel Bull</u> , Ian Sinclair, Fabrice Pierron, Tiina Roose and Joel Smethurst
	<u>Misa Hiraga</u> , Hiroyuki Kyokawa and Junichi Koseki	12010	Root Branching Affects the Mobilisation of Root-Reinforcement in Direct Shear
06002	Effect of Inter-granular Void Ratio on Volume Compressibility and Undrained		<u>Gerrit J. Meijer</u> , David Muir Wood, Jonathan A. Knappett, A. Glyn Bengough and
	Shear Response of Base-sand and Natural Silty-sand of Kutch		Teng Liang
	<u>Majid Hussain</u> and Ajanta Sachan	12011	Root-Reinforced Sand: Kinematic Response of the Soil
11012	Monitoring Hydration Process and Quality of Sand Grouted with Microfine-		<u>Floriana Anselmucci</u> , Edward Andó, Luc Sibille, Nicolas Lenoir, Robert Peyroux,
	Cement Using Shear Wave Velocity and Electrical Conductivity Measurements		Chloé Arson, Gioacchino Viggiani and A. Glyn Bengough
	<u>Hyunwook Choo</u> , Hongyeop Nam, Changho Lee, Woojin Lee and Susan Burns	12012	Uprooting of Tree Induced by Typhoon: A Case Study of Super Typhoon
11020	Experimental Analysis of the Effect of Electrokinetic Treatment of Soils		Mangkhut in University Town of Shenzhen
	<u>Sara Gargano</u> , Stefania Lirer, Barbara Liguori and Alessandro Flora		<u>Junwen Huang</u> , Yan Su, Guanyu Zhu, Rui Chen and Xiaofeng Wu
		12014	Multi-Scale Effects on the Hydraulic Behaviour of a Root-Permeated and
			Compacted Soil
			Alessandro Fraccica, Enrique Romero and Thierry Fourcaud



#### Wednesday 26<sup>th</sup> June - Afternoon

PS 1.5:	Geomaterial Behaviour: Fabric and Fabric Evolution	PS 1.6:	Geomaterial behaviour: cyclic and dynamic
16.00-1	8.00 Auditorium A	16.00-1	8.00 Auditorium B
Chair:	J. Dijkstra	Chair:	S. Nishimura
Theme	Lecture: The particle-scale mechanics of internal erosion by suffusion	Theme	Lecture: Factors affecting the cyclic behaviour of a pyroclastic silty sand
	Catherine O'Sullivan, Imperial College, London, UK		Anna d'Onofrio, University of Naples, Italy
03001	Measuring the Fabric Evolution of Particulate Media During Load Reversals in	08001	Behaviour of a Loose Silty Sand under Static and Cyclic Loading Conditions
	Max Wishiska, Edward Andà, Iva Harla and Ciagoshina Viggiani	00000	Denis Ledoeur
03005	<u>Max Webicke</u> , Edward Anao, No Here and Globacchino Viggiani Self-Sealing Canacity of Araillite Samples	06002	Shear Apparatus
00000	Alice Di Donna, Pascal Charrier, Simon Salager and Pierre Bésuelle		Lucia Mele, Stefania Lirer and Alessandro Flora
03006	Insights into Desiccation and Self-Healing of Bentonite in Geosynthetic Clay	08003	Cyclic and Dynamic Behaviour of a Canadian Sensitive Clay
	Liners under Thermal Loads		Anna d'Onofrio, Anna Chiaradonna, Giuseppe Lanzo and Mourad Karray
	<u>Abbas El-Zein</u> , Bowei Yu and Ali Ghavam-Nasiri	08005	Undrained Response of Sydney Sand under Non-Reversal Cyclic Loading
03007	Microscope Observation of Cracks of Clay		Amirabbas Mohammadi and David Airey
	Chen Liang, <u>Yilin Gui</u> and Cees van der Land	08006	Influence of Overburden on Seismic Compression
02015	A Sample Formation Procedure to Obtain Homogeneous Post-Erosion Particle		<u>Eric Yee</u>
	Size Distribution	08007	Shear Modulus and Damping Ratio of a Nonplastic Silt at Large Shear Strains
	<u>Shijin Li</u> and Adrian R. Russell		<u>Alper Sezer</u> , Eyyub Karakan and Nazar Tanrinian
02016	The Effect of Clay Water Content in the Jet Erosion Test	08008	Soil Liquefaction as an Identification Test
01010	Raniero Beber, Alessandro Tarantino, Matteo Pedrotti and Rebecca J.Lunn	00000	Bozana Bacic and Ivo Herle
01010	Soli Microstructural Changes Induced by Suttusion: X-Kay Computed	08009	Cyclic Resistance of a Decomposed Granite
	Tomography Characterization		<u>vienti Haasati</u> ana Aatian R. Russeli
	Cong Dourn Nguyen, <u>Nadia benanmed,</u> Edward Ando, Loc sibilie and Fielle Philippe		
01009	Pore Size Distribution of Brasilia Tropical Soil in 3 Different Initial States		
01007	Camilla Rodriques Borges Brung de Carvalho Earia Ling Lopes and Manoel		
	Porfírio Cordão Neto		

#### Wednesday 26<sup>th</sup> June - Afternoon

PS 1.7: Geomaterial Behaviour: Particle Crushing, Strength, Critical State		PS 1.8: Treated Geomaterials: Chemical Stabilisation	
16.00-18.00 Auditorium C		16.00-18.00 Conference Room	6&7
Chair: Y. Nakata		Chair: R. Cardoso	
09001	Vulnerability of Volcanic Loose Soils Having Cementation and Crushable Particles <u>Itsuki Sato</u> and Reiko Kuwano Weathering-Induced Deformation of Crushed Weak Rocks and its	Theme Lecture:         Colloidal silica nanoparticle-hydrogel as grouting material for hydra barrier and soil stabilization:         TEM and X-CT analysis on desiccation behaviour           Matteo         Pedrotti, University of Strathclyde, Glasgow, UK	ulic
	Countermeasure		
09004	Andius D. Putra, Masaya Takahashi and <u>Mamoru Kikumoto</u> <b>The Influence of Particle Breakage on Stress-Dilatancy Relationship for Granular</b> <b>Soils</b> Zenon Szypcia	11001       Effect of Curing Conditions on Long Term Mechanical Property of Impro         Surplus Soils       Yukika Miyashita, Dayani Sanjeewani and Reiko Kuwano         11010       Study on Progression of Deterioration in Improved Surplus Soils	ved
09005	AE Signature Interpretation of Single Particle Crushing under Uniaxial Compression Sha Luo Erdin Ibraim and Andrea Diambra	Dayani Sanjeewani,       Yukika Miyashita, Reiko Kuwano and Atsunori Negishi         11002       Desiccation Crack in Lime-Treated Silty Clay: Experimental Evaluation         Constitutive Interpretation	and
14005	Design of Crushable Particles in DEM Based on Single Grain Compression Bruna Tedesco, Manoel Porfirio Cordão Neto, <u>Alessandro Tarantino</u> and Márcio Farias	Nicolas Poncelet       and Bertrand François         11003       Multi-Scale Analysis on Soil Improved By Alkali Activated Binders         Enza Vitale, Giacomo Russo and Dimitri Deneele	
14009	High Resolution Incremental Stress Testing of Crushable Granular Materials Matteo Ciantia, Marcos Arroyo and Antonio Gens	11005 Some Geotechnical Behaviour of Silty Clay Improved with Lime and Nanolime Mobd Raihan Taba, Panbarasi Govindasamy and Jamal Alsharef	е
06003	<b>Critical State Lines of Portuguese Liquefiable Sands</b> Catarina Ramos, <u>Cristiana Ferreira</u> , Fausto Molina-Gómez and António Viana da Fonseca	11006       Effects of Cement and Foam Addition on Chemo-Mechanical Behaviou         Lightweight Cemented Soil (LWCS)         Domenico De Sarno, Enza Vitale, Dimitri Deneele, Marco Valerio Nicot	<b>Jr of</b> tera,
06004	The Influence of Rubber Crumbs on the Critical State Behavior of Waste Mixtures Buddhima Indraratna, Yujie Qi, Ana Heitor and Jayan S. Vinod	Raffaele Papa, Giacomo Russo and Gianfranco Urciuoli 11007 Yielding Behaviour of Cemented Bingry Mixture	
06007	Diffuse and Localized Deformation of a Porous Vosges Sandstone in True Triaxial	Sathya Subramanian and <u>Taeseo Ku</u>	
	<u>Cyrille-B Couture</u> and Pierre Bésuelle	Marina Bellaver Corte, Erdin Ibraim, Lucas Festugato, Andrea Diambra and M Cesar Consoli	Nilo



#### Thursday 27th June - Morning PS 2.1: Geomaterial Behaviour: Small Strains PS 2.2: Discrete Element Modelling 10.45-12.45 Auditorium A 10.45-12.45 **Auditorium B** Chair: C. Ferreira Chair: E. Andò Theme Lecture: Small-strain characterisation – new tools and multi-dimensional Theme Lecture: Uniqueness of pore geometry perspective Adrian Russell, UNSW, Australia Satoshi Nishimura, Hokkaido University, Japan 04002 Shear Modulus of Hydrate Bearing Calcareous Sand-Fines Mixture 14002 Characterisation of Contact Parameters of Sand Grains to Be Used for Discrete Litong Ji, Abraham C.F. Chiu, Lu Ma and Chao Jian **Element Modelling** 04003 Stress Path Dependent Small Strain Stiffness of Shanghai Clay K Balamonica and Siang Huat Goh 14004 Simulation of Realistic Particles with Bullet Physics Engine Xiaogiang Gu, Youhong Li, Fayun Liang and Maosong Huang 04004 **Dynamic Testing of Asphalt Mixes** Hantao He, Junxing Zheng, Quan Sun and Zhaochao Li Jean-Claude Carret, Hervé Di Benedetto and Cédric Sauzéat 14006 Particle-Scale Insight into Transitional Behaviour of Gap-Graded Materials -04005 A Semi-Empirical Relationship for the Small-Strain Shear Modulus of Soft Clays Small-Strain Stiffness and Frequency Response Vashish Taukoor, Cassandra J. Rutherford and Scott M. Olson Masahide Otsubo, Troyee Tanu Dutta, Manushak Durgalian, Reiko Kuwano and 04006 Effects of Curing Stress on the Stiffness of a Cement-Mixed Sand Catherine O'Sullivan Sérgio Filipe Veloso Margues, Nilo Cesar Consoli and Lucas Festugato Influence of Stress Anisotropy on Stress Distributions in Gap-Graded Soils 14007 Marion Artigaut, Adnan Sufian, Xiaoxiao Ding, Tom Shire and Catherine 04008 Characteristics of Elastic Waves Passing Through a Flowable Fill at Early Age WooJin Han, Yong-Hoon Byun and Jong-Sub Lee O'Sulli<u>van</u> 04009 Correlation Between Shear Wave Velocity and Effective Confining Pressure Using 14010 A Numerical and Experimental Study of Sand-Rubber Mixtures Subjected to Cyclic Triaxial Testing Apparatus Oedometric Compression Guojun Liu, Noriyuki Yasufuku, Ryohei Ishikura and Qiana Liu Pravin Badarayani, Patrick Richard, Bogdan Cazacliu, Riccardo Artoni and Erdin 04001 Small-Strain Deformation Behaviour of a Clay at Frozen and Unfrozen States: A Ibraim Comparative Study 14012 DEM Analysis of Passive Failure State Behind a Rigid Retaining Wall: Effect of Satoshi Nishimura, Shota Okajima, Jinyuan Wang and Bhakta Raj Joshi **Boundary Conditions** Adlen Altunbas, Behzad Soltanbeigi and Ozer Cinicioglu

#### Thursday 27<sup>th</sup> June - Morning

PS 2.3: Numerical Modelling of Boundary Value Problems		PS 2.4: Behaviour at Geotechnical Interfaces I	
10.45-12.45 Auditorium C		10.45-12.45 Conference Room 6&7	
Chair: P. Gerard		Chair: G. Miller	
16009	Macro-Element Modelling of Suction-Embedded Plate Anchors for Floating Offshore Structures Anderson Peccin da Silva, Andrea Diambra and Dimitris Karamitros Design of Plate and Screw Anchors in Dense Sand: Equive Mechanism, Capacity	Theme Lecture:         Recent research in soil-structure interface behavior with emphasis on fine and coarse grained soils           Hans Henning Stutz, Department of Engineering, Aarhus University, Denmark	
18010	and Deformation <u>Benjamin Cerfontaine</u> , Jonathan Knappett, Michael Brown and Aaron Bradshaw	13001 Characterisation of Sand-Steel Interface Shearing Behaviour the Interpretation of Driven Pile Behaviour in Sands	
16011	Numerical Simulation of Concrete Pile Groups' Response Bored in Cemented Sand Deposit under Axial Static Load Testing <u>Mehdi Aghayarzadeh</u> and Hadi Khabbaz Flasto-Plastic Analysis of a Multi-Stage Excavation in Bonded Geomaterials	Tingfa Liu, Haoruo Chen, Róisín M. Buckley, V. Santiago Quinteros and Richard J. Jardine 13003 Direct Interface Shear Tests on Dunkirk Sand Imane Salama and Christophe Dano	
16014	Hamed Moghaddasi and Arman Khoshghalb Slope Stability Analysis: Barodesy vs Linear Elastic – Perfectly Plastic Models Franz Tschuchniag, Gertraud Medicus and Barbara Schneider-Muntau	13006 Experimental Investigation of the Mechanical Behaviour of Soft Carbonate Rock/Grout Interfaces for the Design of Offshore Wind Turbines	
16015	Geotechnical Risk Analyses and Evaluation of Design Criteria of Embankment Dam Systems	13007 Modelling and Calibration for Cyclic Soil-Structure Interface Behaviour Borana Kullolli, Pablo Cuéllar, Matthias Baeßler and Hans Henning Stutz	
12013	<u>Hector Marquez</u> and Menrad Kamaizare <b>Timber Sheet Pile-Vegetation Model for Stream Bank Retaining Structure</b> <u>Abhijith Kamath</u> , Wolfgang Gard and Jan-Willem Van de Kuilen	<ul> <li>13008 Strength Anisotropy at Soil-Structure Interfaces with Snake Skin Inspired Structural Surfaces         Hans Henning Stutz, <u>Alejandro Martinez</u>, Lars Heepe, Halvor Tram Tramsen and Stanislav N. Gorb     </li> <li>13009 Laboratory Investigation of Interface Shearing In Chalk         <u>Derek L.H. Chan</u>, Róisín M. Buckley, Tingfa Liu and Richard J. Jardine     </li> <li>13010 Interface Shear Strength of Polypropylene Pipeline Coatings and Granular         Materials at Low Stress Level         <u>Lawrence W de Leeuw</u>, Andrea Diambra, Matt S Dietz, George Mylonakis and Henry Milewski     </li> </ul>	



#### PS 2.5: Constitutive Modelling PS 2.6: Laboratory Experimental Techniques: Element Scale 15.30-18.00 Auditorium A 15.30-18.00 Auditorium B Chair: M. Sanchez Chair: L. Festugato Theme Lecture: Modelling long-term cyclic response and ratcheting of soils Andrea Diambra, University of Bristol, UK 02001 Development of Vertical and Horizontal Disk Transducers for Wave Velocity Measurements in a Large Rectangular Specimen Troyee Tanu Dutta, Masahide Otsubo, Reiko Kuwano and Takeshi Sato 02003 Development of a Pore Gas Pressure Transducer Used in Unsaturated Soils at High 15001 Modelling of Undrained Shearing of Soft Natural Clays Water Content <u>Alexandros L. Petalas</u>, Mats Karlsson and Minna Karstunen Rui Chen, Zhongkui Chen, Charles Wang Wai Ng and Jian Liu 15002 Calibration of a Double Structure Constitutive Model for Unsaturated Compacted 02004 Magnetic Measurement System of Sandy Gravel Specimens Shape During Tests in a Soils Large Triaxial Apparatus Giulia Ghiadistri, Lidija Zdravković, David M. Potts and Aikaterini Tsiampousi Roberta Ventini, Alessandro Flora, Stefania Lirer and Claudio Mancuso 15003 Rational Modelling of Elastic Soil Behaviour in 3D Condition 02006 Characterization of Transverse Anisotropy in Poisson's Ratio Using Three-Point Radial Teruo Nakai, Hossain Md. Shahin and Akira Ishikawa **Deformation Measurements** Preliminary Assessment of Variability of Selected Hardening Soil Model 15004 Nabi Kartal Toker and Kemal Sercan Büyükyılmaz Parameters for Glacial Tills and Clays from Poland An Appraisal of End Conditions in Advanced Monotonic and Cyclic Triaxial Testing 02007 Witold Bogusz and Marcin Witowski on a Ranae of Geomaterials 15005 Constitutive Modelling of Gassy Clay Ken Vinck, Tingfa Liu, Emil Ushev and Richard J. Jardine Zhiwei Gao and Yi Hong Non-Axisymmetric and/or Non-Elementary Response of Anisotropic Tuff in 02008 15007 Modelling Shear Strength of Compacted Soils Axisymmetric, Elementary Triaxial Test Yota Togashi, Mamoru Kikumoto, Kazuo Tani, Koichi Hosoda and Koji Ogawa Sam Bulolo and Eng Choon Leong 02010 Quality Assessment of a New In-Mould Slurry Deposition Method for Triaxial Specimen 15009 Triaxial Testing's 1/6th Rule: Particle-Continuum Analysis of Granular Stability **Reconstitution of Clean and Silty Sands** during Compression Camelia Dominguez-Quintans, V. Santiago Quinteros, J. Antonio H. Carraro, Lidija Peter Hoffman Zdravkovic and Richard J. Jardine 15010 Stress-Strain Behaviour of Toyoura Sand in Undrained Triaxial Compression One-Dimensional Consolidation of Overconsolidated Clav Usina Constant Rate of 02011 Katarzyna Dołżyk-Szypcio Strain Testina 15011 **Deformation Dependencies of Sand Stiffness** Joren Andries, Daniel Verastegui, Kim De Beule and An Baertsoen Tomas Sabaliauskas and Lars Bo Ibsen Seepage Test by HCA for Remolded Kaolin 02012 Jian Zhou, Jie Xu, Linghui Luo, Lianggui Yu and Xiaonan Gong The Use of the Hollow Cylinder Apparatus to Study Stress Paths Relevant to Railway 02013 **Track Foundations** Anna Mamou, William Powrie, Jeffrey Priest and Chris Clayton 02014 Triaxial Simple Shear Test: TxSS Mourad Karray and Mohamed Chekired 12007 Use of Particle Image Velocimetry (PIV) Technique to Measure Strains in Geogrids Chaminda Gallage and Chamara Jayalath

Thursday 27<sup>th</sup> June - Afternoon

Thursda	y 27 <sup>th</sup> June	Afternoon
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PS 2.7: Laboratory/Site investigations, Geophysical Methods	PS 2.8: Behaviour at Geotechnical Interfaces II	PS 2.9: Behaviour of Unsaturated Geomaterials	
15.30-18.00 Auditorium C	15.30-18.00 Conference Room 6	15.30-18.00 Conference Room 7	
Chair: W.W. Moinet	Chair: A. Martinez Vela	Chair: A. Russell	
Theme Lecture:         Some practical applications of advanced laboratory testing to aid the analysis of slopes and embankments           Nebojsa Kovacevic, Geotechnical Consulting Group, UK	13011 Characterization of Peak Shear Strength of Rough Rock Joints Using Limited Displacement Multi-	Theme Lecture:Innovative devices to measure the dynamic response of unsaturated compacted materials Bernardo Caicedo, University of Los Andes, Colombia	
<ul> <li>18002 Compacted States and Physical Properties of Soil Controlled by the Degree of Saturation During Compaction <u>Fumio Tatsuoka</u> and Toru Miura</li> <li>18003 Effects of Compaction on Soil Undrained Shear Strength</li> </ul>	Mary MacLaughlin,       Steve Berry, Michael Petro, Katherine Berry and Anders Bro         13012       Preliminary Evaluation of Concrete-Rock Interface Behavior under the Action of Freeze-Thaw Cycles	07001 Investigating the Use of Boyle's Law to Relate Pore Air Pressures and Volume Changes in Unsaturated Triaxial Samples Katherine Kwa and <u>David Airey</u>	
Deteriorating During Undrained Cyclic Loading and Controlling Seismic Stability of Embankment <u>Antoine Duttine</u> , Fumio Tatsuoka and Kazuhiro Ueno           18004         A Proposed Method to Determine In-Situ Shear Modulus and Shear Strain Decay Curves in Different Structured Soil	<u>Chun-Hsing Ho</u> , Kurtis Chivens, Spencer Floyd, Joshua Barger, Kenya Avina and Mitchell Geier 13013 Effect of Interface Friction on Passive Force on Bridge Abutments	<ul> <li>07002 Effect of Water Infiltration on the Mechanical Behaviour of Unsaturated Soil Ali Murtaza Rasool and Jiro Kuwano</li> <li>07003 Effect of Drainage and Saturation on Undrained Shear Strength for Compacted Sandy Soils</li> </ul>	
Ran An, Lingwei Kong, Aiguo Guo and Xianwei Zhang         18005       A Method for Predicting the Influence of Matric Suction         Changes on CPT Tip Resistance       Gerald A. Miller and Rodney W. Collins	Kyle Rollins, Amy Fredrickson and Eric Scott         13014       Shear Strength of Bonded Concrete-Granite Joints under Constant Normal Stress Conditions         Matthieu Briffaut, Bassel El Merchi, Erédéric Dufour,	Yukio Nakata, Tetsuya Tashita, Hiromu Chibana and Kenji Matsukata         07004       Mechanical Behaviour of Unsaturated Undisturbed Black Volcanic Ash Soil under Static and Cyclic Loading	
18006 The Potential of Seismic Cross-Hole Tomography for Geotechnical Site Investigation Yannick Choy Hing Ng, William Danovan and Taeseo Ku	and Grégory Coubard 13015 Geogrid Pull-Out Modelling Using DEM <u>Marcus Guadagnin Moravia</u> , Pascal Villard and	Okri Asfino Putra, Noriyuki Yasufuku, Ryohei Ishikura, Adel Alowaisy and Yuko Kawaguchi 07005 Prediction of Unsaturated Shear Strength from	
Geotechnical Data in Dynamic Response Analysis Mourad Karray, <u>Simon-Pierre Tremblay</u> , Mahmoud N. Hussein and Mohamed Chekired	Delma de Mattos Vidal 13016 Three-Dimensional Numerical Assessment of Axial and Torsional Interface Shear Behaviour	Régis Mpawenayo and <u>Pierre Gerard</u> 07007       Effect of Different Moisture Content and Triaxial Test         Methods on Shear Strength Characteristics of Loess	
18008 Application of Seismic Tomography for Detecting Structural Faults in a Tertiary Formation <u>Víctor A. Rinaldi</u> , Horacio V. Ibarra, Ricardo F. Viguera and Juan C. Harasimiuk	Jiaxing Su, David Frost and <u>Alejandro Martínez</u> 13017 Asperities Effect on Polypropylene & Polyester Geotextile-Geomembrane Interface Shear Behaviour	Yong Wang, Wanli Xie and Guohong Gao         07008       Novel Rapid Measurement System of Undisturbed Soils         Water       Characteristics       Curve       Utilizing the Continuous         Pressurization       Method	
18009 Systematic Slope Stability Assessment Through Deformation Field Monitoring Yukun Wei, Anders B Lundberg and Fredrik Resare	Daniel Adeleke, Denis Kalumba and Johnny Oriokot	AdelAlowaisy,NoriyukiYasufuku,RyoheiIshikura,Masanori Hatakeyama and Shuu Kyono07010A Comparison Between Simple Shear and Triaxial Tests for	
18011 Thermal Design and Full-Scale Thermal Response Test on Energy Walls Jacopo Zannin, Alessio Ferrari, Maxime Pousse and Lyesse Laloui	Interface Soheib Maghsoodi, <u>Olivier Cuisinier</u> and Farimah	Evaluating the Variations of G and D with Matric Suction. Kazem Fakharian, D Shirkavand and Hejazi O7011 An Experimental Investigation on the Water Retention Behaviour of a Silty Soil for the Computation of the Lateral	
18010 Acoustic Emission Instrumentation Method for Slope Monitoring Bernardo Caicedo and Fernando Patino-Ramirez		Earth Thrust on a Retaining Wall Gianluca Speranza, A Ferrari, M Pousse and L Laloui	

Page | 34



Friday 28 <sup>th</sup> June - Morning		
PS 3.1: Numerical Modelling: THCM Coupling, Localisation, Boundary Value Problems	PS 3.2: Treated Geomaterials: Chemical, Microbial	
11.00-13.00 Auditorium A	11.00-13.00 Auditorium B	
Chair: A. Diambra	Chair: E. Romero	
Theme Lecture: Coupled THM modeling of evolving fractures in geo-materials Marcelo Sanchez, Texas A&M University, USA	Theme Lecture: Engineering Fungal networks for ground improvement Gráinne El Mountassir, University of Strathclyde, Glasgow, UK	
16001 Assessing the Impact of Vertical Heat Exchangers on the Response of a Retaining Wall Eleonora Sailer, David M. G. Taborda, Lidija Zdravkovic and David M. Potts	11013 Using Co-polymers to Improve Soil Strength and Mitigate Fugitive Dust Emissions: Laboratory Evaluation Chun-Hsing Ho, Ziyan Wu, Zhonghan Zhang, Pengxiang Zhao and Junxin Huang	
16002 Modelling and Testing of Optimum Soil Moisture Levels in the Corrosion of Underground Pipelines	11014 Measuring Shear Strength Parameters of Polymer-Added Bentonite-Sand Mixtures in Laboratory Experiments	
Note         Note <th< th=""><th>11015 Geotechnical Characteristics of Polystyrene Treated Sand Boyeong Yoon, Jang-un Kim, Jihwan Lee and Woojin Lee</th></th<>	11015 Geotechnical Characteristics of Polystyrene Treated Sand Boyeong Yoon, Jang-un Kim, Jihwan Lee and Woojin Lee	
and Pedro Cleto 16004 Cracking Behaviour of Fine-Grained Soils: From Laboratory Testing to Numerical	11016 <b>Utilization of a Vinyl Based Copolymer for Improvement of a Kaolin Type Clay</b> Irem Bozyigit, <u>Alper Sezer</u> , Batuhan Erez and Burak Kara	
Modelling <u>Pierre Gerard</u> , Ian Murray and Alessandro Tarantino	Emmanuel Salifu and Gráinne El Mountassir	
16005 A Constitutive Model for Locally Drained Shear Bands in Globally Undrained Dense Sand	11018 Preliminary Tests on a Microfluidic Device to Study Pore Clogging During Biocementation	
Hansini Mallikarachchi       and Kenichi Soga         16006       Prediction of Shear Localisation in Granular Materials Based on a Critical State	Filipe Felicio, Vania Silverio, Sotia Duarte, Ana Galvao, Gabriei Monteiro, Susana Cardoso and <u>Rafaela Cardoso</u>	
Non-Coaxial Model <u>Hansini Mallikarachchi</u> and Kenichi Soga	Carbonate Precipitation	
16007 <b>Seismic behaviour of a Large-Scale Concrete-Block Retaining Wall</b> <u>Noboru Sato</u> , Toshikazu Sawamatsu, Takehiko Nitta, Hiroaki Miyatake and Kazuhito Kondo	James M. Minto, Grainne El Mountassir and Rebecca J. Lunn	



# - Internet

# Notes

# **Poster Presentations**

Poster presentations will be on display in the Level 2 Foyer. Authors will be available during the coffee and lunch breaks to discuss their work.

- 02002 Local Measurements of Axial and Radial Strains Using Magnetic Encoders in Triaxial Apparatus Marcin Witowski
- 02009 Influence of Sample Slenderness and Boundary Conditions in Triaxial Test a Review Elena Peri, Lars Bo Ibsen and Benjaminn Nordahl Nielsen
- 04007 Maximum Shear Modulus of Calcareous Sand in Dejebel Dahar, Tunisia and its Dependency on Applied Stress Hyunwook Choo, Minhyuk Kwon, Lamia Touiti and Young-Hoon Jung
- 06006 Soil Particle Movement and Shear Band Development During Plane Strain Compression Junggeun Hwang and Hoe I. Ling
- 12003 Mechanical Behaviour of Reinforced Sand with Natural Curauá Fibers through Full Scale Direct Shear Tests Leila Maria Coelho de Carvalho and Michelé Dal Toé Casagrande
- 12006 Evaluation of Resilient Behavior of a Clayey Soil with Polyethylene Terephthalate (PET) Insertion for Application in Pavements Base Bárbara Carvalho, Michéle Casagrande and Márcio Farias
- 13004 Influence of Thermal Cycles on the Deformation of Soil-Pile Interface in Energy Piles Roxana Vasilescu, Kexin Yin, Anne-Laure Fauchille, Panagiotis Kotronis, Christophe Dano, Richard Manirakiza and Philippe Gotteland
- 14008 Linking Macro-Scale Yielding and Micro-Scale Response Hoang Nguyen and Catherine O'Sullivan
- 17004 Cyclical Changes in Deformation Process in Granular Material in Active State Magdalena Pietrzak
- N/A Laboratory investigations on the material behaviour of plastic concrete Andreas Becker

# Laboratory Tour

Visit the Geomechanics Laboratories at the University of Strathclyde. A guided tour of the laboratory facilities will be on offer at 16.30 – 18.00 on Friday 28<sup>th</sup> June.

The tour will start at the TIC Main Reception at 16.30 and delegates will be guided to the Department of Civil & Environmental Engineering, about a five minute walk from TIC (see map on page 42).

A sign-up sheet will be available at the Registration Area. If you are interested in participating, please add your name to the list by Friday lunchtime.



Information on the laboratory can be found on the University of Strathclyde website: <a href="http://www.strath.ac.uk/engineering/civilenvironmentalengineering/ourfacilities/geomech\_anicslaboratories/">www.strath.ac.uk/engineering/civilenvironmentalengineering/ourfacilities/geomech\_anicslaboratories/</a>

# Accessibility

## TIC

There is level access to the building (Level 2 is the ground floor).

- Lift access is available to all floors.
- All Auditoria have wheelchair spaces for those unable to transfer into a seat.
- All Auditoria and Conference Rooms are fitted with induction loops.
- There are accessible toilets on all floors, which are clearly signposted.
- There are designated safe areas throughout the building for any delegates unable to evacuate using stairs in the event of an emergency situation.

## **Geomechanics Laboratory**

All laboratory spaces are accessible from the street via lifts. Although the laboratory is wheelchair accessible, please note that as this is a working space, some areas may not be reachable due to running experiments.

## Kelvingrove Art Gallery and Museum & Glasgow City Chambers

Both venues are wheelchair accessible.

#### Please advise us if you have any specific access requirements.

# **Social Programme**

During your short time with us at IS-Glasgow 2019, we want our delegates to relax and enjoy a taste of the city and its culture. We have organised our Social Programme with this in mind, and hope you will leave Glasgow wanting to visit again and see more. For details on travelling between our venues, please see page 42.

## Welcome Drinks at the Glasgow City Chambers

In partnership with the Lord Provost and Glasgow City Council, we will be holding a drinks reception at the Glasgow City Chambers (Banqueting Hall) at 19.00 on Wednesday 26<sup>th</sup> June, to officially welcome you to the Symposium and its host city.



#### Gala Dinner at the Kelvingrove Art Gallery and Museum

We are delighted that the IS-Glasgow 2019 Gala Dinner will be held at the magnificent Kelvingrove Art Gallery and Museum, in Glasgow's West End. Guests will be taken to the venue by coach, gathering outside TIC at 18.30 on Thursday 27<sup>th</sup> June. Coaches will return delegates to George Square at the end of the event (around 23.00). If you would like to leave earlier, we will be happy arrange a taxi to collect you.

The Kelvingrove Art Gallery and Museum is one of Glasgow's most stunning public buildings. Opened in 1901, it houses 22 galleries, exhibiting fine art from around the globe, including Dali, Rembrandt, Turner and Glasgow's own Charles Rennie Mackintosh, as well as artefacts from Ancient Egypt, Medieval Scotland and the natural world. As guests, our delegates will have exclusive access to the public collections throughout the evening.

Following a three-course dinner, we will be treating guests to a traditional Scottish Ceilidh, where dancing is not compulsory, but definitely encouraged! Slàinte!





# The City of Glasgow

Scotland's largest city, Glasgow has a history spanning over 1500 years. Famed for its Victorian architecture, its industrial heritage and the warmth of its people, Glasgow is a city worth exploring.

Glasgow has a rich cultural life and many of its world-class museums and galleries are free of charge. Beyond our Gala Dinner venue, the Kelvingrove Art Gallery and Museum, Glasgow is home to the award winning, Zaha Hadid-designed Riverside Museum, the Gallery of Modern Art (a ten minute walk from TIC), Charles Rennie Mackintosh's own Lighthouse Building, and the Centre for Contemporary Arts, amongst many others.

A walk around the city will allow you to experience its architectural history, from its medieval cathedral, through its stunning Victorian buildings, Mackintosh gems and impressive modern structures. When walking the streets of Glasgow City Centre, it pays to look up!

Visit the city's West End to see the neo-Gothic University of Glasgow. Enjoy the area's lush green parks, including Kelvingrove Park and the Botanic Gardens, or visit the Hunterian Art Gallery and Museum, which includes the Mackintosh House.

Glasgow is also renowned for its vibrant and eclectic theatre and music scene, so explore the listing sites, listed below, and enjoy even more of what Glasgow has to offer.

# **Websites**

Information on getting to Glasgow, and on sightseeing in the city and throughout Scotland, can be found on the IS-Glasgow 2019 website: <u>www.is-glasgow2019.org.uk</u>

The official online guide to Glasgow: <u>https://peoplemakeglasgow.com/</u>

Glasgow events calendar, including theatre, live music, visual arts, dance, sport and much more: <u>https://peoplemakeglasgow.com/whats-on</u>

Come rain or shine, see the best of Glasgow from the comfort of a guided bus tour: <u>https://www.citysightseeingglasgow.co.uk/</u>

Tourist Information for Glasgow and Scotland: <u>https://www.visitscotland.com/</u>



# Travel in Glasgow for IS-Glasgow 2019

The IS-Glasgow 2019 Symposium venue (TIC) is located in the City Centre, close to the mainline train stations (Glasgow Central and Queen Street) and Buchanan Street Bus Station (for buses to and from Glasgow International and Edinburgh Airports). Excellent up-to-date advice on travelling to Glasgow can be found on our website: www.is-glasgow.org.uk

All venue addresses can be found on page 44.

Printed city maps will be available to delegates at registration.

For those attending the Welcome Drinks Reception on Wednesday evening, the Glasgow City Chambers can be found on George Square. The Geomechanics Laboratory is located within the Department of Civil and Environmental Engineering on Montrose Street. All venues are five minutes apart on foot.



The Gala Dinner at the Kelvingrove Art Gallery and Museum is a little further afield, in the city's West End. Coaches will be provided (see page 40 for further details) but if you wish to explore this part of the city, or make your own way to/from the venue, the Glasgow Subway is the most convenient way to travel via public transport. The Subway is the third-oldest in the world, and consists of two circle lines, running in either direction, so it is difficult to get too lost! **Please note: Unfortunately the Subway is not wheelchair accessible. If you require assistance or advice, please contact us directly.** 



Buchanan Street and St. Enoch stations are those closest to TIC, with Kelvinhall found within a ten minute walk of the Kelvingrove Art Gallery and Museum. More information, including service timetables, can be found on the Subway website: http://www.spt.co.uk/subway/.



Of course, if you have any questions, do ask one of the Organising Committee or a member of TIC staff.

# **Useful Information**

#### **Venue Details**

Technology & Innovation Centre (TIC) 99 George Street Glasgow G1 1RD T: +44 (0) 141 444 7000 Department of Civil and Environmental Engineering (Geomechanics Laboratory) University of Strathclyde James Weir Building Level 5, 75 Montrose Street Glasgow, G1 1XJ T: +44 (0)141 548 3275

Kelvingrove Art Gallery and Museum Argyle Street Glasgow G3 8AG Glasgow City Chambers 82 George Square Glasgow G2 1DU

#### Climate

Much is said about the Scottish climate and most of it is true! Even in mid-summer you can expect every type of weather in one day. We recommend that you prepare for temperatures in the mid-high teens (Celsius) with high humidity and a chance of rain. However, the weather changes very rapidly in the West of Scotland so checking the forecast is advisable.

#### Transportation

The People Make Glasgow website offers excellent information on getting to Glasgow: https://peoplemakeglasgow.com/visiting/getting-here. Public transport in Glasgow is privatised, with trains, buses and the Subway owned and run by different companies. Therefore different tickets are required for each service. Most of the main tourist sites in the city can be easily reached by train or the Subway. Travelling around Scotland is easily done by rail or coach. Regular train services to Edinburgh run from Glasgow Queen Street Station and coaches run from Buchanan Street Bus Station.

Taxis can be found at designated taxi ranks around the city. Cabs can also be hailed on the street, if the yellow 'taxi' light is illuminated. Licensed taxis accept cash or card payment. Delegates can receive a discount on taxi journeys between the city centre and Glasgow Airport (see below).

Glasgow Subway: <u>www.spt.co.uk/subway/</u> Glasgow and Scotland-wide rail travel, Scotrail: <u>www.scotrail.co.uk/</u> Scotland-wide coach travel: Citylink: <u>www.citylink.co.uk/index.php</u> Stagecoach: <u>www.stagecoachbus.com</u>

## **Delegate Discounts**

The Glasgow Marketing Bureau has kindly provided IS-Glasgow 2019 delegates with discount vouchers. The discount leaflet is available for download on our website homepage: <u>www.is-glasgow2019.org.uk</u>. Vouchers are redeemable on a wide variety of services and destinations with your delegate badge.

Page | 44













