



# GEOQuébec 2015

September 20-23, 2015, Québec City  
20 au 23 septembre 2015, Québec

*Challenges from North to South  
Des défis du Nord au Sud*

Conference Program | **Abstracts**  
QUÉBEC CITY CONVENTION CENTRE, CANADA

Programme de la conférence | **Résumés**  
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# GREETINGS (CO-PRESIDENTS)

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Dear Delegates and Authors,

On behalf of the **GEOQuébec 2015** organizing committee, we are very pleased to welcome you to the magnificent and UNESCO world heritage site that is Québec City for the 68<sup>th</sup> Canadian Geotechnical Conference and the 7<sup>th</sup> Canadian Permafrost Conference.

Under the umbrella of the Canadian Geotechnical Society (CGS) and its Eastern Québec local section, as well as the Canadian National Committee for the International Permafrost Association, the local organizing committee is confident that the conference will be memorable from both the technical and social standpoints.

**The theme of our conference: “Challenges from North to South”** reflects the desire of North American communities to find solutions to significant issues, particularly those pertaining to geosciences or geoen지니어ing applied to the adaptation to climate change in northern regions. These adaptation efforts are socially, economically and technically very important. The theme also recalls the duality between summer and winter which the people of Québec City have handled so well for so long and which makes this city so unique.

Our technical program focuses on this theme and is spread over three days. It comprises **380 manuscripts, which will be presented** during **63 sessions** of oral presentations and **three poster sessions**. The program also includes a **Symposium in honour of J.R. Mackay**, a prominent Canadian geocryologist who passed away in 2014. During our morning plenary sessions, we will have the opportunity to hear from distinguished speakers: Jean-Marie Konrad (R.M. Hardy Keynote Address), Steven V. Kokej (First J.R. Mackay Lecture), Jean Hutchinson, Guy Doré, Lukas Arenson (keynote speakers) and Greg Siemens (CGS Colloquium). To continue the tradition, our conference offers **short courses** and **technical tours** that will assuredly be of great interest. We are also proud to report that the trade exhibition is sold out and that trade show sessions are planned in the program.

After these busy days we invite you to social events, starting with the Sunday night **Ice breaker cocktail**. This will be followed by the annual **gala and banquet** on Monday night and our very special **Québec local colour night** on Tuesday night. The colour night will be held on the Louis-Jolliet boat and will offer a breathtaking view of the city at sunset, as Québec City and the *Château Frontenac* will be lit up for the night. Several exciting activities are also planned for students, young professionals and accompanying people.

The success of this conference rests on our local organizing committee, who has worked really hard along with the many stakeholders to offer a most successful conference. Many thanks, dear friends! We would also like to acknowledge the support provided by our sponsors and our exhibitors who financially contribute in making this conference a success.

Finally, we would like to thank you, members and guests, for your participation. We hope that you will enjoy the conference and your stay with us in Québec City!

**Jean Côté**  
*Co-chair (geoen지니어ing)*

**Michel Allard**  
*Co-chair (permafrost)*



# MOT DE BIENVENUE (COPRÉSIDENTS)

Chers délégués et auteurs,

Au nom du comité organisateur de **GEOQuébec 2015**, c'est avec un immense plaisir que nous vous accueillons à Québec, ville magnifique et joyau du patrimoine mondial de l'UNESCO, pour la 68<sup>e</sup> Conférence canadienne de géotechnique et la 7<sup>e</sup> Conférence canadienne sur le pergélisol. Sous l'égide de la Société canadienne de géotechnique, de sa Section régionale de l'Est-du-Québec, ainsi que du Comité national canadien de l'Association internationale du pergélisol, le comité local a organisé une conférence mémorable, à la fois techniquement et socialement.

**Le thème de notre conférence : « Des défis du Nord au Sud »** reflète le désir des communautés nord-américaines de répondre à des enjeux importants en matière de géoscience et de géotechnique appliquées à l'adaptation au changement climatique dans les régions nordiques. Ces efforts d'adaptation revêtent une importance majeure sur les plans sociaux, économiques et techniques. Ce thème rappelle aussi la dualité entre l'été et l'hiver que les gens de Québec ont si bien su exploiter depuis tant d'années et qui en a fait une ville unique en son genre.

Axé sur ce thème, notre programme technique, qui s'étend sur 3 jours, regroupe **380 articles** répartis en **63 séances de présentations orales** et **trois séances d'affiches**. Le programme inclut aussi le **Symposium en l'honneur de J.R. Mackay**, réputé géocryologue canadien qui nous a quitté en 2014. De plus, lors de nos conférences plénières en matinée, nous aurons l'occasion d'entendre plusieurs orateurs éminents : Jean-Marie Konrad (allocation R.M. Hardy), Steven V. Kokelj (première allocution J.R. Mackay), Jean Hutchinson, Guy Doré et Lukas Arenson (conférenciers d'honneur), ainsi que Greg Siemens (colloque géotechnique). Comme c'est la tradition, notre conférence offre plusieurs **cours intensifs** ainsi que des **visites techniques**. Nous sommes aussi heureux d'annoncer que le salon des exposants affiche complet, et que des séances de présentations sur la pratique professionnelle sont aussi au programme.

À la fin de ces journées bien remplies, nous vous convions à des activités sociales, en commençant par le **cocktail brise-glace** du dimanche soir. Suivront le **gala/banquet annuel** du lundi soir et notre toute spéciale **soirée à saveur locale** du mardi soir qui se déroulera sur le bateau Louis-Jolliet : vous aurez une vue époustouflante sur la ville au coucher du soleil, alors que Québec et le Château Frontenac s'illumineront pour la nuit. Plusieurs activités excitantes pour les étudiants et les jeunes professionnels, ainsi que pour les conjoints, sont aussi au programme.

Le succès de notre conférence revient à notre comité local qui a travaillé fort avec les divers intervenants pour vous proposer une grande conférence. Mille mercis chers amis! Nous aimerions aussi souligner le support de nos commanditaires et de nos exposants qui contribuent financièrement au succès de cette conférence.

En terminant, nous vous remercions tous, chers collègues et amis, de votre participation et vous souhaitons une excellente conférence et un agréable séjour chez-nous à Québec.

**Jean Côté**  
*Coprésident (géotechnique)*

**Michel Allard**  
*Coprésident (pergélisol)*



# GREETINGS (CGS)

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Dear Conference Delegate

As President of the Canadian Geotechnical Society, I am delighted to welcome you to the 68<sup>th</sup> annual Canadian Geotechnical Conference (GEOQuébec 2015 "Challenges from North to South") in beautiful and historic Québec City. I believe that this annual conference, the centrepiece of CGS activities, is the longest continuously held geotechnical conference in the world, being first held in 1947.

I am particularly pleased that this conference is being held jointly with the 7<sup>th</sup> Canadian Permafrost Conference. The resulting large number of technical papers, presentations and posters cover a wide range of topics in many different fields, and this is the hallmark of the geotechnical profession. I know it will be a difficult task for you to decide which of the many presentations to attend.

But CGS annual conferences are more than just excellent presentations and posters. The interchange, both technically and socially, between the delegates from academia (both faculty and students), consulting, government, industry, contractors, and equipment and manufacturers of geotechnical-related products is just as important. Roll this all into an excellently planned and executed event, I know that this conference will be a success.

I would personally like to thank the Co-Chairs of the Local Organizing Committee of GEOQuébec 2015, Jean Côté and Michel Allard, as well as the Secretary of the Canadian National Committee for the International Permafrost Association, Sharon Smith, for all the hard work they, and their committees, did to organize this event. Also thanks to the corporate sponsors and exhibitors whose financial assistance kept the registration fees low.

In closing, I would like to thank you for attending "GEOQuébec 2015". I wish you an enjoyable time at the conference - meeting old colleagues and making new friends. And don't forget to enjoy all that Québec City has to offer!

**Doug VanDine**

President, Canadian Geotechnical Society



# MOT DE BIENVENUE (SCG)

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Chers participants,

À titre de président de la Société canadienne de géotechnique (SCG), c'est avec plaisir que je vous accueille à la 68<sup>e</sup> Conférence canadienne annuelle de géotechnique intitulée GEOQuébec 2015 « Défis du Nord au Sud » dans la belle ville historique de Québec. Je crois que cette conférence annuelle, l'activité phare de la SCG, est la conférence géotechnique ayant été le plus longtemps tenue sans interruption sur le plan mondial, et ce, depuis la première conférence en 1947.

Je suis particulièrement heureux que cette conférence soit organisée conjointement avec la 7<sup>e</sup> Conférence canadienne sur le pergélisol. Le grand nombre d'articles, de présentations et d'affiches résultant de cette association couvre un large éventail de sujets touchant à plusieurs domaines différents, et ceci est propre au milieu de la géotechnique. Je sais que ce sera une tâche difficile pour vous de décider à laquelle des nombreuses présentations vous assisterez.

Il faut cependant dire que les conférences annuelles de la SCG sont bien plus que d'excellentes présentations et affiches. Les échanges, à la fois techniques et sociaux entre les participants des milieux universitaires (professeurs et étudiants), les consultants, les représentants du gouvernement, les membres de l'industrie, les entrepreneurs et les fabricants de produits reliés à la géotechnique, sont tout aussi importants. L'amalgame de tout cela à l'intérieur d'un événement très bien planifié et pris en charge me permet déjà de dire que cette conférence sera un succès.

Je tiens à remercier personnellement les coprésidents du Comité organisateur local de GEOQuébec 2015, messieurs Jean Côté et Michel Allard, sans oublier la secrétaire du Comité national canadien de l'Association internationale du pergélisol, madame Sharon Smith, pour tous les efforts qu'eux et leurs comités respectifs ont déployés pour organiser cet événement. Je tiens également à remercier les commanditaires et exposants qui, grâce à leur aide financière, ont permis de maintenir de bas frais d'inscription.

En terminant, je voudrais vous remercier de votre participation à ce rendez-vous annuel. Je vous souhaite de vivre des moments agréables lors de la conférence, que ce soit en rencontrant d'anciens collègues ou en faisant de nouvelles connaissances. N'oubliez surtout pas de profiter de tout ce que la ville de Québec a à offrir !

**Doug VanDine**

Président, Société canadienne de géotechnique.

# GREETINGS (CNC-IPA)

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On behalf of the Canadian National Committee for the International Permafrost Association (CNC-IPA), I would like to welcome you to GEOQuébec 2015. We are very pleased to be a co-sponsor of the 68<sup>th</sup> Canadian Geotechnical Conference and the 7<sup>th</sup> Canadian Permafrost Conference. The 5<sup>th</sup> Canadian Permafrost Conference was held 25 years ago in Québec City, and we are very happy to welcome you back to beautiful and historic city.

The Canadian Permafrost Conference is one of the few occasions that bring together permafrost scientists, engineers and practitioners. The northern environment presents us with a number of challenges with respect to infrastructure and resource development and the research presented at this conference will help us to deal with these challenges. You will enjoy many interesting presentations and have fruitful discussions with many of the conference attendees.

Conferences like this do not happen without a lot of hard work by dedicated people. I would like to thank CGS President Doug VanDine and the local organizing committee and especially the Co-Chairs Jean Coté and Michel Allard. Didier Perret and Richard Fortier, the technical committee Chairs, along with the session organizers have worked hard to ensure that you will hear many interesting presentations and also have a record of the proceedings. The efforts of the review team are very much appreciated. The support provided by the corporate sponsors and exhibitors is also greatly appreciated. Finally, I would like to thank all of you for attending the conference, including the many scientists, engineers and the students who will present their work.

I hope that you enjoy the conference, including all the social activities which will allow you to meet old friends and also make new friends. And make sure you also take time to enjoy all that this beautiful city has to offer.

**Sharon Smith**

Secretary of the CNC-IPA



# MOT DE BIENVENUE (CNC-IPA)

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Au nom du Comité national canadien de l'Association internationale du pergélisol (CNC-AIP), permettez-moi de vous souhaiter la bienvenue à GEOQuébec 2015. Nous sommes très heureux d'être un partenaire de la 68<sup>e</sup> Conférence canadienne de géotechnique et de la 7<sup>e</sup> conférence canadienne sur le pergélisol. La 5<sup>e</sup> Conférence canadienne sur le pergélisol s'est tenue à Québec il y a 25 ans et nous sommes ravis de pouvoir vous accueillir à nouveau dans cette ville charmante et riche en histoire.

La Conférence canadienne sur le pergélisol est l'une des rares occasions pour les chercheurs, ingénieurs et autres professionnels œuvrant dans le domaine du pergélisol de se réunir. Les recherches présentées à la conférence nous aideront à faire face aux nombreux défis que pose l'environnement nordique, notamment au niveau des infrastructures et de l'exploitation des ressources. Vous pourrez profiter de nombreuses présentations intéressantes et vous aurez des discussions constructives avec d'autres participants de la conférence.

Les conférences comme celles-ci sont possibles grâce au travail acharné de plusieurs personnes dévouées. J'aimerais donc remercier le président de la Société canadienne de géotechnique, M. Doug VanDine, de même que le Comité organisateur local, et tout particulièrement les coprésidents, M. Jean Côté et M. Michel Allard. Les codirecteurs du programme technique, M. Didier Perret et M. Richard Fortier, ont travaillé fort, avec l'aide des organisateurs de séances, afin que vous puissiez profiter de nombreuses présentations intéressantes et obtenir une copie des actes de la conférence. Les efforts de l'équipe de révision, ainsi que le support fourni par les commanditaires et les exposants sont également grandement appréciés. Enfin, j'aimerais remercier chacun d'entre vous qui assisterez à cette conférence, en particulier les nombreux scientifiques, ingénieurs praticiens et étudiants qui présenteront leurs travaux.

J'espère que vous apprécierez la conférence, y compris les activités sociales, qui seront l'occasion de renouer avec de vieilles connaissances et de faire de nouvelles rencontres. Et n'oubliez pas de prendre le temps de profiter de tous les attraits de cette belle ville.

**Sharon Smith**

Secrétaire du CNC-AIP



# ORGANIZING COMMITTEE / COMITÉ ORGANISATEUR

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**Jean Côté**

Université Laval, Co-Chair / Coprésident

**Michel Allard**

Université Laval, Co-Chair / Coprésident

**Didier Perret**

Natural Resources Canada – Geological Survey of Canada – Technical Program Co-Chair (geotechnical) / Ressources naturelles Canada – Commission géologique du Canada – Coprésident du programme technique (géotechnique)

**Richard Fortier**

Université Laval, Technical program Co-Chair (permafrost) / Coprésident du comité technique (pergélisol)

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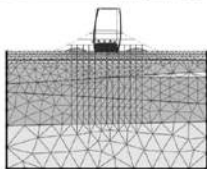


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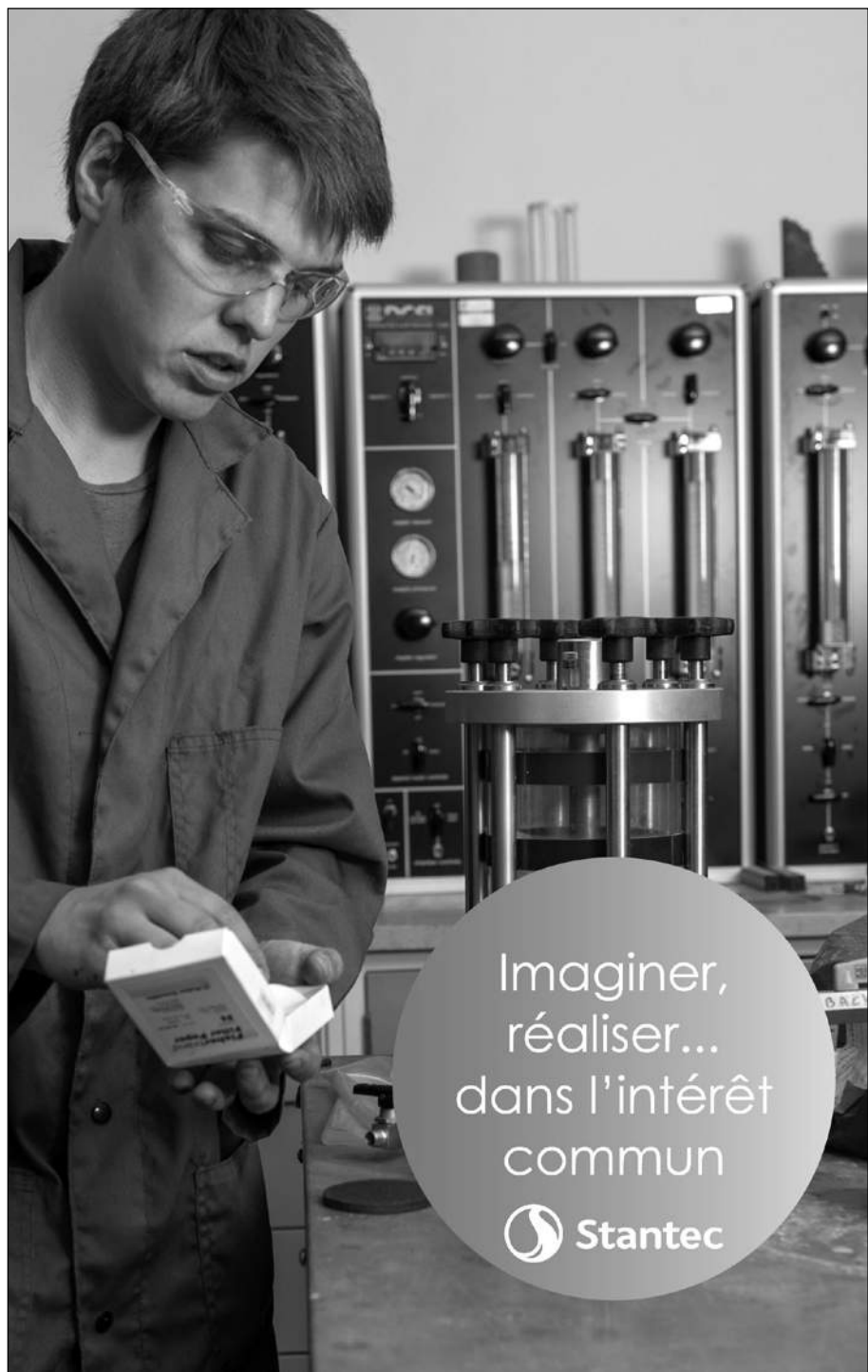
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Campbell Scientific (Canada) Corp. is a provider of rugged, reliable data acquisition systems for Geotechnical Monitoring applications in cold regions. Applications include slope stability, bridge monitoring, structural monitoring, mining, seismology, and hydrology among many others.



Canary Systems provides cost-effective, reliable, state-of-the-art data collection and information systems to a broad market range, including civil engineering, geotechnical engineering, mining, environmental, meteorological, and many more. This includes instrumentation selection, system architecture, hardware and software development, database development and web online data access systems.



CEMATRIX provides lightweight engineered fills for bridge abutments/approaches; MSE panel and retaining wall backfill; insulating road base; tunnel grout and void fill.

CEMATRIX fournit des matériaux de remplissage légers pour les approches et les culées de pont; pour le remblai de murs de soutènement en terre stabilisée mécaniquement (MSE); pour les fondations de chaussée isolantes; pour l'injection de tunnel et combler les vides.



ConeTec Investigations is an international site investigation company with offices in Canada, the United States and South America. ConeTec specializes in the design and use of some of the most advanced in-situ testing equipment available. ConeTec operates a wide range of CPT equipment, sampling systems and seismic testing equipment.





Manufacturation et distribution : Systèmes Crépines pour Puits d'Observation, Piézomètre, Bentonite Polymères et fluides de forage Cetco, Silice, Boyaux, Tuyaux et Raccords, Tube Shelby, Plaque de Tassement, Sonde et enregistreur de données pour nappes d'eau souterraines pression, température, conductivité.

## Firestone

BUILDING PRODUCTS • PRODUITS DE BÂTIMENT • CANADA

With over a hundred years of experience working with rubber and polymer technology and over 40 years in the lining industry, Firestone's GeoGard™ EPDM is proven to be most effective for critical containment applications.



With offices in Montréal, Vancouver and Toronto, Geopac is a nationally renowned specialty contractor, offering proven expertise in the design and execution of ground improvement and geotechnical solutions.

Avec des bureaux à Montréal, Vancouver et Toronto, Geopac est un entrepreneur spécialisé de renommée nationale offrant une expertise prouvée dans la conception et l'exécution de travaux d'amélioration de sol et de solutions géotechniques innovatrices.



Hayward Baker is North America's leader in geotechnical construction and has extensive experience in the full range of geotechnical construction applications. Contact us to see how you can put Hayward Baker's experience to work for you.



HeyJute™ is an Innovative company that offers Environmentally Conscious, Packaging, Promotional Branding, Geo-textile & Erosion Control solutions in a market otherwise saturated by toxic synthetic alternatives. HeyJute™ operates without compromising the Planet or its People.



For over fifty years, Hoskin Scientific has been a supplier of testing and monitoring instrumentation to the Canadian market with offices in Vancouver, Burlington, and Montreal and our three major departments: Material Testing/Petrochemical, Environment, Instrumentation.

Hoskin Scientifique fournit des instruments de mesure, d'échantillonnage ainsi que de surveillance pour le marché canadien avec des bureaux à Vancouver, Burlington et Montréal et nos trois départements : Essai des matériaux / pétrochimie, environnement et instrumentation.





Layfield Environmental Containment is a vertically integrated leading North American manufacturer of flexible geomembrane liners and floating covers. Layfield manufactures some of the industry's most popular brands of geomembranes including our Enviro Liner® and HAZGARD® geomembranes.



LOADTEST, DEEP FOUNDATION RISK MANAGEMENT: Applying state-of-the-art deep foundation analysis, quality control and testing with SoniCaliper® confirmed excavation quality, Osterberg Cell® design calibration, and RIM-Cell® Reliability Improvement Method production foundation verification.

## MACCAFERRI

Maccaferri is a world leader in innovative environmental solutions, including solutions in retaining wall systems, reinforcement of steep slopes, embankments, drainage systems, geosynthetics for basal and soft soils improvement, rockfall mitigation and soil erosion control.



Measurand Inc. is a leader in shape-sensing technology. SAA (ShapeAccelArray), is an inclinometer-type instrument used for monitoring & measuring deformation in a variety of Geotechnical or Civil Engineering applications.

## MORETRENCH

No one has seen more.™

Moretrench Canadian Corporation, based in Calgary, Alberta, is a geotechnical contractor specializing in ground freezing to provide excavation support, water cut-off, and soil stabilization for underground construction, including deep shafts, tunnels, cross passages, and launch/retrieval boxes.



The GNWT Department of Transportation is responsible for operating and maintaining public transportation infrastructure in the NWT. The Department supports climate change research and development initiatives which help ensure a resilient transportation system for the future.





Mobile Augers is a western Canadian based geotechnical / environmental site investigation firm providing a full range of professional drilling services. Now providing real-time QA sampling results, straight from the field to your web browser.



Plasti-Fab® manufactures expanded polystyrene (EPS) geofoam products for geotechnical engineering applications. EPS geofoam products are available with a range of compressive resistance for uses such as insulating structures and reducing stresses on underlying or adjoining soils/structures.

Finite element software PLAXIS is widely used in Canadian geotechnical world for soil and rock modeling. PLAXIS is known as user-friendly, versatile and sophisticated, with special modules for coupled hydraulic mechanical, dynamic, and thermal modeling.



PSI Technologies provides engineering, CCIL certified lab testing, numerical modeling, mining, construction services and is the North American representative for CONTROLS Group equipment, providing testing equipment for soils, aggregates, asphalts, geologic media, and concrete.



**REINFORCED EARTH®**

Reinforced Earth Company Ltd. provides worldwide leadership in the design and supply of innovative civil & geotechnical engineering solutions.



Rocscience has been creating easy to use, reliable geotechnical software since 1996. We specialize in 2D and 3D analysis and design programs for civil engineering and mining applications.



Since 1967 Roctest has designed and manufactured instruments using the most effective technologies for its vibrating wire and fiber-optics products. Roctest is recognized as the global leader for geotechnical monitoring solutions with thousands of projects worldwide.







Founded in 1977, RST Instruments Ltd. is a world leader in the design, manufacturing and sale of innovative geotechnical, environmental and structural monitoring instruments for major dams, mines, tunnels, pipelines, bridges and buildings.



Sobek Technologies offers Geotec - a geotechnical software allowing infinite possibilities for the exploration, design and construction phases of a project - including the production of logs, laboratory tests results, profile views, 3D modeling and quantity calculation.

**Société  
du Plan Nord**

**Québec** 

La SPN, dans une perspective de développement durable, contribue au développement intégré et cohérent du Nord québécois, selon les orientations gouvernementales et en concertation avec les représentants locaux et autochtones et du secteur privé.

The SPN, in a sustainable development perspective, contributes to the integrated and coherent development of northern Québec, in accordance with governmental policy directions and in collaboration with local, aboriginal and private sector representatives.



SoilVision Systems Ltd. provides next-generation finite-element and slope stability numerical modeling software to geotechnical engineers worldwide. Our cutting-edge software products offer features such as automatic mesh refinement, unsaturated soils, and 3D analysis.



At Stantec, we take on complex site conditions across multiple sectors to transform communities. For over 40 years, our geotechnical engineers and material specialists have solved design, construction, and rehabilitation challenges across Canada.



TenCate Geosynthetics is the global leader in geosynthetics. Our geogrids and geotextiles are engineered with advanced application knowledge to meet project specifications for transportation construction, mechanically stabilized earth, erosion control, water and waste management.





Terraquavi est spécialisée dans la fabrication et la distribution de produits de contrôle environnemental. Nous manufacturons une vaste gamme de produits de gestion des sédiments telle que des rideaux de confinement et des poches de décantation.



TRUMER is a leader in geohazard mitigation for rockfall, debris flow, avalanche and slope stabilisation. From slope mesh to massive barriers, we protect life, buildings and infrastructure where failure is not an option.



UniSoft GS specializes in the development and publishing of geotechnical engineering software. Our flagship products are UniSettle 4.0 and UniPile 5.0. Software applications dedicated to the computation of soil consolidation, pile capacity, and pile group settlement.

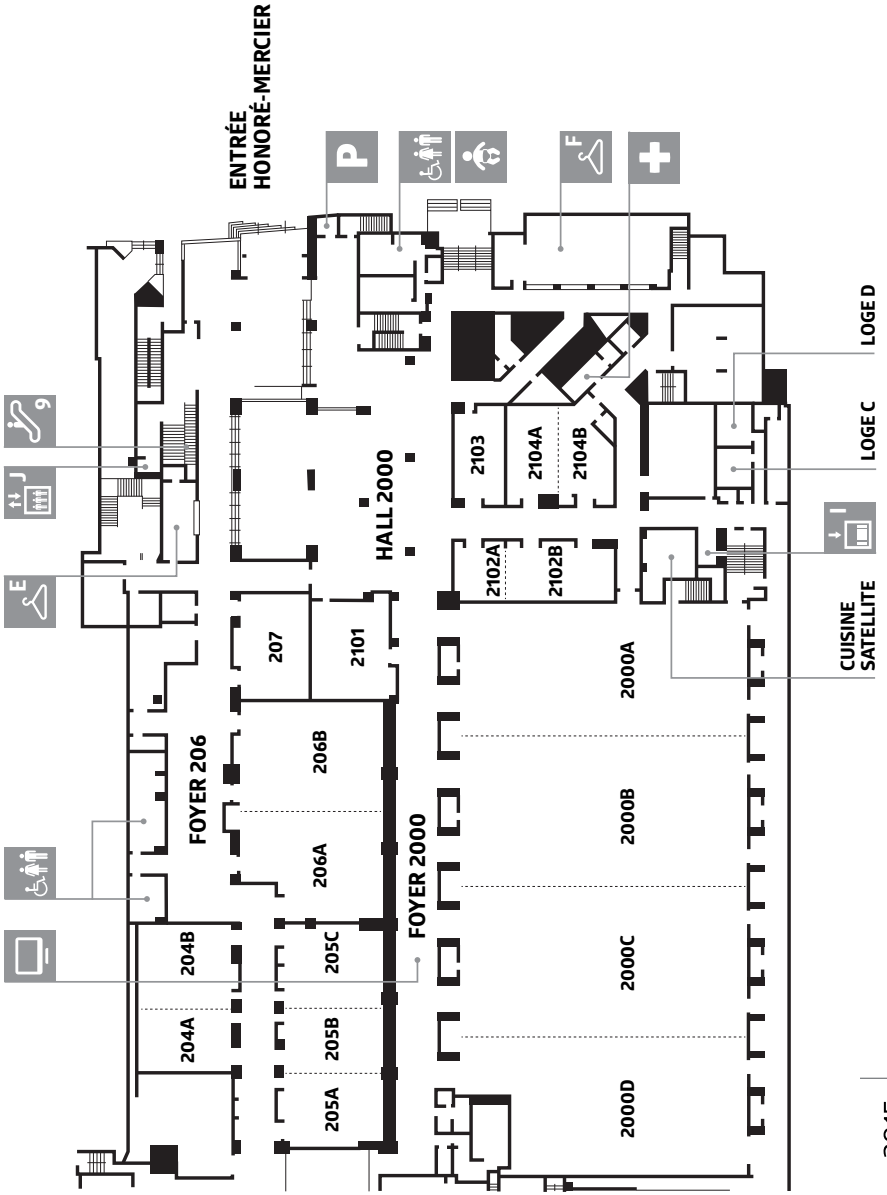


WSP est l'une des plus grandes firmes de services professionnels du monde dans son secteur. Elle offre des services de génie et services multidisciplinaires dans un large éventail de secteurs de l'industrie, mettant l'accent sur l'excellence technique.

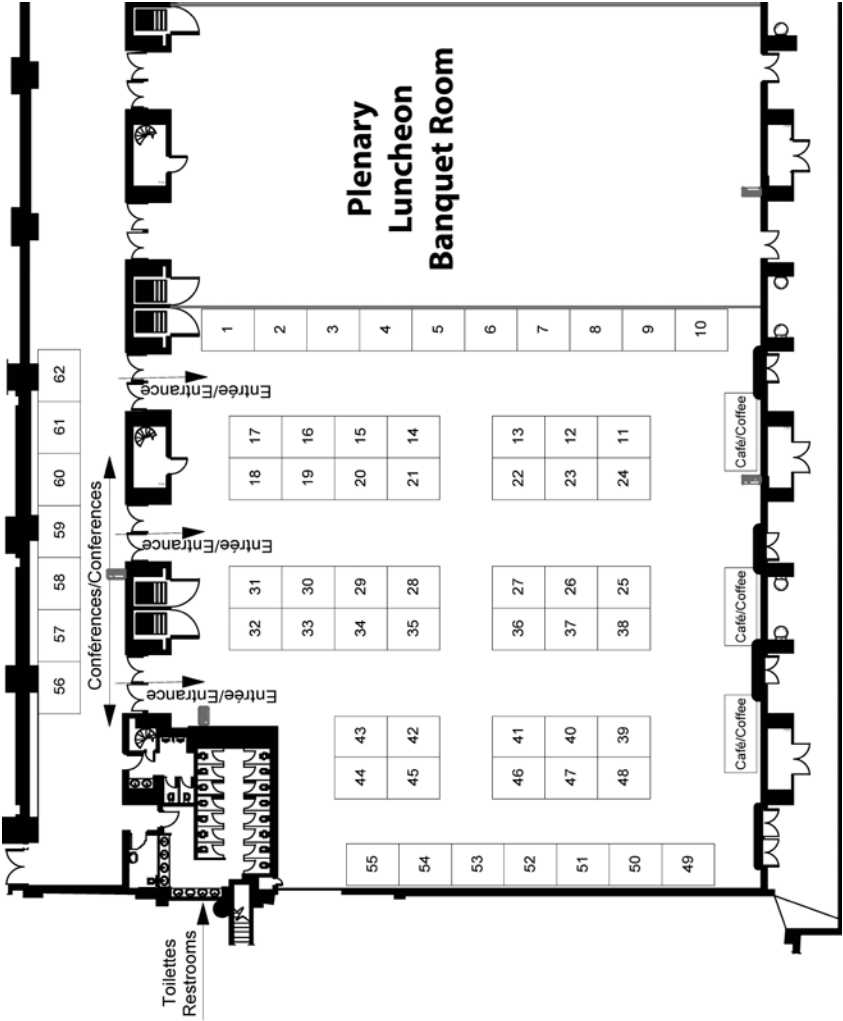
# FLOOR PLAN / PLAN DE SALLE

Room / Salle	Activity / Activité
<b>Foyer 2000</b>	Registration / Inscription
<b>2000AB</b>	Plenary Sessions and Meals / Plénières et repas
<b>2000CD</b>	Trade Show / Salon professionnel
<b>2102A</b>	Speaker Ready Room / Salon des conférenciers
<b>206AB</b>	Speakers' Breakfast / Déjeuner des auteurs
<b>204AB 205A 205BV 2102B 2104AB 2105 207</b>	Technical Sessions / Séances techniques
<b>206A</b>	Technical Sessions / Séances techniques <i>(Wednesday only / Mercredi seulement)</i>
<b>2101</b>	Exhibitor Presentations / Présentations des exposants
<b>Hall 2000</b>	Coffee Breaks / Pauses café <i>Poster Session (Wednesday only) / Session d'affiches (mercredi seulement)</i>





# EXHIBITOR FLOOR PLAN / LOCALISATION DES KIOSQUES COMMERCIAUX



# EXHIBITORS / EXPOSANTS

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<b>Exhibitors / Exposants</b>	<b>Stand # / Emplacement</b>
American Piledriving Equipment Inc.	52
Atlantic Industries Limited	44
Axter Coletanche Inc	13
BiTech Publishers Ltd.	22
Campbell Scientific Canada	11
Canadian Geotechnical Society	60
Canadian Science Publishing	29
Canary Systems	62
Cematrix	43
ConeTec Investigations Ltd.	18
DST Consulting Engineers Inc.	54
Durham Geo Slope Indicator	6
Équipement Environnemental Terra inc.	51
Firestone Building Products Canada	59
GENEQ inc.	19
Geo-Foundations Contractors Inc.	33
Geopac Inc	39
Geo-Slope International	38
GeoSolv Design/Build - Innovative Foundation Solutions	16
GeoStabilization International	61
GKM Consultants Inc.	25
Gravelock	15
Gregg Drilling and Testing, Inc.	56
GroundTech Solutions	31



30	Hayward Baker Canada Ltd. - HB Wick Drains	32
	HeyJute®	46
	Hoskin Scientifique Ltée	36
	IDS North America	10
	Innovex	9
	IPI Packers	26
	Jean Lutz America	55
	Layfield Environmental Containment	2
	Loadtest	3
	M&L Testing Equipment (1995) Inc.	28
	Maccaferri Canada Ltd.	27
	Measurand Inc.	21
	Mobile Augers & Research Ltd.	57
	Moretrench	30
	Norseman Inc.	58
	NWT Transportation	34
	Pile Dynamics, Inc.	23
	Plasti-Fab Ltd.	53
	Plaxis Americas	24
	Poly-Mor Canada Inc.	17
	PSI Technologies	8
	Rocscience Inc.	42
	Roctest Ltd.	5
	RST Instruments Ltd.	37
	Sobek Technologies Inc.	20
	Société du Plan Nord	45
	Société Terre Armée Ltée	40
	SoilVision Systems Ltd.	7
	Stantec Consulting Ltd.	48



TenCate Geosynthetics	14
Terrafix® Geosynthetics Inc.	35
Terraquavie	4
Texel	50
Titan Environmental Containment Ltd.	41
Trumer Schutzbauten	49
UniSoft Geotechnical Solutions Ltd	12
Vertek CPT	47
WSP	1



# EXHIBITOR PRESENTATIONS / PRÉSENTATIONS DES EXPOSANTS

Salle / Room : 2101

Monday, September 21, 10:45 - 17:00 / Lundi 21 septembre, 10 h 45 - 17 h

Time / Heure	Exhibitor / Exposant	Title / Titre
10:45 – 11:00	UniSoft Geotechnical Solutions Ltd	A Quick Overview of the UniSettle and UniPile Software
11:00 – 11:15	Measurand Geotechnical	Advances in SAA Technology
11:15 – 11:30	Plasti-Fab	Plasti-Fab EPS Geofoam Product Application
11:30 – 11:45	Sobek Technologies Inc.	Geotec: The power of a database driven software in geotechnical engineering
11:45 – 12:00	DST Consulting Engineers Inc.	DST, An award winning Geotechnical Consultants
12:00 – 12:15	Plaxis Americas	Recent developments in PLAXIS, including thermal modeling
13:45 – 14:00	Canary Systems	Data Visualization and Integration – Why and How?
14:00 – 14:15	Firestone Building Products	Firestone GeoGard™ EPDM
14:14 – 14:30	WSP	WSP un leader mondial aux racines québécoises
14:30 – 14:45	Association of Geohazard Professionals	An Introduction to the Association of Geohazard Professionals
14:45 – 15:00	Trumer Schutzbauten Canada	Web tool for standardized approach to rockfall catchment fence design



Time / Heure	Exhibitor / Exposant	Title / Titre
15:00 - 15:15	Roctest	Pressuremeter Testing – Main Applications and New Developments
15:15 - 15:30	Roctest	Piber Optic Sensors vs Traditional Sensors for Structural Health Monitoring
15:30 - 15:45	TenCate Geosynthetics	Eliminate differential frost heave on your roadways
15:45 - 16:00	WSP	Réhabilitation du site minier des Mines Gaspé

# CONFERENCE PROGRAM AND TIMETABLE

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## Sunday, September 20, 2015

Short courses and workshops: 8:30 – 17:30

- Quantitative risk assessment in geotechnical engineering: theory and applications, with emphasis on landslides, geohazards, offshore foundations and dams – Room Beauport (Hôtel Hilton)
- Permafrost science and engineering applied to transportation infrastructure – Room Lauzon (Hôtel Hilton)
- Workshop on numerical analysis for embankment and rockfill dams verification & validation for better prediction – Room Ste-Foy/Portneuf (Hôtel Hilton)

Delegates' registration: 12:00 – 19:00 (hall 2000)

Icebreaker reception in the trade exhibition hall: 17:30 – 19:30 (room 2000CD)

## Monday, September 21, 2015

Delegates' registration: 7:00 – 19:00 (hall 2000)

Monday speakers' breakfast: 6:45 – 7:45 (room 206AB)

### Opening plenary session: 8:00 – 10:15 (room 2000AB)

- Opening and welcoming remarks
- R.M. Hardy address: Dr. Jean-Marie Konrad, Université Laval - Design and Analysis of Rockfill Dams: Past, Present and Future.
- J.R. Mackay address: Dr. Steven V. Kokelj, Northwest territories geological survey - retrogressive thaw slumps: from slope process to the landscape sensitivity of northwestern Canada.

Exhibitor trade show: 10:15 – 19:00 (room 2000CD)

Exhibitor presentations: 10:45 – 17:00 (room 2101)

### Monday AM technical sessions: 10:45 – 12:15

- Soil mechanics I – 204AB
- In Situ testing and Instrumentation in cold regions – 205A
- Land slides and slope stability I – 205BC
- Rock mechanics and engineering geology I – 207
- Uncertainty, reliability, and risk – 2102B
- Infrastructure performance in cold regions I – 2104AB
- Mining geotechnique I – 2105

Conference luncheon: 12:15 – 13:45 (room 2000AB)

- CGS R.F. Legget award



# PROGRAMME ET HORAIRE DE LA CONFÉRENCE

## Dimanche 20 septembre 2015

Cours intensifs et ateliers : 8 h 30 – 17 h 30

- Quantitative risk assessment in geotechnical engineering: theory and applications, with emphasis on landslides, geohazards, offshore foundations and dams (en anglais) – salle Beauport (Hôtel Hilton)
- Permafrost science and engineering applied to transportation infrastructure (en anglais) – salle Lauzon (Hôtel Hilton)
- Workshop on numerical analysis for embankment and rockfill dams verification & validation for better prediction (en anglais) – salle Ste-Foy/Portneuf (Hôtel Hilton)

Inscription des délégués : 12 h – 19 h (Hall 2000)

Cocktail de bienvenue dans le salon des exposants : 17 h 30 – 19 h 30 (salle 2000CD)

## Lundi 21 septembre 2015

Inscription des délégués : 7 h – 19 h (hall 2000)

Petit déjeuner des auteurs du lundi : 6 h 45 – 7 h 45 (salle 206 A-B)

### Plénière d'ouverture : 8 h – 10 h 15 (salle 2000 A-B)

- Mots d'ouverture
- Allocution R.M. Hardy : Dr Jean-Marie Konrad, Université Laval - Design and Analysis of Rockfill Dams: Past, Present and Future.
- Conférence J.R. Mackay : Dr Steven V. Kokelj, Northwest Territories Geological Survey - Retrogressive Thaw Slumps: from Slope Process to the Landscape Sensitivity of Northwestern Canada

Salon des exposants : 10 h 15 – 19 h (salle 2000CD)

Présentation des exposants : 10 h 45 – 17 h (salle 2101)

### Séances techniques du lundi matin : 10 h 45 – 12 h 15

- Mécanique des sols I – 204AB
- Essais insitu et instrumentation en milieu nordique – 205A
- Mouvements de terrain et stabilité des pentes I – 205BC
- Mécanique des roches et génie géologique I – 207
- Incertitude, fiabilité et risque – 2102 B
- Performance des infrastructures en régions nordiques 1 – 2104AB
- Géotechnique minière I – 2105

Déjeuner de la conférence : 12 h 15 – 13 h 45 (salle 2000AB)

- Prix Legget de la SCG



**Monday PM1 technical sessions: 13:45 – 15:15**

- Soil mechanics II – 204AB
- Characterization of permafrost state and variability I – 205A
- Landslides and slope stability II – 205BC
- Rock mechanics and engineering geology II – 207
- Laboratory testing in cold regions – 2102B
- Infrastructure performance in cold regions II – 2104AB
- Mining geotechnique II – 2105

**Monday PM2 technical sessions: 15:45 – 17:00**

- Soil mechanics III – 204AB
- Characterization of permafrost state and variability II – 205A
- Landslides and slope stability III – 205BC
- Rock mechanics and engineering geology III – 207
- Laboratory and In Situ testing in cold regions – 2102B
- Foundations in cold regions – 2104AB
- Mining geotechnique III – 2105

**Division and committee meetings: 17:00 - 18:00**

- Soil mechanics and foundations division meeting – 204AB
- Landslide committee meeting – 205A
- Transportation geotechnique committee meeting – 205BC
- Engineering geology division meeting – 207
- Geosynthetics division meeting – 2102B
- Groundwater division meeting – 2104AB
- Heritage committee meeting – 2105
- Geotechnical research board meeting – 2101

**CGS award banquet: 18:15 – 22:00**

- Exhibitor reception: 18:15 – 19:00 (room 2000CD)
- Dinner and award presentation: 19:00 – 22:00 (room 2000AB)

**Tuesday, September 22, 2015**

Delegates' registration: 7:00 – 18:00 (Hall 2000)

Tuesday speakers' breakfast: 6:45 – 7:45 (Room 206AB)

**Plenary Session: 8:00 – 10:15 (room 2000AB)**

- Dr. Lukas Arenson, BGC Engineering Inc. - Cold Regions Engineering in a Changing Climate
- Dr. Jean Hutchinson, Queen's University - Applications of Remote Sensing Techniques to Managing Rock Slope Instability Risk
- Dr. Guy Doré, Université Laval - Adaptation of Transportation Infrastructure in Northern Québec and Canada: Problem Assessment and Development of Solutions



### **Séances techniques du lundi après-midi 1 : 13 h 45 – 15 h 15**

- Mécanique des sols II – 204AB
- Caractérisation et variabilité du pergélisol I – 205A
- Mouvements de terrain et stabilité des pentes II – 205BC
- Mécanique des roches et génie géologique II – 207
- Essais en laboratoire et essais insitu pour les régions nordiques– 2102B
- Performance des infrastructures en régions nordiques II – 2104AB
- Géotechnique minière II – 2105

### **Séances techniques du lundi après-midi 2 : 15 h 45 – 17 h**

- Mécanique des sols III – 204AB
- Caractérisation de l'état et de la variabilité du pergélisol II – 205A
- Mouvements de terrain et stabilité des pentes III – 205BC
- Mécanique des roches et génie géologique III – 207
- Essais en laboratoire et insitu en ingénierie nordique– 2102B
- Fondations en régions nordiques – 2104AB
- Géotechnique minière III – 2105

### **Réunions des divisions et des comités : 17 h – 18 h**

- Division mécaniques des sols et fondations – 204AB
- Comité glissements de terrain – 205A
- Comité géotechnique routière – 205BC
- Division géologie de l'ingénieur – 207
- Division géosynthétique – 2102B
- Division hydrogéologie – 2104AB
- Comité patrimoine – 2105
- Conseil de la recherche en géotechnique – 2101

### **Banquet de remise des prix SCG : 18 h 15 – 22 h**

- Réception des exposants: 18 h 15 – 19 h (salle 2000CD)
- Souper et remise des prix: 19 h – 22 h (salle 2000 AB)

## **Mardi 22 septembre 2015**

Inscription des délégués : 7 h – 18 h (hall 2000)

Petit déjeuner des auteurs du mardi : 6 h 45 – 7 h 45 (salle 206AB)

### **Plénière : 8 h – 10 h 15 (salle 2000AB)**

- Dr Lukas Arenson, BGC Engineering Inc. - Cold Regions Engineering in a Changing Climate
- Dr Jean Hutchinson, Queen's University - Applications of Remote Sensing Techniques to Managing Rock Slope Instability Risk
- Dr Guy Doré, Université Laval - Adaptation of Transportation Infrastructure in Northern Québec and Canada: Problem Assessment and Development of Solutions



Exhibitors trade show: 10:15 – 16:00 (room 2000CD)

### **Tuesday AM technical sessions: 10:45 – 12:15**

- Permafrost degradation I – 205A
- Laboratory Testing I – 205BC
- Foundations I – 207
- Physical and Numerical Modelling – 2102B
- Earthquakes and Geohazards I – 2104AB
- GIS and Remote Sensing in Cold Regions – 2105

J.R. Mackay symposium, permafrost I: 10:45 – 12:15 (room 204AB)

Tuesday Luncheon, CGS Annual Business Meeting 12:15 – 13:45 (room 2000AB)

### **Tuesday PM1 technical sessions: 13:45 – 15:15**

- Permafrost degradation II – 205A
- Laboratory testing II – 205BC
- Foundations II – 207
- Contaminated sites and remediation – 2102B
- Earthquakes and geohazards II – 2104AB
- Permafrost considerations in design – 2105

J.R. Mackay symposium, permafrost II: 13:45 – 15:15 (room 204AB)

GEOparady student competition: 15:15 – 16:00 (room 2000AB)

### **Tuesday PM2 technical sessions: 16:00 – 17:15**

- Barriers and geosynthetics – 205A
- Laboratory testing III – 205BC
- Foundations III – 207
- Geotechnical education challenges – 2102B
- Landslides and slope stability IV – 2104AB
- Geophysical investigations in cold regions – 2105

J.R. Mackay symposium, permafrost III: 16:00 – 17:15 (room 204AB)

Special session on professional practice 1: 16:00 – 17:15 (room 2101)

### **Division and committee meetings: 17:15 – 18:15**

- Rock mechanics division meeting – 204 A-B
- Professional practice committee meeting – 205 A
- Mining geotechnique committee meeting – 205 B-C
- Geoenvironmental division meeting – 207
- Cold regions geotechnology division meeting – 2102 B
- Sustainable geotechnique committee meeting – 2104 A-B
- Education committee meeting – 2105
- Canadian foundation for geotechnique AGM – 2101



### **Séances techniques du mardi matin : 10 h 45 – 12 h 15**

- Détérioration du pergélisol I – 205A
- Essais en laboratoire I – 205BC
- Fondations I – 207
- Modélisation physique et numérique – 2102B
- Séismes et géoaléas I – 2104AB
- SIG et la télédétection en régions nordiques – 2105

Symposium J.R. Mackay, Pergélisol I : 10 h 45 – 12 h 15 (salle 204AB)

Dîner du mardi, Assemblée d'affaire de la SCG : 12 h 15 – 13 h 45 (salle 2000AB)

### **Séances techniques du mardi après-midi 1 : 13 h 45 – 15 h 15**

- Dégradation du pergélisol II – 205A
- Essais en laboratoire II – 205BC
- Fondations II – 207
- Sites contaminés et réhabilitation – 2102B
- Séismes et géoaléas II – 2104AB
- Considérations du pergélisol dans la conception – 2105

Symposium J.R. Mackay, Pergélisol II : 13 h 45 – 15 h 15 (salle 204AB)

Concours GEOparly à l'intention des étudiants : 15 h 15 – 16 h (salle 2000AB)

### **Séances techniques du mardi après-midi 2 : 16 h – 17 h 15**

- Barrières et géosynthétiques – 205A
- Essais en laboratoire III – 205BC
- Fondations III – 207
- Défis de la formation en géotechnique – 2102B
- Mouvements de terrain et stabilité des pentes IV – 2104AB
- Investigations géophysiques en milieu nordique – 2105

Symposium J.R. Mackay, Pergélisol III : 16 h – 17 h 15 (salle 204AB)

Séance spéciale sur la pratique professionnelle 1 : 16 h – 17 h 15 (salle 2101)

### **Réunions des divisions et des comités : 17 h 15 – 18 h 15**

- Division mécanique des roches – 204 A-B
- Comité pratique professionnelle – 205 A
- Comité géotechnique minière – 205 B-C
- Division géoenvironnementale – 207
- Division ingénierie nordique – 2102 B
- Comité géotechnique durable – 2104 A-B
- Comité éducation – 2105
- Fondation canadienne de géotechnique AGA – 2101



Cocktail and local colour night aboard the Louis Jolliet:

- Shuttles from 18:15 to 19:00
- Boat departure at 19:15
- Return shuttles from 21:30 to 22:15

## **Wednesday, September 23, 2015**

Delegates' registration: 7:00 – 15:00 (hall 2000)

Wednesday speakers' breakfast: 7:15 – 8:15 (room 206AB)

CGS Plenary session: 8:30 – 10:00 (room 2000AB)

- 2015 colloquium: Dr. Greg Siemens, Royal Military College of Canada - Unsaturated soil mechanics: bridging the gap between research and practice
- CGS graduate student paper: Amy Rentz, Field performance of exposed geosynthetic composite liner systems: down-slope bentonite erosion from a geosynthetic clay liner (GCL)

Poster session: 10:00 – 10:30 (hall 2000)

- General Geotechnique and Engineering Geology
- Landslide and Slope Stability
- Permafrost and Cold Regions Geotechnology

### **Wednesday AM technical sessions: 10:30 – 12:00**

- Foundations IV – 204AB
- Landslides and slope stability V – 205A
- Transportation and linear infrastructure I – 205BC
- In Situ testing and instrumentation I – 206A
- Groundwater – 2102B
- Problematic soils and ground improvement I – 2104AB
- Geocryology I – 2105

Special session on professional practice II: 10:30 – 12:00 (room 2101)

Eastern Québec Geoengineering Pioneers Luncheon: 12:00 – 13:30 (room 2000AB)

### **Wednesday PM1 technical sessions: 13:30 – 15:00**

- Foundations V – 204AB
- Embankments and dams in cold regions – 205A
- Transportation and linear infrastructures II – 205BC
- In Situ testing and instrumentation II – 206A
- Northern communities – 2102B
- Problematic soils and ground improvement II – 2104AB
- Geocryology II – 2105



Réception et soirée à saveur locale sur le Louis Jolliet :

- Navettes de 18 h 15 à 19 h
- Départ du bateau à 19 h 15
- Navettes de retour de 21 h 30 à 22 h 15

## **Mercredi 23 septembre 2015**

Inscription des délégués : 7 h – 15 h (hall 2000)

Petit déjeuner des auteurs du mercredi : 7 h 15 – 8 h 15 (salle 206AB)

Plénière de la SCG : 8 h 30 – 10 h (salle 2000AB)

- Colloque 2015 de la SCG: Dr Greg Siemens, Collège Militaire Royal du Canada - Unsaturated Soil Mechanics: Bridging the Gap Between Research and Practice
- Article d'étudiant diplômé de la SCG: Amy Rentz, Field performance of exposed geosynthetic composite liner systems: Down-slope bentonite erosion from a geosynthetic clay liner (GCL)

Séance d'affiches : 10 h – 10 h 30 (hall 2000)

- Géotechnique générale et géologie de l'ingénieur
- Mouvements de terrain et stabilité des pentes
- Pergéisol et géotechnologie des régions nordiques

### **Séances techniques du mercredi matin : 10 h 30 – 12 h**

- Fondations IV – 204AB
- Mouvements de terrain et stabilité des pentes V – 205A
- Transports et infrastructures linéaires I – 205BC
- Essais insitu et instrumentation I – 206A
- Eaux souterraines – 2102B
- Sols problématiques et amélioration du comportement I – 2104AB
- Géocryologie I – 2105

Séance spéciale sur la pratique professionnelle II : 10 h 30 – 12 h (salle 2101)

Déjeuner en hommage aux pionniers de la géo-ingénierie de la section de l'Est-du-Québec : 12 h – 13 h 30 (salle 2000AB)

### **Séances techniques du mercredi après-midi 1 : 13 h 30 – 15 h**

- Fondations V – 204AB
- Remblais et barrages en régions nordiques – 205A
- Transports et infrastructures linéaires II – 205BC
- Essais insitu et instrumentation II – 206A
- Communautés nordiques – 2102B
- Sols problématiques et amélioration du comportement II – 2104AB
- Géocryologie II – 2105



Poster session: 15:00 - 15:30 (hall 2000)

**Wednesday PM2 technical sessions: 15:30 – 16:30**

- Mining geotechnique IV – 204AB
- Embankments and dams – 205A
- Transportation and linear infrastructure III – 205BC
- Landslides and slope stability VI – 206A
- Permafrost (other) – 2102B
- Problematic soils and ground improvement III – 2104AB
- Physical and numerical modelling in cold regions – 2105

Closing ceremonies: 16:45 – 17:15 (room 2000AB)

**Thursday, September 24, 2015**

**Technical tours**

- Boischatel's karst topography and Montmorency falls' geology (8:30 – 17:30, meet in the congress center lobby at 8:15)
- Risk analysis and risk management in the Charlevoix region (8:00 – 18:00, meet in the congress center lobby at 7:45)



Séance d'affiches : 15 h – 15 h 30 (hall 2000)

### **Séances techniques du mercredi après-midi 2 : 15 h 30 – 16 h 30**

- Géotechnique minière IV – 204AB
- Remblais et barrages – 205A
- Transports et infrastructures linéaires III – 205BC
- Mouvements de terrain et stabilité des pentes VI – 206A
- Pergélisol (autre) – 2102B
- Sols problématiques et amélioration du comportement III – 2104AB
- Modélisation physique et numérique en régions nordiques – 2105

Cérémonies de clôture de la conférence : 16 h 45 – 17 h 15 (salle 2000AB)

## **Jeudi 24 septembre 2015**

### **Visites techniques**

- Les phénomènes karstiques de Boischâtel et le parc de la Chute Montmorency (8 h 30 à 17 h 30, rassemblement à 8h15 à l'entrée du centre des congrès)
- Analyse et gestion des risques dans la région de Charlevoix (8 h à 18 h, rassemblement à 7 h 45 à l'entrée du centre des congrès)

## Monday, September 21, 2015 / Lundi 21 septembre 2015

6:45 – 7:45	Speaker’s Breakfast / Déjeuner des auteurs – Room/Salle 206AB							
8:00 – 8:25	Opening Ceremony / Cérémonie d’ouverture – Room/Salle 2000AB							
8:25 – 9:20	RM Hardy Keynote Address / Conférence d’ouverture, Allocution R.M. Hardy Dr. Jean-Marie Konrad – Room/Salle 2000AB <i>Design and Analysis of Rockfall Dams: Past, Present and Future</i>							
9:20 – 10:15	John Ross Mackay Lecture / Conférence John Ross Mackay Dr. Steven V. Kokej – Room/Salle 2000AB <i>Retrospective Thaw Slumps: from Slope Process to the Landscape Sensitivity of Northwestern Canada</i>							
10:15 – 19:00	Trade Show / Salon professionnel – Room/Salle 2000CD							
10:15 – 10:45	Break / Pause-santé – Trade Show / Salon des exposants – Room/Salle 2000CD							
<b>Level 2 / Niveau 2</b>								
10:45 – 12:15	Room 204AB	Room 205A	Room 205BC	Room 207	Room 2102B	Room 2104AB	Room 2105	Room 2101
	Soil Mechanics I / Mécanique des sols I	In Situ Testing, Instrumentation, and Monitoring in Cold Regions / Essais institu et instrumentation en milieu nordique	Landslides and Slope Stability I / Mouvements de terrain et stabilité des pentes I	Rock Mechanics and Engineering Geology I / Mécanique des roches et génie géologique I	Uncertainty, Reliability, and Risk / Incertitude, fiabilité et risque	Infrastructure Performance in Cold Regions I / Performance des infrastructures en régions nordiques I	Mining Geotechnique / Géotechnique minière I	Exhibitor Presentations / Présentations des exposants

**Monday, September 21, 2015 / Lundi 21 septembre 2015**

12:15 – 13:45	R.F. Legget Luncheon / Dîner R.F. Legget – Room/Salle 2000AB							
<b>Level 2 / Niveau 2</b>								
13:45 – 15:15	Room 204AB	Room 205A	Room 205BC	Room 207	Room 2102B	Room 2104AB	Room 2105	Room 2101
	Soil Mechanics II / Mécanique des sols II	Characterization of Permafrost State and Variability / Caractérisation et variabilité du pergélisol	Landslides and Slope Stability II / Mouvements de terrain et stabilité des pentes II	Rock Mechanics and Engineering Geology I / Mécanique des roches et génie géologique II	Laboratory Testing in Cold Regions / Essais en laboratoire en ingénierie nordique	Infrastructure Performance in Cold Regions II / Performance des infrastructures en régions nordiques II	Mining Geotechnique II / Géotechnique minière II	Exhibitor Presentations / Présentations des exposants
15:15 – 15:45	Break / Pause-santé – Trade Show / Salon professionnel – Room/Salle 2000CD							
15:45 – 17:00	Soil Mechanics III / Mécanique des sols III	Characterization of Permafrost State and Variability II / Caractérisation et variabilité du pergélisol II	Landslides and Slope Stability III / Mouvements de terrain et stabilité des pentes III	Rock Mechanics and Engineering Geology III / Mécanique des roches et génie géologique III	Laboratory and In Situ Testing in Cold Regions / Essais en laboratoire et essais in situ pour les régions nordiques	Foundations in Cold Regions / Fondations en régions nordiques	Mining Geotechnique III / Géotechnique minière III	Exhibitor Presentations / Présentations des exposants
	Soil Mechanics and Foundations Division Meeting	Landslides Committee Meeting	Transportation Geotechnique Committee Meeting	Engineering Geology Division Meeting	Geosynthetics Division Meeting	Groundwater Division Meeting	Heritage Committee Meeting	Geotechnical Research Board Meeting
17:00 – 18:00	Exhibitor Cocktail / Cocktail des exposants – Room/Salle 2000CD							
18:15 – 19:00	CGS Award Banquet / Banquet de remise des prix SCG – Room/Salle 2000AB							





Program "At a Glance" / Programme synoptique

Monday, September 21 / Lundi 21 septembre

Time/Heure	204AB	205A	205BC	207	2102B	2104AB	2105
10:45 - 11:00	<p><b>Soil Mechanics I / Mécanique des sols I</b> (pp.86-88)</p> <p><b>162 Vincenzo Silvestri</b> An improved solution for the expansion of cylindrical cavities in Modified Cam Clay.</p>	<p><b>In Situ Testing, Instrumentation, and Monitoring in Cold Regions / Essais in situ et instrumentation en milieu nordique</b> (pp.88-90)</p> <p><b>548 Ren Li</b> Investigation on the soil thermal conductivity of different underlying surfaces in the (...)</p>	<p><b>Landslides and Slope Stability I / Mouvements de terrain et stabilité des pentes I</b> (pp.91-93)</p> <p><b>389 Murray Fredlund</b> Poisson's ratio effect on slope stability calculations</p>	<p><b>Rock Mechanics and Engineering Geology I / Mécanique des roches et génie géologique I</b> (pp.93-95)</p> <p><b>500 Mamadou Fall</b> Swelling characteristics of bentonite based barriers for deep geological (...)</p>	<p><b>Uncertainty, Reliability, and Risk / Incertitude, fiabilité, et risque</b> (pp.96-98)</p> <p><b>263 Miroslav (Fred) Matich</b> Dispute Resolution in Geotechnical Engineering Practice - Some Lessons Learned</p>	<p><b>Infrastructure Performance in Cold Regions I / Performance des infrastructures en régions nordiques I</b> (pp.98-101)</p> <p><b>703 Muhammad Idrees</b> Monitoring permafrost conditions along the Dempster Highway</p>	<p><b>Mining Geotechnique I / Géotechnique minière I</b> (pp.101-103)</p> <p><b>54 Kathryn Domplere</b> Evaluation of thermal properties of oil sand fluid fine tailings</p>
11:00 - 11:15	<p><b>768 Hamid Karimpour</b> Application of a Critical State Bounding Surface Model Implemented in Multilaminate (...)</p>	<p><b>146 Valérie Mathon-Dufour</b> Assessment of permafrost conditions in support of the rehabilitation and adaptation to (...)</p>	<p><b>401 Nicholas Vlachopoulos</b> The Influence of Tunneling on Slope Stability</p>	<p><b>639 Ahn Taesang</b> The Effect on Rock Swelling due to the Salinity Difference between Rock Pore Fluid and Ambient (...)</p>	<p><b>321 Frédéric Choquet</b> Tailings management at the iron mine of Mount Wright</p>	<p><b>65 Earl Marvin De Guzman</b> Initial Monitoring of Instrumented Test Sections along the Inuvik-Tuktoyaktuk Highway</p>	<p><b>221 Michaël Demers Bonin</b> Thickened tailings deposition modeling using a large strain consolidation model</p>
11:15 - 11:30	<p><b>414 Rajith Dayarathne</b> Stress-strain behaviour of a clayey silt in triaxial tests.</p>	<p><b>380 Brendan O'Neill</b> Field measurements of permafrost conditions beside the Dempster Highway embankment. Peel Plateau, NWT</p>	<p><b>44 Ximili Wu</b> Numerical Analysis of a Stabilized Natural Slope</p>	<p><b>534 Hayder M.S. Al-Maamari</b> Swelling Potential of Queenston Shale in Lubricant Fluids</p>	<p><b>644 Ning Luo</b> Probabilistic slope stability analysis of reinforced slopes by finite element method</p>	<p><b>115 Stephen Wolfe</b> Disequilibrium permafrost conditions on NWT Highway 3</p>	<p><b>754 Paul Simms</b> Desiccation and consolidation modelling of oil sands fine tailings deposits</p>

**Monday, September 21 / Lundi 21 septembre**

	2105	2104AB	2102B	207	205BC	205A	204AB
<p><b>11:30 - 11:45</b></p>	<p><b>798</b> <i>Amarrebb Sorta</i> The Case for Using Fines Void Ratio</p>	<p><b>266</b> <i>David Flynn</i> Observed Deformations of an Existing Highway Embankment on Degrading Permafrost</p>	<p><b>566</b> <i>Sina Javanikshadell</i> Probabilistic analysis of two mechanisms of failure in geosynthetic reinforced slopes using Monte Carlo (...)</p>	<p><b>583</b> <i>Morteza Mohamadi</i> Thermo-Elastoplastic Study of the Colorado Shale Behaviour</p>	<p><b>369</b> <i>Harpreet Panesar</i> Case Study of a Landslide on Highway 20 North of Craven, SK</p>	<p><b>467</b> <i>Jonathan Roger</i> Evaluating the use of distributed temperature sensing for permafrost monitoring in Salluit, Nunavik</p>	<p><b>218</b> <i>Andrew Drevinikas</i> Geotechnical characteristics of Barlow-Ojibway clay in Northern Ontario</p>
<p><b>11:45 - 12:00</b></p>	<p><b>797</b> <i>Louis Kabwe</i> Effect of flocculent treatments on consolidation of oil sands fluid fine tailings</p>	<p><b>267</b> <i>David Kurz</i> Observed and Predicted Thermal Regime under an Existing Highway Embankment on (...)</p>	<p><b>815</b> <i>Jerry Luo</i> Random Finite Element Analysis of Supported Excavations Considering Spatial Variability</p>	<p><b>731</b> <i>Pedram Abootaleb</i> Thermal property testing of an engineered barrier for use in a deep (...)</p>	<p><b>439</b> <i>Joanna Chen</i> Steepbank River Valley Geomorphological and Geological Categorization</p>	<p><b>705</b> <i>Christopher Burn</i> Permafrost characterization of the Dempster Highway, Yukon and Northwest Territories</p>	<p><b>472</b> <i>André Bom</i> Secondary compression of a cohesive soil in Northern Ontario: A case study</p>
<p><b>12:00 - 12:15</b></p>	<p><b>395</b> <i>Amal Sahi</i> Mise en évidence expérimentale du dosage optimal des ciments composés (liants) utilisés (...)</p>	<p><b>176</b> <i>Ed Hoeye</i> The Inuvik Airport Runway – An evaluation of 50 years of performance</p>	<p><b>204</b> <i>Bruce Jamieson</i> Uncertainty in snow avalanche risk assessments</p>	<p><b>596</b> <i>Catherine Boudreau</i> Caractérisation statistique de la résistance en compression uniaxiale de la (...)</p>	<p><b>523</b> <i>Scott McDougall</i> Preliminary reservoir impact lines for the Site C Clean Energy Project</p>	<p><b>129</b> <i>Sara Holzman</i> The Nunavut Permafrost Databank- centralizing Nunavut permafrost for northern (...)</p>	<p><b>593</b> <i>Kelly Guerrier</i> A rheological approach to the mechanical behavior of some marls samples in Haiti</p>







## Program "At a Glance" / Programme synoptique

## Monday, September 21 / Lundi 21 septembre

	204AB	205A	205BC	207	2102B	2104AB	2105
Time/Heure							
	Soil Mechanics II / Mécanique des sols II (pp.103-105)	Characterization of Permafrost, State and Variability I / Caractérisation et variabilité du pergélisol I (pp.106-108)	Landslides and Slope Stability II / Mouvements de terrain et stabilité des pentes II (pp.108-110)	Rock Mechanics and Engineering Geology II / Mécanique des roches et génie géologique II (pp.111-113)	Laboratory Testing in Cold Regions / Essais en laboratoire en ingénierie nordique (pp.113-115)	Infrastructure Performance in Cold Regions II / Performance des infrastructures en régions nordiques II (pp.115-117)	Mining Geotechnique II / Géotechnique minière II (pp.118-120)
13:45 - 14:00	<b>66</b> <i>Alireza Azami</i> A practical constitutive model for sands	<b>479</b> <i>Vladimir Romanovsky</i> Changes in Permafrost and Active-layer Temperatures along an Alaskan Permafrost-Ecological Transect	<b>285</b> <i>Ryan Kromer</i> Detection of rock slope failure precursors using a terrestrial Laser scanner	<b>661</b> <i>Chrysothemis Paraskevopoulou</i> Long-term behavior of different rock types based on laboratory testing	<b>52</b> <i>Mark Nixon</i> Recent developments in laboratory frost heave testing of soils	<b>116</b> <i>Jason Pellett</i> Slope Stabilization at km 229 and km 701-703 of the Alaska Highway: Site Challenges and Lessons Learned	<b>61</b> <i>Abtin Jahanshahzadeh</i> Numerical simulations to assess the stress state in backfilled stopes with inclined walls
14:00 - 14:15	<b>738</b> <i>Saraneh A. Harehdasht</i> Analyzing the macro and micro-scale response of an idealised granular material in direct (...)	<b>133</b> <i>Jerry Brown</i> Long-term observations of active layer thawing and freezing, Barrow, Alaska	<b>491</b> <i>Dave Gauthier</i> On the precision, accuracy, and utility of oblique aerial photogrammetry (OAP) for rock (...)	<b>348</b> <i>Shahé Shnarhokian</i> Influence of rockmass property variations on pre-mining stresses: a case study	<b>658</b> <i>Vladimir Istomin</i> A method for determination of water content in real and model porous media in (...)	<b>138</b> <i>Guy Dionne</i> Characterization of armour stone breakwater through a freeze-thaw resistance approach	<b>309</b> <i>Mohammad Shahsavari</i> Mine backfill pore water pressure dissipation: numerical predictions and field measurements
14:15 - 14:30	<b>689</b> <i>Mohamed Chekired</i> Approche virtuelle pour la génération de milieux poreux et l'évaluation de la tortuosité	<b>237</b> <i>Sharon Smith</i> Variability and Change in Permafrost Thermal State in Northern Canada	<b>406</b> <i>Megan van Veen</i> Frequency-magnitude of rockfall events for hazard analysis: A comparison of data from LIDAR (...)	<b>342</b> <i>Denis Labrie</i> Résistance mécanique et pressions de fissuration de quelques matériaux rocheux (...)	<b>528</b> <i>Evgeny Chuvilin</i> Experimental evaluation of changes in permeability of frozen sediments at thawing	<b>343</b> <i>Jan Stirling</i> NWT Highway 3 Test Sections near Yellowknife	<b>758</b> <i>Tikou Belem</i> Predictive models of the compressive strength of cemented paste backfills taking into account (...)

Monday, September 21 / Lundi 21 septembre

14:30 - 14:45	204AB	205A	205BC	207	2102B	2104AB	2105
<p><b>351</b> <i>Marijan Oboudi</i> Anisotropy in Granular Geomaterials</p>	<p><b>117</b> <i>Caroline Duchesne</i> Active Layer Variability and Change in the Mackenzie Valley, Northwest Territories</p>	<p><b>808</b> <i>François Noël</i> L'aléa chutes de pierres: la modélisation préliminaire 3D des trajectoires le long (...)</p>	<p><b>642</b> <i>Bradley Forbes</i> Improving Ground Support Design with Distributed Strain Monitoring</p>	<p><b>319</b> <i>Daryl Dagesse</i> Cyclic Freezing and Thawing Effects on Atterberg Limits of Clay Soils</p>	<p><b>91</b> <i>Vincent Lamontagne</i> Suivi du comportement thermique et mécanique de l'adaptation aux (...)</p>	<p><b>760</b> <i>Murray Grabinsky</i> Determining Stable Spans of Undercut Cemented Paste Backfill</p>	<p><b>734</b> <i>Fabrice Beya</i> <i>Kazambua</i> Preliminary study of the influence of temperature and salinity on the (...)</p>
14:45 - 15:00	489	629	217	60	316	203	404
<p><b>15:00 - 15:15</b></p>	<p><i>Mourad Karray</i> Correlation between elastic modulus and shear wave velocity at large strain level</p>	<p><i>Hanne H. Christiansen</i> Arctic permafrost thermal variability across an environmental gradient from (...)</p>	<p><i>Catherine Cloutier</i> An integrated management tool for rockfall evaluation along transportation corridors: (...)</p>	<p><i>Atsushi Sainoki</i> Comparison of mining-induced seismicity within a footwall fault between overhand and underhand (...)</p>	<p><i>Erika Grechishcheva</i> Experimental study of freezing point and water phase composition of saline soils contaminated (...)</p>	<p><i>Fujun Niu</i> Deformation characteristics of the main embankments of the Qinghai-Tibet Railway in (...)</p>	<p><i>Kayumba Kalonji</i> Preliminary investigation of the effect of temperature and salinity on the rheological (...)</p>



## Program "At a Glance" / Programme synoptique

## Monday, September 21 / Lundi 21 septembre

Time/Heure	204AB	205A	205BC	207	2102B	2104AB	2105
15:45 - 16:00	<p><b>762</b> M.J. Siahdashti Inverse Modelling of Desorption Tests to Establish the Hydraulic Conductivity of Unsaturated (...)</p>	<p><b>765</b> Audrey Veillette Contrasting patterns of thermo-erosion gullies formed in syngenetic ice wedge polygonal terrains on Bylot (...)</p>	<p><b>339</b> Lukas Arensen Cathedral Mountain 2014 ice fall and debris flow</p>	<p><b>77</b> Strahimir Antoljak Subsurface Modeling and BIM</p>	<p><b>678</b> Maria Cherbumina The results of 5-year experiment of methane production from frozen soils</p>	<p><b>443</b> Jean-Marie Konrad Effect of stress and temperature history on creep behavior of straight and enlarged-base anchors in (...)</p>	<p><b>255</b> Matthew Buchynski Characterizing the Diffusive Transport of Stable Water Isotopes in Unsaturated Soils</p>
16:00 - 16:15	<p><b>119</b> Feixia Zhang Role of air-entry value and choice of SWCC in the prediction of the unsaturated permeability</p>	<p><b>617</b> Dmitry Drozdov Monitoring of permafrost in Russia. Russian database and the international GTN-P project</p>	<p><b>558</b> Michel Jaboyedoff A review of geometrical methods for determination of landslide volume and failure surface (...)</p>	<p><b>533</b> Nooshin Falaknaz 3D Stability analysis of mine stopes with an open face</p>	<p><b>438</b> Marc-André Ducharme Measurements of undisturbed permafrost thermal conductivity through CT scan analysis</p>	<p><b>735</b> Pierre-Philippe Levasseur A case study of frost action on lightly loaded piles at Ontario solar farms</p>	<p><b>746</b> Michael Angelopoulos Surface Water Infiltration Impacts on the Performance of Thermal Capping Systems (...)</p>
	<p>Soil Mechanics III / Mécanique des sols III (pp.120-122)</p>	<p>Characterization of Permafrost State and Variability II / Caractérisation et variabilité du pergélisol II (pp.122-124)</p>	<p>Landslides and Slope Stability III / Mouvements de terrain et stabilité des pentes III (pp.125-126)</p>	<p>Rock Mechanics and Engineering Geology III / Mécanique des roches et génie géologique III (pp.127-128)</p>	<p>Laboratory and In Situ Testing in Cold Regions / Essais en laboratoire et essais in situ pour les régions nordiques (pp.129-130)</p>	<p>Foundations in Cold Regions / Fondations en régions nordiques (pp.131-132)</p>	<p>Mining Geotechnique III / Géotechnique minière III (pp.133-134)</p>

Monday, September 21 / Lundi 21 septembre

	204AB	205A	205BC	207	2102B	2104AB	2105
16:15 - 16:30	<p><b>110</b> <i>Michael Ghali</i> Influence of Particles Shape, Size and Uniformity of sands on the Void Ratio Range and Consequently (...)</p>	<p><b>193</b> <i>Boris Biskaborn</i> Quality assessment of permafrost thermal state and active layer thickness data in GTN-P</p>	<p><b>782</b> <i>Jacques Locat</i> Tsunamigenic landslides in Québec</p>	<p><b>388</b> <i>Kiarash Farahmand</i> Implementation of a Cohesive Crack Model in Grain-based DEM technique for Simulating (...)</p>	<p><b>305</b> <i>Evgeny Chuvilin</i> Method of determining the thermal conductivity of dispersed gas-saturated (...)</p>	<p><b>33</b> <i>Guangwen Zhang</i> Geotechnical Design of Thermopile Foundation for a Building in Inuvik</p>	<p><b>805</b> <i>Eva Stephani</i> Reclamation of material sites in continuous permafrost of Alaska: An example of groundwater (...)</p>
16:30 - 16:45	<p><b>198</b> <i>Liet Chi Dang</i> Influence of Bagasse Ash and Hydrated Lime on Strength and Mechanical Behaviour of Stabilised (...)</p>	<p><b>431</b> <i>Wei Shan</i> The monitoring of soil pore water pressure and soil temperature in cutting slope before and after aufeis</p>	<p><b>711</b> <i>Martin Franz</i> Testing a landslide -generated tsunami model - The case of the Nicolet landslide (Québec, Canada)</p>	<p><b>603</b> <i>Larfa Cao</i> Engineering characteristic of glacial tills in GTA.</p>	<p><b>557</b> <i>Evgeny Chuvilin</i> Thermal conductivity of bottom sediments in the East Siberian Arctic seas: a case study in the (...)</p>	<p><b>40</b> <i>Hafeez Baba</i> Geotechnical Deep Foundation Design Challenges in Discontinuous Permafrost of (...)</p>	<p><b>362</b> <i>Gary Koop</i> Geotechnical Investigation at the Long Lake Containment Facility, Ekati Diamond (...)</p>
16:45 - 17:00	<p><b>229</b> <i>Moussai Belkacem</i> Effect of salts on the determination of the water content and Atterberg limits of EI-Hodna sabkha soil</p>	<p><b>403</b> <i>Yun Que</i> Hydrothermal regime analysis of shallow depth of a soil slope during short-term freeze-thaw cycles</p>	<p><b>692</b> <i>Jonathan Leblanc</i> Analyse de la signature laissée par le tsunami généré par un glissement de terrain au Lac-des-Seize(...)</p>	<p><b>673</b> <i>Andrew Bajliss</i> Characterization of glacial tills from an excavation near Fort McMurray, Alberta</p>	<p><b>556</b> <i>Olivier Lachance</i> Time evolution of thermal conductivity and intrinsic permeability of a snow cover</p>	<p><b>292</b> <i>Dashjirms Dalai</i> Research on Foundation Design on Permafrost in Mongolia</p>	<p><b>230</b> <i>Miguel Medina</i> A Case Study: Seismic Stability of an Upstream Tailings Impoundment - Empirical Methods (...)</p>



## Tuesday, September 22, 2015 / Mardi 22 septembre 2015

6:45 – 7:45	Speaker's Breakfast / Déjeuner des auteurs – Room/Salle 206AB							
8:00 – 8:45	Keynote / Conférence Dr. Lukas Arenson – Room/Salle 2000AB <i>Cold Regions Engineering in a Changing Climate</i>							
8:45 – 9:30	Keynote / Conférence Dr. Jean Hutchinson – Room/Salle 2000AB <i>Applications of Remote Sensing Techniques to Managing Rock Slope Instability Risk</i>							
9:30 – 10:15	Keynote / Conférence Dr. Guy Doré – Room/Salle 2000AB <i>Adaptation of Transportation Infrastructure in Northern Québec and Canada: Problem Assessment and Development of Solutions</i>							
10:15 – 16:00	Trade Show / Salon professionnel – Room/Salle 2000CD							
10:15 – 10:45	Break / Pause-santé – Trade Show / Salon des exposants – Room/Salle 2000CD							
<b>Level 2 / Niveau 2</b>								
10:45 – 12:15	Room 204AB	Room 205A	Room 205BC	Room 207	Room 2102B	Room 2104AB	Room 2105	Room 2101
	John Ross Mackay Symposium – Permafrost I / Symposium John Ross Mackay – Pergélisol I	Permafrost Degradation I / Dégénération du pergélisol I	Laboratory Testing I / Essais en laboratoire I	Foundations I / Fondations I	Physical and Numerical Modelling / Modélisation physique et numérique	Earthquakes and Geohazards I / Séismes et géoaléas I	GIS and Remote Sensing in Cold Regions / SIG et télédétection en régions nordiques	

**Tuesday, September 22, 2015 / Mardi 22 septembre 2015**

12:15 - 13:45	Tuesday Luncheon, CGS Annual Business Meeting / Dîner du mardi, Assemblée d'affaire de la SCG - Room/Salle 2000 A-B							
<b>Level 2 / Niveau 2</b>								
13:45 - 15:15	Room 204AB John Ross Mackay Symposium - Permafrost II / Symposium John Ross Mackay - Pergélisol II	Room 205A Permafrost Degradation II / Dégénération du pergélisol II	Room 205BC Laboratory Testing II / Essais en laboratoire II	Room 207 Foundations II / Fondations II	Room 2102B Contaminated Sites and Remediation / Sites contaminés et réhabilitation	Room 2104AB Earthquakes and Geohazards II / Séismes et géoaléas II	Room 2105 Permafrost Considerations in Design / Considérations du pergélisol dans la conception	Room 2101
15:15 - 16:00	Break / Pause-santé - Trade Show / Salon des exposants - Room/Salle 2000CD							
GEOparody Student Competition / Concours « GEOparody » à l'intention des étudiants - Room/Salle 2000AB								
16:00 - 17:15	John Ross Mackay Symposium III - Permafrost III / Symposium John Ross Mackay - Pergélisol III	Barriers and Geosynthetics / Barrières et géosynthétiques	Laboratory Testing III / Essais en laboratoire III	Foundations III / Fondations III	Geotechnical Education Challenges / Défis de la formation en géotechnique	Landslides and Slope Stability IV / Mouvements de terrain et stabilité des pentes IV	Geophysical Investigation in Cold Regions / Investigations géophysiques en milieu nordique	Professional Practice / Pratique professionnelle
17:15 - 18:15	Rock Mechanics Division Meeting	Professional Practice Committee Meeting	Mining Geotechnique Committee Meeting	Geoenvironmental Division Meeting	Cold Regions Geotechnology Division Meeting	Sustainable Geotechnique Committee Meeting	Education Committee Meeting	Canadian Foundation for Geotechnique AGM Meeting
18:15 - 19:00	Shuttle Service to Le Louis-Jolliet / Navette vers Le Louis-Jolliet							
19:15 - 21:30	Québec Local Colour Night / Soirée à saveur locale de Québec							
21:30 - 22:15	Return Shuttle to Hilton Hotel / Navette de retour à l'Hôtel Hilton							





## Program "At a Glance" / Programme synoptique

## Tuesday, September 22 / Mardi 22 septembre

	204AB	205A	205BC	207	2102B	2104AB	2105
Time/Heure	John Ross Mackay Symposium – Permafrost I / Symposium John Ross Mackay – Pergélisol I (pp 136-137)	Permafrost Degradation I / Dégénération du pergélisol I (pp 138-140)	Laboratory Testing I / Essais en laboratoire I (pp 140-142)	Foundations I / Fondations I (pp 142-144)	Physical and Numerical Modelling / Modélisation physique et numérique (pp 144-146)	Earthquakes and Geohazards I / Séismes et Géohazards I (pp 147-149)	GIS and Remote Sensing in Cold Regions / SIG et télédétection en régions nordiques (pp 149-151)
10:45 – 11:00	258 Michael Church Reconstructing geomorphology: an appreciation of the contributions of J. Ross Mackay (1915-2014)	402 Wayne Poillard The Eureka Sound lowlands: an ice-rich permafrost landscape in transition	126 Federico Fernandez Laboratory Assessment of Energy-Efficiency in Vibratory Compaction of Granular Materials	789 Suzanne Lacasse GeoSuite – A computerized modular system for geotechnical design	299 Bipul Hawlader Physical modelling of submarine gassy slope failures	786 Pooneh Maghoul A Review of Seismic Site Amplification by Considering Geometrical and Geotechnical (...)	440 Brianna Rick Detection and inventorying of slope movements in the Brooks Range, Alaska using DInSAR; (...)
11:00 – 11:15		600 Alison Cassidy Ecosystem Impacts of High Arctic Permafrost Disturbances	655 William Smith The Formation of Laboratory Analogues of Natural Hydrate-Bearing Fine-Grained Soil	100 Brian Hall Fraser Heights Bridge – Geotechnical Challenges of Top-Down Construction on Difficult Soils	640 Heon-Joon Park Current research activities in KAIST Geo-Centrifuge Center focusing on soil-foundation(...)	447 Graeme McAllister Nonlinear site response analyses and high frequency dilation pulses	455 Anne-Marie LeBlanc DInSAR seasonal surface displacement in built and natural permafrost environments; (...)
11:15 – 11:30	469 Guodang Cheng John Ross Mackay – The Greatest Tutor and Best Friend of Chinese Permafrost Researchers	219 Brendan O'Neill Permafrost degradation adjacent to snow fences along the Dempster Highway, Peel (...)	171 Grytan Sarkar X-ray CT observation on the Light Backfill	42 Anna-Maria Zakkh Effects of Tunnelling On the Bearing Capacity of Shallow Foundations	697 Jonathan Black Centrifuge modelling of shallow foundations on firm over soft layered clay	781 Daniel Verret Effets de site du barrage en enrochement Denis-Perron (SM-3), Québec	418 Bernhard Rabus Advanced InSAR for Permafrost Related Ground Motion

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	204AB	205BC	207	2102B	2104AB	2105
11:30 – 11:45	<p><b>241</b> <i>Don Hayley</i> Science to Technology – The importance of understanding the fundamentals of permafrost science (...)</p>	<p><b>468</b> <i>Achala Souza</i> Simple shear loading response of undisturbed and reconstituted silt</p>	<p><b>411</b> <i>Mahra Al Massri</i> Numerical Investigation of the Bearing Capacity of Ring Foundations on Inhomogeneous Clay</p>	<p><b>575</b> <i>Mostafa Abolfazl Zadeh</i> Estimation of Residual Friction Angle of Clay Soils Using Artificial Neural Networks Modelling</p>	<p><b>611</b> <i>Olivier Hurley</i> Assessment of soil liquefaction potential of an embankment dam in the Charlevoix seismic zone</p>	<p><b>367</b> <i>Jayson Eppler</i> InSAR Monitoring of Infrastructure in Permafrost Regions</p>
11:45 – 12:00	<p><b>99</b> <i>Hugh French</i> JRM: His early accomplishments, 1950s to mid 1980s, and his results, 1990-2005</p>	<p><b>723</b> <i>Daniel Barnes</i> Some initial experimental findings on the influence of mode of shear on the monotonic shear (...)</p>	<p><b>487</b> <i>Prapote Boonsinsuk</i> Effects of varying modulus of subgrade reaction on structural design of mat foundation (...)</p>	<p><b>442</b> <i>Jinyuan Liu</i> Numerical simulation of wave propagation along a soil nail</p>	<p><b>748</b> <i>Andres Barrero</i> Application of an advanced constitutive model in nonlinear dynamic analysis of tailings dam</p>	<p><b>177</b> <i>Thomas Douglas</i> Using remote sensing and ground based measurements to identify vegetation-geomorphology (...)</p>
12:00 – 12:15	<p><b>417</b> <i>Julian Murtton</i> Late Wisconsin glaciation of Hadwen and Summer islands, Tuktoyaktuk Coastlands, NWT, Canada</p>	<p><b>161</b> <i>Mireille Sandrine Ewane</i> Essais d'indentation sur une argile sensible</p>	<p><b>249</b> <i>Pirahas Balasingam</i> High strain dynamic pile testing in a challenging soil condition A case study in Southern (...)</p>	<p><b>569</b> <i>François Duhaime</i> Modelling of elution tests with the ICP interface between COMSOL and Phreeqc</p>	<p><b>668</b> <i>Mahya Hatambeigi</i> Numerical analysis of liquefaction mechanism in hydraulic fill dams</p>	<p>Discussions</p>





## Tuesday, September 22 / Mardi 22 septembre

	204AB	205A	205BC	207	2102B	2104AB	2105
Time/Heure							
	<p><b>John Ross Mackay Symposium - Permafrost II / Symposium John Ross Mackay - Pergélisol II</b> (pp.151-153)</p> <p><b>296 Kenneth Hinkel</b> Estimating Tailk Depth Beneath Lakes in Arctic Alaska</p>	<p><b>Permafrost Degradation II / Dégénération du pergélisol II</b> (pp.153-156)</p> <p><b>320 Ashley Rudy</b> Watershed delineation in areas of permafrost disturbance on eastern Banks (...)</p>	<p><b>Laboratory Testing II / Essais en laboratoire II</b> (pp.156-158)</p> <p><b>541 Marc Lebeau</b> A generalized global optimization application and its use in determining the hydraulic (...)</p>	<p><b>Foundations II / Fondations II</b> (pp.158-160)</p> <p><b>598 J. Suzanne Powell</b> Design and construction of a three-storey concrete building on liquefiable soils (...)</p>	<p><b>Contaminated Sites and Remediation / Sites contaminés et réhabilitation</b> (pp.161-163)</p> <p><b>271 Victoria Stevens</b> Incorporating Geotechnical Investigations to Support Reclamation on Resource Projects</p>	<p><b>Earthquakes and Geohazards II / Séismes et géolés II</b> (pp.163-166)</p> <p><b>127 Ahmed Mahmoud</b> Failure mechanisms of underground structures during earthquake: an overview</p>	<p><b>Permafrost Considerations in Design / Considérations du pergélisol dans la conception</b> (pp.166-168)</p> <p><b>349 Fabrice Caimels</b> A practical guide to permafrost vulnerability for Yukon's North Alaska Highway</p>
<b>13:45 - 14:00</b>							
<b>14:00 - 14:15</b>	<p><b>284 Pascale Roy-Leveillee</b> Geometry of oriented lakes in Old Crow Flats, northern Yukon</p>	<p><b>144 Michael Braverman</b> The effects of permafrost degradation on the hydrological regime of subarctic peatlands</p>	<p><b>122 Ahlam Abdulnabi</b> Laboratory Testing Program for the Prediction of Rainfall Runoff from Soil Cover Systems</p>	<p><b>604 Renato Clementino</b> Comparison of pile capacity estimated by signal matching (CAPWAP®), iCAP® and Case Method (...)</p>	<p><b>265 Fereshteh Arab</b> On the effect of sophorolipids on different fractions of mine tailing and the speciation of arsenic</p>	<p><b>278 Partheeban Selvarajah</b> The Beneficial and Detrimental Effects of Rocking Shallow Foundations on Super Structure during (...)</p>	<p><b>341 Lukas Arenson</b> Considering Permafrost in the Design of Linear Infrastructure through Mountainous Terrain</p>
<b>14:15 - 14:30</b>	<p><b>236 Stephen Wolfe</b> Holocene lake-level recession, permafrost aggradation and lithalsa formation in the Yellowknife area, (...)</p>	<p><b>269 Changwei Xie</b> Estimating annual apparent thermal diffusivity in permafrost using temperature time(...)</p>	<p><b>444 Lu Zhang</b> Constant-Head Permeability Tests Performed in Monitoring Wells at Laboratory Scale</p>	<p><b>511 Weidong Li</b> OpenSees Simulations of Axial Behaviour of Single-Helix Piles</p>	<p><b>370 Ichrak Hadimi</b> Effect of cementitious amendment on the geochemical behavior of a surface paste tailings disposal</p>	<p><b>484 Hamid Karimian</b> A procedure for estimation of lateral spreading displacement using results of (...)</p>	<p><b>744 Kumari Karunaratne</b> Metadata Template for Ground Temperature Records in the Northwest Territories</p>

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	204AB	205A	205BC	207	2102B	2104AB	2105
14:30 - 14:45	102 Philip Marsh Lakes of the western Canadian Arctic: Past Controls and Future Changes	140 Chengwei Wan Hydrologic connections in the Source Area of the Yellow River as inferred by (...)	365 Mohamed Chekired Experiment setup for simple shear tests in a triaxial cell: TXSS	751 Lassaad Hazzar Numerical study for soil-spring stiffness of pile group	163 Abdelkadir Maqoud The hydrochemical behavior of the Aldermac abandoned mine site after its rehabilitation	561 Pete Quinn Liquefaction susceptibility mapping derived from terrain mapping: (...)	112 Yves Cormier Coordination and Completion of Multi-Year Geotechnical Investigation in the Canadian Arctic: (...)
	301 Ming-Ko Woo Summer and winter flows of the Mackenzie River system	191 Dmitry Streletskiy Spatial variability of soil temperature and active-layer thickness in the permafrost regions of Russia (...)	393 Mahmoud Hussien Evaluation of DSS test results on granular soils based on TXSS results	25 Lassaad Hazzar 3D modeling laterally loaded battered piles in sand	13 Lamine Boumaiza Caractérisation environnementale des sols et du remblai contenant des matières résiduelles à l'endroit (...)	567 Berthoumieux Junior Jean Comparaison expérimentale des méthodes MASW et H/V bruit de fond dans l'estimation (...)	372 Marcus Phillips Improving water content description of ice-rich permafrost soils
15:00 - 15:15	512 Michelle Côté Geohazard investigations of permafrost and gas hydrates in the outer shelf and upper (...)	361 Anatoli Brushkov Viruses in ancient ice wedges in the Central Yakutia, Siberia	130 Marwan Khashila Evaluation of equivalent cycle liquefaction concept based on TXSS test results	21 Ahmed Fahmy Lateral Performance of Helical Tapered Piles in Sand	18 Abdelkadir Maqoud Influence of Extreme Events and Hydrogeological Properties on the Release Capacity of (...)	608 Bétegard Jeudy Microzonage sismique de la ville des Cayes à Haïti	105 Yongping Wang Pipe-laying Technology in a Subarctic Permafrost Region – A Case Study for the (...)



## Program "At a Glance" / Programme synoptique

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	204AB	205A	205BC	207	2102B	2104AB	2105
Time/Heure							
	John Ross Mackay Symposium - Permafrost III / Symposium John Ross Mackay - Pergélisol III (pp. 168-170)	Barriers and Geosynthetics / Barrières et géosynthétiques (pp. 170-172)	Laboratory Testing III / Essais en laboratoire III (pp. 172-174)	Foundations III / Fondations III (pp. 174-176)	Geotechnical Education Challenges / Défis de la formation en géotechnique (pp. 176-178)	Landslides and Slope Stability IV / Mouvements de terrain et stabilité des pentes IV (pp. 178-180)	Geophysical Investigation in Cold Regions / Investigations géophysiques en milieu nordique (pp. 180-182)
16:00 - 16:15	<b>234</b> Peter Morse Meteorological and geological influences on icing dynamics in subarctic Northwest Territories, Canada	<b>806</b> Andrew Mills The Practical Limits of Cold Temperature Geomembrane Installation in Northern Canada	<b>812</b> Muhammad Irfan Novel evaluation of binder response in sand specimens using a laser vibrometer	<b>633</b> Peiyuan Lin Evaluation of prediction accuracy of ultimate bond strength of soil nails by the effective (...)	<b>742</b> Jean Lafleur Pourquoi pas un baccalauréat en génie géotechnique?	<b>373</b> Jayanti Sharma Monitoring Geohazards near Pipeline Corridors with an Advanced InSAR Technique (...)	<b>205</b> Marat Sadurtdinov Seismic studies of frozen ground in Russian Arctic areas
16:15 - 16:30	<b>429</b> Frederick Nelson Topoclimatic controls on active-layer thickness, Alaskan Coastal Plain	<b>27</b> Mohamed Shaab Effect of brine solution on antioxidants of HDPE geomembranes	<b>586</b> Ahmed Mhenni Improvement of the Piezo-electric Ring Actuator technique (P-RAT) using 3D numerical (...)	<b>149</b> Yunlong Liu Estimation of uplift shaft friction for a single pile in expansive soil using the mechanics of (...)	<b>145</b> Jinyuan Liu Personal reflection of teaching advanced foundation design course	<b>513</b> Matt Lato 3D data collection for rapid rock fall response situations	<b>336</b> Svet Milanovskiy Geophysical Monitoring of Engineering Constructions in Western Yakutia (...)

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	204AB	205A	205BC	207	2102B	2104AB	2105
16:30 - 16:45	422 Denis Lacelle Geochemistry of the active layer and permafrost in northwestern Canada: from measurements (...)	775 Vincent Daviacchi Advances in Geomembranes: Leak Location Liner: Geomembrane Barrier Systems with (...)	121 Mohamed Ben Romdhan Minimizing scaling effect on the measured Vs using the P-RAT	75 Mark Tighehaar Innovative Deep Foundation Support using Ductile Iron Piles	752 Efosyni-Maria Skaradaki Blended training and collaborative learning for software users in the geosciences	492 David Wood Rockfall protection along Highway 403 in Hamilton, ON: A recent re-assessment and application (...)	396 Robert Way Investigations of discontinuous permafrost in coastal Labrador with DC electrical (...)
	16:45 - 17:00	248 Denis Sarrazin The thermo-mechanical behavior of frost-cracks over ice wedges: new data from extensometer (...)	601 Stephan Fourmont Behavior of Drain Tubes planar drainage geocomposite under extreme cold temperatures	449 Jesús González-Hurtado Measuring the small-strain elastic modulus of gap-graded soils using an effective-medium model (...)	23 Mahmoud Hussien Evaluation of seismic kinematic and inertial forces in piles	356 Chen Wang Some factors affecting retrogressive failure of sensitive clay slopes using (...)	283 Joel Pumple Characterizing permafrost valley fills along the Alaska Highway, southwest Yukon
17:00 - 17:15	252 Christopher Burn Subdivision of ice-wedge polygons, western Arctic coast	280 Steven Harms Field testing large sand-filled geotextile containers used as a temporary flood protection system	736 Jonathan Black Visualization of heat transfer to characterize energy foundations	72 Farzaneh Naghibi Total versus Differential Settlement of Deep Foundations	390 Vicki Remenda A longitudinal survey of experimental field-based learning in geological sciences and geological engineering at (...)	650 Alain Durand Nouvelle investigation géotechnique du glissement de terrain de 1971 le long (...)	318 Greg A. Oldenborger Geophysical imaging of permafrost conditions along the northern Yukon Alaska Highway



## Wednesday, September 23, 2015 / Mercredi 23 septembre 2015

7:15 – 8:15	Speaker's Breakfast / Déjeuner des auteurs – Room/Salle 206AB							
8:30 –9:25	2015 CGS Colloquium / Colloque 2015 de la SCG Dr. Greg Siemens – Room/Salle 2000AB <i>Unsaturated Soil Mechanics : Bridging the Gap between Research and Practice</i>							
9:25 -10:00	Graduate Student Lecture / Conférence étudiant gradué Amy Rentz – Room/Salle 2000AB <i>Field Performance of Exposed Geosynthetic Composite Liner Systems: Down-slope Bentonite Erosion from a Geosynthetic Clay Liner</i>							
10:00 – 10:30	Break / Pause-santé – Hall 2000  Poster Session / Séance d'affiches – Hall 2000							
<b>Level 2 / Niveau 2</b>								
10:30 – 12:00	Room 204AB Foundations IV / Fondations IV	Room 205A Landslides and Slope Stability V / Mouvements de terrain et stabilité des pentes V	Room 205BC Transportation and Linear Infrastructure I / Transports et infrastructures linéaires I	Room 206A In Situ Testing and Instrumentation I / Essais in situ et instrumentation I	Room 2102B Groundwater / Eaux souterraines	Room 2104AB Problematic Soils and Ground Improvement I / Sols problématiques et amélioration du comportement I	Room 2105 Geocryology I / Géocryologie I	Room 2101 Professional Practice / Pratique professionnelle
12:00 – 13:30	Wednesday Luncheon / Dîner du mercredi – Room/Salle 2000AB Program Pioneers / Événement Héritage							

**Wednesday, September 23, 2015 / Mercredi 23 septembre 2015**

Level 2 / Niveau 2								
13:30 – 15:00	Room 204AB	Room 205A	Room 205BC	Room 206A	Room 2102B	Room 2104AB	Room 2105	Room 2101
	Foundations V / Fondations V	Embankments and Dams in Cold Regions / Remblais et barrages en régions nordiques	Transportation and Linear Infrastructure / Transports et infrastructures linéaires II	In Situ Testing and Instrumentation II / Essais in situ et instrumentation II	Northern Communities / Communautés nordiques	Problematic Soils and Ground Improvement II / Soils problématiques et amélioration du comportement II	Geocryology II / Géocryologie II	<i>Sustainable Geotechnique / Géotechnique durable</i>
	Break / Pause-santé – Hall 2000							
	Poster Session / Séance d'affiches – Hall 2000							
	15:30 – 16:30	Mining Geotechnique IV / Géotechnique minière IV	Embankments and Dams / Remblais et barrages	Transportation and Linear Infrastructure III / Transports et infrastructures linéaires III	Landslides and Slope Stability VI / Mouvements de terrain et stabilité des pentes VI	Permafrost (Other) / Pergélisol (autre)	Problematic Soils and Ground Improvement III / Soils problématiques et amélioration du comportement III	Physical and Numerical Modelling in Cold Regions / Modélisation physique et numérique en régions nordiques
16:45 – 17:15	Closing Ceremonies / Cérémonies de clôture – Room/Salle 2000AB							





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10:30 - 10:45	<b>Foundations IV / Fondations IV</b> (pp 196-198)	<b>Landslides and Slope Stability V / Mouvements de terrain et stabilité des pentes V</b> (pp 198-200)	<b>Transportation and Linear Infrastructure / Transports et infrastructures linéaires I</b> (pp 200-202)	<b>In Situ Testing and Instrumentation I / Essais insitu et instrumentation I</b> (pp 202-204)	<b>Groundwater / Eaux souterraines</b> (pp 205-207)	<b>Problematic Soils and Ground Improvement I / Sols problématiques et amélioration du comportement I</b> (pp 207-209)	<b>Geocryology I / Géocryologie I</b> (pp 209-211)
	<b>750 Xiaobo Wang</b> Full-scale Pile Loading Tests on Instrumented Concrete Piles in Clay Till, in Edmonton, Alberta	<b>153 Ali Khalil</b> Slope Observations and Field Mapping to Verify the Stability of Slopes near Kitimat, BC	<b>749 Shawn Kenny</b> Integrated Framework in Support of Pipeline Engineering Design for Geohazards	<b>606 Mark Styler</b> Effect of soil structure on in-situ field vane and seismic piezocene tests in Champlain Clay	<b>529 Robert P. Chapuis</b> Pumping Test in a Confined Aquifer: How to Detect a Poorly Sealed Monitoring Well	<b>670 Mustapha Zergoun</b> Site Preparation for Vancouver Airport, Designer Outlet Centre, Richmond, BC	<b>352 Caitlin Lapalme</b> Cryostratigraphy of near-surface permafrost in University Valley, McMurdo Dry (...)
10:45 - 11:00	<b>510 Weidong Li</b> In-situ loading tests of small-diameter helical piles and evaluation of design methods	<b>17 Barry Meays</b> Eureka River Landslide, Hwy 726.02 Near Worsley, Alberta: Design and Construction of (...)	<b>713 Matt Lato</b> Hazard identification and evaluation using UAV photogrammetry for pipeline routing	<b>35 Raymond Haché</b> Evaluation of the undrained shear strength of Champlain Sea clays (Leda clay) in Ottawa using CPT	<b>508 Dominique Beaulieu</b> A numerical study of the influence of groundwater flow on heat loss from residential foundations	<b>486 Mourad Karray</b> Assessment of compatibility between existing liquefaction charts in Eastern regions of North (...)	<b>641 Daniel Fortier</b> Contrasting patterns of thermo-erosion gullies formed in syngenetic ice wedge polygonal terrains (...)
	<b>155 Fazli Shah</b> In-situ Axial Load Tests of Drilled Displacement Steel Piles	<b>215 Matthew Schafer</b> Instrumenting and Monitoring a Slow Moving Landslide	<b>610 Aiden Horan</b> Secant Piled Shaft Construction and Microtunnelling in Sand	<b>251 Lincar Pedroni</b> Interpretation and Correlation of CPTu and Vane Shear Tests for Very Soft Varved Silty Clays - A (...)	<b>286 Adrian Glowacki</b> The Effect of Flow Reversal on Permeability Measurement in Rocks	<b>206 Jason Brown</b> Liquefaction Mitigation using Rapid Impact Compaction and a Comparison of SPT and CPT (...)	<b>259 Adrian Gaanderse</b> Origin and composition of a lithalsa in the Great Slave Lowland, Northwest Territories
11:00 - 11:15							

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	204AB	205A	205BC	206A	2102B	2104AB	2105
11:15 - 11:30	<p><b>793</b> <i>Mohammadamin Hosseini</i> Evolution of Pile Shaft Capacity over Time in Soft Clays</p>	<p><b>616</b> <i>Marc-André Brideau</i> Engineering geology, electrical resistivity tomography and displacement monitoring of the (...)</p>	<p><b>334</b> <i>Kshama Roy</i> Soil Failure Mechanism for Lateral and Upward Pipeline-Soil Interaction Analysis in Dense Sand</p>	<p><b>355</b> <i>Baolin Wang</i> Geotechnical investigations of a large landside site at Quyon, Québec</p>	<p><b>725</b> <i>Djapouida Chenaf</i> Interpreting pumping test in stratified confined aquifer using the equivalent model</p>	<p><b>609</b> <i>Oliver Hurley</i> Finite element modelling of stone column installation: Review of modelling practices and (...)</p>	<p><b>160</b> <i>Oliver Bellehumeur-Genier</i> Permafrost patch size in the sporadic discontinuous and isolated patches permafrost zones, (...)</p>
11:30 - 11:45	<p><b>227</b> <i>Mohammed Al-Khazaali</i> Numerical modelling technique to predict the load versus settlement behavior of single piles in (...)</p>	<p><b>326</b> <i>Bronwen Kelley</i> Temporary Slope Stabilization at the Airport Trail Underpass Excavation, Calgary (...)</p>	<p><b>795</b> <i>Dahlia Hafez</i> Numerical Modeling of Stress Reducing Effects of Rigid Inclusions above Buried FRP Pipes</p>	<p><b>9</b> <i>Valérie Michaud</i> Piezocone testing applications for safety analyses of dams on stratified deposits</p>	<p><b>11</b> <i>Lamine Boumaiza</i> Estimation de la conductivité hydraulique et la porosité des lithofaciés identifiés dans les (...)</p>	<p><b>700</b> <i>Amir Poshnejad</i> Foundation solutions for light and heavy construction on expansive soils: Case studies</p>	<p><b>169</b> <i>Stephan Gruber</i> Permafrost in mountainous regions of Canada</p>
11:45 - 12:00	<p><b>325</b> <i>Mina Lee</i> Environmental Impacts of Drilled Shaft Design in Sand</p>	<p><b>514</b> <i>Daniel Huang</i> Use of Native Soil in the MSE Structures</p>	<p><b>577</b> <i>Mohamed Meguid</i> On the numerical modeling of buried structures with compressible inclusion</p>	<p><b>503</b> <i>Jean-François St-Laurent</i> EGT Sampling Method - Toward undisturbed sand sample</p>	<p><b>216</b> <i>Vahid Marefat</i> Performance of fully grouted piezometers subjected to transient flow conditions</p>	<p><b>202</b> <i>Jérôme Lapierre</i> Stability design of a tallings dam on a glaciolacustrine clay foundation</p>	<p><b>453</b> <i>Nicole Couture</i> Ground Ice determinations along the Yukon coast using a morphological model</p>







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	204AB	205A	205BC	206A	2102B	2104AB	2105
Time/Heure							
	<p><b>Foundations V / Fondations V</b> (pp 212-213)</p>	<p><b>Embankments and Dams in Cold Regions / Remblais et barrages en régions nordiques</b> (pp 214-216)</p>	<p><b>Transportation and Linear Infrastructure II / Transports et infrastructures linéaires II</b> (pp 216-218)</p>	<p><b>In situ Testing and Instrumentation II / Essais in situ et instrumentation II</b> (pp 218-220)</p>	<p><b>Northern Communities / Communautés nordiques</b> (pp 221-223)</p>	<p><b>Problematic Soils and Ground Improvement II / Sols problématiques et amélioration du comportement II</b> (pp 223-225)</p>	<p><b>Geocryology II / Géocryologie II</b> (pp 226-228)</p>
<b>13:30 - 13:45</b>	<p><b>55 Jamie Schweighofer</b> Case Study: A simplified evaluation of load transfer from a monopole foundation</p>	<p><b>108 Maritz Rykkaart</b> Evaluating the Performance of a Frozen Core Dam Founded on Ice Rich Saline Marine Silts (...)</p>	<p><b>804 Lynden Penner</b> Terrain analysis for high voltage transmission line routing using remote sensing techniques</p>	<p><b>452 Kanagaratnam Balachandran</b> Correlations between Pressuremeter Modulus and SPT-N-value for Glacial Till</p>	<p><b>338 Antoni Lewkowicz</b> Development of a new CSA standard for moderating the effects of permafrost degradation on (...)</p>	<p><b>57 Sandro Sandroni</b> The Santana Port: accident: Could it be a sensitive clay flowslide under the Equator?</p>	<p><b>499 Maxime Duguay</b> Quantifying the significance of the hydrological contribution of a rock glacier - A review</p>
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<b>14:30 - 14:45</b>	<b>554</b> <i>Axel Nernheim</i> Static and Cyclic Design Aspects for Foundation Piles of Offshore Wind Farms	<b>540</b> <i>Marc Lebeau</i> Non-Darcy and radiative effects on convective embankment modelling	<b>76</b> <i>Alex Campbell</i> Effect of corrosion on the soil structure interaction of CSP culverts	<b>36</b> <i>Raymond Haché</i> Formation of soil plugs within H-Piles driven in stiff clayey Port Stanley till near London, Ontario	<b>691</b> <i>Karen Mckenna</i> Agricultural adaptations to changing permafrost conditions in southern Yukon	<b>547</b> <i>Tonje Eide Helle</i> Laboratory setup to evaluate the improvement of geotechnical properties from (...)	<b>113</b> <i>Peter Morse</i> Permafrost occurrence in subarctic forests of the Great Slave region, Northwest Territories, Canada
<b>14:45 - 15:00</b>	<b>109</b> <i>Serge Bourque</i> The Use of the Geopier® Intermediate Foundation® System for Support of Seven Wind Turbine (...)	<b>89</b> <i>Loriane Périer</i> Influence of water temperature and flow on thermal regime around culverts built on permafrost	<b>696</b> <i>Jessica Abrahamse</i> Responsible Culvert Design, Evaluating Culvert Design Life from a Sustainable Perspective	<b>190</b> <i>Suman Manandhar</i> Effect of long-term static load on the L-shaped retaining wall installed with thinned wooden pile and (...)	<b>123</b> <i>Dmitry Streltskiy</i> Arctic cities, permafrost and changing climatic conditions	<b>63</b> <i>Mohamed Shahin</i> Assessment of different treatment methods by microbial-induced calcite precipitation for (...)	<b>226</b> <i>Anna N. Kurchatova</i> Hydrocarbon seepage and formation of authigenic minerals in the permafrost of West Siberia



## Program "At a Glance" / Programme synoptique

## Wednesday, September 23 / Mercredi 23 septembre

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# KEYNOTES/MORNING PLENARY SESSIONS

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## Monday September 21<sup>st</sup>, 2015

**R.M. Hardy Keynote Address – Dr. Jean-Marie Konrad, Université Laval**

### ***Design and Analysis of Rockfill Dams: Past, Present and Future***

The 2015 R.M. Hardy lecture reviews the evolution of the design practice at Hydro-Québec for four generations of rockfill dams. Innovative research to advance the practice is presented with particular emphasis on scale effect and particle breakage, internal erosion and contact erosion. Future developments with respect to seismic design are outlined with an emphasis on permanent deformation prediction and in situ testing in rockfill to obtain representative material parameters. Finally, analysis of rockfill dams considering evolving material properties is discussed.

**John Ross Mackay Lecture – Dr. Steven V. Kokelj, Northwest Territories  
Geological Survey**

### ***Retrogressive Thaw Slumps: from Slope Process to the Landscape Sensitivity of Northwestern Canada***

Retrogressive thaw slumping is a dynamic thermokarst process and an important driver of change in ice-cored, glaciogenic landscapes across the circumpolar North. In this talk, dedicated to the memory of John Ross Mackay, research on the processes and feedbacks that influence the growth of retrogressive thaw slumps is summarized with focus on studies from the Peel Plateau, northwestern Canada. Landsat imagery (1985 to 2011) and high frequency climatic and photographic time-series for the summers of 2010 and 2012 indicate that an increase in rainfall has accelerated downslope sediment flux from slump scar zones, perpetuating slump activity and intensifying this disturbance regime. Environmental impacts are significant: these mega slumps now commonly exceed 15 ha in area, displace up to 106 m<sup>3</sup> of materials from slopes to valley bottoms, reconfigure slopes and drainage networks, and significantly increase stream sediment and solute loads.

Remote sensing of slump-impacted terrain across a 1, 275, 000 km<sup>2</sup> area of northwestern Canada has revealed a close association with ice-rich hummocky moraine landscapes, which were deposited at the margins of the former Laurentide Ice Sheet. In conjunction with process-oriented thaw slump studies, this mapping provides a quantitative basis and a geomorphic context for evaluating the distribution of ice-cored permafrost and the potential for climate-driven landscape change across northwestern Canada.



# CONFÉRENCES D'HONNEUR/ SESSIONS PLÉNIÈRES DU MATIN

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**Lundi 21 septembre 2015**

**Conférence d'ouverture, Allocution R.M. Hardy – Dr Jean-Marie Konrad, Université Laval**

***Design and Analysis of Rockfill Dams: Past, Present and Future***

L'allocution R.M. Hardy revoit l'évolution des pratiques de conception chez Hydro-Québec pour quatre générations de barrages en enrochement. Des recherches innovantes visant à l'amélioration de la pratique sont présentées en mettant une emphase particulière sur les effets d'échelle, la fragmentation des particules, l'érosion interne et l'érosion de contact. Les besoins futurs vis-à-vis de la conception sismique sont abordés en soulignant l'importance de la prédiction des déformations permanentes et des mesures in situ sur les enrochements afin d'obtenir des paramètres de matériaux représentatifs. En conclusion, l'analyse des barrages en enrochement est abordée en considérant le caractère évolutif des propriétés des matériaux.

**Conférence John Ross Mackay – Dr Steven V. Kokelj, Commission géologique des Territoires du Nord-Ouest**

***Retrogressive Thaw Slumps: from Slope Process to the Landscape Sensitivity of Northwestern Canada***

Les glissements rétrogressifs dus au dégel du pergélisol sont des processus thermokarstiques dynamiques et un facteur majeur de changement des paysages périglaciaires dominés par le pergélisol riche en glace du Nord circumpolaire. Les travaux de recherche sur les processus et les boucles de rétroaction qui influencent la croissance de ces glissements rétrogressifs seront présentés dans cette conférence dédiée à la mémoire de John Ross Mackay en mettant l'emphase sur nos études du Plateau Peel dans le nord-ouest du Canada. Selon les analyses d'images satellitaires Landsat de 1985 à 2011, d'enregistrements climatiques et de séries chronologiques de photographies prises lors des étés 2010 et 2012, l'augmentation des précipitations a accéléré l'écoulement de sédiments dans les zones de glissement ce qui a favorisé davantage les processus de glissement et intensifié les perturbations du milieu. Les impacts environnementaux sont significatifs dans la région d'étude. En effet, les méga glissements couvrent des surfaces qui dépassent régulièrement 15 ha, ils peuvent déplacer jusqu'à 106 m<sup>3</sup> de matériaux vers le fond des vallées. Ces matériaux déplacés reconfigurent les pentes et les réseaux de drainage. De plus, la charge de sédiments en suspension et de minéraux dissous dans l'eau a augmenté de façon importante dans les cours d'eau.

La cartographie de ces glissements rétrogressifs sur une zone de 1 275 000 km<sup>2</sup> dans le Nord-Ouest du Canada a révélé une association étroite entre ces glissements et la présence de moraines mamelonnées riches en glace qui ont été déposées à la limite de l'Inlandsis Laurentien. En parallèle avec les études des processus de dégradation du pergélisol et de glissement de terrain, cette cartographie fournit une base quantitative et un contexte géomorphologique pour évaluer la répartition du pergélisol riche en glace ainsi que pour évaluer l'influence du climat sur l'évolution du paysage périglaciaire dans le Nord-Ouest du Canada.



**Keynote – Dr. Lukas U. Arenson, BGC Engineering**  
***Cold Regions Engineering in a Changing Climate***

Considering climate change is an integral part of any infrastructure design that has an extended design life and of particular importance with respect to perpetual designs. Various technical guidelines indicate that global warming should be addressed in the design but often details on how to do this are missing. Also, climate projection models have seen significant improvement over recent years, but the biggest challenge in terms of designing for climate change are not changes in air temperature, but second and third order effects, together with changes in climate extremes. Non-linear changes in precipitation, adjustments in vegetation and/or related geohazards are of relevance rather than average changes in air temperature alone, which are typically the products with the lowest uncertainties available from climate projection models. The keynote presentation provides an overview of these challenges, a summary of latest climate change modeling products and introduces the use of a systematic, risk based approach for cold regions designs considering climate change.

**Keynote – Dr. Jean Hutchinson, Queen's University**  
***Applications of Remote Sensing Techniques to Managing Rock Slope Instability Risk***

The recent development of rapid, accurate and sophisticated remote sensing tools has provided valuable rock slope change data, previously impossible to obtain. The analysis techniques discussed in this paper utilize detailed and precise models of three-dimensional geometry developed from photographs and LiDAR point clouds. Models of the rock slope from data collected at similar times can be combined, taking advantage of data at different resolutions and collected from different vantage points and platforms. Such models can be used for remote mapping of discontinuities and lithology, as well demonstrated by others. The added value for slope stability management discussed in this conference is realized when geometrical models from different times are compared. Depending upon the frequency of measurements and the rate of change of the rock slope, prior to slope failure it is possible to hypothesize the slope failure mode, the potential volume of the impending failure and in some cases, to provide an accurate estimate of the time of failure. In back analysis, it is possible to determine the distribution of the source zone(s), to assess the path of movement, and to calculate the volume of the source volume and accumulated debris. The case histories demonstrate our enhanced ability to detect and manage the risk of rock slope failure.

**Keynote – Dr. Guy Doré, Université Laval**  
***Adaptation of Transportation Infrastructure in Northern Québec and Canada: Problem Assessment and Development of Solutions***

Transportation infrastructure is essential for social and economic development of Northern regions. Permafrost degradation caused by poorly adapted design and construction practices and by climate change is now threatening the structural and functional capacities of roads and airstrips. The presentation will describe a research program conducted over the last 15 years with the support of several industrial partners. The goal of the program is to improve our capacity to build and maintain transportation infrastructure on sensitive permafrost. The objectives are (1) to improve knowledge on factors causing permafrost degradation around airport and road embankments, (2) to assess the vulnerability of airstrips and roads in Northern Canada, (3) to propose adaptation strategies for vulnerable



**Conférence d'honneur – Dr Lukas U. Arenson, BGC Engineering**  
***Cold Regions Engineering in a Changing Climate***

Considérer les changements climatiques est une partie à intégrer lors de la conception de toute infrastructure nécessitant une durée de vie prolongée et est d'une importance particulière pour les conceptions perpétuelles. De nombreuses directives techniques montrent que le réchauffement global doit être considéré lors de la conception, mais les détails sur la façon de faire sont souvent manquants. Les modèles de projection climatique ont connus une amélioration significative au cours des dernières années, toutefois le plus gros défi sur le plan de la conception n'est pas le changement dans les températures de l'air, mais plutôt les effets de deuxième et troisième ordres, liés aux changements dans les extrêmes climatiques. Les changements non linéaires dans les précipitations, dans les modifications de la végétation et/ou reliés aux géorisques sont pertinents, comparés aux seuls changements de température de l'air, lesquels sont généralement les produits de plus faible incertitude disponibles à partir des modèles de projection climatique. La conférence fournit un survol de ces défis, un résumé des derniers produits de modélisation climatique, et introduit l'utilisation d'une approche systématique basée sur le risque et considérant les changements climatiques lors de la conception dans les régions froides.

**Conférence d'honneur – Dr Jean Hutchinson, Université Queen's**  
***Applications of Remote Sensing Techniques to Managing Rock Slope Instability Risk***

Le développement récent d'outils de télédétection rapides, précis et sophistiqués, a fourni des données précieuses sur les changements de pentes dans le roc, lesquelles étaient auparavant impossibles à obtenir. Les techniques d'analyses discutées lors de cette conférence utilisent des modèles détaillés et précis de la géométrie en 3 dimensions, développés à partir de photographies et de données Lidar. Les modèles des pentes rocheuses provenant de données prises à des moments similaires peuvent être combinés afin de mettre à profit des données de différentes résolutions et recueillies selon différents points de vue et plates-formes. De tels modèles peuvent être utilisés pour la cartographie à distance des discontinuités et des lithologies, tel que démontré par d'autres. Tel que discuté dans cette conférence, la valeur ajoutée pour la gestion de la stabilité des pentes est obtenue lorsque les modèles géométriques pris à différents moments sont comparés. En fonction de la fréquence de mesures et du taux de changement des pentes rocheuses avant la rupture de la pente, il est possible de poser l'hypothèse du mode de rupture de la pente, du volume potentiel de la rupture imminente et dans certains cas, de fournir une estimation précise du moment de la rupture. Dans l'analyse à rebours, il est possible de déterminer la distribution de la ou des zone(s) source(s), d'évaluer la trajectoire et de calculer le volume de la source et des débris accumulés. Les cas historiques présentés démontrent notre habileté à détecter et gérer les risques de rupture dans les pentes rocheuses.

**Conférence d'honneur – Dr Guy Doré, Université Laval**  
***Adaptation of Transportation Infrastructure in Northern Québec and Canada: Problem Assessment and Development of Solutions***

Les infrastructures de transport sont essentielles pour le développement social et économique des régions nordiques. La dégradation du pergélisol causée par des pratiques mal adaptées de conception et de construction et par le changement climatique menace maintenant les capacités structurelles et fonctionnelles de routes et de pistes d'atterrissage.





facility, and (4) to develop performing stabilization techniques and document their cost effectiveness. The program involves documenting the problems affecting transportation infrastructure and the development of solutions through rigorous modelling and experimentation, and finally, the implementation of the solutions through pilot projects conducted with the cooperation of transportation agencies.

## **Wednesday September 23<sup>rd</sup>, 2015**

### **CGS Colloquium – Dr. Greg Siemens, Royal Military College of Canada**

#### ***Unsaturated Soil Mechanics: Bridging the Gap Between Research and Practice***

Most geo-engineering applications occur within the unsaturated zone or include an unsaturated component. For example all compacted construction materials are unsaturated following placement. In nature, the unsaturated zone (also known as the vadose zone) is the near-surface ground area, which is the linkage between weather systems above and the saturated groundwater system below. Unsaturated soil mechanics describes the principles of soil behaviour for the conditions ranging from completely dry ( $S_r=0$ ) to saturated ( $S_r=1.0$ ). Canada has a long and productive legacy of unsaturated soils research focusing on advancing the theory and practical use of unsaturated soil mechanics. The Canadian Geotechnical Journal is widely recognized for its repository of unsaturated soils publications in theoretical, laboratory, and case studies from Canadian and international authors. New advancements in laboratory testing, constitutive modeling, and field studies have provided breakthroughs in fundamental understanding and provide for the practical use of unsaturated soil principles in some cases. However, use of unsaturated soil mechanics in practice continues to lag significantly behind the state-of-the-art. In design, unsaturated effects are often viewed as providing additional safety factor rather than an opportunity for greater efficiency. For example, design of a shallow foundation will often consider the saturated friction angle of a granular material and ignore the depth of the foundation relative to the water table. This colloquium will examine the principles of unsaturated soil mechanics principles through illustrative examples. The illustrations will provide motivation for examining the tension between research and practical use of unsaturated soil mechanics. The 'lessons learned' from the cases are beneficial to the geo-engineering community and to generate new interest and wider use of unsaturated soil principles.



La présentation décrira un programme de recherche mené au cours des 15 dernières années avec l'appui de plusieurs partenaires industriels. Le but du programme est d'améliorer notre capacité à construire et entretenir les infrastructures de transport sur le pergélisol sensible. Les objectifs sont: (1) améliorer la connaissance sur les facteurs causant la dégradation du pergélisol autour des remblais, (2) d'évaluer la vulnérabilité des pistes d'atterrissage et des routes dans le Nord canadien, (3) de proposer des stratégies d'adaptation pour les infrastructures vulnérables, et (4) de développer des techniques de stabilisation et de documenter leur rentabilité. Le programme consiste à documenter les problèmes affectant les infrastructures de transport et le développement de solutions à travers un programme rigoureux impliquant la modélisation et l'expérimentation, et enfin, la mise en œuvre des solutions par le biais de projets pilotes menés avec la coopération des organismes de transport.

## **Mercredi 23 septembre 2015**

**Colloque de la société canadienne de géotechnique– Dr Greg Siemens,  
Collège militaire royal du Canada**

### ***Unsaturated Soil Mechanics: Bridging the Gap Between Research and Practice***

La plupart des applications en géo-ingénierie se situe dans la zone non-saturée ou inclue une composante non-saturée. Par exemple, tous les matériaux de construction compactés sont non-saturés après leur mise en place. Dans la nature, la zone non-saturée (aussi appelée zone vadose) est située près de la surface du sol et fait le lien entre le système soumis aux intempéries, au-dessus, et celui d'en-dessous, saturé par l'eau souterraine. La mécanique des sols non-saturés décrit les principes du comportement du sol pour des conditions allant de complètement sec ( $S_r=0$ ) à saturé ( $S_r=1,0$ ). Le Canada a un héritage long et productif dans la recherche des sols non-saturés centrée sur l'avancement de la théorie et sur l'utilisation pratique de la mécanique des sols non-saturés. La Revue canadienne de géotechnique est largement reconnue pour le dépôt de publications par des auteurs canadiens et internationaux sur la théorie, les essais en laboratoire et des études de cas de sols non-saturés. De nouveaux progrès sur les essais en laboratoire, sur des modélisations constitutives et sur les études de terrain ont permis des percées dans la compréhension fondamentale et permis dans certains cas des applications pratiques des principes des sols non-saturés. Cependant, l'utilisation de la mécanique des sols non-saturés dans la pratique accuse un retard significatif par rapport aux règles de l'art. Les effets de la non-saturation sont souvent perçus comme un facteur de sécurité supplémentaire plutôt qu'une occasion d'optimiser la conception. Par exemple, la conception d'une fondation peu profonde considère souvent l'angle de friction d'un matériau granulaire saturé et néglige la profondeur de la fondation par rapport à la nappe phréatique. Ce colloque examinera les principes de la mécanique des sols non-saturés à l'aide d'exemples révélateurs. Ceux-ci inciteront à examiner les tensions entre la recherche et l'utilisation de la mécanique des sols non-saturés dans la pratique. Les leçons apprises de ces cas sont bénéfiques pour la communauté en géo-ingénierie et pour générer de nouveaux intérêts et des applications plus larges sur les principes des sols non-saturés.



# SPECIAL SESSIONS

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## **GEOParly Student Competition**

**Tuesday September 22 – 15:15 to 16:00 (room 2000AB)**

GEOQuébec 2015 is pleased to present the popular student-targeted event – “GEOparly”, on Tuesday September 22 at 3:15 p.m. Sponsored by Golder Associés, this will be a fun student competition based (loosely) on the Jeopardy game show.

Competing teams will duel it out by answering questions in three separate categories pertaining to geotechnical and permafrost, and one category in general knowledge of the Canadian Geotechnical Society. With prizes to be awarded, this event will be spectated by an audience of engineers and geoscientists. Don't miss out on this opportunity to participate and have fun!

## **Eastern Québec Geoengineering Pioneers Luncheon**

**Wednesday September 23– 12:00 to 13:30 (room 2000AB)**

The closing Luncheon of the GEOQuébec 2015 conference will recognize and honor geoengineering pioneers of the Eastern Québec section. These are individuals who have made significant contributions to the development of the science of geotechnical engineering in Québec City and the Eastern part of the Province of Québec, and in so doing have had a major impact on the economic development of the region and of Canada.

The GEOQuébec 2015 program will provide the opportunity to formally honor individuals who have done so much to provide a safe environment for residents of Québec City and the Eastern part of the Province. A plaque honoring individuals will be presented during this closure luncheon.

**Please join us to celebrate the achievements of our pioneers.**



## **Concours GEOPardy à l'intention des étudiants**

**Mardi 22 septembre – de 15 h 15 à 16 h (salle 2000AB)**

GEOQuébec 2015 a le plaisir de présenter le populaire concours à l'intention des étudiants, « GEOPardy », le mardi 22 septembre à 15h15. Commandité par Golder Associés, cette compétition amicale s'inspire (plus ou moins) du jeu télévisé Jeopardy.

Les équipes d'étudiants concurrentes se livreront bataille en répondant à des questions sur trois catégories distinctes de connaissances en géotechnique, en pergélisol ainsi que sur une catégorie axée sur la Société canadienne de géotechnique. Des prix seront décernés et l'évènement se déroulera devant un public composé des participants de GEOQuébec. Ne manquez pas votre chance d'y participer et d'y assister !

## **Déjeuneurs en hommage aux pionniers de la géo-ingénierie de la section de l'Est-du-Québec**

**Mercredi 23 septembre – de 12 h à 13 h 30 (salle 2000AB)**

Le déjeuner de clôture de la conférence GEOQuébec 2015 honorera les « pionniers » de la géo-ingénierie de la section de l'Est-du-Québec. Il s'agit de personnes qui ont contribué grandement au développement de la science de la géotechnique à Québec et dans l'Est-du-Québec, et ce faisant, qui ont un impact important sur le développement économique de la région et du Canada.

Le programme des pionniers de GEOQuébec offrira l'occasion d'honorer officiellement des personnes qui ont fait beaucoup pour offrir un environnement sécuritaire aux résidents de Québec et de l'Est-du-Québec. Une plaque pour chaque personne sera dévoilée lors de ce déjeuner de clôture.

**Veillez-vous joindre à nous pour célébrer les réalisations de nos pionniers.**

## Special Technical Sessions / Séance techniques spéciales

### Professional Practice Special Session I / Séance spéciale sur la pratique professionnelle I

**Tuesday, September 22, 15:45-17:00 / Mardi 22 septembre, 16 h - 17 h 15**

Room / Salle: 2101

#### **Commission of inquiry on the awarding and management of public contracts in the construction industry: Lessons from the Québec Experience**

Stéphane Bilodeau, Director and Member of the Executive Committee at Engineers Canada

Four years after its creation, the Québec Commission of Inquiry on the Construction Industry is about to end its mandate, which was extended by the Government of Québec up to November the 30<sup>th</sup>, 2015. Since the beginning, this Inquiry has regularly made headlines in Québec and across Canada, especially during the hearings in 2013-2014. This presentation will summarize the schemes revealed by this commission and the involvement of certain engineers and other stakeholders in the Construction Industry. It will review the reactions of the various actors (governments, consulting engineering firms, etc.) and give a summarized account of the many actions taken by professional regulatory bodies on their members, the firms, the government, the media and the Commission in an effort to restore public confidence in the profession. Indeed, no province is entirely safe from these schemes. The presentation will be outlining lessons learned from Québec's experience to help professionals and their associations better understand the context and the outcomes, but also to enhance standards, practices and servicing of public interests.

### Professional Practice Special Session II / Séance spéciale sur la pratique professionnelle II

**Wednesday, September 23, 10:30-12:00 / Mercredi 23 septembre, 10 h 30-12 h**

Room / Salle: 2101

#### **Post Project Review and Risk Drivers**

Wilma Schreuders (1) and Robert vanArsdall (2)

(1) Vice President & General Manager, Design Professional Group, XL Insurance;

(2) Director, Market and Sector Analysis, XL Insurance

Geotechnical firms, architects, and engineers too often move on after a project is closed out without reviewing whether the project actually met the firm's original goals. This talk presents the current data on the gap between the project plan and the actual project results for the owners, contractors, and design firms. We present a simple plan for improving your process delivery and profitability and reveal cultural and institutional barriers that keep firms from maximizing their potential.



## Sustainable Geotechnics Special Session / Séance spéciale sur le développement géotechnique durable

**Wednesday, September 23, 13:30-15:00 / Mercredi 23 septembre, 13 h 30-15 h**  
Room / Salle: **2101**

13:30-13:45

### **Session Introduction**

*Tim Newson, Western University*

This special session will introduce the emerging sub-discipline of Sustainable Geotechnics. Geo-structures and geo-operations often form important interfaces between the built and natural environments, and interact with and affect a wide variety of externalities. Thus, geotechnical engineering has a wide gamut and a global reach, and can influence the sustainable development of infrastructure and civil societies in a significant way. Geotechnical design and construction, being placed early in a typical civil engineering project, can significantly contribute to sustainable development by adopting environment-friendly, cost-effective and socially-acceptable choices and setting a precedent for the remainder of the project. The role of geotechnical engineering in sustainable development is being increasingly recognized. The session will showcase the area and the activities of the new CGS Sustainable Geotechnics committee. A number of presentations will show different aspects of Sustainable Geotechnics and will be followed by a general panel discussion with a number of members the new committee.

13:35-13:50

### **Talk 1: Sustainability in Geotechnical Engineering - Overview and Assessment**

*Dipanjan Basu, University of Waterloo*

Sustainability is recognized as a principle that advocates a balanced development maintaining harmony between the three Es: environment, economy and equity, so that the quality of life of the current and future generations are not compromised. Engineered systems serve human societies by drawing resources from nature and, in the process, generate emissions and wastes that nature has to absorb. The civil engineering industry has its footprints on all human efforts to control, modify and dominate nature and natural systems. A geotechnical construction project not only has the above detrimental effects on earth's resources and environment but also changes the land use pattern that persists for centuries and affects the social and ethical values of a community. Thus, geotechnical projects interfere with many social, environmental and economic issues, and improving the sustainability of geotechnical processes is extremely important in achieving overall sustainable development. In this presentation, the broader scope of sustainable development is connected with geotechnical engineering. The definitions and concepts of sustainability are introduced and the different approaches for sustainable practices in engineering are discussed with an aim to relate sustainability to geotechnical engineering.

**Talk 2: Climate Change Related Geotechnical Considerations from the June 2013 Southern Alberta Flood***Roger Skirrow, Alberta Transportation*

Climate change has the potential to create a cascade of impacts on interrelated and integrated systems. The capacity of natural systems and society to adapt to new extremes and vulnerabilities and to mitigate appropriately are being studied by scientists, policy makers, industry and others. With respect to highways or linear corridors, and more specifically, the geotechnical component of these structures there are expected and unexpected consequences to climate change. The geotechnical consequences are mostly related to changed conditions at known and potential geohazard locations and the mitigation of these geohazards where they intersect with existing highway corridors. This presentation provides a brief overview of significant and likely consequences of climate change on geohazards that occur along Alberta highways. The Southern Alberta flood of June 2013 is used to support the assessment.

14:05-14:20

**Talk 3: Sustainable Low-Cost Engineered Fills***Ian Fleming, University of Saskatchewan*

Various "green" materials have been evaluated for use as engineered fills. These include organic-rich soils, tire-derived-aggregates, and "fines" materials resulting from excavation and screening of waste from old landfills. These latter consisted of soil and soil-like material with some organics and debris composing small fragments of wood, brick and plastic. Traditional geotechnical practice has been to eliminate such materials from use as engineered fills because of concerns that degradation of the fines fraction may result in long term creep settlement as a result of degradation and related processes. Bulk samples of each material have been tested in large-scale consolidometers, (and in the case of the waste-derived fills, with conditions optimized for biodegradation) to determine the potential for long term creep settlement. The response of the samples to loading and degradation has suggested that reuse of these materials should not be prevented on the basis of their geotechnical properties. This work potentially has wide application and significance as the construction industry evolves to "greener" practices, including the use or re-use of substandard soils, tire-derived aggregates and soils containing organics. TDA, in particular has a number of significant benefits in terms of high strength and low weight and the creep behaviour of these materials is thus critical to their wider acceptance in construction practice.



14:20-14:35

**Talk 4: Sustainable Development and Corporate Social Responsibility***Tim Newson, Western University*

Recent discussion of sustainable development (SD) in business practice has increased rapidly and this has led to a very broad and unspecified view of this concept. Corporate Social Responsibility (CSR) involves the voluntary integration of social, environmental and economic concerns into a company's values and culture. This can be incorporated into business practice and is reflected in company policy, strategy, decision-making and operations. In the sustainability literature, the link between SD and CSR is currently unclear and concepts range from: i) CSR as a stakeholder-oriented, social pillar of SD, to ii) replacement of the term SD by CSR without restrictions, which makes CSR a much more comprehensive concept of sustainability. One of the key challenges for implementation is that best practice management systems for applying CSR are currently not available and there are no internationally recognized CSR standards for benchmarking efforts. In 2009, the Government of Canada launched its CSR Strategy for the Canadian Extractive Sector, which currently being led the Department of Foreign Affairs, Trade and Development. This government support of CSR for the Canadian mining industry has created some polarized viewpoints. This presentation will discuss these issues and the consequences for geotechnical practice in both Canada and abroad.

14:35-15:00

**Panel Discussion: Sustainable Geotechnics***Chair - Tim Newson, with Dipanjan Basu, Ian Fleming, Stan Gonsalves and Roger Skirrow*



# SOCIAL ACTIVITIES

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**GEOQuébec 2015 is planning exciting social events for delegates to meet and mingle with their professional colleagues or to make new friends in a more relaxed environment, outside of the technical and business streams.**

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Be sure to join us at the following:

## **Icebreaker Reception**

**Sunday September 20, 17:30 to 19:30**

**Trade Exhibition Hall, room 2000 C-D, Centre des Congrès de Québec**

Come chat with old friends and make new acquaintances with colleagues from across the country and around the world at this cocktail reception including free drinks and snacks in the lobby of the Trade Exhibition Hall.

## **Exhibitor Cocktail Annual GCS Banquet Awards Gala**

**Monday September 21, 18:00 to 22:00**

**Banquet room 2000 A-B, Centre des Congrès de Québec**

Come celebrate the professional achievements and merits of your colleagues. The Organizing Committee of GEOQuébec 2015 is planning a gourmet feast with stunning entertainments combining music, skill and humor in an energetic atmosphere. A show that you'll never forget!

## **Local Colour Night aboard the Louis-Jolliet**

**Tuesday September 22, 19:00 to 21:30**

**On the St. Lawrence River, with a view on Québec City!**

***Meet in the main Centre des congrès de Québec entrance at 18:15 for shuttles to Québec City port***

The Organizing Committee of GEOQuébec 2015 has planned an unforgettable evening with local flavour for all delegates and guests aboard the Louis-Jolliet for a cocktail-cruise. Come see the Fall colours from the majestic St. Lawrence River, and also the Cap Diamant, the Château Frontenac, Montmorency Falls, Île d'Orléans and Québec City bridges, while chatting with friends and colleagues.



# ACTIVITÉS SOCIALES

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**GEOQuébec 2015 propose des activités sociales permettant aux délégués de passer de bons moments avec leurs collègues et offre aussi l'opportunité de faire de nouvelles rencontres dans une ambiance plus décontractée que lors des séances techniques.**

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Ne manquez pas de vous joindre à nous pour les activités suivantes :

## Cocktail de bienvenue

**Dimanche 20 septembre, de 17 h 30 à 19 h 30**

**Salon des exposants, salle 2000 C-D, Centre des Congrès de Québec**

Venez renouer avec de vieilles connaissances et faire de nouveaux contacts avec des collègues de partout au pays et ailleurs dans le monde, en assistant à un cocktail comprenant consommations et amuse-gueules dans le hall du Salon des exposants.

## Cocktail des exposants

### Banquet annuel de remise des prix SCG

**Lundi 21 septembre, de 18 h à 22 h**

**Salle de banquet 2000 A-B, Centre des Congrès de Québec**

Venez célébrer avec nous les accomplissements professionnels et les mérites de vos collègues. Le Comité organisateur de GEOQuébec 2015 prévoit une soirée gastronomique où vous pourrez déguster un bon repas accompagné d'un divertissement époustouflant combinant musique, prouesse et humour dans une atmosphère énergique. Un spectacle dont vous vous rappellerez longtemps !

## Soirée à saveur locale à bord du Louis-Jolliet

**Mardi 22 septembre de 19 h à 21 h 30**

**Sur le fleuve St-Laurent face à la Ville de Québec !**

***Point de rencontre à l'entrée principale du Centre de congrès de Québec à 18 h 15 pour des navettes jusqu'au port de Québec.***

Le Comité organisateur de GEOQuébec 2015 a concocté une soirée inoubliable à saveur locale pour les délégués et leurs invités à bord du Louis-Jolliet pour un cocktail-croisière. Venez admirer les couleurs de l'automne à partir du majestueux fleuve St-Laurent, ainsi que le cap Diamant, le Château Frontenac, la Chute Montmorency, l'Île d'Orléans et les ponts en discutant entre amis et collègues.



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# MONDAY TECHNICAL PROGRAM / PROGRAMME TECHNIQUE DU LUNDI

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## Session/Séance : Soil Mechanics I / Mécanique des sols I

Monday, September 21, 10:45 - 12:15 / Lundi 21 septembre, 10 h 45 - 12 h 15

Room / Salle : **204AB**

Chair / Présidente de séance : **Ariane Locat**

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### 162 - AN IMPROVED SOLUTION FOR THE EXPANSION OF CYLINDRICAL CAVITIES IN MODIFIED CAM CLAY.

Vincenzo Silvestri(1), Youssef Bentaiebi (1), Ghassan Abou- Samra (2), Mireille Sandrine Ewane (1), Christian Bravo-Jonard (1)

(1) *École polytechnique de Montréal (Montréal, Canada)*; (2) *Université de Moncton (Moncton, Canada)*

Recently the authors presented a semi-analytical solution for the undrained plane strain expansion of vertical cylindrical cavities in Modified Cam Clay, in which the hardening parameter  $\lambda$  remained constant. This allowed the determination of explicit expressions for the principal effective stresses. In the present paper, the restriction imposed on  $\lambda$  is relaxed, as it varies during undrained shearing in Modified Cam Clay. The new semi-analytical solution is applied to a well-known benchmark case involving remoulded Boston Blue Clay. Comparisons are first made with the case of constant  $\lambda$  and then with both a finite difference solution and published finite element results.

### 768 - APPLICATION OF A CRITICAL STATE BOUNDING SURFACE MODEL IMPLEMENTED IN MULTILAMINATE FRAMEWORK FOR NUMERICAL MODELING OF SOILS

Hamid Karimpour (1), Seyed Amirodin Sadrnejad (2)

(1) *Stantec (Edmonton, Canada)*; (2) *Khaje-Nasir Toosi University of Technology (Tehran, Iran)*

A new plasticity model is proposed based on implementing a critical state based bounding surface model in multilaminate framework. The original bounding surface model is defined by the following four surfaces: (i) failure surface (ii) bounding surface; (iii) loading surface and (iv) plastic dilatancy surface. These surfaces are defined in multilaminate framework to introduce a new constitutive model. In this framework, the failure, bounding, loading and plasticity dilatancy surfaces are formulated on  $2 \times 13$  local planes with varying orientations over a virtual unit sphere around a stress point. A weight factor is assigned to each plane with respect to the volume of the unit sphere. The overall response of the material when subjected to a load will then be integrated by summation of the contributions of all planes. The model parameters are calibrated by modeling nine triaxial tests under different densities and confining stresses. Application of the new constitutive model is then studied by its implementation into a finite difference code and modeling a soil-pipe laboratory test. It is concluded that the new constitutive model could accurately predict the observed triaxial and laboratory tests.

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Underlined names correspond to speakers / Les noms soulignés correspondent aux auteurs présentant les articles



#### 414 - STRESS-STRAIN BEHAVIOUR OF A CLAYEY SILT IN TRIAXIAL TESTS

Rajith Dayarathne (1), Bipul Hawlader (1)  
(1) Memorial University (St. John's, Canada)

Frost heave is one the major issues in the design of pipelines in cold regions. The pipelines generally traverse through a variety of soils. Among the different types of soil, clayey silt has been identified as one of the highly frost susceptible soils. In the analyses of pipeline-soil interaction due to frost heave, the stress-strain behaviour of both unfrozen and unfrozen soil is equally important. In the current research program, centrifuge physical modeling and finite element analysis will be performed to examine the effects of frost heave on chilled gas pipelines. While a large number of laboratory test results on different sands and clays are available in the literature, laboratory tests on clayey silt, which is highly frost susceptible, are very limited. In this paper, some triaxial and consolidation test results on clayey silt are presented, which could be used to understand its constitutive behaviour. The soil used in this experimental program is same as the soil used for centrifuge physical modeling. Comparing test results with typical behaviour of sand and clay in the critical state framework, some similarity and differences are highlighted.

#### 218 - GEOTECHNICAL CHARACTERISTICS OF BARLOW-OJIBWAY CLAY IN NORTHERN ONTARIO

Andrew Drevininkas (1), Masoud Manzari (2), Tony Sangiuliano (3), David Staseff (3)  
(1) Downunder Geotechnical Limited (Maple, Canada); (2) Thurber Engineering (Oakville, Canada); (3) Ministry of Transportation of Ontario (Toronto, Canada)

After the Late Wisconsinan glaciation retreat, the last proglacial lake was formed in northern Ontario and Québec and is called Lake Barlow-Ojibway. The clay is typically known to be slightly overconsolidated, soft to firm in consistency, with a high compression index. To date a consolidated study based on large scale data in order to provide typical ranges of geotechnical properties and possible correlations for this specific lake deposit has not been conducted.

Hundreds of geotechnical investigations have been carried out within the Lake Barlow-Ojibway clay deposits in northern Ontario by the Ministry of Transportation of Ontario and others since the 1950s. This paper presents a summary of all the testing available to the authors in conjunction with the results from published literature. An analysis of the compiled results is further provided to characterize the compressibility characteristics of the Lake Barlow-Ojibway clays and its correlations with simple geotechnical index properties.

#### 472 - SECONDARY COMPRESSION OF A COHESIVE SOIL IN NORTHERN ONTARIO: A CASE STUDY

André Bom (1), J.Paul Dittrich (1), Matthew Thibeault (1), Greg Qu (2), Keli Shi (3), Tony Sangiuliano (4)  
(1) Golder Associates (Sudbury, Canada); (2) Hatch Ltd. (Niagara Falls, Canada); (3) Thurber Engineering (Oakville, Canada); (4) MTO Foundations (Toronto, Canada)

Long-term field settlement data and short-term and long-term laboratory consolidation test data provide a comparison of typical values used in the assessment of secondary compression (creep) of a cohesive soil beneath a highway embankment crossing a swamp area south of Sudbury in Northern Ontario. Design of the approximately 10 m high embankment with surcharge over an approximately 23 m thick clay deposit was based on the standard Terzaghi primary and secondary compression concepts. The secondary compression design parameters, which are the focus of this paper, were based





on standard 24 hour load increment, one-dimensional laboratory consolidation tests and embankment construction included wick drains, staged construction and a surcharge. Regular monitoring of the consolidation of the cohesive layer using Settlement Rods (SRs), Vibrating Wire Piezometers (VWPs) and deep settlement Profilers (PRs) was carried out during embankment construction and surcharge period and annual readings have been taken following completion of the highway and opening to traffic in 2009. Secondary compression indices back-calculated from the long-term, post-construction field data are compared to values derived from the short-term (standard) laboratory consolidation tests as well as from long-term laboratory consolidation tests that have been running for about 15 years.

### **593 - A RHEOLOGICAL APPROACH TO THE MECHANICAL BEHAVIOR OF SOME MARLS SAMPLES IN HAITI**

Kelly Guerrier (1), Dominique Boisson (1), Jean-François Thimus (2), Christian Schroeder (3)  
(1) *URGéo-FDS-UEH (Port-au-Prince, Haiti)*; (2) *GCE-IMMC-UCL (Louvain-la-Neuve, Belgium)*; (3) *BATir-ULB (Bruxelles, Belgium)*

Soils can be considered as viscoelastic materials having an intermediate behavior between Newtonian fluids and the perfectly elastic bodies. This type of behavior is the basis of the birth of rheology which studies the flow, deformation and viscosity of materials under external stress taking into account its speed rate. Haiti is a country where seismic risk is very high. It is therefore important to study dynamically the mechanical properties of soils. This paper presents how rheology has been used to study the deformation and structural collapse of marl samples of the "Morne Delmas" geological formation in Haiti.

## **Session/Séance : In Situ Testing, Instrumentation, and Monitoring in Cold Regions / Essais insitu et instrumentation en milieu nordique**

**Monday, September 21, 10:45 - 12:15 / Lundi 21 septembre, 10 h 45 - 12 h 15**

Room / Salle : **205A**

Chair / Présidente de séance : **Eva Stephani**

### **548 - INVESTIGATION ON THE SOIL THERMAL CONDUCTIVITY OF DIFFERENT UNDERLYING SURFACES IN THE NORTHERN QINGHAI-TIBETAN PLATEAU, CHINA**

Ren Li (1), Tonghua Wu (2), Lin Zhao (2), Changwei Xie (2), Yao Xiao (2), Guojie Hu (2), Yizhen Du (2)

(1) *Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (Lanzhou, China)*; (2) *Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Science (Lanzhou, China)*

Several numerical methods are applied and compared in the calculation of soil thermal conductivity (STC) in the Kekexili (QT01), Beiluhe (QT02, QT03), Kaixinling (QT05), and Tongtianhe (QT06) regions in the northern Qinghai-Tibetan Plateau based on data from January 2004 to December 2013. The results show that the STC of the active layer in the study region exhibited marked seasonal variations: it was low during the cold season but high in the warm season. Averagely, the mean value was 1.080 Wm<sup>-1</sup>K<sup>-1</sup>, ranging from 0.752 to 1.371 Wm<sup>-1</sup>K<sup>-1</sup>. In the frozen state (FS), STC was 0.955 W.m<sup>-2</sup>K<sup>-1</sup> while in the unfrozen state (UFS), it was 1.204 W.m<sup>-2</sup>K<sup>-1</sup>. STC increased with increasing soil bulk density but



decreased with increasing vegetation cover of the underlying surface; STC of alpine frost meadow soil was greater than that of alpine frost steppe soil; fine-grained soil with low unfrozen water content and a low saturation degree resulted in low STC in the cold season; and monthly mean STC can be well expressed as a function of conventional meteorological data. Verification results further ensured that the proposed model accurately predicts monthly STC values.

#### **146 - ASSESSMENT OF PERMAFROST CONDITIONS IN SUPPORT OF THE REHABILITATION AND ADAPTATION TO CLIMATE CHANGE OF THE IQALUIT AIRPORT, NUNAVUT, CANADA.**

Valérie Mathon-Dufour (1), Michel Allard (1), Anne-Marie LeBlanc (2)

(1) *Centre d'études nordiques, Université Laval (Québec, Canada)*; (2) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*

Iqaluit, the territorial capital of Nunavut and hub for air transport in the eastern Canadian Arctic, had an airport in poor condition and not adapted to the expected increase in air traffic in the coming years. In fact, the runway, taxiways and aprons are affected by permafrost degradation. This study aims to contribute to the development of an integrated geoscientific approach to make up for lack of adequate characterization of permafrost during construction in order to support rehabilitation work now in progress at the Iqaluit airport and adapt the infrastructures to new climatic conditions. The results confirm that the initial conditions (e.g. drainage, cryostratigraphy) of the terrain have a considerable impact on the current stability of the infrastructure. In addition, the presence of the infrastructure itself modify the surface conditions (e.g. albedo, drainage) which have an impact on the thermal regime of permafrost.

#### **380 - FIELD MEASUREMENTS OF PERMAFROST CONDITIONS BESIDE THE DEMPSTER HIGHWAY EMBANKMENT, PEEL PLATEAU, NWT**

Brendan O'Neill (1), Chris Burn (1), Steve Kokelj (2)

(1) *Carleton University (Ottawa, Canada)*; (2) *Northwest Territories Geological Survey (Yellowknife, Canada)*

Permafrost conditions were examined adjacent to the Dempster Highway road embankment on Peel Plateau, NWT. Ground temperatures recorded in 2013-14 at five sites at the embankment toe and at two control sites are presented. Annual mean temperatures near 5 m depth ranged between -2.2 and 0.0 °C at the embankment toe, and were -1.8 and 2.6 °C at control sites. Permafrost has degraded near the road at four sites. Thaw depths at degrading sites were typically >1 m, but < 1 m in the undisturbed tundra of the region. High ground temperatures at road sites were associated with deep snow accumulation. Numerical modelling should be used to explore the effects of snow compaction or removal to reduce ground temperatures.

#### **467 - EVALUATING THE USE OF DISTRIBUTED TEMPERATURE SENSING FOR PERMAFROST MONITORING IN SALLUIT, NUNAVIK**

Jonathan Roger (1), Michel Allard (2), Denis Sarrazin (2), Emmanuel L'Hérault (2), Guy Doré (2), Anick Guimond (3)

(1) *Centre d'études nordiques (Québec, Canada)*; (2) *Centre d'études nordique (CEN) (Québec, Canada)*; (3) *Bureau de coordination du Nord-du-Québec - Ministère des Transport du Québec (Rouyn Noranda, Canada)*

Fiber optics distributed temperature sensing (DTS) is a new technology. It opens the doors on original approaches to study permafrost temperature regime in a variety of



environmental settings and engineering situations. An opportunity presented itself to try this new technology in 2012 as it was decided to rebuild the Salluit road to the community airport. It had been seriously impacted by permafrost degradation. A total length of 3.4 km of DTS cable was buried under the embankment slope, on both sides of the road. The data obtained allowed detection of localised heat sources along its length and gave temperature variations both in time and space since 2012.

### **705 - PERMAFROST CHARACTERIZATION OF THE DEMPSTER HIGHWAY, YUKON AND NORTHWEST TERRITORIES**

Christopher Burn (1), Jeff Moore (1), Brendan O'Neill (1), Don Hayley (2), Richard Trimble (3), Fabrice Calmels (4), Sandra Orban (5), Muhammad Idrees (5)  
 (1) Carleton University (Ottawa, Canada); (2) Hayley Arctic Geoscience (Kelowna, Canada); (3) Tetra Tech EBA (Whitehorse, Canada); (4) Yukon Research Centre (Whitehorse, Canada); (5) Yukon Highways and Public Works (Whitehorse, Canada)

The Dempster Highway was built over permafrost to connect the western Arctic with the national highway system. Mean annual permafrost temperatures along the route are  $\geq -4$  °C. Most ground ice is found in glacial deposits, and in these materials the embankment is particularly prone to thaw subsidence. Extended periods of rain have led to debris flows blocking the road and wash outs in steep terrain and near rivers. Icings may impede drainage during freshet. These hazards are of varying relative importance along the route. The principal terrain units and permafrost-related hazards are: North Klondike, icing; Blackstone Uplands, thaw subsidence; Engineer Creek/Ogilvie River, debris flows and wash outs; Eagle Plains, relatively unaffected; Richardson Mountains and Peel Plateau, thaw subsidence; Northern Plains, icing.

### **129 - THE NUNAVUT PERMAFROST DATABANK- CENTRALIZING NUNAVUT PERMAFROST FOR NORTHERN DECISION-MAKING**

Sara Holzman (1)  
 (1) Government of Nunavut, Department of Environment, Climate Change Section (Iqaluit, Canada)

The Government of Nunavut's Climate Change Section is developing a centralized Permafrost Databank that will house permafrost data for Nunavut by 2016. This databank will make permafrost data, in its various forms, more accessible to practitioners. The major components of the project include collecting permafrost temperature data from various sources, including governments, academia, and industry, and integrating it into an online interface. This databank is being designed for user-friendly accessibility and is intended for Nunavut researchers, government and community decision makers, as well as the general public. Due to the varied formats and sources of data, the databank will be developed as a geo-referenced map, linking to other online forums that contain key permafrost data, publications, or references. This project is not intended to duplicate existing work or databases, but rather to compile and centralize these sources into one centralize location. The Government of Nunavut is in the development phase of this project and welcomes feedback on its design and data sources before the Permafrost Databank is released in 2016.



## Session/Séance : Landslides and Slope Stability I / Mouvements de terrain et stabilité des pentes I

Monday, September 21, 10:45 - 12:15 / Lundi 21 septembre, 10 h 45 - 12 h 15

Room / Salle : 205BC

Chair / Président de séance : Michael Porter

### 389 - POISSON'S RATIO EFFECT ON SLOPE STABILITY CALCULATIONS

Murray Fredlund (1), Rob Thode (1)

(1) SoilVision Systems Ltd. (Saskatoon, Canada)

This paper presents the results of a study on the effect of varying Poisson's ratios on limit equilibrium slope stability analyses performed using the dynamic programming search technique. An example model is completed to show the impact of Poisson's ratio on the strain vectors, the critical slip surfaces and factor of safety. The results showed that decreasing Poisson's ratio causes the location of the critical slip surface, selected by the dynamic programming method, to move deeper into the slope, leading to a higher factor of safety. The critical slip surface is selected based upon kinematic admissibility criteria. The results of the method were also shown to become numerically unstable as cohesion approaches zero if adjustments to the kinematic admissibility criteria are not made. Therefore, care needs to be taken when analyzing cohesionless soils with low values of Poisson's ratio.

### 401 - CASE STUDY: THE INFLUENCE OF TUNNELLING ON SLOPE STABILITY

Nicholas Vlachopoulos (1), Ioannis Vazaios (2)

(1) Royal Military College of Canada (Kingston, Canada); (2) Queen's University (Kingston, Canada)

Tunneling projects oftentimes involve the design and construction of two adjacent (twin) tunnels with respect to underground infrastructure projects for road, railway or subway systems within mountainous terrain. Currently, there is limited investigation associated with the interaction generated between the excavations of two adjacent tunnels, especially in conjunction with slope stability issues. One of the major drawbacks with regards to such inherently complex, 3D investigations (i.e. a precursor to design) is the increased computational cost required to model the detailed three-dimensional excavation process utilizing 3D numerical analysis tools. As such, the use of idealized two-dimensional simulation can be employed in order to draw selected preliminary results with respect to the impact of the interaction between twin tunnels constructed within or adjacent to slopes. Despite of being conservative, these slope stability problems can be satisfactorily simulated in two dimensions. In this particular paper, twin tunneling excavation interaction within slopes is investigated utilizing 2D numerical models for tunnels close to the ground surface within weak rockmasses. A case study of the S3 tunnel of Egnatia Odos is also incorporated in order to highlight the very real requirement to take such factors into consideration prior and during the twin tunnel design stage.

### 44 - NUMERICAL ANALYSIS OF A STABILIZED NATURAL SLOPE

Xinli Wu (1), Hany El Naggar (2), A.J. Valsangkar (3)

(1) University of New Brunswick (Fredericton, Canada); (2) Dalhousie University (Halifax, Canada); (3) University of New Brunswick (Fredericton, Canada)

Marginally stable slopes coupled with heavy rainfall represent a common challenge to rapid urban development in hilly terrain. These conditions lead to landslides that can be



disastrous causing significant damage to nearby properties and loss of lives. In this paper, the stabilization of a 60 m high natural slope is analyzed using finite element and limit equilibrium methods. The contribution of the post-tensioned ground anchors and face plates used for slope stabilization is considered in the analysis. The strength reduction finite element analysis was able to capture the behavior of the slope before the stabilization and its performance after stabilization. The factors of safety obtained with two different approaches are compared and discussed in this paper.

### **369 - CASE STUDY OF A LANDSLIDE ON HIGHWAY 20 NORTH OF CRAVEN, SK**

Harpreet Panesar (1), Hung Vu (2), Laurie Stang (2), Jody Schafer (1), Hamid Soleymani (1)  
(1) *Saskatchewan Ministry of Highways and Infrastructure (Regina, Canada)*; (2) *Golder Associates Ltd (Saskatoon, Canada)*

Saskatchewan's climate is classified as semi-arid; however, the occurrence of rainfall events and the intensity of rainfall have increased significantly in recent years. An increased frequency and intensity of rainfall events results in more water infiltration and a subsequent increase in groundwater table elevations and reduced soil suctions on the side slopes of highways. Higher groundwater tables and reduced soil suctions are contributing to the destabilization of marginally stable natural slopes and manmade fills across many valleys throughout Southern Saskatchewan.

Two such failures were observed on Highway 20 north of Craven, SK. Highway 20 has a number of high fills across ravines that feed into the valley of Last Mountain Lake just a few kilometers north of Craven where the highway starts to climb out of the valley. The fill at the location of the failure is more than 20 m high. Severe cracking along the shoulder was observed in August 2014.

This paper documents the results of a geohazard risk assessment, terrain analysis, site investigation, instrumentation monitoring, slope stability analysis and an evaluation of remediation options.

### **439 - STEEPBANK RIVER VALLEY GEOMORPHOLOGICAL AND GEOLOGICAL CATEGORIZATION**

Joanna Chen (1), Rob Charron (1), Dan Hepp (1), Jeff MacLean (1), Jason Chen (2)  
(1) *Klohn Crippen Berger Ltd (Calgary, Canada)*; (2) *Suncor Energy Inc. (Calgary, Canada)*

Natural terrain hazard assessments require the development of geomorphological and engineering geological maps to understand the past and current performance of the natural river valley slopes. This paper outlines the approach adopted for the geomorphological and engineering geological inventory maps developed for the natural riverbank slopes along the Steepbank River Valley escarpment in Fort McMurray, Alberta.

The inventory maps document the location and spatial distribution of the observed major slope movements and geological features as well as the current physical conditions of the River Valley escarpment slopes. These maps provide an understanding of the nature and magnitude of the various potential hazards in the natural slopes and are considered to be representative of baseline conditions against which future conditions can be compared. The available aerial photographs and surveys indicate that on-going regression of the escarpment slopes is occurring as a result of natural processes.



Scott McDougall (1), Michael Porter (1), Andrew Watson (2)

(1) *BGC Engineering (Vancouver, Canada)*; (2) *BC Hydro (Vancouver, Canada)*

The Site C Clean Energy Project is a planned third dam and hydroelectric generating station on the Peace River in northeast British Columbia, Canada. The Site C dam would be an earthfill dam with a height of approximately 60 m and would create a reservoir that would be approximately 83 km long. A detailed assessment was undertaken to characterize the potential for groundwater changes, flooding, shoreline erosion, slope instability and landslide-generated waves resulting from the impoundment and operation of the reservoir. The results of this assessment were used to generate preliminary reservoir impact lines that delineate areas of potential hazard. Four preliminary impact lines have been prepared in accordance with guidance provided by the International Commission on Large Dams: a Flood Impact Line, an Erosion Impact Line, a Stability Impact Line, and a Landslide-Generated Wave Impact Line. The reservoir impact lines are linked to recommendations for site-specific analysis, land use, and monitoring. They were intended to support the environmental assessment and the management of risks to public safety, land use and infrastructure. This paper provides definitions for the impact lines, describes how they were developed, and illustrates how they can be used to help communicate and manage geohazard risks.

## **Session/Séance : Rock Mechanics and Engineering Geology I / Mécanique des roches et génie géologique I**

**Monday, September 21, 10:45 - 12:15 / Lundi 21 septembre, 10 h 45 - 12 h 15**

Room / Salle : **207**

Chair / Président de séance : **Doug Stead**

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### **500 - SWELLING CHARACTERISTICS OF BENTONITE BASED BARRIERS FOR DEEP GEOLOGICAL REPOSITORY FOR NUCLEAR WASTES: IMPACT OF UNDERGROUND WATER CHEMISTRY AND TEMPERATURE**

Mamadou Fall (1), Asmaa Shehata (1), Mamadou Fall (1), Christian Detellier (1)

(1) *University of Ottawa (Ottawa, Canada)*

The presence of bentonite-sand in deep geological repositories surrounded by aggressive environments of highly saline underground water, high temperature and under confining stress may cause mineralogical changes for bentonite-based materials and impact their physical and physiochemical properties. This could affect the bentonite performance as an engineered barrier system and the overall safety of the deep geological repositories. The objective of this research is to investigate the impact of Ontario's underground water salinity and heat generated by the nuclear wastes on the swelling capacity of bentonite-sand engineered barrier materials. Free-swelling and swelling pressure tests have been performed on bentonite-sand mixtures subjected to various chemical (groundwater chemistry) and thermal (heat generated) loading conditions. The obtained results have shown that the groundwater chemistry can significantly deteriorate the swelling properties of the tested bentonite-sand barrier material, whereas the temperature has little effect on the bentonite-sand swelling potential.



### **639 - THE EFFECT ON ROCK SWELLING DUE TO THE SALINITY DIFFERENCE BETWEEN ROCK PORE FLUID AND AMBIENT FLUID**

Taesang Ahn (1), Silvana Micic (1), Kwan Yee Lo (2)

(1) *Ph.D., P.Eng. (Markham, Canada); (2) Western University (London, Canada)*

A consideration of swelling characteristics of shaley rock is essential for underground structures such as tunnels. The swelling characteristic known as time dependent deformation is mainly due to a mechanism of osmosis and diffusion between pore fluid in rock and ambient fluid. An extensive experimental program has been carried out to investigate the effect on rock swelling due to the salinity difference between rock pore fluid and ambient fluid having different salt concentrations. The test program includes free swell tests, semi-confined swell tests and null swell tests with measurements of salinity of rock pore fluid and calcite content on three rock formations including Georgjan Bay, Queenston and Shaftesbury. It is observed that, for a given salinity difference between pore fluid of rock and the ambient fluid, a significant effect on swelling potentials exists both in vertical and horizontal directions during the free swell tests and semi-confined tests on Queenston, Georgjan Bay and Shaftesbury shale samples.

### **534 - SWELLING POTENTIAL OF QUEENSTON SHALE IN LUBRICANT FLUIDS**

HAYDER MOHAMMED SALIM AL-MAAMORI (1), M. HESHAM EL NAGGAR (2), SILVANA MICIC (3), LO K.Y. (4)

(1) *Ph.D. Candidate (London, Canada); (2) Professor and Associate Dean, Department of Civil and Environmental Engineering, Western University (London, ON, Canada);*

(3) *Adjunct Professor, Department of Civil and Environmental Engineering, Western*

*University (London, ON, Canada); (4) Professor Emeritus and Chair of The Geotechnical Research Centre (London, ON, Canada)*

The effect of lubricant fluids used in the drilling process for microtunnels, such as polymers solution and bentonite slurry, on the swelling behaviour of Queenston Shale from Southern Ontario was investigated. Lubricant fluids and fresh water were used as ambient fluids in a series of free swell tests performed on Queenston shales from Niagara and Milton regions. The tests results revealed a significant difference in the swelling behaviour of the Queenston Shales in these fluids. The polymers solution caused a significant suppression of the swelling of both Queenston shales, while the bentonite slurry caused moderate suppression of the swelling of Niagara Queenston shale, and a slight increase of the swelling of Milton Queenston shale, compared to water. This finding may have a significant impact on evaluating the swelling associated with the drilling process and in the design of underground structures in Queenston Shale.

### **583 - THERMO-ELASTOPLASTIC STUDY OF THE COLORADO SHALE BEHAVIOUR**

Morteza Mohamadi (1), Richard Wan (1)

(1) *University of Calgary (calgary, Canada)*

The thermo-hydro-mechanical behaviour of shale has gained increasing attention in cap rock integrity assessment of fairly shallow steam injection oil recovery projects in western Canada. The paper presents an integrated experimental/constitutive study of the Colorado shale which serves as a cap rock to underlying oil-rich formations in the Cold Lake area, east-central Alberta, Canada. Results of drained thermal consolidation and isothermal triaxial compression tests at different temperatures on Colorado shale show that: 1) volume changes due to drained heating are greatly influenced by consolidation history, 2) initial elastic moduli of the tested samples decrease with elevation of temperature, and 3) the peak and post-peak failure envelopes are nonlinear and show reduced shear strength at elevated



temperatures. These phenomenological mechanisms were implemented in an elastoplastic constitutive model which was used to describe the experimental data. Comparison of the experimental measurements and model calculations verify the usefulness of the model.

### **731 - THERMAL PROPERTY TESTING OF AN ENGINEERED BARRIER FOR USE IN A DEEP GEOLOGICAL REPOSITORY**

Pedram Abootalebi (1), Gregory Siemens (2)  
(1) *Queen's University (Kingston, Canada)*; (2) *RMC (Kingston, Canada)*

There are over 2.5 million bundles of used nuclear fuel in Canada and upwards of an additional 2 million bundles anticipated to be generated in the future. Canada, and all countries around the world that have taken a decision on long-term storage of spent nuclear fuel, has decided on central storage within a deep geological repository. A deep geological repository provides centralized containment and isolation of the used nuclear fuel hundreds of meters below ground. Spent nuclear fuel bundles are to be placed at depth within containers and surrounded by engineered barriers. A key component of the performance of a repository is the capability of the engineered barriers to transfer the thermal energy to the surrounding geosphere. In this paper thermal property testing of a high density bentonite material is presented. The challenges associated with high density specimen preparation are highlighted and preliminary results are reported.

### **596 - CARACTÉRISATION STATISTIQUE DE LA RÉSISTANCE EN COMPRESSION UNIAXIALE, DE LA RÉSISTANCE EN TENSION ET DE L'INDICE DE DOUBLE POINÇONNEMENT DU ROC INTACT POUR UN PROJET MINIER**

Catherine Boudreau (1), Martin Grenon (1), Geneviève Bruneau (1), Paul Germain (2)  
(1) *Université Laval (Québec, Canada)*; (2) *Mine Éléonore, Goldcorp inc, (Baie - James, Canada)*

La conception des ouvrages miniers souterrains repose sur une caractérisation géotechnique du massif rocheux. Les propriétés du roc intact sont évaluées au laboratoire selon les recommandations prescrites par la Société internationale de mécanique des roches. Lors d'essais en laboratoire, il est suggéré de tester un nombre minimal de spécimens par type de roche. Néanmoins, la variabilité, l'hétérogénéité et l'anisotropie du massif rocheux rendent parfois difficile l'établissement de valeurs représentatives de ces paramètres. Une campagne d'essais géomécaniques doit également répondre à des contraintes pratiques et financières. À l'aide d'une étude de cas réalisée sur un site minier québécois, cet article présente une méthodologie permettant de lier directement les résultats d'analyses statistiques des données de laboratoire à des niveaux de connaissance cibles pour les données géotechniques et ce à toutes les étapes d'un projet minier.





## Session/Séance : Uncertainty, Reliability, and Risk / Incertitude, fiabilité et risque

Monday, September 21, 10:45 - 12:15 / Lundi 21 septembre, 10 h 45 - 12 h 15

Room / Salle : 2102B

Chair / Présidente de séance : Suzanne Lacasse

### 263 - DISPUTE RESOLUTION IN GEOTECHNICAL ENGINEERING PRACTICE - SOME LESSONS LEARNED

Miroslav (Fred) Matich (1), J.L. Seychuk (2), Gordon C. McRostie (2)

(1) MAJM Corporation Ltd. (Toronto, Canada); (2) Golder Associates Ltd. (Toronto, Canada)

The scope of applied geotechnology has increased greatly since it was introduced into modern engineering practice by prominent pioneers in the profession. Geotechnical expertise is increasingly applied in conjunction with other specialty fields and to a broad range of end uses including design, construction and performance. More formal contractual arrangements have evolved together with greater expectations by clients. Notwithstanding significant advances in the state of practice, disputes unfortunately still arise which require resolution by arbitration or litigation. Avoidance of claims and exposure to risk is an important issue. The Authors provide lessons from their experience particularly to benefit younger members of the geotechnical profession.

### 321 - TAILINGS MANAGEMENT AT THE IRON MINE OF MOUNT WRIGHT

Frédéric Choquet (1), David Bédard (1), Desheng Deng (1), Claude Bédard (1), Serge Thériault (2), Sébastien Moreau (2)

(1) Amec Foster Wheeler (Dorval, Canada); (2) ArcelorMittal Mining Canada (Port-Cartier, Canada)

The tailings storage facility (TSF) of the Mount Wright mine, a property of ArcelorMittal Mining Canada, has been active since 1976. It is located in the Fermont area and spreads across 15 km<sup>2</sup> which makes it one of the largest impoundments in North America.

This paper discusses the choice of the appropriate raising method at the TSF and introduces the systems implemented to monitor the structures.

During winter, both coarse and fine tailings are mixed and pumped into the impoundment.

In summer, the fine tailings are redirected towards the north edge of the impoundment. Meanwhile, the coarse tailings are deposited with a patented system that allows the coarsest particles to decant and settle more quickly along the dam to be raised. This system creates beaches with steeper slopes and higher crests than with a traditional spigot system. The beaches are then used as borrow pits in order to elevate the crests further.

In order to ensure the safety of the retaining dams and dykes, many of them are equipped with various instruments, as detailed later in this paper. The analysis of the data constitutes an excellent tool to monitor the behaviour of the structures and illustrates their evolution through time.



#### **644 - PROBABILISTIC SLOPE STABILITY ANALYSIS OF REINFORCED SLOPES BY FINITE ELEMENT METHOD**

Ning Luo (1), Richard J. Bathurst (2), Sina Javankhoshdel (1)  
(1) *Queen's University (Kingston, Canada)*; (2) *Royal Military College of Canada (Kingston, Canada)*

A probabilistic slope stability analysis tool for geosynthetic reinforced slopes (and embankments) that combines shear strength reduction method (SSR) with probability theory was developed using a finite element method (FEM) source code for unreinforced slopes. The original numerical model in combination with the shear strength reduction method and Monte Carlo simulation (MC) was first used to compute probability of failure and factor of safety for simple unreinforced slopes with purely cohesive and cohesive-frictional soil. The results are compared to those from combined limit equilibrium method (LEM) and probability theory recently published in the literature. The results are shown to be in good agreement. The validated FEM code was then modified to investigate reinforced slope cases. To verify the new code, a general reinforced slope case was examined using the new program and the FEM software package SIGMA/W. Displacements and reinforcement strains calculated using both programs agreed well. The utility of the new code is demonstrated by a number of examples. The general approach applied to reinforced soil slopes is novel and offers a powerful tool to relate conventional notions of factor of safety for reinforced soil slopes to margins of safety described by more meaningful probability of failure.

#### **566 - PROBABILISTIC ANALYSIS OF TWO MECHANISMS OF FAILURE IN GEOSYNTHETIC REINFORCED SLOPES USING MONTE CARLO SIMULATION**

Sina Javankhoshdel (1), Richard J. Bathurst (2)  
(1) *Queen's University, (Kingston, Canada)*; (2) *Royal Military College of Canada (Kingston, Canada)*

Reinforced slopes with horizontal layers of geosynthetic reinforcement can have different mechanisms of failure. In this paper two major mechanisms of failure of reinforced slopes are investigated. An external mechanism occurs when the critical slip surface passes beyond the reinforced zone. Internal mechanisms are characterized by failure surfaces that intersect all of the reinforcement layers. For a target value of the factor of safety, and a specific value of the reinforcement length, there is a minimum value of the reinforcement tensile strength to generate only external mechanism types. On the other hand, increasing the reinforcement length generates an internal mechanism type. In this study, probabilistic slope stability analysis of these two mechanisms is carried out using Monte Carlo simulation of slopes with different purely frictional soils and slope angles. For a target value of the factor of safety, two sets of charts for external and internal failure mechanism types are presented that can be used to calculate probability of failure for simple slopes with purely frictional soils.

#### **815 - RANDOM FINITE ELEMENT ANALYSIS OF SUPPORTED EXCAVATIONS CONSIDERING SPATIAL VARIABILITY**

Jerry Luo (1), Sedat Sert (2), Wenping Gong (3), C. Hsein Juang (3)  
(1) *University of Akron (Akron, United States)*; (2) *Sakarya University (Adapazari, Turkey)*; (3) *Clemson University (Clemson, United States)*

This paper presents a study of the effect of spatial variability on the estimated lateral wall deflection and bending moment of a cantilever retaining wall that supports excavations in sands. A commercially available finite element program, PLAXIS, is adopted to predict the



excavation-induced maximum lateral wall deflection and maximum bending moment. The spatial variability of the internal friction angle is modeled using random field theory. A series of systematic numerical simulations are performed based on the Monte Carlo simulation to investigate various levels of spatial effect. This study reveals that the spatial variability has considerable influence on the estimated maximum lateral deflection and maximum bending moment. The negligence of spatial variability of soil parameters will lead to an underestimation of the variation in the excavation-induced maximum wall deflection and maximum bending moment. The probability of failure for the serviceability limit state can be either overestimated or underestimated depending on the limiting lateral wall deflection. This study points to the importance of random field modeling in coping with the problem of excavations supported by cantilever retaining walls.

## 204 - UNCERTAINTY IN SNOW AVALANCHE RISK ASSESSMENTS

Bruce Jamieson (1), Pascal Haegeli (2), Grant Statham (3)

(1) *University of Calgary (Calgary, Canada)*; (2) *Avisualanche Consulting (Vancouver, Canada)*; (3) *Alpine Specialists (Canmore, Canada)*

Snow avalanche risk assessments are applied in planning for residential areas, energy corridors, transportation corridors, industrial sites, ski area expansions, as well as for operational decisions for work sites, ski areas and commercial backcountry recreation. While many of these assessments are qualitative, some are quantitative. Increasingly, uncertainty has become an explicit part of snow avalanche risk assessments. Sources of uncertainty in snow avalanche risk assessments include weather, climate, snowpack, vegetation, terrain, as well as the exposure of people and things of value. We review strategies for reducing uncertainty in the assessment process including the use of independent predictive methods as well as reviews. To reduce the frequency of death and damage from snow avalanches, analytical methods such as non-exceedance probabilities can ensure that much of the uncertainty lies below the applicable threshold of acceptable risk. Finally, we summarize strategies for communicating uncertainty about avalanches to the risk owner.

## Session/Séance : Infrastructure Performance in Cold Regions I / Performance des infrastructures en régions nordiques I

Monday, September 21, 10:45 - 12:15 / Lundi 21 septembre, 10 h 45 - 12 h 15

Room / Salle : **2104AB**

Chair / Président de séance : **Baolin Wang**

## 703 - MONITORING PERMAFROST CONDITIONS ALONG THE DEMPSTER HIGHWAY

Muhammad Idrees (1), Chris Burn (2), Jeff Moore (3), Fabrice Calmels (4)

(1) *APEY and PEO (Whitehorse, Canada)*; (2) *Professor in Carleton University (Ottawa, Canada)*; (3) *student (Ottawa, Canada)*; (4) *Northern Climate ExChange- Yukon Research Centre (Whitehorse, Canada)*

The Dempster Highway, which connects the western Arctic to the national highway network, is built almost entirely on permafrost. Four long-term permafrost monitoring sites were established on the highway in 2013-14 to determine baseline thermal conditions and to follow changes in ground temperatures driven by climate change. The sites are at km 124 and 421 in Yukon and km 8.5 and 51.5 in NWT. Boreholes, up to 10 m in depth, were drilled at each site in the highway centerline, at the embankment toe, and in undisturbed



ground. Data have been retrieved from thermistor cables at these sites since February 2014. The embankment toe is the warmest location at each site. In undisturbed ground, annual mean temperatures range from -3.6 to -1.1 °C. The centerline is relatively cold, with annual mean temperatures ranging from -3.9 to -2.4 °C. The permafrost at km 124 is unexpectedly thin due to groundwater movement

### **65 - INITIAL MONITORING OF INSTRUMENTED TEST SECTIONS ALONG THE INUVIK-TUKTOYAKTUK HIGHWAY**

Earl Marvin De Guzman (1), Earl Marvin De Guzman (1), Aron Piamsalee (1), Marolo Alfaro (1), Lukas Arenson (2), Guy Doré (3), Don Hayley (4)

(1) *University of Manitoba (Winnipeg, Canada)*; (2) *BGC Engineering Inc. (Vancouver, BC, Canada)*; (3) *Université Laval (Québec City, QC, Canada)*; (4) *Independent Consultant (Kelowna, BC, Canada)*

There are uncertainties related to the mechanical behaviour of embankments that were initially compacted with frozen fill and then experienced natural thawing and settlements during the summer following construction. Side-slope sloughing and fill cracking may occur because of localized thaw settlements under the shoulders and side slopes of the embankment. Two instrumented test sections were constructed side by side along the new Inuvik-Tuktoyaktuk Highway and are being continuously monitored after its construction to study these uncertainties. This paper presents the initial monitoring recorded from the completion of the test sections. Test Section A, the control section, is an unreinforced slope section conforming to the original design of the road embankment. Test Section B is a reinforced slope section with geotextile layers at the slope acting as its reinforcement. Section A and Section B are both instrumented with thermistors for temperature readings, ShapeAccelArrays for the vertical and horizontal deformation monitoring, vibrating wire piezometers for pore water pressures, and thermal conductivity sensors for matric suctions. Strain gauges were also installed in the geotextile reinforcements for Section B to measure the deformations in the geotextile layers.

### **115 - DISEQUILIBRIUM PERMAFROST CONDITIONS ON NWT HIGHWAY 3**

Stephen Wolfe (1), Peter Morse (1), Ed Hoeve (2), Wendy Sladen (1), Steve Kokelj (3), Lukas Arenson (4)

(1) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*; (2) *Tetra Tech EBA Inc. (Yellowknife, Canada)*; (3) *Northwest Territories Geological Survey, Government of the Northwest Territories (Yellowknife, Canada)*; (4) *BGC Engineering Inc. (Vancouver, Canada)*

The thermal and physical states of permafrost in natural and developed settings along NWT Highway 3 are examined and implications of recent realignment between Behchoko and Yellowknife are discussed. Permafrost occurs in natural terrain beneath peatlands and forested fine-grained (glacio) lacustrine sediments. Natural and developed sites indicate surface warming especially beneath the highway embankment, which was straightened and reconstructed between 1999 and 2006. Fine-grained sediments are thaw-sensitive and ice-rich. The terrain could experience up to 1.3 m of settlement with thawing of the top 5 m of permafrost. Permafrost had aggraded into the old highway embankment comprised of fine-grained materials, but is unlikely to be sustained beneath the new highway embankment comprised primarily of blast rock.



## 266 - OBSERVED DEFORMATIONS OF AN EXISTING HIGHWAY EMBANKMENT ON DEGRADING PERMAFROST

David Flynn (1), Marolo Alfaro (2), Jim Graham (2), Lukas Arenson (3)  
 (1) KGS Group, Winnipeg, Canada (Winnipeg, Canada); (2) University of Manitoba (Winnipeg, Canada); (3) BGC Engineering Inc. (Vancouver, Canada)

The integrity of infrastructure in northern regions is negatively impacted by thawing and degradation of the underlying permafrost foundation initiated by changes in both air and ground temperatures. Subsequent deformations due to settlement and lateral spreading can lead to potentially hazardous driving conditions for linear infrastructure, such as highways. This paper discusses the deformation of an instrumented highway embankment sitting on degrading permafrost observed since September 2012. The site is located 18 km north of Thompson, Manitoba on Provincial Road (PR) 391. Earlier papers on this site reported results from three years of data, but with incomplete instrumentation. Newly-added instrumentation installed in September 2012 has identified a frost bulb in the centre of the embankment. We assessed the effect of the frost bulb, which had not been known and therefore not included in previous studies, on the embankment deformation. Lateral and vertical embankment deformations were measured using ShapeAccelArrays installed vertically below the shoulder of the embankment and horizontally at its toe. New instrumentation also included vibrating wire piezometers and thermistors to monitor groundwater and temperatures. Readings from the new instruments provide an improved understanding of the pore pressures and the thermal regime at the site.

## 267 - OBSERVED AND PREDICTED THERMAL REGIME UNDER AN EXISTING HIGHWAY EMBANKMENT ON DEGRADING PERMAFROST

David Flynn (1), David Kurz (2), Marolo Alfaro (3), Jim Graham (3), David Kurz (2), Lukas Arenson (4)  
 (1) KGS Group (Winnipeg, Canada); (2) Golder Associates Ltd. (Winnipeg, Canada); (3) University of Manitoba (Winnipeg, Canada); (4) BGC Engineering Inc. (Vancouver, Canada)

Temperature changes of ground thermal regimes in permafrost regions can initiate thawing and degradation of permafrost and potentially damage existing infrastructure. Subsequent settlements and lateral spreading can lead to hazardous driving conditions on highways. Future changes in climate will exacerbate thermal degradation and negatively impact the long-term performance of linear infrastructure like highways, runways, rail lines, and pipelines. The paper discusses numerical thermal modeling of an instrumented highway embankment on degrading permafrost, both for simulating current conditions and projecting future behaviour. The embankment is located 18 km north of Thompson, Manitoba on Provincial Road (PR) 391. Thermistors were installed beneath the toe, mid-slope, shoulder and centerline of the embankment. Five years of data have been collected. Earlier papers by the authors outlined the instrumentation and development of a first generation of numerical thermal models for the site. This new contribution describes how projected trends in climate change have been used to assess future behaviour.

## 176 - THE INUVIK AIRPORT RUNWAY – AN EVALUATION OF 50 YEARS OF PERFORMANCE

Ed Hoeve (1), Don Hayley (2)  
 (1) Tetra Tech EBA Inc. (Yellowknife, Canada); (2) Hayley Arctic Geoconsulting (Kelowna, Canada)

The Inuvik airport is in continuous permafrost. The overburden is predominantly fine-grained ice-rich till. The runway embankment was constructed in the late 1950's,



using locally quarried rock. The selected fill thickness balanced the objectives of limiting the thermal impact on the permafrost and controlling cost. The runway was paved in 1969. Ground temperature monitoring until 1974 indicated that the runway was exceeding expectations, from a ground thermal response perspective. The active layer was being maintained within the embankment fill. A climate warming trend was first noticed in the 1970's. At Inuvik, the mean annual air temperature has averaged about  $-8^{\circ}\text{C}$  over the last 30 years. The embankment was designed when the mean annual air temperature was about  $-10^{\circ}\text{C}$ . Ground temperatures in the vicinity of the runway have warmed significantly. Seasonal thaw is now extending below the embankment at some locations. The thaw of ice-rich subgrade soil has resulted in settlement, which is an operational and safety concern. This thaw is exacerbated by seepage through the thawed base of embankment. Measures to stabilize the settlement by controlling seepage have been proposed and are described. The implications for a future runway extension are also described.

## Session/Séance : Mining Géotechnique I / Géotechnique minière I

Monday, September 21, 10:45 - 12:15 / Lundi 21 septembre, 10 h 45 - 12 h 15

Room / Salle : 2105

Chair / Président de séance : Robert Chapuis

### 54 - EVALUATION OF THERMAL PROPERTIES OF OIL SAND FLUID FINE TAILINGS

Kathryn Dompierre (1), Lee Barbour (1)  
(1) *University of Saskatchewan (Saskatoon, Canada)*

Synchrude Canada Ltd. has developed the first end pit lake in the oil sands region at their Mildred Lake Mine site. The end pit lake, referred to as Base Mine Lake, was constructed within a mined-out pit, and incorporates 186 Mm<sup>3</sup> of fluid fine tailings (FFT) below an 8 m water cap. Fluid fine tailings are deposited at elevated temperatures, and act as a heat source to the overlying lake. The thermal properties of the FFT must be defined to evaluate the long-term thermal regime within the tailings and lake. Samples were collected from Base Mine Lake at various depths. Select samples were chosen to represent a range of oil contents, and pore water salinity. Water was added or removed from each sample to create multiple tailings sub-samples of varying water content. Thermal conductivity and volumetric heat capacity of each sub-sample was measured with a KD2 Pro Probe, and this dataset was analyzed to determine the influence of water content, oil content, and salinity on the thermal properties of FFT. Thermal conductivity and volumetric heat capacity values were similar to those estimated using theoretical relationships for the thermal properties and water content, when volumetric oil content was taken into consideration.

### 221 - THICKENED TAILINGS DEPOSITION MODELING USING A LARGE STRAIN CONSOLIDATION MODEL

Michaël Demers Bonin (1), Nuth Mathieu (2), Anne-Marie Dagenais (1), Alexandre R.Cabral (2)  
(1) *Golder Associés Ltée (Montréal, Canada)*; (2) *Université de Sherbrooke (Sherbrooke, Canada)*

The use of thickened tailings (TT) has increased over the last forty years due to the perceived benefits of using this technology for tailings disposal. Observations from self-weight consolidation tests performed in settling columns on gold mine tailings indicated that thickened tailings at higher solids content typically exhibit self-weight consolidation behavior only. Based on this observation, the CS2 code was used to model the experimental



consolidation behavior of thickened tailings observed in settling columns. The results from CS2 were conclusive and lead to further modeling tailings deposition on a large scale using the CS4 1D code, which shares the same formulation as CS2 but considers layer accretion, rather than instantaneous filling. The numerical formulation of the two codes accounts for large strain and variable compressibility and hydraulic conductivity during the consolidation process.

#### **754 - DESICCATION AND CONSOLIDATION MODELLING OF OIL SANDS FINE TAILINGS DEPOSITS**

Paul Simms (1), S. Soleimani (1), L. Rozina (1), S. Mizani (1)  
(1) Carleton University (Ottawa, Canada)

Oil sands tailings deposition is regulated by enforcing reduction of the volume of fluid fine tailings over the life of an operation. Fluid fine tailings are defined by a 5 kPa undrained shear strength value. Operators are meeting these targets by improving dewatering and consolidation characteristics of fine tailings through various techniques, often involving addition of polymer or other flocculation-inducing treatment. Dewatering occurs through several mechanisms, including particle aggregation through application of the polymer, but also consolidation and desiccation through evaporation, drainage, or freeze-thaw. Understanding the relative contribution of each mechanism will assist in selecting optimal thickness, polymer dose, and rate of rise, to minimize and control impoundment footprints. In this paper, we examine the utility of consolidation and desiccation modelling to interpret laboratory experiments and field trials, to separate out the contribution of each mechanism, and to generalize these contributions to hypothetical deposition scenarios.

#### **798 - THE CASE FOR USING FINES VOID RATIO**

Amarebh Sorta (1), Nicholas Beier (1), Nicholas Beier (1), Louis Kabwe (1), Don Scott (1), Ward Wilson (1)  
(1) University of Alberta (Edmonton, Canada)

Generally in geotechnical engineering, the relationships of compressibility, hydraulic conductivity and shear strength are plotted as functions of total void ratio. However, for oil sands and other tailings containing both fines and sand, it has been found that the sand does not significantly influence the compressibility, hydraulic conductivity and shear strength of sandy, fluid fine tailings. The sand only functions as filler material that displaces the fines matrix. In plotting the relationships, the fines void ratio, therefore, should be used not the total void ratio. Test results proving the case for using fines void ratio not total void ratio is included using a Soil Structure Behaviour Diagram.

#### **797 - EFFECT OF FLOCCULENT TREATMENTS ON CONSOLIDATION OF OIL SANDS FLUID FINE TAILINGS**

Louis Kabwe (1), Nicholas Beier (1), Louis K. Kabwe (1), G. Ward Wilson (1), J. Don Scott (1), Amarebh Sorta (1), Nicholas A. Beier (1)  
(1) Department of Civil & Environmental Engineering, University of Alberta (Edmonton, Canada)

Regulatory policy and regulations in Alberta require oil sands companies to reduce their production and storage of fluid fine tailings by creating deposits that can be reclaimed in a more timely manner. To meet the regulatory requirements, some companies are adding flocculants to the fluid fine tailings, using thickeners or centrifuges to increase the solids content and then using freeze/thaw processes to further thicken the tailings. The effects of



flocculating, thickening and freeze/thaw treatments were investigated by performing large strain consolidation tests and shear strength tests on fluid fine tailings which had these treatments. The consolidation and shear strength results were then compared to those of untreated fluid fine tailings. All of the treatments increased the hydraulic conductivity of the fine tailings to some degree, but had no effect on the compressibility and shear strength. The effects and evaluations of the treatments are discussed.

### **395 - MISE EN ÉVIDENCE EXPÉRIMENTALE DU DOSAGE OPTIMAL DES CIMENTS COMPOSÉS (LIANTS) UTILISÉS DANS LA FABRICATION DES REMBLAIS EN PÂTE CIMENTÉS**

*Amal Sahi* (1), *Tikou Belem* (1), *Mostafa Benzaazoua* (1)

(1) *Université du Québec en Abitibi Témiscamingue (Rouyn-Norand, Canada)*

Des paramètres physico-chimiques ont été proposés pour caractériser la réactivité relative des agents liants dans les remblais miniers en pâte cimentés (module hydrauliques, facteur de réactivité relative et indice d'hydratation relative, Ha). L'étude a pour objectif de vérifier expérimentalement la cohérence et la validité de ces paramètres physico-chimiques en vue de leur utilisation sur une base routinière. Pour ce faire, différentes recettes de mélanges de remblai ont été préparées avec quatre catégories de liant : ciment Portland à usage courant (témoin), liants à base de slag, liants à base de fly ash F et de fly ash C. Pour chaque recette de mélange deux % liant ont été utilisés : 4,5% et 7%. La résistance à la compression uniaxiale (UCS) remblais a été déterminée à quatre temps de cure : 14, 28, 56 et 90 jours. Les résultats de montrent que les recettes de mélanges ayant un indice Ha équivalant à celui du liant dit de référence (20GU/80Slag) ont développé les résistances les plus élevées. Ces paramètres peuvent donc être utilisés comme outil d'aide à la présélection et/ou lors du changement d'un agent liant et à son dosage optimal dans la fabrication des remblais miniers en pâte cimentés.

## **Session/Séance : Soil Mechanics II / Mécanique des sols II**

**Monday, September 21, 13:45 – 15:15 / Lundi 21 septembre, 13 h 45 – 15 h 15**

Room / Salle : **204AB**

Chair / Président de séance : **Vincenzo Silvestri**

### **66 - A PRACTICAL CONSTITUTIVE MODEL FOR SANDS**

*Alireza Azami* (1), *Thamer Yacoub* (2), *John Curran* (3)

(1) *Rocscience Inc., Toronto, Ontario, Canada (Toronto, Canada)*; (2) *President of Rocscience Inc (Toronto, Canada)*; (3) *CEO of Rocscience Inc, and Civil Engineering, University of Toronto (Toronto, Canada)*

This paper will focus on the behaviour of granular materials under monotonic loads and presents a constitutive model that is simple yet practical for engineering applications. The model is based on the well-known Mohr-Coulomb model with only one additional material parameter to make it as simple and practical as possible. The applicability of the model is demonstrated by simulations of triaxial tests, and various model tests, including strip foundation and tunnels with and without nearby surface load and also an excavation benchmark case study.





### 738 - ANALYZING THE MACRO AND MICRO-SCALE RESPONSE OF AN IDEALISED GRANULAR MATERIAL IN DIRECT SHEAR TEST USING 3D-DEM SIMULATIONS AND EXPERIMENTAL INVESTIGATIONS

Samaneh Amirpour Harehdasht (1), Mourad Karray (2), Mahmoud N. Hussien (3), Varvara Roubtsova (4), Mohamed Chekired (4)  
 (1) *Civil Engineering, Université de Sherbrooke (Sherbrooke, Canada)*; (2) *Professor, Department of Civil Engineering, Université de Sherbrooke (Sherbrooke, Canada)*; (3) *Post-doctoral fellow, Department of Civil Engineering, Université de Sherbrooke (Sherbrooke, Canada)*; (4) *Ph.D., Researcher, Institut de Recherche d'Hydro-Québec (Varenes, Canada)*

This paper describes a promising virtual approach using SiGran (3D virtual laboratory for geotechnical applications) to observe the micro-scale behaviour of an idealized material in direct shear test, based on the discrete element methods (DEM). To validate the numerical simulations, a series of experimental tests were also carried out. The macro-scale results obtained from DEM simulations show good agreement with those of the laboratory tests. The micro scale results from numerical simulations also were derived showing the initiation of shear bands from the side boundaries toward the centre. When sample reached the peak state the distinct shear band along the middle plane developed and became more continuous and expansive during the post-peak. The micro scale results are in good agreements with previous study tried to evaluate the formation of shear band in two or three dimensional simulations

### 689 - APPROCHE VIRTUELLE POUR LA GÉNÉRATION DE MILIEUX POREUX ET L'ÉVALUATION DE LA TORTUOSITÉ

Mohamed Chekired (1), Varvara Roubtsova (2), Marin Lagacé (1)  
 (1) *Hydro-Québec (Varenes, Canada)*; (2) *Hydro-Québec (Varenes, Canada)*

La tortuosité dans les milieux granulaires a été introduite pour tenir compte des caractéristiques du réseau poral nécessaire à l'estimation de la perméabilité. Plusieurs modèles de tortuosité ont été proposés dans la littérature. Ces modèles sont basés sur un écoulement bidimensionnel qui ne reflète pas la réalité car l'écoulement est intrinsèquement liée au caractère tridimensionnel de la forme des particules. Cet article présente les possibilités qu'offre un outil de simulation numérique, développé à l'IREQ, appelé SiGran, et dont la vocation est de constituer un logiciel robuste et opérationnel pour traiter, entre autres, des problématiques liées aux écoulements au travers des milieux granulaires. Cet outil permet de générer un milieu granulaire constitué de particules de forme sphérique ou naturelle et simuler un écoulement. L'approche retenue dans le développement de cet outil permet d'investiguer les différentes variables à l'échelle microscopique. Les résultats de simulation obtenus, lorsque confrontés à ceux issus d'expériences, montrent que l'outil SiGran reproduit fidèlement la réalité.

### 351 - ANISOTROPY IN GRANULAR GEOMATERIALS

Marjan Oboudi (1), Stan Pietruszczak (2)  
 (1) *Isherwood Associates (Mississauga, Canada)*; (2) *McMaster University (Hamilton, Canada)*

The primary objective of this study is to demonstrate that a significant degree of anisotropy may occur in particulate materials that have nearly spherical aggregates (i.e. are typically considered as isotropic) provided there is a bias in the distribution of pore space due to the initial densification process. The study includes both an experimental and theoretical component. An experimental program is conducted on dynamically compacted samples of Ottawa standard sand (C109), and incorporates a series of tests performed at different



orientation of the specimens. Following the experimental part, a plasticity formulation based on the critical plane approach is presented for transversely isotropic granular media.

### **111 - LABORATORY INVESTIGATION ON THE EFFECT OF GRAIN SIZE DISTRIBUTION OF GRANULAR MATERIAL ON CONE PENETRATION TEST RESULTS**

Michael Ghali (1), Mourad Karray (1), Mohamed Chekirad (2), Varvara Roubtsova (2)  
(1) *Sherbrooke University (Sherbrooke, Canada)*; (2) *Hydro-Québec (Montréal, Canada)*

This paper initially compares and discusses a majority of correlations of ( $q_c$ ) and ( $f_s$ ) with typical geotechnical parameters such as relative density ( $D_r$ ), the effective overburden pressure ( $\sigma'_v$ ), void ratio ( $e$ ), mean grain size ( $D_{50}$ ), the degree of uniformity ( $C_u$ ), lateral stress ( $\sigma'_h$ ), mean confinement pressure ( $\sigma'_m$ ), overconsolidation (OCR), and angularity. The paper then presents the results of a series of experimental simulations for cone penetration test (CPT) on both polydisperse spherical glass beads and natural sands samples with different mechanical properties as well as different loading conditions. Stress-strain records along the soil samples are monitored during the tests. Results obtained for ( $q_c$ ) and ( $f_s$ ) are correlated with such geotechnical parameters and the corresponding graphs are plotted in order to predict the real behavior of natural soils in the field.

### **489 - CORRELATION BETWEEN ELASTIC MODULUS AND SHEAR WAVE VELOCITY AT LARGE STRAIN LEVEL**

Mourad Karray (1), Mohamed Ben Romdhan (1), Mahmoud N. Hussien (1)  
(1) *Université de Sherbrooke (sherbrooke, Canada)*

Geotechnical studies on large projects need constitutive relations for modeling deformation behavior of soils and construction materials. Modeling is particularly important for zoned dams to examine the compatibility of deformations between pervious and impervious zones, generally made of different materials. The determination of the deformation behavior of granular materials, especially coarse granular soils, requires special equipment's and remains a complex issue. The small strain shear modulus ( $G_{max}$ ) is an attractive parameter as it can be measured in the field under the true in-situ conditions using non-destructive tests (e.g., MMASW). However, the exploitation of these measures requires the establishment of correlations between this modulus ( $G_{max}$ ) and other soil parameters at large deformations (e.g.,  $E$ ,  $E_{oed}$ ,  $n$ ). This can be achieved by measuring simultaneously the oedometer module and the shear wave velocity ( $V_s$ ) in the laboratory on materials having a similar gradation to that used for the geotechnical structure construction. This paper presents the results of experimental work carried out at the soil mechanics laboratory of the University of Sherbrooke on different sands.

## Session/Séance : Characterization of Permafrost State and Variability I / Caractérisation et variabilité du pergélisol I

Monday, September 21, 13:45 – 15:15 / Lundi 21 septembre, 13 h 45 – 15 h 15

Room / Salle : 205A

Chair / Président de séance : Fabrice Calmels

### 479 - CHANGES IN PERMAFROST AND ACTIVE-LAYER TEMPERATURES ALONG AN ALASKAN PERMAFROST-ECOLOGICAL TRANSECT

Vladimir Romanovsky (1), William Cable (1), Alexander Kholodov (1)

(1) *Geophysical Institute, University of Alaska Fairbanks (Fairbanks, United States)*

In this paper we report changes in permafrost temperatures during the last 30 years in Alaska. Most of the research sites in our network are located along an Alaskan Permafrost-Ecological Transect. This transect spans all permafrost zones in Alaska. Most of the sites in Alaska show substantial warming of permafrost since the 1980s. The magnitude of warming has varied with location, but is typically from 0.5 to 3°C. However, this warming is not linear in time and is not spatially uniform. While permafrost warming has been more or less continuous on the North Slope of Alaska with a rate between 0.2 to 0.5°C per decade, permafrost temperatures in the Alaskan Interior started to experience a slight cooling in the 2000s that has continued during the first half of the 2010s. The observed climate warming has triggered permafrost degradation in Alaska, especially in the north and at the locations which are affected by human activities.

### 133 - LONG-TERM OBSERVATIONS OF ACTIVE LAYER THAWING AND FREEZING, BARROW, ALASKA

Jerry Brown (1), Frederick Nelson (2), Vladimir Romanovsky (3), Cathy Seybold (4), Robert Hollister (5), Craig Tweedie (6)

(1) - *(Woods Hole, United States)*; (2) *Northern Michigan University (Marquette, United States)*; (3) *Geophysical Institute, University of Alaska (Fairbanks, United States)*; (4) *USDA Natural Resources Conservation Service (Lincoln, United States)*; (5) *Grand Valley State University (Allendale, United States)*; (6) *University of Texas at El Paso (El Paso, United States)*

Beginning in the early 1950s and continuing to the present, Barrow has been a region of numerous active layer and permafrost investigations. The average active layer thickness (ALT) obtained by physical probing at two, permanently gridded sites for the periods (1962 -1970) and (1991-present) was 35 cm, with mean minimum of 22 cm in 1992 and a maximum of 45 in 1968. Additional 1970s ALT data from the nearby U.S. Tundra Biome sites are compared with these long-term data. ALT values based on measured soil temperatures from 1997 to present ranged from 33 to 63 cm with final freezeback dates ranging from October 9 to November 12. Average ALT calculated from modeled soil-permafrost temperatures (1924 to present) was 34 cm with a minimum of 18 cm in both 1945 and 1969 and a maximum of 54 cm in 1998. Modeled ALT values are comparable to those determined by temperature point measurements.



### **237 - VARIABILITY AND CHANGE IN PERMAFROST THERMAL STATE IN NORTHERN CANADA**

Sharon Smith (1), Antoni Lewkowicz (2), Caroline Duchesne (3), Mark Ednie (3)  
 (1) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*; (2) *University of Ottawa (Ottawa, Canada)*; (3) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*

The thermal state of permafrost snapshot established during the International Polar Year (IPY 2007-09) provided a baseline against which future change could be measured. Comparison of permafrost temperatures measured 4 to 5 years post IPY to the IPY snapshot indicates that temperatures have increased at many sites with larger increases found in the eastern and high Arctic compared to the western Arctic, a continuation of a longer term trend. These regional differences in the changes in permafrost thermal state are associated with regional variations in air temperature trends.

### **117 - ACTIVE LAYER VARIABILITY AND CHANGE IN THE MACKENZIE VALLEY, NORTHWEST TERRITORIES**

Caroline Duchesne (1), Philip Bonnaventure (2), Sharon Smith (1), Mark Ednie (1), Philip Bonnaventure (2)  
 (1) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*; (2) *University of Lethbridge (Lethbridge, Canada)*

The Geological Survey of Canada has maintained an active layer monitoring network in the Mackenzie Valley, Northwest Territories since 1991. Active layer thickness exhibits a great deal of spatial and temporal variability particularly at tree dominated sites. Active layer thickness generally increased between 1991 and 1998 and then generally declined until about 2004. Since 2005 active layer thickness has generally increased reaching peak values in 2012, although still less than the 1998 peak. Although thicker active layers may result from higher summer air temperatures, warmer conditions during the preceding winter can also substantially contribute to active layer thickness.

### **823 - DTS GROUND TEMPERATURE MEASUREMENTS IN MOUNTAIN PERMAFROST – THE 2ALPES-3065 BOREHOLE (FRENCH ALPS)**

Philippe Schoeneich (1), Jean-Michel Krysiecki (2), Ludovic Mingrat (2), Hendrik Huwald (3)  
 (1) *Université de Grenoble Alpes (Grenoble, France)*; (2) *Bureau SAGE/ADRGT (Gières, France)*; (3) *Ecole Polytechnique Fédérale de Lausanne (Lausanne, Switzerland)*

A 100 m deep borehole in mountain permafrost has been equipped with both a thermistor chain and a fiber optic cable for DTS measurements. The device permits to assess the resolution and accuracy of DTS measurements through the comparison of parallel DTS profiles and with classical sensors. First results show a resolution in the order of 0.1 °C can be achieved, but that the accuracy is strongly dependent on the calibration of the measurement.

## 629 - ARCTIC PERMAFROST THERMAL VARIABILITY ACROSS AN ENVIRONMENTAL GRADIENT FROM CONTINUOUS TO SPORADIC PERMAFROST IN THE NORTHERN HEMISPHERE – A PAGE21 COMPILATION

Hanne H. Christiansen (1), Julia Boike (2), J. van Huissteden (3), Birger U. Hansen (4), Margareta Johansson (5), Go Iwahana (6), Boris K. Biskaborn (2)

(1) *The University Centre in Svalbard, UNIS (Longyearbyen, Norway)*; (2) *Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Potsdam (Potsdam, Germany)*; (3) *Department of Earth Sciences, University of Amsterdam (Amsterdam, Netherlands)*; (4) *Center for Permafrost, Department of Geoscience and Natural Resource Management, University of Copenhagen (Copenhagen, Denmark)*; (5) *Department of Physical Geography and Ecosystem Science, University of Lund (Lund, Sweden)*; (6) *International Arctic Research Center, University of Alaska, Fairbanks (Fairbanks, United States)*

Permafrost temperatures are recorded in dominant ice-rich periglacial landforms in five different sites of continuous and sporadic permafrost for improved understanding of physical permafrost processes, and for the comparison of these processes between the five sites. Additionally active layer thickness from the official CALM data from each of the same sites have been compared. The landscapes vary from high-relief mountainous terrain to deltaic and floodplain lowlands, and are thus characteristic of large parts of the permafrost landscapes in the Northern Hemisphere, representing the landscape variability. Significant variation is seen in terms of the sensitivity towards climate change between the five sites, ranging from relatively cold  $-8^{\circ}\text{C}$  permafrost in Siberia, but with very large thermal conductivity, over warmer  $-4^{\circ}\text{C}$  permafrost in Svalbard with normal thermal conductivity, to permafrost warmer than  $-1^{\circ}\text{C}$  in Abisko. Thickest active layer is found in Svalbard, and thinnest in Kytalyk in Siberia, but with the peat of the sporadic permafrost in Abisko at an intermediate level.

## Session/Séance : Landslides and Slope Stability II / Mouvements de terrain et stabilité des pentes II

Monday, September 21, 13:45 – 15:15 / Lundi 21 septembre, 13 h 45 – 15 h 15

Room / Salle : 205BC

Chair / Président de séance : Michel Jaboeudoff

### 285 - DETECTION OF ROCK SLOPE FAILURE PRECURSORS USING A TERRESTRIAL LASER SCANNER

Ryan Kromer (1), Jean Hutchinson (2), Matt Lato (3), Dave Gauthier (3), Tom Edwards (4)  
(1) *Queens University (Kingston, Canada)*; (2) *Queens University (Kingston, Canada)*; (3) *BGC Engineering (Ottawa, Canada)*; (4) *CN Rail (Edmonton, Canada)*

In this study, we monitored a slope along the CN Rail line in the Fraser River Valley, BC using terrestrial laser scanning (TLS) to: identify rockfall source areas based on precursor deformation, track the deforming areas in 3D, project their potential volumes and provide early warning to the railway prior to rockfall. We identified three areas of deformation, between December 2013 and June 2014, the largest having a potential failure volume of  $4800\text{ m}^3$ . Three-dimensional tracking of this block allowed us to identify the failure kinematics prior to failure of the largest block, a wedge type failure plunging at  $140^{\circ}$  with a vector deformation magnitude of  $0.1\text{ m}$ . In September of 2014, we gave warning to the railway of the potential rockfall volume and of the kinematics for the largest identified area. We continued to monitor the deforming areas of the slope until all three rockfalls occurred, in December 2014 after a large rainfall event. We collected oblique helicopter photos for



photogrammetric analysis three days post failure and calculated a depletion area volume for the largest block of 4200 m<sup>3</sup> and volumes of 210 and 220 m<sup>3</sup> for the smaller two deforming areas.

#### **491 - ON THE PRECISION, ACCURACY, AND UTILITY OF OBLIQUE AERIAL PHOTOGRAMMETRY (OAP) FOR ROCK SLOPE MONITORING AND ASSESSMENT**

Dave Gauthier (1), Jean Hutchinson (2), Matthew Lato (1), Tom Edwards (3), Chris Bunce (4), David Wood (5)

(1) BGC Engineering (Kingston, Canada); (2) Queen's University (Kingston, Canada); (3) CN (Edmonton, Canada); (4) CP Rail (Calgary, Canada); (5) DFWCL (Sudbury, Canada)

In this paper we summarize our experience in testing and refining various applications of oblique aerial 'structure from motion' photogrammetry to rock slope monitoring and assessment. We tested this method at a number of Canadian railway rock slope sites using both autonomous-UAV and handheld-helicopter photography of steep, otherwise inaccessible rock slopes. We demonstrate that change-detection between detailed 3D slope models acquired at different times is possible, with lower detection limits in the range of 0.5 - 1 m<sup>2</sup> given careful data collection and processing. We explore the precision and accuracy of this method, and demonstrate that both are comparable to other 3D remote sensing methods. While the advantages of this approach are rapid deployment at sites not amenable to other sensors, the limitations are in detection of small deformations, and uncertainties in the scale problem, which is ubiquitous in photogrammetric approaches.

#### **406 - FREQUENCY-MAGNITUDE OF ROCKFALL EVENTS FOR HAZARD ANALYSIS; A COMPARISON OF DATA FROM LIDAR SCANNING WITH TRADITIONAL METHODS OF REPORTING**

Megan van Veen (1), D. Jean Hutchinson (2), Ryan Kromer (2), Dave Gauthier (3), Matt Lato (4), Tom Edwards (5)

(1) Department of Geological Sciences and Geological Engineering - Queen's University (Kingston, Canada); (2) Department of Geological Sciences and Geological Engineering, Queen's University (Kingston, Canada); (3) BGC Engineering Inc. (Kingston, Canada); (4) BGC Engineering Inc. (Ottawa, Canada); (5) CN Rail (Edmonton, Canada)

Railways in Western Canada are exposed to rockfall hazards that can be understood and managed through the use of a rockfall database, which includes information on rockfall magnitude and frequency. Traditional rockfall inventories collected by railway personnel are often incomplete or lacking in volume information. In this study, LiDAR change detection is used to understand rockfall magnitudes, mechanisms, and source zones for an area of track along the Thompson River valley near Lytton, BC. Results are compared to traditional inventories to understand how each may contribute to establishing a complete rockfall inventory for this section of vulnerable railway track.

#### **808 - L'ALÉA CHUTES DE PIERRES : LA MODÉLISATION PRÉLIMINAIRE 3D DES TRAJECTOIRES LE LONG D'UNE INFRASTRUCTURE LINÉAIRE**

François Noël (1), Catherine Cloutier (1), Dominique Turmel (1), Jacques Locat (1)

(1) Département de géologie et de génie géologique, Université Laval (L'Ancienne-Lorette, Canada)

La caractérisation détaillée de vastes territoires pose un défi de taille et est souvent limitée par les ressources disponibles et le temps. Dans le cadre du développement d'outils reliés à l'aléa chutes de pierres, nous proposons une méthodologie qui aide la planification des travaux de terrain le long d'une infrastructure linéaire. Le secteur couvert débute à une

dizaine de kilomètres de Port-Cartier (Québec) et s'étend sur 260 km jusqu'au nord des monts Groulx, le long du chemin de fer de la compagnie ArcelorMittal Infrastructures Canada. La trajectographie 3D aide à cibler les secteurs où des investigations plus détaillées sont nécessaires. Le logiciel RockyFor3D est utilisé pour les simulations. La topographie provient de données LiDAR aéroportés. Dans cet article, nous présentons une méthode partiellement automatisée qui permet d'éliminer les secteurs qui ne sont pas susceptibles de générer des chutes de pierres ayant le potentiel d'atteindre l'infrastructure.

### **217 - AN INTEGRATED MANAGEMENT TOOL FOR ROCKFALL EVALUATION ALONG TRANSPORTATION CORRIDORS: DESCRIPTION AND OBJECTIVES OF THE PARACHUTE RESEARCH PROJECT**

*Catherine Cloutier* (1), Jacques Locat (1), Mélanie Mayers (1), François Noël (1), Dominique Turmel (1), Pierre Gionet (2), Michel Jaboyedoff (3), Chantal Jacob (4), Pierre Dorval (4), François Bossé (4)

*(1) Laboratoire d'Études sur les risques naturels - Université Laval (Québec, Canada); (2) ArcelorMittal Infrastructure Canada (Port-Cartier, Canada); (3) Risk-group, ISTE, Institute of Earth Sciences, Faculté des Géosciences et de l'Environnement, Université de Lausanne (Lausanne, Switzerland); (4) Ministère des transports du Québec (Québec, Canada)*

Natural and man-made rock slopes are frequent along the railroad linking Port-Cartier to Fermont. The aim of the ParaChute research project is to integrate various technologies into a workflow for rockfall characterization along linear infrastructures (including roads) and to test its application along a portion of 260 km of this railroad. Our work will focus around different objectives: (1) to optimize the use of terrestrial, mobile and airborne laser scanners data into terrain analysis, structural geology analysis and rock fall susceptibility rating, (2) to further develop the use of unmanned aerial vehicles for photogrammetry applied to rock cliff characterization, (3) to integrate rockfall simulation studies into a rock slope classification system similar to the Rockfall Hazard Rating System and (4) to consider climate change impact on mass movements. With this paper we want to share our approach and preliminary results.

### **814 - PIERRE 2: A STOCHASTIC ROCK FALL SIMULATOR – DEVELOPMENT, CALIBRATION AND APPLICATIONS**

*Andrew Mitchell* (1), Oldrich Hungr (1)

*(1) University of British Columbia (Vancouver, Canada)*

Computer models have become standard in assessing the hazards posed by rock falls, with a wide variety of models currently available. The PIERRE 2 model, presented here, returns to a simplified lumped-mass model assuming collinear impact conditions. The natural variability of rock falls is represented using:

- A stochastic roughness angle applied to the slope;
- Hyperbolic restitution factors to define the conservation of momentum; and,
- A stochastic shape factor, used to vary the sphere dimensions at impact.

Impact mechanics theory was used as the basis for these features. Their validity is demonstrated through extensive 2D and 3D model calibration for 5 distinct sites. The calibration was directed to optimal simulation of rock fall behaviour in multiple dimensions, including runout distance, jump height and both linear and rotational velocity. The focus of the model development was to produce accurate statistical distributions of the outputs for hazard assessments with limited site information.



# Session/Séance : Rock Mechanics and Engineering Geology II / Mécanique des roches et génie géologique II

Monday, September 21, 13:45 – 15:15 / Lundi 21 septembre, 13 h 45 – 15 h 15

Room / Salle : 207

Chair / Président de séance : **Davide Elmo**

## **661 - LONG-TERM BEHAVIOR OF DIFFERENT ROCK TYPES BASED ON LABORATORY TESTING**

Chrysothemis Paraskevopoulou (1), Mark Diederichs (2), Matthew Perras (3)

(1) *PhD Candidate (Kingston, Canada)*; (2) *Professor at Department of Geological Sciences and Geological Engineering, Queen's University, Kingston, Ontario, Canada (Kingston, Canada)*; (3) *Institute of Geology, ETH (Zurich, Switzerland)*

Over the past few decades' significant interest from rock engineers has been given to the understanding of the long-term strength and the susceptibility to damage of different rock types. The long-term behaviour of underground openings, in general, is usually associated with time-dependent deformations. Tunnel construction can be very challenging due to the difficulties in making reliable predictions at the preliminary stages of the design of a project. It is necessary to understand the time-dependent mechanisms of the host rock and the gradual development of the irreversible deformations around underground openings. Excessive deformations can take place and cause severe damage both to the support system that can result in construction delays and cost overruns. The latter could be more challenging in the case of the design and construction of nuclear waste repositories where the generally accepted life time of such engineering projects is in the order of one million years. During time creep and strength degradation phenomena can take place and govern the material behaviour. This study tries to give more insight into the long-term behaviour of brittle rocks through a series of unconfined static load tests (constant loading) performed on Jura Limestone. The results are compared to reported data from literature to review different rock types as an attempt to create and establish a database.

## **348 - INFLUENCE OF ROCKMASS PROPERTY VARIATIONS ON PRE-MINING STRESSES: A CASE STUDY**

Shahé Shnorhokian (1), Hani Mitri (1), Lindsay Moreau-Verlaan (2)

(1) *McGill University (Montreal, Canada)*; (2) *Vale Canada Ltd. (Sudbury, Canada)*

Variations in rockmass properties are commonly encountered in underground mines. When undertaking numerical modeling, the selection of different rockmass input properties can result in a wide range of results. In this paper, a simplified mine-wide model of a deep Canadian metal mine is constructed in FLAC3D to study the influence of variations in rockmass properties on pre-mining stresses at two drift locations 1500 m below ground surface. It is calibrated using boundary tractions based on an in-situ stress measurement point. Laboratory results and borehole data are analyzed to determine the minimum, average, most likely, and maximum rockmass strength levels. It is observed that pre-mining stresses plotted for the drift locations follow regular patterns that depend on the rockmass properties of the formation in which the readings are taken, as well as other influential units. The methodology uses a range of vertical stress values to narrow down a large number of variations in rockmass properties into a smaller set that is realistically possible in the field. It is shown that the possible range of stress levels at locations of interest can be assessed, and key formations that influence the readings identified.





## **342 - RÉSISTANCE MÉCANIQUE ET PRESSIONS DE FISSURATION DE QUELQUES MATÉRIEAUX ROCHEUX SÉDIMENTAIRES TYPIQUES**

Denis Labrie (1)

(1) *Ressources naturelles Canada (Gatineau, Canada)*

Des essais de compression et de microfissuration hydraulique ont été réalisés au Laboratoire de mécanique des roches de CanmetMINES à Ottawa, Ontario, pour déterminer la résistance mécanique, les modules de déformation élastique et les pressions de fissuration ou d'injection de quelques matériaux rocheux sédimentaires typiques. Ces travaux ont été entrepris d'abord pour caractériser les matériaux soumis aux essais, ensuite pour appuyer l'étude de projets éventuels de production, séquestration, stockage et/ou d'enfouissement de combustible naturel ou usé, de nature radioactive ou pas, à l'intérieur de ces mêmes matériaux. Les essais ont donné d'excellents résultats, autant en ce qui concerne leur cohérence que leur dispersion relative autour des moyennes mesurées. Les écarts observés s'expliquent principalement par les conditions de déposition ou de prélèvement, ou de façonnage des matériaux. Les essais de microfissuration en laboratoire ont permis de vérifier les méthodes usuelles de prédiction des pressions de fracturation hydraulique et d'écoulement des fluides à l'intérieur des matériaux rocheux intacts et fissurés, de faible porosité et/ou perméabilité.

## **642 - IMPROVING GROUND SUPPORT DESIGN WITH DISTRIBUTED STRAIN MONITORING**

Bradley Forbes (1), Nicholas Vlachopoulos (1), Mark Diederichs (1)

(1) *Queen's University (Kingston, Canada)*

An experimental application of a distributed optical strain sensing technique is presented with forepole support members of the umbrella arch tunnel support system. A laboratory testing scheme was conducted to verify the capability of the optical technique to capture expected support behaviour throughout all stages of construction as well as to demonstrate the potential to be used a novel geotechnical tool for optimizing support design in response to future ground conditions.

## **60 - COMPARISON OF MINING-INDUCED SEISMICITY WITHIN A FOOTWALL FAULT BETWEEN OVERHAND AND UNDERHAND STOPING METHODS**

Atsushi Sainoki (1), Hani Mitri (2)

(1) *Mining Engineering, McGill (Montreal, Canada); (2) Department of Mining and Materials Engineering, McGill (Montreal, Canada)*

The behaviour of faults in underground mines has been attracting much attention from rock mechanics specialists. In this study, a comparison between overhand and underhand sublevel stoping methods is made whilst focusing on the static and dynamic behaviour of a footwall fault intersecting with a steeply dipping orebody. A mine-wide numerical model representing the geological features is constructed. Using the model, static analyses are performed to extract stopes in the orebody. It is found from the result that the stope extraction with the underhand mining method produces more seismically active conditions on the fault, compared to the overhand method. Then, fault-slip is simulated with an instantaneous change of the friction law from static to dynamic. The analysis indicates that there is no significant difference in the intensity of near-field ground motion between fault-slips induced by the stope extraction with the two mining methods.



**335 - THE INFLUENCE OF SEGMENTAL LINING IN DEEP TBM TUNNELLING**

Ioannis Vazaios (1), Nicholas Vlachopoulos (1)  
(1) *Queen's University (Kingston, Canada)*

The shield-driven tunnelling method has been mainly adopted for the construction of urban underground tunnels in soft ground due to its flexibility, cost effectiveness and the minimum impact on the ground surface. However, due to the efficiency of the shield-driven tunnelling techniques, Tunnel Boring Machines (TBMs) have also been employed in deep, weak rock tunnelling. In shield-driven, tunnelling techniques the final support is usually composed by assembling pre-cast concrete segments into a ring, and multiple rings placed side-by-side form the final tunnel lining. Due to the ring geometry and joint distribution, segmental liners do not show a two dimensional (2D) behaviour but rather exhibit a three dimensional one (3D). However, due to the complex geometry 2D numerical analyses are employed because of their flexibility and the reduced computational time and cost. For the purposes of this paper, two different types of concrete liners, (i) monolithic, and (ii) segmental liners, are adopted in order to investigate the influence of the in-situ conditions on the structural forces developing in the liner under different ground-tunnel interface conditions.

## **Session/Séance : Laboratory Testing in Cold Regions / Essais en laboratoire en ingénierie nordique**

**Monday, September 21, 13:45 – 15:15 / Lundi 21 septembre, 13 h 45 – 15 h 15**

Room / Salle : **2102B**

Chair / Président de séance : **Ed Hoeve**

**52 - RECENT DEVELOPMENTS IN LABORATORY FROST HEAVE TESTING OF SOILS**

Mark Nixon (1), J.F. (Derick) Nixon (2)  
(1) *Golder Associates Ltd. (Calgary, Canada)*; (2) *Nixon Geotech Ltd. (Calgary, Canada)*

This paper describes some recent advances in frost heave testing, suitable for a large scale project where several tests and freeze cycles can be carried out at the same time. Many test procedures freeze the soil too fast for practical field applications (i.e. chilled pipelines). Other shortcomings may include ignoring the side-friction component of stress, blockage of the drainage filter for water intake, inadequate permeability measurements to estimate suction at the freezing front, and only occasional water intake measurements. Each of these oversights involve a non-conservative assessment of the frost heave response of the soil.

A test procedure is described that addresses and rectifies each of these issues, and a demonstration series of tests on an artificial soil is carried out. Continuous evaluations of heave, water intake, frost depth, SP, suction and freezing rate are made using software written to accept the raw laboratory data. The results are presented in detail, and illustrate how the frost heave parameters required for design can be extracted from the data. The results are interpreted in terms of the Segregation Potential (SP) method, and also in terms of the Discrete Ice Lens approach.



## **658 - A METHOD FOR DETERMINATION OF WATER CONTENT IN REAL AND MODEL POROUS MEDIA IN EQUILIBRIUM WITH BULK ICE OR GAS HYDRATE**

Vladimir Istomin (1), Evgeny Chuvilin (1), Boris Bukhanov (1), Tutomu Uchida (2)  
(1) *Skolkovo institute of science and technology (Skoltech) (Moscow, Russia)*; (2) *Faculty of Engineering, Hokkaido University (Sapporo, Japan)*

A method for estimation of equilibrium water content in porous media in contact with bulk ice or gas hydrate is discussed. Measurements of water potential (and/or thermodynamic activity of water) were carried out on the Decagon company WP 4 device. Two types of porous media were used: the artificial samples with known sizes of pores (controlled pore glasses - CPG) and the polymineral clay. On the base of experimental determination of water potential in porous media the thermodynamic schemes are considered for: 1) unfrozen water estimation from the equilibrium "bulk ice - confined water in hydrophilic porous media" depending on temperature (for negative temperatures on Celsius); 2) nonclathrated water content from the equilibrium "bulk gas hydrate - confined water in hydrophilic porous media" depending on temperature and pressure of gas hydrate-former (methane, natural gas, etc.). The model is applied for estimations the unfrozen and nonclathrated water contents in the pore samples.

## **528 - EXPERIMENTAL EVALUATION OF CHANGES IN PERMEABILITY OF FROZEN SEDIMENTS AT THAWING**

Evgeny Chuvilin (1), Sergey Grebenkin (1)  
(1) *Moscow State University (Moscow, Russia)*

Testing of water saturated samples of the fine-grained sediments conducted in a special device under a wide range of temperatures (-15 to +30°C) and pressures (up to 100 bar) allowed to evaluate their gas permeability. It has been found that increase in permeability during thawing of frozen samples depends on moisture content (ice content) and it is associated with the change in the structure of the pore space, the possible redistribution of water in the pores and volume changes during phase transitions of ice - water. At the ice saturation below 40% the difference of values of the gas permeability of frozen and thawed samples was less than one order of magnitude. At an ice saturation more 40% the difference in permeability was more than 3 orders of magnitude.

## **319 - CYCLIC FREEZING AND THAWING EFFECTS ON ATTERBERG LIMITS OF CLAY SOILS**

Daryl Dagesse (1)  
(1) *Brock University (St. Catharines, Canada)*

Several previous studies suggest Atterberg limits may change as a result of mechanical disruption. This study tests the hypothesis that liquid and plastic limits may be altered by the cyclic freezing and thawing process. Four soils with different clay contents were used. In one group of samples initial structure was maintained while a second group were ultrasonically dispersed at a high water content. Cyclic freezing at -15°C for 6 hr and thawing at +15°C for 6 hr was performed for 1, 5, 10, and 25 cycles at 25% gravimetric water content. Both liquid limits and plastic limits showed increases with an increasing number of freeze/thaw cycles for the structured soils but decreases in both limits for the unstructured soils. However, regression analysis revealed that the slopes of these relationships did not significantly differ from zero suggesting no effect of cyclic freezing and thawing on soil plasticity.



### 316 - EXPERIMENTAL STUDY OF FREEZING POINT AND WATER PHASE COMPOSITION OF SALINE SOILS CONTAMINATED WITH HYDROCARBONS

Erika Grechishcheva (1), Rimma Motenko (2)  
(1) OJSC Fundamentproject (Moscou, Russia); (2) MSU (Moscou, Russia)

In the article the results of freezing point research are discussed for pure and saline - oil-contaminated soil. The data were obtained by different methods and the latest equipment. The data obtained using different equipment is compared. The thawing thermogramms both pure and contaminated saline soils of different particle size distribution are studied. The dominant influence of salinity is revealed.

### 792 - FROST HEAVE BEHAVIOR OF UNSATURATED SOILS UNDER LOW OVERBURDEN PRESSURE AND ITS ESTIMATION

Tatsuya Ishikawa (1), Tetsuya Tokoro (2), Satoshi Akagawa (3)  
(1) Hokkaido University (Sapporo, Japan); (2) Tomakomai National College of Technology (Tomakomai, Japan); (3) Cryosphere Engineering Laboratory (Tokyo, Japan)

This study proposes two kinds of estimation methods for the frost heave ratio of unsaturated frost-susceptible soils under low overburden pressure such as subgrade soils at the pavement structure in cold regions. One is the modified Takashi's equation in contemplation of matric suction of soils under low overburden pressure. The other is the simple frost heave model which evaluates the effects of initial water content, Bishop's effective stress and water absorption during freezing on the frost heave ratio. In addition, the applicability and the usefulness of both methods were discussed based on the results of frost susceptibility tests. As the results, it was revealed that the estimation methods proposed in this study have an excellent applicability to the precise prediction for the frost-heave phenomenon of unsaturated subsurface ground in cold regions.

## Session/Séance : Infrastructure Performance in Cold Regions II / Performance des infrastructures en régions nordiques II

Monday, September 21, 13:45 – 15:15 / Lundi 21 septembre, 13 h 45 – 15 h 15

Room / Salle : **2104AB**

Chair / Président de séance : **Stephen Wolfe**

### 116 - SLOPE STABILIZATION AT KM 229 AND KM 701-703 OF THE ALASKA HIGHWAY: SITE CHALLENGES AND LESSONS LEARNED

Jason Pellett (1), Andrew Horwood (1)  
(1) Tetra Tech EBA Inc. (Vancouver, Canada)

The Alaska Highway (BC No. 97) traverses numerous areas of difficult, landslide-prone terrain across northern BC and the Yukon. Public Works and Government Services Canada retained Tetra Tech EBA Inc. to evaluate unstable slopes at km 229 and km 701-703 and to complete the design of stabilization works. At km 229, slope movements were occurring along a very weak sliding plane in glaciolacustrine clay. Stabilization works included a cut-off drain along the ditch and a series of counterfort drains below the road. Follow-up monitoring suggests the slope movements have slowed but not stopped. At km 701-703, three sections of the highway along the eastern shore of Muncho Lake had a dangerously narrow shoulder due to erosion and slumping of the shoulder material into the lake. Stabilization of these



areas was successfully completed using wire-basket MSE walls. This paper discusses the site conditions, design of the stabilization works, construction challenges and other lessons learned.

### **138 - CHARACTERIZATION OF ARMOUR STONE BREAKWATER THROUGH A FREEZE-THAW RESISTANCE APPROACH**

Philippe Morin (1), Guy Dionne (1)  
(1) GHD (Québec, Canada)

A study was performed on the prematurely degraded breakwater stone on the bay at Rivière-au-Renard and from the quarries in which they originate. The objective of the study was to highlight, through observation and laboratory testing, the probable causes of deterioration and to further propose new criteria to include in the specifications in order to minimize the number of problematic stones implemented in future coastal structures. The test for resistance to freezing and thawing cycles was carried out on slices of rock in order to recreate with more accuracy the observed degradation phenomena on the structures in place.

### **343 - NWT HIGHWAY 3 TEST SECTIONS NEAR YELLOWKNIFE**

Jan Stirling (1), Jack Seto (1), Lukas Arenson (1), Muhammad Abu Bakar (2)  
(1) BGC Engineering (Vancouver, Canada); (2) Government of the Northwest Territories, Department of Transportation (Canada)

Highway 3 is the only all-weather road connecting southern Canada to the City of Yellowknife. The last 100 km of the highway is located in an area of extensive discontinuous permafrost in the Great Slave Lowlands. Ground temperatures are typically warmer than  $-1^{\circ}\text{C}$  and extensive permafrost degradation has been noted in recent years. Originally constructed as a gravel road in the mid-1960's, the highway was straightened and reconstructed between 1999 and 2006. Since reconstruction, sections of the highway have experienced significant sagging in soil-covered areas and considerable maintenance is required to maintain safe driving conditions. In 2012, four test sections were constructed to evaluate potential mitigation techniques for road embankments on permafrost foundations. The test sections involved different levels of embankment reconstruction, from dressing the existing side slopes, to partial and full replacement of the road embankment fills. Thermistors were installed in the test sections and bi-annual inspections carried out to monitor the thermal and structural behaviour of the embankment. This paper presents data and findings from the first 2.5 years of monitoring.

### **91 - SUIVI DU COMPORTEMENT THERMIQUE ET MÉCANIQUE DE LA ROUTE D'ACCÈS À L'AÉROPORT DE SALLUIT AU NUNAVIK, QUÉBEC**

Vincent Lamontagne (1), Loriane Périer (1), Chantal Lemieux (1), Guy Doré (1), Michel Allard (2), Jonathan Roger (2), Anick Guimond (3)  
(1) Université Laval - Département de génie civil et Centre d'études nordiques (Québec, Canada); (2) Université Laval - Département de géographie et Centre d'études nordiques (Québec, Canada); (3) Transports Québec, Bureau de la coordination du Nord-du-Québec (Rouyn-Noranda, Canada)

À l'été 2012, des travaux de réhabilitation, de stabilisation et d'adaptation au contexte de changement climatique ont été effectués sur la route d'accès à l'aéroport du village nordique de Salluit. Depuis ces travaux, un suivi de la performance des adaptations ainsi que de la stabilité de la route a été fait à deux stations (A et B). Les températures du sol ont



montré une remontée du plafond du pergélisol aux deux stations. Par contre, l'efficacité du drain thermique a pu être confirmée seulement à la station B où les conditions pour générer un mouvement convectif optimal de l'air sont présentes. Les inclinomètres montrent tous des déplacements de l'épaulement du remblai suivant la pente du terrain naturel, un mouvement qui s'apparente à un évasement du remblai. La fibre optique DTS a permis d'analyser les performances et l'efficacité du drain thermique.

### **203 - DEFORMATION CHARACTERISTICS OF THE MAIN EMBANKMENTS OF THE QINGHAI-TIBET RAILWAY IN PERMAFROST REGIONS**

Fujun Niu (1), Minghao Liu (1), Libo Wu (1), Guodong Cheng (1), Qingbai Wu (1)  
 (1) *Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (Lanzhou, China)*

A principle of 'cooling roadbed' was applied during the construction of the Qinghai-Tibet Railway (QTR) in permafrost regions. The main embankments include crushed-rock basement embankment (CRBE), crushed-rock sloped embankment (CRSE) and U-shaped crushed-rock embankment (UCRE), along with traditional embankment (TE). Eleven years of monitored data show that, the deformation of all the embankments generally show as settlement. Among the four types of the embankments, the CRBE has a maximum settlement with a value of more than 31 cm. The deformations are related to geological conditions of the underlain permafrost, thermal regimes of the roadbeds. For an embankment, different deformations occur in the two shoulders with north-facing slope and south-facing slope. Therefore, considering the mechanical stability, cooling effect, symmetry of the ground temperature regime, material property and construction technique, UCRE can be recommended for future application. And also some improvement measures for the other embankment structures are proposed.

### **532 - HIGH-RESOLUTION MONITORING OF THAW SUBSIDENCE AFFECTING THE ACCESS ROAD TO UMIUJAQ AIRPORT IN NUNAVIK (Québec)**

Richard Fortier (1), Shuai Guo (2), Pierrick Lamontagne-Hallé (2), Wenbing Yu (3)  
 (1) *Centre d'études nordiques (Québec, Canada); (2) Centre d'études nordiques, Université Laval (Québec, Canada); (3) State Key Laboratory of Frozen Soil Engineering, Cold and Arid Regions Environment and Engineering Research Institute (Lanzhou, China)*

The thaw subsidence along a 300 m long segment of the access road to Umiujaq Airport in Nunavik (Québec) has been annually monitored since 2006. This subsidence is due to thaw consolidation taking place in a layer of ice-rich silt underneath the road embankment. The increase in air temperature over the last two decades and the thermal insulation of snow cover on the embankment shoulders and toes explain the permafrost degradation. Thaw subsidence as much as 1.50 m has been recorded since the road completion in 1991. Rates of thaw subsidence from 0.056 to 0.138 m/year were observed. According to numerical modeling, the thawing rate is 0.317 m/year. The coefficient of consolidation varies between 1.63 and 3.14 m<sup>2</sup>/year for corresponding thaw consolidation ratio from 0.937 to 0.675. The thaw consolidation of the silt layer is now completed and no more thaw subsidence is expected along the monitored road.



## Session/Séance : Mining Geotechnique II / Géotechnique minière II

Monday, September 21, 13:45 – 15:15 / Lundi 21 septembre, 13 h 45 – 15 h 15

Room / Salle : **2105**

Chair / Président de séance : **Paul Simms**

### **61 - NUMERICAL SIMULATIONS TO ASSESS THE STRESS STATE IN BACKFILLED STOPES WITH INCLINED WALLS**

Abtin Jahanbakhshzadeh (1), Michel Aubertin (1), Li Li (1)  
(1) *École Polytechnique de Montréal (Montréal, Canada)*

Adding backfill in mine stopes improves ground stability and reduces the volume of solid wastes disposed on the surface. To ensure the safe use of backfill, practical tools are required to assess the stress state in the stopes and on support structures. Previous work has shown that these stresses are influenced by an arching effect related to the stress transfer between the soft fill and stiff rock mass. However, in inclined stopes, the shear stresses developing along the walls are not the same on each side of the opening, so the arching effect is typically less well developed than in vertical stopes. In this article, 2D and 3D numerical simulations results are presented to illustrate the interaction between the backfill and rock mass in stopes with inclined walls. The influence of strength parameters of the backfill and of stope geometry is examined and discussed.

### **309 - MINE BACKFILL PORE WATER PRESSURE DISSIPATION: NUMERICAL PREDICTIONS AND FIELD MEASUREMENTS**

Mohammad Shahsavari (1), Murray Grabinsky (1)  
(1) *University of Toronto (Toronto, Canada)*

Cemented paste backfill (CPB) has gained popularity in underground mining operations over the past decade. Fresh CPB is being held in the stope by a barricade until it cures and is self-supportive. Therefore, the barricade safety is crucial in mining industry. The pressure acting on the barricade is dependent on the pore water pressure within the CPB. The problem of self-weight consolidation of an accreting material was first studied by Gibson (1958). Fahey et al. (2010) applied Gibson's solution to the consolidation of CPB and introduced lower and upper bound solutions. Shahsavari and Grabinsky (2014), based on the in-situ measurements, introduced a new boundary condition and studied its effect on the pore pressure variations with time. However, the effect of the slurry layer weight on the pore pressure was not considered. In the current study, the stresses due to the presence of a slurry layer in addition to the hydraulic boundary condition are considered in the analysis. The process of consolidation is modeled in FLAC3D using Terzaghi's consolidation theory assumptions. The effects of slurry layer height and weight on pore pressure are studied. At the end a comparison between numerical analysis results and field measurements is made.



## **758 - PREDICTIVE MODELS OF THE COMPRESSIVE STRENGTH OF CEMENTED PASTE BACKFILLS TAKING INTO ACCOUNT SELF-WEIGHT CONSOLIDATION**

Tikou Belem (1), Erol Yilmaz (2), Mostafa Benzaazoua (3)  
 (1) *Research Institute in Mining and Environment (RIME), UQAT (Rouyn-Noranda, Canada)*; (2) *First Quantum Minerals Ltd., Cayeli Bakir Isletmeleri A.S., Madenli, Cayeli, Rize TR53200, Turkey (Cayeli, Turkey)*; (3) *Research Institute in Mining and Environment (RIME), University of Québec UQAT (Rouyn-Noranda, Canada)*

This paper present numerous UCS results obtained from plastic moulds, CUAPS (Curing Under Applied Pressure System) apparatus and In Situ core specimens. It was confirmed that the UCS from CUAPS-cured cemented paste backfill specimens were consistently higher than the one from plastic mould-cured cemented paste backfill specimens for a given backfill mixture recipe. Two semi-empirical general equations were proposed in order to predict the UCS of CUAPS-consolidated backfills from known UCS of plastic mould backfill specimens and the CUAPS-predicted UCS at a corresponding backfill depth. These two equations were both defined as a function of curing time and binder content. In addition, these equations can take into account the arching effect on the strength development within a backfilled stope. It has been demonstrated that these predictive equations can be used with 60% and 75% confidence limit.

## **760 - DETERMINING STABLE SPANS OF UNDERCUT CEMENTED PASTE BACKFILL**

Murray Grabinsky (1), Amin Jafari (1)  
 (1) *University of Toronto (Toronto, Canada)*

A significant underground mine design challenge is predicting the stability of a previously placed cemented backfill when it is to be undercut in a subsequent stage of mining. Mitchell (1991) proposed several limit equilibrium analyses for this design situation based on different assumed modes of failure, but little has been done since then to more carefully consider the most appropriate means analysis approach. This paper considers a tentative framework for an alternate limit equilibrium solution, based on the assumption that the cemented backfill behaves as rigid struts to support the overlying fill. The advantage of this analysis approach is that it provides a unifying model for the previous disparate analysis methods. Remaining challenges to using this analysis for practical design will be addressed.

## **734 - PRELIMINARY STUDY OF THE INFLUENCE OF TEMPERATURE AND SALINITY ON THE THERMAL PROPERTIES OF HARDENING CEMENTED PASTE BACKFILL**

Fabrice BEYA KAZAMBUA (1), Mamert Mbonimpa (1), Tikou Belem (1), Mostafa Benzaazoua (1), Kayumba Kalonji (1), Serge Ouellet (2)  
 (1) *UQAT (Rouyn-Noranda, Canada)*; (2) *Agnico Eagles Mines Limited (Rouyn-Noranda, Canada)*

Thermal curing conditions of cemented paste backfill (CPB) in mine stopes with frozen walls in the permafrost can be assessed using numerical modeling. For this purpose, thermal conductivity and capacity functions of CPB with respect to curing time and temperature are required. In permafrost regions, CPB mixing water is expected to contain brine. The goal of this study was to investigate the influence of temperature and salinity on CPB's thermal properties. KD2 Pro apparatus was used to determine these properties for different CPB mixtures prepared at a solid mass concentration of 76.3%, with 0% (control) and 5% contents of type HE Portland cement. Mixing water with salt concentrations from 0 to 1% was also studied. Changes in thermal properties of CPB were measured at temperatures of -8°C, 2°C and 22°C. Results indicated that binder content (0, 3, and 5%), salt concentration in the mixing water (0 – 1%) and positive temperatures (2 and 22°C) have a negligible influence





on thermal properties with curing time (0 - 28 d). However, freezing conditions (-8°C) has significant effect on these thermal properties.

#### **404 - PRELIMINARY INVESTIGATION OF THE EFFECT OF TEMPERATURE AND SALINITY ON THE RHEOLOGICAL PROPERTIES OF FRESH CEMENTED PASTE BACKFILLS**

*Kayumba Kalonji* (1), Mamert Mbonimpa (1), Tikou BELEM (1), Mostafa BENZAAZOUA (1), Fabrice BEYA (2), Serge OUELLET (3)  
(1) UQAT/RIME (Rouyn-Noranda, Canada); (2) UQAT/IRME (Rouyn-Noranda, Canada); (3) Agnico-Eagle Mines Limited (Rouyn-Noranda, Canada)

Underground backfilling under cold climate conditions in permafrost, factors such as saline water and low temperatures must be taken into account during the design process of the hydraulic transport and distribution system of cemented paste backfill (CPB). The impact of these factors on the rheological properties of CPBs must be carefully characterized in the laboratory. This study examines the effect of temperature (2 to 45°C) and salinity of the mixing water (0 and 5 g/L) on the rheological properties of uncemented tailings and CPB with 5% HE cement prepared at a slump of 7 inches. A rotational vane rheometer equipped with a temperature control system was used. Measured flow and viscosity curves were fitted using the Herschel-Bulkley and Sisko models, respectively, providing different rheological parameters (yield stress, viscosity, consistency index, and flow index). The results illustrate the effects of binder, temperature, and salinity on the rheological behavior of CPB. For the CPB mixtures, the rheological properties (yield stress, dynamic viscosity at high shear rate) tend to increase with temperature increase. Salinity of 0.5% slightly improved these rheological properties.

### **Session/Séance : Soil Mechanics III / Mécanique des sols III**

**Monday, September 21, 15:45 – 17:00 / Lundi 21 septembre, 15 h 45 – 17 h**

Room / Salle : **204AB**

Chair / Président de séance : **Marolo Alfaro**

#### **762 - INVERSE MODELLING OF DESORPTION TESTS TO ESTABLISH THE HYDRAULIC CONDUCTIVITY OF UNSATURATED Québec GRANITIC SAND**

M.J. Siahdashti (1), *Jean Côté* (1), Jean Côté (1)  
(1) Laval University (Québec City, Canada)

The Multistep outflow method (MSO) has been widely used to determine the hydraulic conductivity functions of unsaturated soils. Accurate determination of these parameters is important to predict the subsurface flow and water transport in soils. Inverse modeling methods can be used to estimate the hydraulic conductivity of unsaturated soils. These methods can be applied to the existing expressions of flow of water in unsaturated soils to fit the experimental data. In this study, inverse modeling combined with the multistep outflow data was used to estimate the unsaturated hydraulic conductivity of three reconstituted samples of the Québec Valcartier granitic sand. These tests were performed in laboratory under controlled initial and boundary conditions. During each test, soil matric suctions were measured at the bottom and within the soil sample using the transducers and microtensiometers. The commonly used models of van Genuchten (1980) and Mualem (1976) were used in this study.



### **119 - ROLE OF AIR-ENTRY VALUE AND CHOICE OF SWCC IN THE PREDICTION OF THE UNSATURATED PERMEABILITY**

Feixia Zhang (1), Delwyn Fredlund (2), Murray Fredlund (3), Ward Wilson (1)  
(1) *University of Alberta (Edmonton, Canada)*; (2) *Golder Associates Ltd, Saskatoon (Saskatoon, Canada)*; (3) *SoilVision System Ltd. (Saskatoon, Canada)*

The permeability function is commonly estimated by integrating along the soil-water characteristic curve (SWCC) based on a particular integral formula. The Fredlund, Xing and Huang (1994) permeability function is a commonly used estimation technique. It has become common practice to start the integration procedure from a value near zero rather than the originally specified air-entry value (AEV). This paper undertakes a study on the effect of the lower limit of integration on the estimation of the permeability function. A mathematical algorithm is also proposed for the calculation of the AEV for integration purposes. The results reveal that the relative coefficient of permeability can be significantly under-estimated if the lower limit of integration is smaller than the AEV. The recommendation is that the AEV always be used as the lower limit of integration when using the Fredlund et al (1994) permeability estimation equation.

### **110 - INFLUENCE OF PARTICLES SHAPE, SIZE AND UNIFORMITY OF SANDS ON THE VOID RATIO RANGE AND CONSEQUENTLY ON THE DYNAMIC PENETRATION TESTS RESULTS**

Michael Ghali (1), Mourad Karray (1), Mohamed Chekirad (2), Varvara Roubtsova (3)  
(1) *Sherbrooke University (Sherbrooke, Canada)*; (2) *Hydro-Québec (Montréal, Canada)*; (3) *Hydro-Québec (Montréal, Canada)*

It has been discussed earlier in the 20th & 21st centuries that the particles shape, size, uniformity, and distribution have great influences on geotechnical properties such as the void ratio range ( $e_{max} - e_{min}$ ) consequently on the geotechnical tests results. Although this is very well known, a minor progress for studying their effects on the void ratio range has been carried out as a parametric study, this is due to three reasons; first: These parameters are deeply integrated with other parameters such as the relative density. second: There are insufficiency in the most common used techniques to differentiate between these parameters; e.g. in the sieve analysis test, there is failure to differentiate between the real size of particles and the shape effect. Third: The overview has shown that there is no certain quantitative descriptor used in the geotechnical field for the particles shape. This paper presents a literature review on such parameters and initially proposes some solutions for the problem by several techniques such as the Image analysis which seem to be promising tool. correlation between the old and new techniques are also proposed and finally a majority of correlations of  $(N_1)_{60}$  with such geotechnical parameters are discussed.

### **198 - INFLUENCE OF BAGASSE ASH AND HYDRATED LIME ON STRENGTH AND MECHANICAL BEHAVIOUR OF STABILISED EXPANSIVE SOIL**

Liet Chi Dang (1), Hayder Hasan (1), Behzad Fatahi (2), Hadi Khabbaz (3)  
(1) *PhD Candidate, School of Civil and Environmental Engineering, University of Technology Sydney (UTS) (Ultimo, Australia)*; (2) *Senior Lecturer in Geotechnical Engineering, School of Civil and Environmental Engineering, University of Technology Sydney (UTS) (Ultimo, Australia)*; (3) *Associate Professor of Geotechnical Engineering, School of Civil and Environmental Engineering, University of Technology Sydney (UTS) (Ultimo, Australia)*

This paper presents the results of an experimental study undertaken to investigate the effects of using bagasse ash and hydrated lime for improving the strength and mechanical



properties of expansive soil. The bagasse ash, a fibrous waste by-product of the sugar cane refining industry, and the expansive soil samples were collected from Queensland, Australia. The specimens were prepared by varying the percentage of bagasse ash up to 25% by dry weight of expansive soil mixed with various hydrated lime contents. A series of experimental tests have been undertaken on untreated and treated soil samples consisting of Atterberg limits, linear shrinkage, compaction, unconfined compressive strength tests after various curing periods of 3, 7 and 28 days. Results of this investigation are analysed to illustrate the influence of hydrated lime and bagasse ash treatment on mechanical properties and stress-strain behaviour of expansive soil. The findings indicate a considerable increase in strength and stiffness, mechanical properties with increased hydrated lime-bagasse ash contents and curing time. An optimum combination of hydrated lime and the soil bagasse ash stabilized expansive soil are also presented. Results are significant in that the chemical stabilization using hydrated lime-bagasse ash improves the strength and mechanical properties of expansive soil.

### **229 - EFFECT OF SALTS ON THE DETERMINATION OF THE WATER CONTENT AND ATTERBERG LIMITS OF EL-HODNA SABKHA SOIL**

BELKACEM MOUSSAI (1), ALI MESSAD (1)

(1) *USTHB university (Algiers, Algeria)*

In this paper, the effect of salts on the determination of the water content and Atterberg limits of sabkha soils has been studied. The tests were performed using distilled water, natural sabkha brine and saline solutions with different salt concentrations. The results indicate that the liquid and plastic limits decrease with pore fluid salinity when the conventional water content procedure is used, but increase when the fluid content method is used. Also, the liquid and plastic limits measured using percussion-cup test and rolling test method are compared to those measured using the fall cone test method.

## **Session/Séance : Characterization of Permafrost State and Variability II / Caractérisation et variabilité du pergélisol II**

**Monday, September 21, 15:45 – 17:00 / Lundi 21 septembre, 15 h 45 – 17 h**

Room / Salle : **205A**

Chair / Présidente de séance : **Sharon Smith**

### **765 - CONTRASTING PATTERNS OF THERMO-EROSION GULLIES FORMED IN SYNGENETIC ICE WEDGE POLYGONAL TERRAINS ON BYLOT ISLAND, EASTERN CANADIAN ARCTIC: CASE STUDIES FROM THREE DIFFERENT SEDIMENTARY ENVIRONMENTS**

Audrey Veillette (1), Daniel Fortier (1), Etienne Godin (1)

(1) *Département de Géographie, Université de Montréal, Montréal, QC, CAN; Centre d'Études Nordiques, Université Laval, Québec, QC, CAN (Montréal, Canada)*

Ice wedge polygonal terrains, typical of Arctic permafrost geosystems, are vulnerable to thermo-erosional gullying and thermokarst. Gullies located on Bylot Island (NU) have distinct shapes and dynamics on factors such as their age, alluvial activity level, water balance and nature of the sedimentary environment. In this paper we focus on the contrasts differentiating gullies observed in aeolian sands, colluvium/alluvium and peaty-loess deposits. Polygons areas, ice wedges size and consequently gully shapes were distinct for each environment: the peaty-loess-zone had medium-sized polygons and generally larger



ice wedges, which erosion resulted in well-developed multi-channel gullies. The aeolian sands-zone had smaller polygons and thinner ice wedges, where quasi-linear gullies were formed. The colluvium/alluvium-zone had large polygons with large primary ice wedges. The erosion was concentrated, very active, and essentially restricted to the primary ice wedges. The role of the ice wedges geometry and size in the evolution of the gullies was major, putting thermo-erosion gullies as distinct landforms from gullies found in warmer, non-permafrost zones.

### **617 - MONITORING OF PERMAFROST IN RUSSIA. RUSSIAN DATABASE AND THE INTERNATIONAL GTN-P PROJECT.**

Dmitry Drozdov (1), Yana Rumyantseva (1), Galina Malkova (1), Vladimir Romanovsky (2), Yana Rumyantseva (1), Andrew Abramov (3), Pavel Konstantinov (4), Dmitry Sergeev (5), Nikolay Shiklomanov (6), Aleksandr Kholodov (7), Olga Ponomareva (8), Dmitry Streletskiy (6) (1) *Earth Cryosphere Institute SB RAS (ECI SB RAS) (Tyumen, Russia)*; (2) *Professor of Geophysics Geophysical Institute UAF (Fairbanks, United States)*; (3) *Institute of Physico-Chemical and Biological Problems of Soils Science RAS (Pushchino, Russia)*; (4) *Melnikov Permafrost Institute SB RAS (MPI SB RAS) (Yakutsk, Russia)*; (5) *Institute of Environmental Geoscience (IEG RAS) (Moscow, Russia)*; (6) *Department of Geography, George Washington University (Washington, DC, United States)*; (7) *Geophysical Institute, University of Alaska (Fairbanks, United States)*; (8) *Russian State Geological Prospecting University n.a. S.Ordzhonikidze (MGRI-RSGPU) (Moscow, Russia)*

The progress in the worldwide permafrost monitoring activity is a result of close and long-term cooperation between the scientists, research institutes and various organizations. There are number of leading international projects, including the GTN-P (Global Terrestrial Network for Permafrost), CALM (Circumpolar Active Layer Monitoring), ACD (Arctic Coastal Dynamics), TSP (Thermal State of Permafrost) and others.

The short review of the Russian activities is presented. The huge database about the long-term dynamics of permafrost parameters is very useful, especially due to the similar research organization concept. The next improvement should be the closer interaction with the National Weather Observation Services.

In terms of the future development of the GTN-P project there is a great potential for conducting comprehensive monitoring of the permafrost zone. It should be noted that a close interaction with the National Weather Service is a huge advantage to empower GTN-P databases.

### **193 - QUALITY ASSESSMENT OF PERMAFROST THERMAL STATE AND ACTIVE LAYER THICKNESS DATA IN GTN-P**

Boris Biskaborn (1), Jean-Pierre Lanckman (2), Hugues Lantuit (1), Vladimir Romanovsky (3), Dmitry Sergeev (4), Gonçalo Vieira (5), William Cable (3), Paolo Pogliotti (6), Jeannette Nötzli (7), Hanne Christiansen (8), Halldór Jóhannsson (2) (1) *Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (Potsdam, Germany)*; (2) *Arctic Portal (Akureyri, Iceland)*; (3) *University of Alaska Fairbanks (Fairbanks, United States)*; (4) *Institute of Environmental Geoscience RAS (Moscow, Russia)*; (5) *CEG/ Instituto de Geografia e Ordenamento do Território, Universidade de Lisboa (Lisbon, Portugal)*; (6) *Environmental Protection Agency of Valle d'Aosta (Aosta, Italy)*; (7) *Department of Geography, University of Zurich (Zurich, Switzerland)*; (8) *Arctic Geology Department, University Centre in Svalbard (Longyearbyen, Norway)*

The Global Terrestrial Network for Permafrost (GTN-P, [gtnp.org](http://gtnp.org)) established the new 'dynamic' GTN-P Database ([gtnpdatabase.org](http://gtnpdatabase.org)), which targets the essential climate variable



(ECV) permafrost, described by the thermal state of permafrost (TSP) and active layer thickness (ALT). In this paper we outline the requirements for assessing the GTN-P data quality. Our aim is to conceive and discuss useful data quality indices as a basis for the 2nd official GTN-P National Correspondents Meeting in Québec, September 2015. We describe the TSP and ALT data structures and the importance of precise metadata for the reliability of sound statements on the state and changes of permafrost. We define the most critical parameters related to quality assessment of TSP (borehole depth, number of sensors per depth, recording interval, sensor calibration) and ALT (grid structure, null values and exceeded maximum values, time consistency). We conceive and discuss a set of potential (to be reviewed at the GTN-P meeting) data quality indices by distinguishing between different borehole depths and spatial and temporal data dimensions of TSP and ALT datasets.

### **431 - THE MONITORING OF SOIL PORE WATER PRESSURE AND SOIL TEMPERATURE IN CUTTING SLOPE BEFORE AND AFTER AUFEIS**

Wei Shan (1), Ying Guo (1), Ying Guo (2), Zhaoguang Hu (2)

(1) *Northeast Forestry University (Harbin, China); (2) Institute of Cold Regions Science and Engineering, Northeast Forestry University (Harbin, China)*

In northeast China, the cutting slope in road segments of Bei'an to Heihe Highway often occur aufeis. In winter, icings are formed by refreezing at the surface of emergent discharge from the cutting slope, which destroyed the slope surface and threaten road traffic safety. Monitoring points of ground temperature and pore water pressure were laid out on the cutting slope where aufeis ever happened. The results show that, when soil temperature dropped below 0 °C, the soil pore water pressure rised rapidly to a maximum value. With the water outflow, soil pure water pressure declined slowly. When soil temperature rised above 0 °C, the soil pore water pressure declined rapidly. In same depth, soil temperature where aufeis ever happened is higher than those never had aufeis. Aufeis had the characteristic of seasonal cycles and uncertainty location.

### **403 - HYDROTHERMAL REGIME ANALYSIS OF SHALLOW DEPTH OF A SOIL SLOPE DURING SHORT-TERM FREEZE-THAW CYCLES**

Yun Que (1), Xiaopeng Chen (1), Jinyuan Liu (2)

(1) *College of Civil Engineering, Fuzhou University (Fuzhou, China); (2) Department of Civil Engineering, Ryerson University (Toronto, Canada)*

This paper presents a study on hydrothermal regime in shallow depth of soil slope during short-term freeze-thaw cycles. The study is conducted by combining both meteorological monitoring and numerical simulation methods and taking a typical short-term frozen zone in Fujian province of China as an example. From December 2013 to February 2014, there were a total of 18 times of freeze-thaw cycles of ambient air temperature: 16 times of two-day, one time of three-day, and one time of six-day cycles. During these short-term freeze-thaw cycles, the air temperature reached the lowest at -4.40C and the highest at 10.80C. The peak of daily radiation ranged from 41 to 827 W/m<sup>2</sup> with an average wind speed from 3.5 to 3.7 m/s. During two-day freeze-thaw cycle of air temperature, the soil freezing time was between 3:00 am and 8:00 am. Based on this study, it is found that air temperature is a major factor in soil freezing, but it is not easy for soil to be frozen in shorter frozen duration.



## Session/Séance : Landslides and Slope Stability III / Mouvements de terrain et stabilité des pentes III

Monday, September 21, 15:45 – 17:00 / Lundi 21 septembre, 15 h 45 – 17 h

Room / Salle : 205BC

Chair / Président de séance : **Marc André Brideau**

### 339 - CATHEDRAL MOUNTAIN 2014 ICE FALL AND DEBRIS FLOW

Lukas Arenson (1), Richard Guthrie (2), Chris Bunce (3), Dave Gauthier (4), Richard Guthrie (2), Jean Hutchinson (4), Matthias Jakob (1), Cory McGregor (2)  
(1) BGC (Vancouver, Canada); (2) SNC-Lavalin (Calgary, Canada); (3) CP (Calgary, Canada); (4) Queens University (Kingston, Canada)

Cathedral Mountain is located in the southern Rocky Mountains of British Columbia along the Continental Divide. High elevations of the mountain are occupied by the Cathedral Glacier and a supra-glacial lake that drains north towards the Kicking Horse River through Cathedral Gulch. Since 1925, 16 debris flows have been recorded in Cathedral Gulch impacting both Canadian Pacific railway and the TransCanada Highway. At 06:30 on July 10, 2014, approximately 100,000 m<sup>3</sup> of ice collapsed from Cathedral Glacier followed by the drainage of the supra-glacial lake. Ice and water descended Cathedral Gulch, transformed into a debris flow and buried the uppermost CP tracks. Analysis of the event included: a rapid assessment and safety plan for workers who had the track functional by 14:20 on the day of the incident, a qualitative assessment using detailed 3D surface models from oblique aerial photos, an analysis of the stability of the remaining glacier and supra-glacial lake, and a magnitude frequency analysis of Glacial Lake Outburst Floods (GLOF) and debris flows that have occurred down Cathedral Gulch. This case study highlights the key results of the analyses and reports on some of the innovative techniques available for rapid Geohazard assessments in similar terrain.

### 558 - A REVIEW OF GEOMETRICAL METHODS FOR DETERMINATION OF LANDSLIDE VOLUME AND FAILURE SURFACE GEOMETRY

Michel Jaboyedoff (1), Marc-Henri Derron (2), Benjamin Rudaz (2), Thierry Oppikofer (3), Ivanna Penna (3), Sergio Daicz (4)

(1) Risk-group - ISTE (Lausanne, Switzerland); (2) Risk-group - ISTE - Université de Lausanne (Lausanne, Switzerland); (3) Geological Survey of Norway (Trondheim, Norway); (4) Computer Sciences Department - University of Buenos Aires (Buenos Aires, Argentina)

Cet article présente une première tentative de revue des méthodes dédiées à la caractérisation des surfaces de rupture et des volumes des mouvements de versants. Ces méthodes se basent sur des données de surface. On rappelle les modèles les plus simples tels que l'estimation de volumes à l'aide des ellipsoïdes et les informations que l'on peut obtenir à partir de déplacements de surface et de la morphologie. Une méthode pour définir le volume d'éboulement rocheux est également présentée. Enfin, les nouveaux développements liés au sloping local base level (SLBL), qui permet d'obtenir, à partir d'un modèle numérique de terrain, une possible surface de rupture automatiquement, sont présentés. Les perspectives liées à ces méthodes sont abordées et le problème de l'incertitude est partiellement abordé.



Jacques Locat (1), Dominique Turmel (1), Jonathan Leblanc (1), Denis Demers (2)  
 (1) *Université Laval (Québec, Canada)*; (2) *Ministère des Transports (Québec, Canada)*

This paper will present some of the known cases histories in Québec where a tsunami wave was or could have been generated by a landslide, either subaerial or subaqueous: the 1908 Notre-Dame-de-la-Salette slide, which is the one that caused the greatest number of casualties (34), the La Grande (1987) slide and the Cap Trinité rockslide (Saguenay Fjord). This analysis will provide an opportunity to illustrate the destructive power of these events. The analysis of those in quick clays will show that the actual tsunami mechanics is very much influenced by the fact that the rupture surface is nearly horizontal. It will be shown that the presence of an ice cover can be a significant aggravating factor associated with the generation of a tsunami wave. Finally, some discussion will be made regarding the approach which could be followed to take this hazard into account as part of a landslide hazard assessment procedure in Québec.

### **711 - TESTING A LANDSLIDE-GENERATED TSUNAMI MODEL. THE CASE OF THE NICOLET LANDSLIDE (Québec, CANADA)**

Martin Franz (1), Michel Jaboyedoff (1), Jacques Locat (2), Yury Podladchikov (1)  
 (1) *Institute of Earth Sciences, University of Lausanne (Lausanne, Switzerland)*; (2) *Département de géologie et génie géologique, Université Laval (Québec, Canada)*

In order to assess comprehensively landslide-triggered tsunamis and the induced risks, we have developed a numerical model which simulates this phenomenon. In order to confirm its capacity to be used as a predictive tool for risk assessment, the model is tested on a real case. The Nicolet landslide (Québec, Canada) occurred on the 8 May 2006 on the Nicolet Sud-Ouest River located in the center of the St-Laurence Lowland. This partially submerged landslide has a volume of about 13,000 m<sup>3</sup>. The slide led to a wave and the resulting horizontal run-up distance reached 60 meters on the opposite shore (clearly identifiable on an aerial). The results of our model fit well with the real case, which indicate its ability to simulate such phenomenon and thus confirm its validity.

### **692 - ANALYSE DE LA SIGNATURE LAISSÉE PAR LE TSUNAMI GÉNÉRÉ PAR UN GLISSEMENT DE TERRAIN AU LAC-DES-SEIZE-ÎLES, QUÉBEC, CANADA, LE 15 AVRIL 2014.**

Jonathan Leblanc (1), Dominique Turmel (1), Jacques Locat (1), Julie Therrien (2)  
 (1) *Université Laval (Québec, Canada)*; (2) *Ministère des Transports du Québec (Québec, Canada)*

Le 15 avril 2014, un glissement de terrain s'est produit sur la berge d'un lac dans la municipalité de Lac-des-Seize-Îles, à 100 km au nord de Montréal. Le glissement a mobilisé un volume estimé à 30 500 m<sup>3</sup> de till et a généré une vague qui a soulevé et brisé le couvert de glace du lac, provoquant la destruction partielle ou totale de nombreuses résidences saisonnières, quais et abris à bateaux sur près de 450 m au nord et 500 m au sud du glissement. Des photographies aériennes prises peu de temps après l'événement ont révélé l'existence d'un patron de fissurations radiales sur la glace, montrant la propagation de la vague. Des données bathymétriques issues des sondages de l'Université de Montréal en 2013 ont permis de déterminer la profondeur du lac dans la zone affectée. Des investigations de terrain ont permis d'observer des marques sur des troncs d'arbre expliquées par le choc des fragments de glace et associées à la hauteur d'inondation.



# Session/Séance : Rock Mechanics and Engineering Geology III / Mécanique des roches et génie géologique III

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Monday, September 21, 15:45 – 17:00 / Lundi 21 septembre, 15 h 45 – 17 h

Room / Salle : 207

Chair / Président de séance : **Nick Vlachopoulos**

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## 77 - SUBSURFACE MODELING AND BIM

Strahimir Antoljak (1)

(1) *Bentley Systems, Inc (Santa Rosa, United States)*

This paper evaluates how subsurface database management fits into and complements the traditional procedures and practices in geoenvironmental engineering and enables easier interoperability with other engineering disciplines. The presentation reveals how subsurface data, when properly managed in geoenvironmental database can be easily turned into information and supplied to engineers in various disciplines in a desirable form that can be quickly and easily interpreted. Managing and modeling subsurface data consists of many aspects and this presentation places an emphasis is placed on modeling of subsurface strata, Building Information Modeling (BIM) and an interdisciplinary approach.

## 533 - ON THE STABILITY OF EXPOSED BACKFILL IN MINE STOPES

Nooshin Falaknaz (1), Michel Aubertin (2), Li Li (2)

(1) *BGC Engineering Inc. (Vancouver, Canada)*; (2) *Département des génies civil, géologique et des mines, Ecole polytechnique Montreal (Montreal, Canada)*

Backfilling of mine stopes for ground control around large openings provides a safe work place. The exposed face in the cemented backfill pillars is required to remain stable during removal of one of the support walls to create the adjacent stope. The minimum strength of the backfill is a critical issue to avoid safety problems and save the operational costs. A few studies have been conducted to assess the required strength of backfill in stopes with an open face. This paper presents 3D numerical simulations results to investigate the response of exposed backfill during sequential excavation, considering the effect of stope geometry and material strength. Numerical modelling results are then compared with analytical solutions to obtain the required backfill strength.

## 388 - IMPLEMENTATION OF A COHESIVE CRACK MODEL IN GRAIN-BASED DEM TECHNIQUE FOR SIMULATING FRACTURE IN QUASI-BRITTLE GEOMATERIAL

Kiarash Farahmand (1), Mark Stephan Diederichs (2)

(1) *Queen's University (Kingston, Canada)*; (2) *Professor at Queen's University (Kingston, Canada)*

This paper presents a grain-based discrete element model for simulating the quasi-brittle failure of rocks under mechanical loading. In this approach, the development of crack along grain boundaries controls the degree of damage in rock. A cohesive crack model based on the theory of "Non-linear Elastic Fracture Mechanics (NLEFM)" is implemented into the UDEC distinct element numerical code to define the constitutive behavior of the grain interfaces under different modes of fracturing. Implementation of the crack model in the grain-based simulator aims at enhancing the capability of the UDEC-Voronoi scheme to simulate the micro-cracking mechanisms more realistically similar the micro-cracking mechanisms. Rock heterogeneity, due to the presence of different mineral grains, is introduced to the model





by considering the mineral composition of real rock and contrast in mechanical properties of the constituent minerals. The elastic properties of the grains and the strength properties at grain boundaries are extracted based on the experimental data. Then, the capability of the model to replicate the mechanical behavior of Lac du Bonnet (LDB) granite under compression and tension is evaluated. To do so, a series of uniaxial and triaxial compression and Brazilian tests is simulated. The mechanical response of the numerical models is found to be in good agreement with the response of the real rock observed in laboratory.

### **603 - ENGINEERING CHARACTERISTIC OF GLACIAL TILLS IN GTA**

Laifa Cao (1), Scott Peaker (1), Shaheen Ahmad (2)

(1) *Principal Engineer (Toronto, Canada)*; (2) *Senior Consultant (Toronto, Canada)*

This paper presents geotechnical investigation results conducted in the glacial till deposits in relation with a light rail transit project in Toronto, Ontario. The ranges of soil parameters including unit weight, water content, strength, modulus, consolidation parameters and shear wave velocity are provided. Statistical analyses of soil parameters are conducted, where available. Possible correlations between SPT N value and pressuremeter modulus and soil friction angle are discussed. In addition, the distribution of boulders and cobbles in the glacial till deposits is also discussed through the observation of a shaft excavation for a tunnel project in Markham, Ontario.

### **673 - CHARACTERIZATION OF GLACIAL TILLS FROM AN EXCAVATION NEAR FORT MCMURRAY, ALBERTA**

Andrew Bayliss (1)

(1) *Klohn Crippen Berger (Calgary, Canada)*

An excavation conducted beneath the north starter dyke of the Sand Cell 2 Tailings Dam has permitted the geological mapping and geotechnical characterization of complex sub-glacial assemblage composed of glacial tills and rafted bedrock that overlie an infilled, tunnel valley, known as the Kearn Channel. The mapping data was supplemented with borehole and laboratory testing data from drilling programs and geographical information system data from the Alberta Geological Survey. This study concluded that the moraine was composed of a sub-glacial traction till, analogous to the Firebag Till, and rafted bedrock derived from the Clearwater Formation. The moraine was overlain and interbedded by deformed sands and gravels indicative of a sub-glacial braided canal system. Updated interpretations of the glacial units are proposed based on recent developments in glaciological studies.



## Session/Séance : Laboratory and In Situ Testing in Cold Regions / Essais en laboratoire et essais insitu pour les régions nordiques

Monday, September 21, 15:45 – 17:00 / Lundi 21 septembre, 15 h 45 – 17 h

Room / Salle : 2102B

Chair / Président de séance : Mark Nixon

### 678 - THE RESULTS OF 5- YEAR EXPERIMENT OF METHANE PRODUCTION FROM FROZEN SOILS

Maria Cherbunina (1), Anatoli Brouchkov (2), Elina Karnysheva (2), Masami Fukuda (3), Valeri Galchenko (4)

(1) MSU (Moscow, Russia); (2) Lomonosov Moscow State University (Moscow, Russia); (3) Fukuyama City University (Fukuyama, Japan); (4) Winogradsky Institute of Microbiology (Moscow, Russia)

The question of origin of the methane and activity of methanogenes at low temperatures remains unclear. Methane production was observed at low temperatures in the laboratory during a long-term experiment. Samples of frozen soils were taken from Yakutsk (Russia), Fairbanks (USA) and Tomakomai (Japan) and incubated at - 5°C in order to study possible methane production. The soil was incubated in glass flasks for 4,5 years under anaerobic conditions. The measurement of methane content in the air of the flasks was conducted at various intervals-from week to a month. During the experiment some samples were thawed and frozen again. We almost did not observed methane emission from the Yakutsk samples. The emission from the Alaskan and Tomakomai samples was slow. However, methane concentration in the air of flasks was significantly increased at thawing.

### 438 - MEASUREMENTS OF UNDISTURBED PERMAFROST THERMAL CONDUCTIVITY THROUGH CT SCAN ANALYSIS

Marc-André Ducharme (1), Michel Allard (1), Jean Côté (2), Emmanul L'Hérault (1)

(1) Université Laval, CEN (Québec, Canada); (2) Université Laval (Québec, Canada)

When building in the Arctic, design considerations require precise knowledge of the thermal and geotechnical properties of the permafrost. Computed tomography provides visualization of the cryostructure of permafrost. Previous studies showed great potential in using this technology for classification and volume measurements of permafrost components, i.e. sediment (solid), ice and gas (void) contents. The aims of this study are (1) to develop an innovative and non-destructive approach using CT scan to compute the thermal conductivity of undisturbed permafrost samples and (2) to validate the results computed from CT scan image analysis with proven experimental thermal conductivity data. The very good results obtained so far show that CT scan thermal conductivity measurements yield results comparable to other existing methods. The new approach could still be significantly improved by the use of a higher resolution CT scanner.



### 305 - METHOD OF DETERMINING THE THERMAL CONDUCTIVITY OF DISPERSED GAS-SATURATED SEDIMENTS UNDER CONDITIONS OF HYDRATE AND ICE FORMATION

Evgeny Chuvilin (1), Boris Bukhanov (2), Boris Bukhanov (2), Gennagy Brovka (3) (1) Moscow State University (Moscow, Russia); (2) Skolkovo institute of science and technology (Skoltech) (Odintsovo, Russia); (3) Nature Management Institute (Minsk, Belarus)

This paper presents a new method of experimental investigation of thermal conductivity of fine-grained gas-saturated sediments during hydrate accumulation at temperatures above and below 0°C. The testing was conducted with a special gas hydrate experimental setup featuring an integrated measurement system for measuring thermal conductivity of the fine-grained sediments under high gas pressure. Measurements of soil thermal conductivity were carried out in steady-state thermal mode (the stationary thermal method). This method allows to quantify the impact of hydrate saturation and the extent of pore water to hydrate transition on the thermal conductivity of the fine-grained sediments.

### 557 - THERMAL CONDUCTIVITY OF BOTTOM SEDIMENTS IN THE EAST SIBERIAN ARCTIC SEAS: A CASE STUDY IN THE BUOR-KHAYA BAY

Evgeny Chuvilin (1), Boris Bukhanov (2), Sergey Grebenkin (1), Vladimir Tymskoy (1), Natalia Shakhova (3), Oleg Dudarev (4), Igor Semiletov (3)

(1) Moscow State University (Moscow, Russia); (2) Skolkovo Institute of Science and Technology (Skoltech) (Odintsovo, Russia); (3) International Arctic Research Center, University of Alaska (Fairbanks, United States); (4) Il'ichev Pacific Institute of Oceanology (Vladivostok, Russia)

Among Arctic carbon reservoirs, subsea permafrost, hydrates, and associated methane (CH<sub>4</sub>) deposits are the most worrisome owing to high heat transfer from rapidly warming shallow Arctic seas. The East Siberian Arctic Shelf is a big portion of the Arctic shelf and hosts over 80% of current subsea permafrost and along with it, unique Arctic shallow CH<sub>4</sub> hydrates. Degradation of subsea permafrost results in increasing permeability for gaseous CH<sub>4</sub> long preserved in seabed deposits within and beneath permafrost. Nevertheless, knowledge about the present thermal state of subsea permafrost is mainly based on modeling results, which are controversial. In that sense, actual values of thermal conductivity are crucially needed. In this report, we represent the first results of In Situ measurements of the major sediment core thermodynamically parameters in the ESAS.

### 556 - TIME EVOLUTION OF THERMAL CONDUCTIVITY AND INTRINSIC PERMEABILITY OF A SNOW COVER

Olivier Lachance (1), Jean Côté (1) (1) Université Laval (Québec, Canada)

This paper presents the experimental results of a study on the time-evolution of the intrinsic permeability, thermal conductivity and porosity of a single snow layer. Undisturbed snow batches were collected at Laval University in the winter of 2014 at weekly intervals. They were later reworked to produce samples of different porosities. The experimental results obtained for the different samples ranged from  $3.59 \times 10^{-9}$  to  $8.71 \times 10^{-11}$  m<sup>2</sup> for the permeability and from 0.089 to 0.372 W/mK for conductivity with porosity varying from 0.46 up to 0.80. A temporal evolution of the relation permeability-porosity has been observed and an effective radius corresponding to each snow batch and sample was obtained using an existing permeability model (Calonne et al. (2012)). That radius has allowed the quantification of the temporal evolution process. A structure effect resulting from compaction has also been noticed on the thermal conductivity measurements of fresh snow samples.



## Session/Séance : Foundations in Cold Regions / Fondations en régions nordiques

Monday, September 21, 15:45 – 17:00 / Lundi 21 septembre, 15 h 45 – 17 h

Room / Salle : 2104AB

Chair / Président de séance : Jinyuan Liu

### 443 - EFFECT OF STRESS AND TEMPERATURE HISTORY ON CREEP BEHAVIOR OF STRAIGHT AND ENLARGED-BASE ANCHORS IN FROZEN SILTY SOIL

Jean-Marie Konrad (1), Luc Boisvert (1)

(1) *Dép. de génie civil et génie des eaux, Université Laval (Québec, Canada)*

The objective of this project was to study the pullout creep behavior of anchors of different geometries embedded in a frozen silty soil. A cylindrical steel rod of 16 mm of diameter and a hybrid anchor having a coned-shaped enlarged base were tested at temperatures of  $-1,2^{\circ}\text{C}$  and  $-0,6^{\circ}\text{C}$ . Good agreement of creep behavior on cylindrical anchors with field data reported in the literature was observed. Important attenuations of the creep rates in time were recorded on enlarged base anchors, particularly at  $-1,2^{\circ}\text{C}$ . Also, an important reduction of creep rate was observed after rest periods with cyclic temperatures.

### 735 - A CASE STUDY OF FROST ACTION ON LIGHTLY LOADED PILES AT ONTARIO SOLAR FARMS

Pierre-Philippe Levasseur (1), Paul Dittrich (2), Michael Maher (3)

(1) *Golder Associates Ltd (Mississauga, Canada)*; (2) *Golder Associates Ltd. (Mississauga, Canada)*; (3) *Golder Associates Ltd. (Whitby, Canada)*

The Ontario Feed-in Tariff (FIT) program was launched in 2009 to encourage the development of renewable energy technology in Ontario and quickly initiated the development of many solar farms across the province. Many developers applied foundation designs that were more suited to the southern United States or Europe than to Ontario conditions. This often resulted in constructability issues as well as poor foundation performance related to frost action of the solar panel supports. This paper considers several key findings and remedial measures associated with poor foundation performance at a number of solar farm developments in Ontario. Minimum adfreeze values back-calculated from the observed pile heave at one of the sites is also presented, for comparison purposes with values published in literature and local design guidelines. A discussion on retrofit measures utilized to remediate heaved piles is also provided.

### 33 - GEOTECHNICAL DESIGN OF THERMOPILE FOUNDATION FOR A BUILDING IN INUVIK

Guangwen (Gordon) Zhang (1), Ed Hoeve (1)

(1) *Tetra Tech EBA (Edmonton, Canada)*

A thermopile foundation has been designed for a new building in Inuvik. Challenging geotechnical ground conditions at the site include an up to 3 m thick unfrozen zone (closed talik) below the active layer, up to 10 m thick ice and ice-rich soils, and warm permafrost temperatures. A set of geothermal analyses were carried out to estimate the building foundation ground temperatures with depth and time under normal working conditions of the thermopiles and climatic conditions considering projected climate changes over the building design life of 50 years. Geotechnical evaluations were conducted to estimate the required pile embedment depths in consideration of specified pile long-term creep



settlement criteria and design criteria against potential frost jacking. A total of three design groups of the thermopiles were recommended for the building foundation.

#### **40 - GEOTECHNICAL DEEP FOUNDATION DESIGN CHALLENGES IN DISCONTINUOUS PERMAFROST OF NORTHERN MANITOBA**

Hafeez Baba (1), Jim Oswell (1), Kristopher Matusiewicz (2), Giovanni Militano (2)  
(1) SNC-Lavalin (Toronto, Canada); (2) Manitoba Hydro (Winnipeg, Canada)

Geotechnical foundation design challenges associated with the climatic and geotechnical conditions pertinent to northern Manitoba are presented and discussed. The challenges associated with a predicted warming trend for the degradation of frozen ground and its impact on the geotechnical foundation design was, in particular, a challenge at the Keewatinohk Converter Station site. Due to remoteness and cold climate at the site, the project owner's preference was for a relatively long service life and reduced maintenance during the operations. The challenges included establishing a design freezing index, predicting and designing for frost depth and adfreeze forces. Driven steel tubular pipe piles were selected as a most feasible foundation option for the project. The paper also presents axial and lateral pile load and pile drivability analysis challenges and solutions, and construction consideration.

#### **292 - RESEARCH ON FOUNDATION DESIGN ON PERMAFROST IN MONGOLIA**

Dashjamts Dalai (1), Ariunjargal Anand (2), Ninjarav Enebish (3), Batsaikhan Anand (2)  
(1) Mongolian University of Science Technology (Ulaanbaatar, Mongolia); (2) Soil Trade LLC (Ulaanbaatar, Mongolia); (3) Mongolian University of Science and Technology (Ulaanbaatar, Mongolia)

Mongolia is a land-locked country in Central Asia, located between Russia and China. The country's high altitude results in cold, dry and harsh climatic conditions with permafrost being widespread through the territory. Permafrost is spread on 63.0 percent of the territory of Mongolia. Although the capital city Ulaanbaatar is sited on area with discontinuous permafrost, in next 10 years projects such as a university campus, a logistics center, "New Nalaikh" residential block and the extension of railway and highway connecting Russia and China have been planned. Engineering-geological and geotechnical studies have been conducted for these construction projects. This paper emphasizes that the main conditions of permafrost existence are the climate and geocryological location. Regional classification of permafrost areas, in order to select optimal principle of foundation design have been suggested based on the many years of experience and lessons learned from construction works in Mongolian geotechnical and climatic conditions.



## Session/Séance : Mining Geotechnique III / Géotechnique minière III

Monday, September 21, 15:45 – 17:00 / Lundi 21 septembre, 15 h 45 – 17 h

Room / Salle : 2105

Chair / Présidente de séance : Denise Leahy

### 255 - CHARACTERIZING THE DIFFUSIVE TRANSPORT OF STABLE WATER ISOTOPES IN UNSATURATED SOILS

Matthew Buchynski (1), Lee Barbour (1), Jim Hendry (2)

(1) Department of Civil and Geological Engineering, University of Saskatchewan (Saskatoon, Canada); (2) Department of Geological Sciences, University of Saskatchewan (Saskatoon, Canada)

Two phase transport of the stable isotopes of water has been presented by many authors, but these studies tend to not include a detailed investigation on the volumetric water content dependencies of two phase diffusive transport. Here, a common model for two phase diffusive transport, synthesized from isotope and gas diffusion literature, is combined with tortuosity models for aqueous and vapour transport. The goal of this study is to find tortuosity models that provide the best fit to observed diffusion data collected from unsaturated double half-cell diffusion tests.

### 746 - SURFACE WATER INFILTRATION IMPACTS ON THE PERFORMANCE OF THERMAL CAPPING SYSTEMS FOR WASTE ROCK IN CONTINUOUS PERMAFROST

Michael Angelopoulos (1), Anne-Marie Dagenais (1), Steve Anderson (1), Eva Stephani (1),

Mayana Kissiova (1), Patrick Gince (1)

(1) Golder Associates (Montreal, Canada)

The use of thermal caps for reclamation of acid generating waste piles or backfilled open pit mines in continuous permafrost requires long-term simulations of the ground thermal regime. The common approach models heat conduction through materials to design the thermal cap thickness, but the thermal impacts of surface water infiltration are often ignored. This paper describes modeling the effects of snowmelt and summer rainfall on the performance of two cover concepts at a pit in a Canadian sub-arctic continuous permafrost zone. The cover concepts modelled were Thermal Cap #1 (65-200 millimeter [mm] sized clean rockfill) and Thermal Cap #2 (0-600 mm sized coarse rockfill overlying a densely compacted till layer). The pit is located on sloping terrain and underground site observations indicate infiltration into frozen waste rock during the thawing season. The modelling results show that thermal infiltration effects depend highly on the hydrogeological properties of coarse materials (waste rock and rockfill) and the presence a low permeability barrier in the cover design.

### 805 - RECLAMATION OF MATERIAL SITES IN CONTINUOUS PERMAFROST OF ALASKA: AN EXAMPLE OF GROUNDWATER FLOW BETWEEN PITS

Eva Stephani (1), eva stephani (1), mark musial (1), steve anderson (1)

(1) Golder Associates (anchorage, United States)

Development of material sites in northern Alaska can result in multiple pits separated by buffer zones with some pits partially filled with water as they are reclaimed. This common reclamation concept relies on cold frozen ground to prevent hydraulic connection between



the pits. However, mining operations and the presence of water bodies that do not entirely freeze in winter can trigger changes in the thermal regime. As a result, groundwater flow paths can develop in the buffer zone separating the former and active pits. This paper presents a case study example where groundwater flow through a buffer zone separating a pit in reclamation and an active pit was assessed using a combination of geophysical methods and borehole data. Preliminary review of the instrument data results suggest that the reclamation concept, which allows pits to be filled with surface water while adjacent pits are still active, should be assessed and possibly modified.

### **362 - GEOTECHNICAL INVESTIGATION AT THE LONG LAKE CONTAINMENT FACILITY, EKATI DIAMOND MINE, NT**

Gary Koop (1), Elizabeth Garven (1), Lukas Novy (2)

(1) *Tetra Tech EBA Inc. (Edmonton, Canada)*; (2) *Dominion Diamond Ekati Corporation (Yellowknife, Canada)*

The Long Lake Containment Facility (LLCF) at the Ekati Diamond Mine (Ekati) is the primary containment area for processed kimberlite generated during diamond ore processing. In the winter of 2013, a geotechnical investigation was completed in the LLCF to investigate the In Situ conditions of the processed kimberlite (PK) and to evaluate permafrost growth in the facility. Continuous core samples were obtained with a sonic drill rig. Geotechnical and geochemical testing was completed to characterize the material. Investigation results indicate significant permafrost growth in the LLCF, with unfrozen material encountered at the southern limits of the investigation area where recent processed kimberlite deposition has occurred. Geochemical testing on recovered samples suggest some expulsion of solutes during the freezing process.

This paper provides an overview of the investigation and summarizes the geotechnical and geochemical test results. Comparison with previous investigation results are also made to evaluate historical permafrost growth and material variations within the LLCF.

### **230 - A CASE STUDY: SEISMIC STABILITY OF AN UPSTREAM TAILINGS IMPOUNDMENT – EMPIRICAL METHODS AND INPUT GROUND MOTIONS**

Miguel Medina (1), Denise Leahy (1), Nicolas Lemieux (1)

(1) *SNC Lavalin (Montreal, Canada)*

This paper presents the implications of the selection and treatment of input ground motions for the seismic stability evaluation of an upstream-raised tailings impoundment currently under construction. This impoundment contains niobium tailings, considered susceptible to liquefaction under seismic loads. Therefore a shell of compacted coarse tailings was built along the perimeter and is subsequently raised in the upstream direction with a decreasing width with height. An extensive monitoring program of the compacted shell, including CPTu and SPT testing, has been implemented to evaluate the compaction methods implemented and for quality control. The site lies in the seismic zone that produced the 1988 Saguenay earthquake (magnitude 5.9) and is capable of producing earthquakes with magnitudes as great as 7.5. The different methodologies and results are compared and discussed in the light of the empirical liquefaction assessment method.







# TUESDAY TECHNICAL PROGRAM / PROGRAMME TECHNIQUE DU MARDI

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## Session/Séance : John Ross Mackay Symposium - Permafrost I / Symposium John Ross Mackay - Pergélisol I

Tuesday, September 22, 10:45 - 12:15 / Mardi 22 septembre, 10 h 45 - 12 h 15

Room / Salle : **204AB**

Co-Chairs / Coprésidents de séance : **Antoni Lewkowicz & Michel Allard**

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### 258 - RECONSTRUCTING GEOMORPHOLOGY: AN APPRECIATION OF THE CONTRIBUTIONS OF J. ROSS Mackay (1915-2014)

Michael Church (1)

(1) *The University of British Columbia (Vancouver, Canada)*

Based as they are entirely on his own field experiences, Ross Mackay's geomorphological contributions are commonly regarded as the fruit of solo inspiration. In fact, his work is decidedly the product of its time. At the outset of his career, geomorphology was entering a radical transformation from interpretive study of landscape history toward quantitative study of landscape-forming processes. Accordingly, Mackay's earliest works are accounts of regional geography. From 1960, however, his work, following the new perspective, expresses its dominant character: quantitative measurement in the field and on maps, and application of physical theory for interpreting the observations. By 1965 his mature style was firmly established. The outstanding aspects of Mackay's contributions are his genius for making critical field observations and his ability to use them to test geophysical theory. But his early regard for landscape history remained an important aspect of his insight throughout his career.

### 469 - JOHN ROSS Mackay - DEVOTED TUTOR AND BEST FRIEND OF CHINESE PERMAFROST RESEARCH

Guodong Cheng (1), Zhijiu Cui (2), Baolai Wang (3), Huijun Jin (4)

(1) *State Key Laboratory of Frozen Soils Engineering, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (Lanzhou, China)*; (2) *Beijing (Peking) University (Beijing, China)*; (3) *Citizenship and Immigration Canada, Ottawa, Canada (Ottawa, Canada)*; (4) *Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI), Chinese Academy of Sciences (CAS), Lanzhou, China (Lanzhou, China)*

The scientific accomplishments of Mackay were of great benefit to China, especially his research on ground ice. Permafrost studies began in China in the 1960s. They were mainly concerned with the impact of near-surface layers of ground ice upon engineering infrastructure. However, Chinese geocryologists had little knowledge of ground-ice genesis and massive ground ice bodies. After 1982, under the influence and generous help of Mackay, Chinese research on permafrost and ground ice became increasingly sophisticated. Mackay was respected and admired not only for his outstanding accomplishments in scientific



## **241 - SCIENCE TO TECHNOLOGY--THE IMPORTANCE OF UNDERSTANDING THE FUNDAMENTALS OF PERMAFROST SCIENCE FOR ENGINEERS PRACTICING IN THE NORTH**

Don Hayley (1)

(1) *Hayley Arctic Geoconsultants (Peachland, Canada)*

The author met Ross Mackay in 1972 after requesting his assistance preparing for a pipeline data collection program in the Mackenzie Valley. Mackay provided selflessly of his time to transfer basic knowledge of permafrost and ground ice with advice on what to look for in the field. That relationship carried on to the end of his life with exchange of information useful for engineering purposes. He was outstanding in his dedication to his research and to those who worked with him and went on to carve out their own niche in this important region of Canada. The paper looks at the importance of understanding the genesis of ground ice and its importance to engineering. Polygonal ground formed by ice wedges is identified as a high-risk terrain unit. The paper relates this knowledge to decisions that had to be made when routing a new highway from Inuvik to Tuktoyaktuk. The route crosses 140 km of some of the most difficult terrain for road building in Canada.

## **99 - JRM: HIS EARLY ACCOMPLISHMENTS, 1950S TO MID 1980S, AND HIS RESULTS, 1990-2005**

Hugh French (1)

(1) *University of Ottawa/University of Victoria (North Saanich, Canada)*

Ross Mackay's main scientific accomplishments were as a permafrost scientist working in the Western Canadian Arctic. Starting in 1951, he would spend approximately 3 months in the field each year for more than 40 years. He described many geographical features including the closed-system pingos of the Mackenzie Delta. In 1968, when the PCSP Western Arctic logistics base moved to Tuktoyaktuk, he commenced long-term permafrost studies in the delta region. His research added significantly to our general understanding of permafrost terrain, the nature of ground ice, the controls over permafrost distribution, the dynamics of the active layer and the effects of natural and man-induced disturbances to the tundra and arctic ecosystems.

## **417 - LATE WISCONSIN GLACIATION OF HADWEN AND SUMMER ISLANDS, TUKTOYAKTUK COASTLANDS, NWT, CANADA**

Julian Murton (1), Mark Bateman (2), Richard Waller (3), Colin Whiteman (4)

(1) *University of Sussex (Brighton, United Kingdom)*; (2) *University of Sheffield (Sheffield, United Kingdom)*; (3) *Keele University (Keele, United Kingdom)*; (4) *University of Brighton (Brighton, United Kingdom)*

The exact timing of the last major advance of the Laurentide Ice Sheet onto the Beaufort Sea coastlands of western Arctic Canada is unclear but significant to our understanding of landscape change and palaeo-ice stream chronology. Optical stimulated luminescence dating of preglacial and postglacial aeolian sand from Hadwen and Summer islands, in the Tuktoyaktuk Coastlands, indicates that glaciation took place between about 17.5 and 15 ka, and most likely between 16.6 and 15.9 ka, coinciding with Heinrich event 1. At this time the Mackenzie Trough palaeo-ice stream advanced into a cold-climate sandy desert, interrupting aeolian activity.



## Session/Séance : Permafrost Degradation I / Dégénération du pergélisol I

Tuesday, September 22, 10:45 - 12:15 / Mardi 22 septembre, 10 h 45 - 12 h 15

Room / Salle : 205A

Chair / Président de séance : Peter Morse

### 402 - THE EUREKA SOUND LOWLANDS: AN ICE-RICH PERMAFROST LANDSCAPE IN TRANSITION

Wayne Pollard (1), Melissa Ward (2), Michael Becker (2)

(1) McGill University (Montreal, Canada); (2) grad student (Montreal, Canada)

The Eureka Sound area is characterized by cold polar desert conditions (MAAT of  $-19.7^{\circ}\text{C}$ ), permafrost  $>500$  m thick and a dynamic landscape where rapid change linked to melting ground ice is common. Massive ground ice and ice-rich sediments are widespread below the Holocene marine limit (150 m asl) where its distribution, content, and stratigraphic character are closely related to the nature of marine sediments. Since 1990 approximately 450 natural exposures of massive ice have been mapped, including  $\sim 100$  that were studied in detail. Most are headwall exposures in retrogressive thaw slumps. These data are supplemented by 50+ core holes up to 15 m deep and GPR surveys. Over 25 years of observation the average retreat is 6.9 m/yr, but in the past 5 years the average is 7.5 m and the highest annual retreat is 23.9m. Since 2005 many new slumps have formed and ice wedges have exhibited significant thaw degradation.

### 600 - ECOSYSTEM IMPACTS OF HIGH ARCTIC PERMAFROST DISTURBANCES

Alison Cassidy (1), Manon Desforges (2), Greg Henry (3)

(1) UBC (Vancouver, Canada); (2) graduate student (Vancouver, Canada); (3) Professor (Vancouver, Canada)

Active layer detachment slides located at Hot Weather Creek, Ellesmere Island, were studied during the growing season of 1994 and revisited during 2012 to determine the short- and long-term impacts on vegetation and ecosystem processes. Distinct vegetation communities exist in differently aged disturbances with unique species defining various zones and ages of disturbance. Zonal differences illustrate the varying responses of the ecosystem to disturbance and differing modes of recovery. Disturbances affect site soil characteristics over the long-term, exemplified through soil nutrients (specifically nitrate), soil moisture, and active layer depths measured during the 2012 sampling period.

### 219 - PERMAFROST DEGRADATION ADJACENT TO SNOW FENCES ALONG THE DEMPSTER HIGHWAY, PEEL PLATEAU, NWT

Brendan O'Neill (1), Chris Burn (1)

(1) Carleton University (Ottawa, Canada)

The long-term ground thermal effects of a snow fence in continuous permafrost (Fence 1) were examined on Peel Plateau, west of Fort McPherson, NWT. Active-layer thicknesses and vegetation changes were also described at three additional fences (Fences 2-4). The fences were erected in the early 1980s, so present environmental conditions represent the effects of over 30 years of modification to snow conditions. We observed increased snow cover, active-layer thickness (ALT), and moisture content at Fence 1, which have combined to prevent winter freezback, so that a talik now exists at the site. ALTs were statistically related to distance from the fence at flat sites, but not at sites of slope  $\geq 5^{\circ}$  with good drainage.



## 67 - THE GROUND THERMAL REGIME ACROSS THE MACKENZIE VALLEY CORRIDOR, NORTHWEST TERRITORIES CANADA

Philip Bonnaventure (1), Sharon Smith (2), Dan Riseborough (2), Caroline Duchesne (2), Mark Ednie (2)

(1) *University of Lethbridge (Ottawa, Canada)*; (2) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*

Ground thermal data generated from an enhanced monitoring network have been summarized for the Mackenzie Valley corridor, Northwest Territories. The snapshot developed for 2007-09 provided a baseline against which future change in ground thermal conditions could be measured as well as providing essential information to support land use planning decisions in the region. Comparison of ground temperatures measured during 2012-14 to this baseline indicates some recent warming of permafrost has occurred with greater changes in ground temperature within colder permafrost in the northern portion of the corridor.

## 331 - CHARACTERIZATION OF PERMAFROST THERMAL STATE IN THE SOUTHERN YUKON

Sharon Smith (1), A Lewkowicz (2), Mark Ednie (3), Maxime Duguay (4), Alexandre Bevington (5)

(1) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*; (2) *University of Ottawa (Ottawa, Canada)*; (3) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*; (4) *BGC Engineering Inc. (Calgary, Canada)*; (5) *Ministry of Forests, Lands and Natural Resources Operations (Prince George, Canada)*

Boreholes in the northwestern portion of the Alaska Highway Corridor, Yukon were instrumented for temperature measurement between 2011 and 2013. The data acquired has enabled characterization of the ground thermal regime in this section of the corridor. Permafrost is generally warm with temperatures above  $-1.5^{\circ}\text{C}$ . However, colder permafrost at temperatures as low as  $-3^{\circ}\text{C}$  was found in the immediate vicinity of the Alaska border. Comparison of recent ground temperatures with those measured in boreholes by the Geological Survey of Canada in the late 1970s indicates that warming of permafrost has occurred. These instrumented boreholes complement those established previously in the southern and central Yukon and facilitate an improved understanding of the regional thermal state of permafrost.

## 182 - DEVIATIONS IN GRIDDED FIELD MEASUREMENTS OF GROUND TEMPERATURE AND ACTIVE LAYER THICKNESS IN WUDAOLIANG BASIN, QINGHAI-TIBET PLATEAU

Guan YIN (1), Fujun Niu (2), Jing Luo (2), Zhanju Lin (2), Bingzhuo Yang (3), Minghao Liu (2), Anyuan Li (2)

(1) *Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (Lanzhou, China)*; (2) *State Key Laboratory of Frozen Soils Engineering, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (Lanzhou, China)*; (3) *Lanzhou University (Lanzhou, China)*

Ground temperatures were measured with 60 boreholes at four study sites (1, 2, 3, and 4). Under the similar climate condition, the ground surface temperatures in the same site from 15 boreholes were not similar. There is a maximum difference of  $2.4^{\circ}\text{C}$  at site 1 (alpine meadow with rock grids),  $2.6^{\circ}\text{C}$  at site 2 (alpine meadow),  $3.0^{\circ}\text{C}$  at site 3 (transitional area), and  $3.1^{\circ}\text{C}$  at site 3 (alpine grassland), respectively. The active layer thickness measured from 15 boreholes is also have a maximum deviation of 118.0 cm at site 1, 78.5 cm at site 2, 64.0 cm site 3 and 65.0 cm site 4. The climate changing, soil moisture content loss and the



environmental variables (thermokarst, strong sand wind, and vegetation degeneration) may be the main reason for these deviations, which should be better evaluated when mapping the permafrost spatial distribution and assessing local factors influence.

## **Session/Séance : Laboratory Testing I / Essais en laboratoire I**

**Tuesday, September 22, 10:45 - 12:15 / Mardi 22 septembre, 10 h 45 - 12 h 15**

Room / Salle : **205BC**

Chair / Président de séance : **Mathieu Nuth**

### **126 - LABORATORY ASSESSMENT OF ENERGY-EFFICIENCY IN VIBRATORY COMPACTION OF GRANULAR MATERIALS**

Federico Fernandez (1), Garrett Osborne (2), Garrett Osborne (2)  
(1) *Geofed (Ottawa, Canada)*; (2) *Algonquin College (Ottawa, Canada)*

Laboratory testing equipment was customized to assess energy-efficiency in the compaction of granular materials using a vibratory hammer. During the compaction process, the density growth is derived by tracking the downwards displacement of the tamper in contact with the surface of a constant mass of granular material contained in a standard compaction (Proctor) mold. The energy used during the compaction process is estimated as the product of the elapsed compaction time and the impact power rated by the manufacturer of the vibratory hammer.

The graphic representation of density versus the cumulative energy consumed during the compaction test produces a density growth curve. Energy-efficient compaction is achieved when the desired state of compactness is reached at the expense of lesser energy. The paper describes a laboratory test method used to evaluate both the compactibility and the maximum density attainable by the vibratory compaction process. This approach can be used in support of sustainable earthwork construction practices to guide the optimal selection of compaction variables such as vibratory frequency, surcharge or lift characteristics.

### **655 - THE FORMATION OF LABORATORY ANALOGUES OF NATURAL HYDRATE-BEARING FINE-GRAINED SOIL**

William Smith (1), Jocelyn Grozic (1), Jeffrey Priest (1)  
(1) *University of Calgary (Calgary, Canada)*

Gas hydrates form in deep-water marine sediments, and have been suggested as being a geohazard when temperature or pressure changes result in hydrate dissociation, with fine-grained hydrate-bearing sediments posing the greatest potential risk. Recent drilling expeditions with improved sampling techniques have revealed that within fine-grained soils, hydrates form complex, sub-vertical veins. These veins are hypothesized to lead to an increase in the strength and stiffness of the hydrate-bearing soil. However, current understanding of the strength and deformation behaviour of hydrate-bearing sediments is limited to laboratory studies in which hydrate is formed within the pore space of sediments. This paper presents a detailed procedure in which vertical, cylindrical synthetic hydrate veins are formed within a consolidated laboratory-mixed fine-grained soil, and are then isotropically reconsolidated within a triaxial cell. Results indicate that hydrate veins remain intact throughout this process.



## 171 - X-RAY CT OBSERVATION ON THE LIGHT BACKFILL

Grytan Sarkar (1), [Sumi Siddiqua](#) (2)

(1) MASc Student (Kelowna, Canada); (2) Assistant Professor (Kelowna, Canada)

Bentonite and / bentonite-sand mixture is widely used in the deep geological repositories for sealing nuclear wastes because of the high swelling capacity and low hydraulic conductivity, which largely depends on its microstructure as well as the pore space geometry. The microstructural behaviour such as pore size, pore distribution and pore connectivity of the LBF samples was investigated using Xradia Micro XCT-400. However to get a preliminary idea on the microstructural behaviour of the materials used in the LBF were observed. The X-ray source, detector, and a small portion of LBF specimen (5.5 mm in diameter) were placed closely to acquire a good quality image with a voxel size of  $1.15 \times 1.15 \times 1.15 \mu\text{m}$ . The scanned images were de-noised and segmented to study the pore space geometry. An algorithm was developed to compute the volume porosity and pore-size distribution of the scanned samples. Additionally, the interconnected pore components and absolute permeability of the LBF samples were analyzed using Avizo software.

## 468 - SIMPLE SHEAR LOADING RESPONSE OF UNDISTURBED AND RECONSTITUTED SILT

[Achala Soysa](#) (1), [Dharma Wijewickreme](#) (1)

(1) University of British Columbia (Vancouver, Canada)

The mechanical behavior of relatively undisturbed low plastic natural silt was investigated using monotonic and cyclic constant volume direct simple shear testing for comparison with that derived from reconstituted specimens prepared from the same material. Natural silt, retrieved from a deltaic deposit located within the Lower Mainland of British Columbia, Canada were used for the study. Reconstituted specimens were prepared using a method of slurry deposition. During monotonic shear loading, reconstituted specimens exhibited slightly higher shear strength than that of undisturbed specimens. In cyclic direct simple shear tests, all reconstituted specimens displayed higher rate of strain accumulation and pore water pressures development compared to those observed for relatively undisturbed specimens. It appears that the combination of competing effects arising from void ratio and particle structure contribute to the shear behavior of observed at a given confining stress.

## 723 - SOME INITIAL EXPERIMENTAL FINDINGS ON THE INFLUENCE OF MODE OF SHEAR ON THE MONOTONIC SHEAR RESPONSE OF RECONSTITUTED SILTS

Daniel Barnes (1), [Dharma Wijewickreme](#) (1), [Priyesh Verma](#) (1), [Dharma Wijewickreme](#) (1)

(1) University of British Columbia (Vancouver, Canada)

An experimental research program has been undertaken to investigate the influence of mode of shear on the monotonic shear response of relatively low plastic reconstituted silt obtained from a soil deposit located in Kamloops, British Columbia, Canada. The consolidated monotonic shear response of the reconstituted silt under undrained triaxial compression, undrained triaxial extension, and constant volume direct simple shear loading conditions were compared. In the triaxial tests, the silt specimens were reconstituted from an initial slurry state and then consolidated to three target effective confining stress levels. At all confining stress levels, the undrained shear strength observed under triaxial compression was observed to be approximately 20% greater than that noted from triaxial extension tests. The undrained shear strength measured from the direct simple shear loading at an effective confining stress level of 100kPa was observed to be similar to that measured in the triaxial extension test. This limited test data suggests similar trends to what has been observed for  $K_0$  - consolidated low plastic soft clays.



**161 - ESSAIS D'INDENTATION SUR UNE ARGILE SENSIBLE.**

Mireille Sandrine Ewane (1), Vincenzo Silvestri (1), Ghassan Abou- Samra (2)  
 (1) *École polytechnique de Montréal (Montréal, Canada);* (2) *Université de Moncton (Moncton, Canada)*

Cet article présente les résultats d'une série d'essais conventionnels et d'indentation effectués sur des échantillons intacts d'une argile très sensible prélevée dans la région de Beloeil, sur la rive sud de Montréal. Les essais d'indentations qui ont été réalisés à l'aide de trois types d'indenteurs et permis de déterminer le module de déformation (E) du sol. Les résultats ont été comparés à ceux obtenus à l'aide d'essais au laboratoire conventionnels. Les résultats obtenus montrent que les essais d'indentation donnent des résultats comparables à ceux issus des essais conventionnels.

**Session/Séance : Foundations I / Fondations I**

**Tuesday, September 22, 10:45 - 12:15 / Mardi 22 septembre, 10 h 45 - 12 h 15**

Room / Salle : **207**

Chair / Président de séance : **Bipul Hawlader**

**789 - GEOSUITE - A MODULAR SOFTWARE FOR GEOTECHNICAL DESIGN**

Suzanne Lacasse (1), Hans Petter Jostad (1), Jean-Sebastien L'Heureux (1), Oeyvind Torgersrud (1), Rolf Sandven (2)  
 (1) *NGI (Oslo, Norway);* (2) *Multiconsult AS (Trondheim, Norway)*

Remarkable advances in geotechnical analysis tools have happened since the 90s. Yet, experience, judgment and quality control remain the key to reliable foundation design. Software is not the asset that differentiates among consultants any more. The competence and experience of the personnel and the appropriateness of the parameters and soil models in the analyses are the factors that give competitive edge. The geotechnical profession of Norway and Sweden entered an alliance to develop GeoSuite. The first version of the software was issued in 2006, followed by a second generation in 2015. A third generation is planned for 2019. The objective is to make design as simple as possible by providing 1D, 2D and 3D calculation and visualization tools, and providing user-assistance along the way. The paper describes the GeoSuite software, and its modules for stability, settlement, bearing capacity, pile and excavation calculations, as well as the Wizard for user assistance. Plans are made for add-ons with slope runout calculations, soil profile decisions and statistical analyses of soil parameters.

**100 - FRASER HEIGHTS BRIDGE – GEOTECHNICAL CONSIDERATIONS FOR TOP-DOWN CONSTRUCTION ON DIFFICULT SOILS**

Brian Hall (1), Ali Azizian (1), David Harvey (2)  
 (1) *Tetra Tech EBA (Vancouver, Canada);* (2) *Associated Engineering (Vancouver, Canada)*

The Fraser Heights Bridge was constructed span-by-span, using a top-down approach, to satisfy the environmental obligations to minimize the impact on an environmentally sensitive wetland. Because of highly variable subsurface conditions, driven pipe piles supporting the bridge extended to almost 45 m depth on the east, but on the west where glacial till-like material was shallow, it was difficult to drive the piles sufficiently deep to obtain the necessary lateral support. Other geotechnical considerations included obstructions



(tree trunks, boulders or glacial erratics); artesian pressure; high compressibility and seismic softening of silts, sensitive clays and peat; and, liquefaction and lateral spreading of hydraulically placed sand fills. Another factor related to top-down construction was the minimal time available to address unexpected geotechnical issues such as damaged or obstructed piles.

#### **42 - EFFECTS OF TUNNELLING ON THE BEARING CAPACITY OF SHALLOW FOUNDATIONS**

Anna-Maria Zakhem (1), Hany El Naggar (2)  
(1) *Dalhousie University (Halifax, Canada)*; (2) *Associate Professor (Halifax, Canada)*

Urban tunnelling can induce distortion to the existing three-dimensional stress regime due to the development of ground arching and the associated stress redistribution. In some cases this may decrease the bearing capacity of nearby foundations which could cause damage to the overlying structures especially in soft soils and/or densely populated areas. Thus, the effect of tunneling on the performance and capacity of nearby foundations may be significant and should be considered in their design. This paper uses the finite element method with an elastic-plastic model and the Plaxis 3D software to study this interaction problem considering a number of parameters such as the tunnelling processes, construction sequence, proximity, and the burial depth. Accordingly, recommendations for the design of shallow foundations in close vicinity to shallow tunnels were proposed.

#### **411 - NUMERICAL INVESTIGATION OF THE BEARING CAPACITY OF RING FOUNDATIONS ON INHOMOGENEOUS CLAY**

Maha Al Massri (1), Timothy Newson (1), Timothy Newson (1)  
(1) *UWO (Kingston, Canada)*

Although the bearing capacity of ring foundations has been addressed in the literature, this is currently limited to drained soil behaviour only. Ring foundations are commonly used for supporting cylindrical structures such as oil tanks, bins, hoppers, bridge piers and silos. With more construction of large cylindrical structures occurring, ring foundations have the potential to become a very economical solution. The time and construction cost reduction of ring foundations compared to circular footings has motivated engineers to look for more guidance for the determination of the bearing capacity of ring foundations. This paper presents the results of a numerical investigation of the performance of ring footings on soft clay soils with increasing shear strength with depth. The study includes investigation of the effect of the footing diameter ratios and soil strength increase on the undrained bearing capacity factor  $N_c$ . This research has been conducted using finite element analysis with the software PLAXIS. The variation of  $N_c$  is shown to vary with both the geometry and soil properties. The research has both practical application to the design of circular foundations and academic interest related to the interaction of other closely spaced foundation systems on clay soils.

#### **487 - EFFECTS OF VARYING MODULUS OF SUBGRADE REACTION ON STRUCTURAL DESIGN OF MAT FOUNDATION**

Prapote Boonsinsuk (1), George Chow (1), Siva Nadarajah (1)  
(1) *Amec Foster Wheeler (Scarborough, Canada)*

Geotechnical engineers are normally requested by structural engineers to provide "modulus of subgrade reaction -  $k_s$ " for the design of mat foundation or slab-on-grade. The geotechnical engineers will provide the values of  $k_s$  which are deemed applicable to the





planned sizes of mat foundation to the structural engineers, who will subsequently use the ks as elastic springs underneath the mat foundation in typical analytical models, e.g., slab on elastic foundation, to determine contact pressure, settlement, bending moment, etc. From the previous paper on the ks by the same authors, the values of ks will not normally lead to the same foundation settlements when comparing the analyses by geotechnical engineers (using elastic modulus) and structural engineers (using ks). Such discrepancy can be resolved by repetitive analyses to be performed between the two engineers to satisfy a common criterion (e.g., similar foundation settlements). This paper presents the effects of varying ks values on the structural design of mat foundation, if used without the benefit of repetitive analyses between geotechnical and structural engineers to match the same foundation settlements.

### **249 - HIGH STRAIN DYNAMIC PILE TESTING IN A CHALLENGING SOIL CONDITION A CASE STUDY IN SOUTHERN ALBERTA CANADA**

Pirahas Balasingam (1), Pedram Roshani (2), Jason Jagodich (1)  
(1) Morton & Jagodich Incorporated (Calgary, Canada); (2) Morotn & Jagodich Incorporated (Calgary, Canada)

Driven piles are increasingly utilized as foundation elements in challenging geotechnical conditions that have where drilled peers would have been deemed appropriate historically. Predicting driven pile performance and capacity can be daunting task. Unique soil conditions or diversity across the subsurface of a project site can add further challenges to predicting performance. High strain dynamic pile testing provides a fast, effective, and economical quality control tool for the installation of driven piles. This paper describes the application of Pile Driving Analyzer® (PDA) in performance evaluation of driven piles installed in a hard clay ground condition in southern Alberta, Canada. The project site is located in the vicinity of Fort MacLeod, Alberta. Site conditions and pile installation process are described in detail. Pile instrumentation, test procedures, and PDA test results and their relevancy are discussed in detail. Finally, CAse Pile Wave Analysis, performed using CAPWAP® software are discussed comprehensively in order to provide baseline conclusion that can be used in future for analysis of driven piles with similar soil conditions.

## **Session/Séance : Physical and Numerical Modelling / Modélisation physique et numérique**

**Tuesday, September 22, 10:45 - 12:15 / Mardi 22 septembre, 10 h 45 - 12 h 15**

Room / Salle : **2102B**

Chair / Président de séance : **Richard Bathurst**

### **299 - PHYSICAL MODELLING OF SUBMARINE GASSY SLOPE FAILURES**

Ryan Phillips (1), Sylvia Bryson (1), Shantanu Kar (1), Bipul Hawlader (1)  
(1) C-CORE (St-Johns, Canada)

This paper investigates the stability of a submarine gassy slope triggered by tidal variations. Under tidal variations on an unsaturated slope, failure may occur under specific combinations of degree of saturation and soil permeability, and decreasing tidal period. A novel physical model test in a geotechnical centrifuge was undertaken of a submarine slope containing gassy sediments. The model preparation techniques, measurement systems and



preliminary results are presented. The response observed in the model test is discussed and further developments proposed. Existing numerical simulations may provide a basis for verification and validation of future physical model test results.

#### **640 - CURRENT RESEARCH ACTIVITIES AT KAIST GEO-CENTRIFUGE CENTER FOCUSING ON SOIL-FOUNDATION-STRUCTURE INTERACTION UNDER SEISMIC LOADING**

Heon-Joon Park (1), Jeong-Gon Ha (1), Jun-Tae Seong (1), Dong-Soo Kim (1)  
(1) KAIST (Daejeon, South Korea)

This paper presents a general overview of the KAIST Geotechnical Centrifuge Testing Center and the current research activities therein focusing on soil-foundation-structure interaction (SFSI) under seismic loading. The KAIST centrifuge facility, developed in 2009, includes a geotechnical centrifuge with a radius of 5 m, an in-flight shaking table, a four-degrees-of-freedom in-flight robot, and general modeling equipment. The facility is providing a good opportunity to perform various research experiments, and research and development will be further activated in this area. Dynamic centrifuge model tests for a single-degree-of-freedom system with a shallow foundation and offshore wind turbine structures with bucket foundation are among the current research activities at the center. The dynamic behavior of the models under both fixed and SFSI conditions is obtained by applying small-amplitude dynamic loading. The model structures are exposed to various seismic loadings to evaluate the seismic behavior of prototype structures. Through the physical modeling of the model structures, the importance of SFSI in performance-based seismic design is derived.

#### **697 - CENTRIFUGE MODELLING OF SHALLOW FOUNDATIONS ON FIRM OVER SOFT LAYERED CLAY**

Jonathan Black (1), Alireza Tatari (2), Manouchehr Hakhamaneshi (2)  
(1) University of Sheffield (Sheffield, United Kingdom); (2) University of Sheffield (Sheffield, United Kingdom)

In practice shallow foundations are rarely simply founded on a homogenous soil beds hence there are uncertainties surrounding the mode of failure that will prevail and the bearing capacity factor that should be adopted in design. A series of centrifuge model tests on surface strip footings resting on a layered soil bed having firm clay overlying soft clay of varying thickness are presented. Plane strain test conditions enabled the use of Digital Image Correlation (DIC) to determine the relative displacement of the soil and reveal the foundation failure mechanics. Complementary numerical modelling is also conducted which verifies the model experimental data. General shear and punch failure were observed and the dominant failure mechanism shown to depend on the ratio of the upper layer thickness and footing width.

#### **575 - ESTIMATION OF RESIDUAL FRICTION ANGLE OF CLAY SOILS USING ARTIFICIAL NEURAL NETWORKS MODELLING**

Mostafa Abolfazl Zadeh (1), Amin Falamaki (2)  
(1) Clifton Associates Ltd. (Calgary, Canada); (2) Department of Civil Engineering – Payam Noor University, Shiraz (Shiraz, Iran)

Accurate estimation of site-specific soil strength parameters (e.g., the internal friction angle and cohesion) is challenging in geotechnical engineering due to the limitations and complexities associated with obtaining undisturbed soil samples and laboratory shear test analysis. The residual friction angle of clay soils is particularly important parameter in slope



stability analysis, especially in case of pre-existing slip surfaces and large deformations, and is commonly approximated from Atterberg limits and grain size distribution using traditional regression analysis. In this study, we tested the reliability of Artificial Neural Networks (ANNs) in predicting the residual friction angle degrees of different soil types based on their Atterberg Limits, clay size fraction and normal stress. The main objective was to find a satisfactory relationship between input and actual measured values using artificial neural network models. The effect of the network geometry on the performance of the models was also assessed. Strong correlation factors (e.g., 0.99) for training and testing data sets in model MLP741 demonstrate that ANNs are powerful tools for predicting soil strength parameters.

#### **442 - NUMERICAL SIMULATION OF WAVE PROPAGATION ALONG A SOIL NAIL**

Jinyuan Liu (1), Xiaoyang Rong (2), Peiyuan Lin (1)

(1) *Ryerson University (Toronto, Canada); (2) Northwestern University (Shenyang, China)*

This paper presents a numerical simulation of wave propagation along a soil nail in order to develop a non-destructive testing (NDT) technique for quality control of soil nail walls. Soil nailing is a popular retention system where nails are encapsulated in grouted drillholes and contribute to the stability when the reinforced soil mass moves. Due to the fact that many defects could occur, the quality control of soil nail construction is very critical to ensure the safe performance of soil nailed structures. Currently, there are only destructive pullout tests available. This research is to address the need for an efficient and reliable NDT technique for soil nails. This research uses the finite element method (FEM) to study the complex wave propagation along a nail and the influences of various factors, including a radius of a grouted nail, material properties, and necking defects. The findings of this study demonstrate that the guided wave NDT technique is a very promising technique and can be used to detect defects and their locations in a soil nail.

#### **569 - MODELLING OF ELUTION TESTS WITH THE ICP INTERFACE BETWEEN COMSOL AND PHREEQC**

François Duhaime (1), Céline Rep (1), Jean-Sébastien Dubé (1)

(1) *École de technologie supérieure (Montréal, Canada)*

The iCP interface allows the coupling of Phreeqc, a geochemical modelling code, and COMSOL, a finite element solver, for the modelling of reactive transport in soils. With the iCP interface, the equations describing the transport of chemical species in pore water are first solved in COMSOL. The updated chemical analyses for each cell are then sent to Phreeqc for thermodynamic equilibrium and kinetics calculations. In this paper, the iCP interface was tested by modelling a series of laboratory tests conducted with a natural soil (calcareous sand). These tests included a batch test where a solution of lead, copper, cadmium and zinc nitrates was put in contact with the soil, a conservative tracer test with bromide and an elution test with the same metal nitrates as for the batch test. For the batch and elution tests, Phreeqc was used to model the dissolution of calcite in the soil and the precipitation of metal carbonates. COMSOL was used to model solute transport for the tracer and elution tests. This paper is centered on a coupling between hydrodynamic and geochemical phenomena, but iCP could also be applied to multiphysics models involving mechanical (e.g., cementation) and thermal (e.g., heat produced by chemical reactions) equations.



## Session/Séance : Earthquakes and Geohazards I / Séismes et géoaléas I

Tuesday, September 22, 10:45 - 12:15 / Mardi 22 septembre, 10 h 45 - 12 h 15

Room / Salle : **2104AB**

Chair / Président de séance : **Mahdi Taiebat**

### 786 - A REVIEW OF SEISMIC SITE AMPLIFICATION BY CONSIDERING GEOMETRICAL AND GEOTECHNICAL CHARACTERISTICS OF SITES

Pooneh Maghoul (1)

(1) *University of Manitoba, Department of Civil Engineering (Winnipeg, Canada)*

An extensive numerical analysis on the seismic site effects due to local topographical and geotechnical characteristics is carried out. Two dimensional (2D) configurations under incidence of vertically propagating SV waves is modeled with the aid of HYBRID program, combining finite elements in the near field and boundary elements in the far field. A parametric study is conducted to examine the combined effects of topography and geology on the amplification of the response spectrum at various points across the valley. The influence of different parameters is considered, such as filling ratios (from empty to full valleys), impedance contrasts between bedrock and sediments, and dimensions. Finally, some criteria are proposed in terms of engineering applications to assess the spectral response at the surface of sedimentary valleys.

### 447 - NONLINEAR SITE RESPONSE ANALYSES AND HIGH FREQUENCY DILATION PULSES

Graeme McAllister (1), Mahdi Taiebat (1), Alborz Ghofrani (2), Long Chen (2), Pedro Arduino (2)

(1) *University of British Columbia (Vancouver, Canada); (2) University of Washington (Seattle, United States)*

Nonlinear seismic site response analyses can provide an accurate representation of soil behaviour in response to the propagation of seismic waves. However their use has been limited in conventional engineering practice due to the perceived complexity in parameter selection and usage protocols. Moreover, both total and effective stress nonlinear analyses can be conducted to evaluate seismic site response. It would be insightful from a practical point of view to explore the difference in results when either a total or effective nonlinear analysis is carried out using an advanced soil constitutive model. In this paper, the critical state bounding surface plasticity constitutive model SANISAND is used to investigate the nonlinear response of a thin sand surface layer subjected to seismic loading. The importance of modeling the porous solid-pore fluid interaction is explored and the site response high frequency ground motion is suggested to be caused by dilation pulses during the soil phase transformation process.

### 781 - EFFETS DE SITE DU BARRAGE EN ENROCHEMENT DENIS-PERRON (SM-3), QUÉBEC

Daniel Verret (1), Denis LeBoeuf (2), Éric Péloquin (1)

(1) *Hydro-Québec Production (Montréal, Canada); (2) Université Laval (Québec, Canada)*

Spectral analysis of strong-motion and ambient noise were carried out at the Denis-Perron (SM-3) dam to evaluate possible site effects and the actual frequency of resonance (FN). This dam is a rockfill embankment dam standing 171 meters high, built in a narrow valley with its abutments resting on a gneissic rock foundation. Strong-motion stations were installed on



the dam's crest and on the left bedrock abutment. The spectral response is estimated from a series of three small earthquakes that occurred in 1999 and 2002. The FN was estimated by calculating standard spectral ratios using the bedrock station as the reference site. For all earthquakes, the spectral amplification curves show a clear peak between 2.0 and 2.2 Hz, in the transverse direction, and between 1.55 and 1.8 Hz, in the longitudinal direction. Amplification ratios range between 5.0 and 18.5 in the transverse directions and between 2.8 and 19.5 in the longitudinal direction. When the site response is evaluated from ambient noise recordings and using the H/V technique of interpretation, the FN is about 2.1 Hz in the transverse direction and 1.8 in the longitudinal direction. A strong amplification of the vertical motion component was also observed at both station sites.

### **611 - ASSESSMENT OF SOIL LIQUEFACTION POTENTIAL OF AN EMBANKMENT DAM IN THE CHARLEVOIX SEISMIC ZONE – CASE STUDY WITH THE COMPARAISON OF THREE TOTAL STRESS METHODS**

Oliver Hurley (1), Pierre Boulanger (1), Juliana Ruiz Suescun (1)  
(1) *Tetrattech QE (Montreal, Canada)*

This paper aims to compare three total stress methods to evaluate soil liquefaction triggering of an embankment dam located in the CSZ, a highly seismic region of Québec in eastern Canada. The three approaches are: 1- a preliminary semi-empirical method based on Idriss & Boulanger (2008), 2- a 1D nonlinear Finite Difference Method site response with FLAC and 3- a 2D equivalent linear Finite Element Method analysis with QUAKE/W. All methods estimate or calculate the cyclic shear stress ratio (CSR) and the cyclic resistance ratio (CRR) is estimated from In Situ testing. For the fill in place, all three analysis show potential for liquefaction triggering since the CSR is always higher than the CRR. The simplified solution shows good results with the 2D analysis with QUAKE/W while the 1D analysis underestimates the CSR profile. The effect of the 2D geometry is verified by fitting the response spectra between the 2D and 1D dynamic analysis with a factor of 2.

### **748 - APPLICATION OF AN ADVANCED CONSTITUTIVE MODEL IN NONLINEAR DYNAMIC ANALYSIS OF TAILINGS DAM**

Andres Barrero (1), Mahdi Taiebat (1), Arcesio Lizcano (2)  
(1) *Department of Civil Engineering - University of British Columbia (Vancouver, Canada);*  
(2) *SRK Consulting (Vancouver, Canada)*

Tailings are residual material produced during the process of extraction of minerals from mined ores. Saturated tailings are usually retained in the impoundments by means of raised embankments (tailings dams). Due to the usually huge dimensions of the impoundments, the great highs of the embankments and the site conditions like saturated loose granular foundation materials, tailings dams represent a high-risk construction for the environment in case of a dam failure. In general, detailed numerical studies are conducted for seismic analyses of high- risk tailings dams during the design phase. However most of the analyses are performed using very simplistic stress- strain models such as Mohr-Coulomb model even for loose sand layers. For the present study the SANISAND constitutive model was implemented in the finite difference code FLAC as a dynamic-link library. Then the liquefiable sand layer of a tailings dam under a seismic motion was analyzed using this more representative model. A number of representative results of the dynamic analysis including contours of shear strain and time history of the excess of pore pressure ratio for are presented and discussed. Results of the analysis suggest that at least for the analyzed motion the safety of the dam is not compromised.



Mahya Hatambeigi (1), Amir Hamidi (1)  
(1) Kharazmi University (Tehran, Iran)

As one of the most complex and controversial topics in geotechnical engineering, liquefaction is a major seismic hazard to various earth structures. Loose and saturated sandy deposits in seismic areas are most susceptible to this phenomenon. Reports of failure in Hydraulic fill dams indicate that one of the most prevalent and destructive failure modes in such geotechnical structures is liquefaction. In this paper, using FDM, the behavior of the Lower San Fernando dam during 1971 earthquake was studied and the corresponding liquefaction induced slide was investigated. So, using nonlinear soil constitutive models, the excessive pore water pressures and displacements in different points of the model were computed. Furthermore, the results were compared with those obtained from field investigations and numerical analyses conducted by other researchers. Based on the current comparisons, the predicted displacements, pore pressures and deformation patterns are in a reasonable agreement with the findings of previous studies.

## Session/Séance : GIS and Remote Sensing in Cold Regions / SIG et télédétection en régions nordiques

Tuesday, September 22, 10:45 - 12:15 / Mardi 22 septembre, 10 h 45 - 12 h 15

Room / Salle : 2105

Chair / Président de séance : Richard Fortier

### 440 - DETECTION AND INVENTORYING OF SLOPE MOVEMENTS IN THE BROOKS RANGE, ALASKA USING DINSAR: A TEST STUDY

Brianna Rick (1), Reynald Delaloye (1), Chloé Barboux (1), Tazio Strozzi (2)  
(1) University of Fribourg (Fribourg, Switzerland); (2) Gamma Remote Sensing (Bern, Switzerland)

This study investigates the potential of inventorying slope movements in a continuous permafrost and mountainous Arctic environment, namely along the Dalton Highway corridor in the Brooks Range, Alaska, applying a satellite-based radar interferometric (DInSAR) approach developed for use in the Swiss Alps. The exploration of the DInSAR dataset was conducted in two stages: a) systematic analysis of two approximately 50 km<sup>2</sup> sub-regions, and b) identification of specific features over the entire region. Using archived ERS and ALOS SAR data, as well as recent TerraSAR data, 77 high reliability movements were detected in the sub-regions. The main mass wasting categories identified were lobes (frozen debris lobes (FDL) or rock glaciers), landslides, solifluction slopes, and areas of heave/subsidence, with velocities ranging in magnitude order from cm/year to cm/day. Twenty FDLs have so far been identified using DInSAR, 75% of which were detected at a velocity rate of cm/day.

### 455 - DINSAR SEASONAL SURFACE DISPLACEMENT IN BUILT AND NATURAL PERMAFROST ENVIRONMENTS, IQALUIT, NUNAVUT, CANADA

Anne-Marie LeBlanc (1), Naomi Short (2), Valérie Mathon-Dufour (3), Michel Allard (3), Tommy Tremblay (4), Greg A. Oldenborger (1), Jason Chartrand (1)  
(1) Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada); (2) Canada Centre for Mapping and Earth Observation, Natural Resources Canada (Ottawa, Canada); (3) Centre d'études nordiques, Université Laval (Ottawa, Canada); (4) Canada-Nunavut Geoscience Office (Iqaluit, Canada)



Three consecutive years of seasonal surface displacement in Iqaluit, Nunavut, were derived using Differential Interferometric Synthetic Aperture Radar (DInSAR). Results show that low displacement is associated with bedrock and coarse sediments. Finer sediments, more likely to be ice-rich, show higher values of displacement. In addition to ground ice, other factors such as water at the surface and within the active layer, but also the mapping scale of surficial deposits can explain some displacement patterns. For a given surficial geology unit, displacements were generally lower in built areas than in the natural environment. One DInSAR season could be used to identify difficult terrain for construction. However, more than one season helps to differentiate between different causes of displacement. Findings are useful to guide DInSAR applications especially for infrastructure management and planning.

#### **418 - ADVANCED INSAR FOR PERMAFROST RELATED GROUND MOTION**

Bernhard Rabus (1), Jon Leighton (2), Alex LeFort (2), Colin Avey (3)  
 (1) 3vGEOMATICS; SFU (Vancouver, Canada); (2) 3vGEOMATICS (Vancouver, Canada); (3) Centre for Geomatics (Yellowknife, Canada)

Monitoring permafrost with InSAR is well established with 3vGeomatics alone having operational projects with over 20 affected communities. However, the Arctic environment is uniquely challenging for InSAR, due to winter snow cover, and summer fluctuations of surface water diminishing InSAR quality, as well as seasonal dynamics of the active layer causing temporally non-linear motion. This study focuses on Inuvik, in Canada's Northwest Territories, which presents the largest challenge to InSAR processing of the communities monitored. Traditional InSAR methods did not yield useful results here. In addition to the problems above, vegetation (also diminishing InSAR quality) is more abundant here, and Inuvik is also too small to rely solely on buildings for stable targets. However, an exceptional dataset of 42 very high resolution RADARSAT-2 Spotlight images provided a unique opportunity to develop a new InSAR solution to monitor ground motion in the Arctic. Several new methods: temporary target selection, advanced atmospheric error correction, and spatio-temporal adaptive filtering combined with parametric modeling of the active layer dynamics, have been developed to enhance our existing InSAR processing solution. We discuss the enhancements and show preliminary results demonstrating significant improvement. The enhanced InSAR solution is generally applicable to all Arctic sites.

#### **367 - INSAR MONITORING OF TRANSPORTATION INFRASTRUCTURE IN PERMAFROST REGIONS**

Jayson Eppler (1), Jayanti Sharma (1), Mike Kubanski (1), Jennifer Busler (1), Jonathan Roger (2), Michel Allard (2)  
 (1) MDA Systems Ltd (Richmond, Canada); (2) Centre d'Etudes Nordiques, Université Laval (Québec City, Canada)

The combined effect of climate change and accelerated economic development in Northern regions increases the threat of permafrost related surface deformation of transportation infrastructure. Satellite based Synthetic Aperture Radar Interferometry (InSAR) provides a means for monitoring deformation over remote and spatially extensive areas and is hence potentially well suited for monitoring Northern roadways.

However, permafrost poses challenges for InSAR monitoring due to complex deformation patterns caused by seasonal heave and settlement of the active layer with freeze-thaw cycles. We have developed an InSAR method that optimizes spatial and temporal resolution by joint adaptive filtering of multiple InSAR datasets.

The proposed InSAR method is demonstrated using data collected over the communities



of Salluit and Umiujaq in Northern Québec. Surface deformation estimates are compared to surficial geology maps provided by project partners from the Centre d'Études Nordiques and show potential for mapping risks to infrastructure posed by permafrost.

### **177 - USING REMOTE SENSING AND GROUND BASED MEASUREMENTS TO IDENTIFY VEGETATION-GEOMORPHOLOGY PATTERNS IN PERMAFROST**

Thomas Douglas (1), Christopher Hiemstra (1), Kevin Bjella (1), Torre Jorgenson (2), Stephen Newman (1), Elias Deeb (1), John Anderson (3)

(1) *U.S. Army Cold Regions Research and Engineering Laboratory (Fort Wainwright, United States)*; (2) *Alaska Ecoscience (Fairbanks, United States)*; (3) *U.S. Army Geospatial Research Laboratory (Alexandria, United States)*

Ice content, sediment composition, and vegetation are key variables in predicting how and where permafrost will respond to projected Arctic climate warming. Orbital and suborbital remote sensing tools, historical imagery, pattern detection, and LiDAR can be combined to provide a holistic view of how and where the landscape will respond to climate warming. However, this information can only provide realistic results when it is calibrated with field measurements representing a variety of terrain states, seasonal variations, and physical and chemical processes. This presentation will include remote sensing, field survey, and ground based geophysical measurements from a variety of discontinuous permafrost terrains in interior Alaska. We have combined electrical resistivity tomography, airborne LiDAR, active layer measurements, and high resolution surveying to link landscape features with permafrost ice content, vegetation, and the soil thermal regime.

## **Session/Séance : John Ross Mackay Symposium - Permafrost II / Symposium John Ross Mackay - Pergélisol II**

**Tuesday, September 22, 13:45 - 15:15 / Mardi 22 septembre, 13 h 45 - 15 h 15**

Room / Salle : **204AB**

Co-Chairs / Coprésidents de séance : **Jerry Brown & Guodong Cheng**

### **296 - ESTIMATING TALIK DEPTH BENEATH LAKES IN ARCTIC ALASKA**

Kenneth Hinkel (1), Christopher Arp (2)

(1) *University of Cincinnati (Cincinnati, United States)*; (2) *Institute of Northern Engineering, University of Alaska Fairbanks (Fairbanks, United States)*

Water temperature and morphometric data were collected from 28 lakes in Arctic Alaska of various size, geometry, depth and genesis. Using methods pioneered by J. Ross Mackay, calculations of temperature beneath the lake indicate that 20 of these have through taliks. We estimate that over 2100 lakes in the study area have through taliks, suggesting that the continuous permafrost is riddled with taliks that may connect surface lake water with sub-permafrost water.

### **284 - GEOMETRY OF ORIENTED LAKES IN OLD CROW FLATS, NORTHERN YUKON**

Pascale Roy-Leveillee (1), Christopher B (2)

(1) *Laurentian University (Sudbury, Canada)*; (2) *Carleton University (Ottawa, Canada)*

Old Crow Flats is an interior basin with thousands of thermokarst lakes. These lakes have irregular shapes where they are surrounded by trees and tall shrubs that may remain





rooted after bank subsidence and protect the underlying sediment from erosion. In polygonal tundra, the vegetation cover is easily removed and wave action can erode and redistribute bank sediment to form rectilinear shores. The majority of lakes with rectilinear shores are aligned parallel to dominant winds and expand most rapidly in this direction. This is contrary to the oriented lakes of the Arctic coastal plain and is due to the fine texture of glacio-lacustrine deposits in OCF, which contain very little sediment sufficiently coarse to accumulate near-shore along the leeward side of the lake, leaving the bank vulnerable to thermo-mechanical erosion caused by wave action.

### **236 - HOLOCENE LAKE-LEVEL RECESSION, PERMAFROST AGGRADATION AND LITHALSA FORMATION IN THE YELLOWKNIFE AREA, GREAT SLAVE LOWLAND**

Stephen Wolfe (1), Peter Morse (1)

(1) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*

The Great Slave Lowland occupies the north shore of Great Slave Lake. After glaciation, it was inundated by Glacial Lake McConnell and ancestral Great Slave Lake. Holocene lake-level recession around Yellowknife is determined from accelerator mass spectrometer ages of peat and detrital organics. In the last 8000 years, recession occurred at about 5 mm/year, and permafrost is youngest near the modern shoreline and older at higher elevations. Silty-clay sediments are abundant, and lithalsas (ice-rich permafrost mounds within mineral soils) occurring within 40 m above the present lake level are less than 6000 years old. They are common on Yellowknife River alluvium deposited within the last 3000 years. Lithalsas on this surface are assumed to have developed as permafrost aggraded into saturated sediments, and ground ice has formed within the last 250 years.

### **102 - LAKES OF THE WESTERN CANADIAN ARCTIC: PAST CONTROLS AND FUTURE CHANGES**

Philip Marsh (1), Tyler de Jong (1), Lance Lesack (2), Cuyler Onclin (3), Mark Russell (3)

(1) *Wilfrid Laurier University (Waterloo, Canada)*; (2) *Simon Fraser University (Burnaby, Canada)*; (3) *Environment Canada (Saskatoon, Canada)*

The western Canadian Arctic is lake rich with over 40,000 lakes in the Mackenzie Delta, and thousands more to the east of the Delta in the Tuktoyaktuk Peninsula. To address unknowns concerning these lakes, Professor Mackay published at least 19 papers over the period 1956 to 2013 that dealt with various aspects of lakes in the western Canadian Arctic. These papers outlined many of the controlling processes and considered the complex interactions between lakes and the permafrost landscape. Subsequent research has built on Professor Mackay's legacy and has gradually developed a better understanding of the hydrology and ecology of these lakes, as well considered the interactions between climate, permafrost and hydrology, and developed predictive models.

### **301 - SUMMER AND WINTER FLOWS OF THE MACKENZIE RIVER SYSTEM**

Ming-ko Woo (1), Robin Thorne (2)

(1) *McMaster University (Hamilton, Canada)*; (2) *School of Geography and Earth Sciences, McMaster University (Hamilton, Canada)*

The Mackenzie River Basin contains major hydro-physiographical regions representative of northern permafrost and non-permafrost zones. The regional environments exert influences, best expressed by the summer and winter hydrographs of headwater rivers. Summer flow is particularly responsive to the varied climatic, topographic and hydrologic settings of the Cordilleran mountains, the low gradient Interior Plains and the bedrock terrain of the Canadian Shield with myriad lakes. In winter, streamflow is sustained by



groundwater discharge and by lake outflow. Most rivers in Mackenzie Basin show only weak flow trends in the summer but winter flows in the lower basin exhibit statistically significant rising trends between years, which may be attributed to permafrost degradation and increased autumn rainfall, though these hypotheses warrant further verification.

### **512 - GEOHAZARD INVESTIGATIONS OF PERMAFROST AND GAS HYDRATES IN THE OUTER SHELF AND UPPER SLOPE OF THE CANADIAN BEAUFORT SEA**

Scott Dallimore (1), C.K. Paull (2), A.E. Taylor (3), M. Riedel (1), H.A. MacAulay (1), M.M. Côté (1), Y.K. Jin (4)

(1) *Geological Survey of Canada (Sidney, Canada)*; (2) *Monterey Bay Aquarium Research Institute (Moss Landing, United States)*; (3) *Geological Survey of Canada (Retired) (Sidney, Canada)*; (4) *Korean Polar Research Institute (Incheon, South Korea)*

Building on the early work of J. Ross Mackay, this paper reviews the state of knowledge of offshore permafrost and gas hydrates beneath the Beaufort Shelf. A thick and extensive interval of transgressed terrestrial permafrost is present beneath the central shelf, warming seaward and pinching out at 90-100m water depth near the shelf-slope break. A complex gas hydrate regime is recognised with possible intrapermafrost and subpermafrost gas hydrate beneath the shelf, a zone with no gas hydrates at the shelf-slope transition, and a marine gas hydrate zone where water depths are greater than ~270 m. We believe that changes induced by transgression (formation and thawing of ground ice and gas hydrate) have created unique porous media conditions in this setting that can influence geohazards and active geologic processes. To this end we have undertaken a variety of multidisciplinary field investigations that have included marine geophysics, high resolution sea bed mapping, sediment coring, sea floor moorings and ROV dives.

## **Session/Séance : Permafrost Degradation II / Dégradation du pergélisol II**

**Tuesday, September 22, 13:45 - 15:15 / Mardi 22 septembre, 13 h 45 - 15 h 15**

Room / Salle : **205A**

Chair / Président de séance : **Stephan Gruber**

### **320 - WATERSHED DELINEATION IN AREAS OF PERMAFROST DISTURBANCE ON EASTERN BANKS ISLAND, NWT: A GEOMATICS APPROACH FOR PREDICTING WATER QUALITY IMPACTS**

Ashley Rudy (1), Scott F. Lamoureux (1), Jean E. Holloway (1), Melissa J. Lafrenière (1), Steve V. Kokelj (2), Rebecca Segal (3), Trevor C. Lantz (3), Robert H. Fraser (4), I. Rod Smith (5)  
(1) *Queen's University (Kingston, Canada)*; (2) *Northwest Territories Geological Survey (Kingston, Canada)*; (3) *University of Victoria (Victoria, Canada)*; (4) *Canadian Centre for Remote Sensing (Ottawa, Canada)*; (5) *Geological Survey of Canada (Calgary, Canada)*

The goal of this study was to develop a framework for informing water-sampling strategies to evaluate the relationships between thermokarst disturbances and impacts on water quality. A permafrost disturbance inventory for the Johnson Point area, eastern Banks Island was produced through a visual inspection of SPOT 4 and 5 satellite imagery. A total of 197 retrogressive thaw slumps were identified and digitized, ranging in size from



2600 to 885 500 m<sup>2</sup> with the majority of slumps located adjacent to lakes and streams. Watersheds were derived from the Canadian CDED DEM and NHN stream network data sets using ArcGIS with Spatial Analyst extensions. Specific criteria were used to create a hierarchy of nested watersheds. This contextual information will enable us to determine if: 1) the relative density of disturbance is related to the intensity of water quality effects; 2) if water quality is impacted more by the areal extent of disturbance or numbers of individual disturbances; and 3) whether the hydrological connectivity and distance of a disturbance to a water body affects downstream water quality. This knowledge will provide information suitable for researchers, communities and decision makers to assess the impact of permafrost disturbance on surface water environments.

#### **144 - THE EFFECTS OF PERMAFROST DEGRADATION ON THE HYDROLOGICAL REGIME OF SUBARCTIC PEATLANDS**

Michael Braverman (1), William Quinton (2)

*(1) Inspec-Sol Inc (Waterloo, Canada); (2) Cold Regions Hydrology – Wilfrid Laurier University, Waterloo, Ontario, Canada (Waterloo, Canada)*

Permafrost thaw is a direct consequence of human disturbance in Arctic and Subarctic regions. Thin and warm permafrost is most sensitive to surface disturbance and may disappear within a few decades following an initial disturbance. Seismic lines are one of the most common types of linear disturbance, yet their impact is poorly understood. A distinctive feature of seismic lines is their geometry. These straight cut lines cross fens, bogs, peat plateaus, rivers and lakes thereby connecting hydrological units, which were otherwise disconnected. The relatively warm water from lakes and fens may enter these lines contributing to further degradation of permafrost.

The purpose of this study is to characterize ground water dynamics between major hydrological units in the region of discontinuous permafrost. A number of geophysical surveys were conducted to delineate permafrost, peat and mineral soil borders. We found that as soon as the permafrost table descends below the water table, the seismic line creates a link between fens and bogs, slowly conveying water along the line. The water flow may take place all year round if it is not interrupted by accidental freeze of the talik layer between the active layer and permafrost.

#### **269 - ESTIMATING ANNUAL APPARENT THERMAL DIFFUSIVITY IN PERMAFROST USING TEMPERATURE TIME SERIES ON THE QINGHAI-TIBET PLATEAU, CHINA**

Changwei Xie (1), Gough William (2), Lin Zhao (1), Tonghua Wu (1)

*(1) Cold & Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (Lanzhou, China); (2) University of Toronto-Scarborough (Toronto, Canada)*

Soil temperature data used in this study were obtained from 17 monitoring boreholes during the period from 2006 to 2010 on the Qinghai-Tibet plateau. Measurements show that the permafrost temperature is higher than -1.0°C at eleven sites and at eight sites it is higher than -0.5°C. We calculated the annual apparent thermal diffusivity (AATD) in permafrost at different horizons. Results indicate that the latent heat effects have important implications for the permafrost thermal regime. In warm permafrost regions, the latent heat effects buffered heat exchange and resulted in shallow depths of zero annual amplitude (DZAA) of ground temperature and AATD. At the same sites, thermal diffusivity is usually lower at the bottom of the active layer since ice-water conversion consumes most of heat exchange at this horizon. The thermal diffusivity is usually larger in the deep permafrost especially when the permafrost temperature is low. For the 17 monitoring boreholes, there is a causal relationship between the small AATD and the



high permafrost temperature. The temperature-dependent adjustments of the thermal diffusivity have important implications for the warming trend of permafrost. The permafrost temperature gradient is greater in cold permafrost with large AATD than it is in warm permafrost with small AATD.

#### **140 - HYDROLOGIC CONNECTIONS IN THE SOURCE AREA OF THE YELLOW RIVER AS INFERRED BY HYDROGEN AND OXYGEN ISOTOPES**

Chengwei Wan (1), Peng Yi (1), Minjie Zheng (1), Zhongbo Yu (1), Jie Wang (1), Huijun Jin (2), Dongliang Luo (2), Yuzhong Yang (2), Qingfeng Wang (2), A. Aldahan (3)  
(1) Hohai University (Nanjing, China); (2) Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (Lanzhou, China); (3) United Arab Emirates University (Al Ain, United Arab Emirates)

Analyses of stable ( $^2\text{H}$  and  $^{18}\text{O}$ ) and radioactive ( $^3\text{H}$ ) isotopes of different waters are applied here to investigate the potential changes in hydrologic connections of the surface and subsurface water in the Source Area of the Yellow River (SAYR), in northeast of Qinghai-Tibet Plateau. A record of tritium in historical precipitation from 1956 to 2003 in the SAYR has been reconstructed and the results show that groundwater with tritium concentration fewer than 3.05 TU had a pre-1956 age. The spring water could be recognized as former years precipitation and had is around 10 years in age while the ages of well water in Madoi Town reflect recent precipitation. The  $\delta^2\text{H}$  and  $\delta^{18}\text{O}$  variability of the water system suggest that the Yellow River and its tributaries were mainly recharged by the shallow ground water in the continuous permafrost, while in seasonal permafrost region, surface water recharged the groundwater.

#### **191 - SPATIAL VARIABILITY OF SOIL TEMPERATURE AND ACTIVE-LAYER THICKNESS IN THE PERMAFROST REGIONS OF RUSSIA DURING THE LAST FIFTY YEARS**

Artem Sherstiukov (1), Dmitry Streletskiy (2), Dmitry Streletskiy (2)  
(1) All-Russian Research Institute of Hydrometeorological Information - World Data Center (Obninsk, Russia); (2) The George Washington University (Washington, United States)

GTN-P CALM and soil temperature data collected by the Russian Weather Stations network were used to estimate spatial and temporal trends in ALT and soil temperature in the permafrost regions of Russia. Analysis of soil temperature at 3.2 m depth show an increasing trend over the last fifty years, with the most significant changes found in the north of West Siberia and the northern part of the East European Plain (0.02-0.04oC/y), and in the Central Siberian Plateau (0.04-0.05oC/y). Most locations experience 1-3 cm/y increase in ALT over the same period, although in some regions, such as southwest Yakutia, ALT decreased significantly. The last fifteen years (chosen to correspond with the majority of observations at the Russian CALM sites) are characterized by considerably higher rates of change, as compared to 1963-2013.

#### **361 - VIRUSES IN ANCIENT ICE WEDGES IN THE CENTRAL YAKUTIA, SIBERIA**

Anatoli Brushkov (1), Elna Karnysheva (1), Mariia Cherbunina (2), Gennady Griva (3), Svetlana Filippova (4), Dmitry Scladnev (4), Valery Galchenko (4)  
(1) Moscow State University (Moscow, Russia); (2) Moscow State University (Moscow, Russia); (3) ATEMA Lab (Ottawa, Canada); (4) Vinogradsky Institute of Microbiology (Moscow, Russia)

The study of the viral component of ancient microbial communities from permafrost is important for the understanding evolution of microbial communities, possibility of their



variations due to climate change, changes in the physical-chemical state of permafrost and practical questions of biosafety. For the first time the virus particles in native samples of ancient ice wedges of the Mammoth Mountain in Siberia have been discovered. Defined morphological diversity of viruses that can be attributed to five main types: miavirus, sifovirus, podovirus, spherical and filamentous. Specific characteristic of these viruses are small size and fever genome.

## **Session/Séance : Laboratory Testing II / Essais en laboratoire II**

**Tuesday, September 22, 13:45 - 15:15 / Mardi 22 septembre, 13 h 45 - 15 h 15**

Room / Salle : **205BC**

Chair / Président de séance : **Jean Lafleur**

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### **541 - A GENERALIZED GLOBAL OPTIMIZATION APPLICATION AND ITS USE IN DETERMINING THE HYDRAULIC PROPERTIES OF UNSATURATED SAND**

Marc Lebeau (1), Jean-Marie Konrad (1)

(1) *Laval University (Québec, Canada)*

Global optimization consists in finding the best solution to a problem that may contain multiple sub-optimal solutions. Although it dates back to the origins of geometry, it is now extensively applied in various fields of engineering. This paper focuses on the deterministic algorithms that have been implemented in a generalized global optimization application. The application integrates the algorithms into a comprehensive modeling environment that uses the JUPITER API to communicate with any process model with batch processing capabilities. After a brief description of its structure and algorithms, the capabilities of the application are illustrated by finding the hydraulic property functions of unsaturated silica sand through inverse modeling of a multistep outflow experiment with both suction and cumulative outflow measurements. The canonical differential evolution algorithm is shown to be particularly well suited to this optimization problem in which the objective function is topographically complex. The estimated hydraulic property functions are also shown to be in excellent agreement with those independently determined using steady-state methods.

### **122 - LABORATORY TESTING PROGRAM FOR THE PREDICTION OF RAINFALL RUNOFF FROM SOIL COVER SYSTEMS**

Ahlam Abdulnabi (1), G. Ward Wilson (1)

(1) *University of Alberta (Edmonton, Canada)*

Soil covers are commonly utilized to prevent Acid Rock Drainage (ARD). The design is governed by the net infiltration into the system. Infiltration prediction models require calibration using water balance controls. This requires rainfall runoff measurements, yet, such measurements are rarely available. Alternatively, accurate predictions of rainfall runoff for soil cover systems facilitate the calibration procedure.

A laboratory-testing program was developed to formulate a reliable model to predict rainfall runoff for soil covers. Both single layer and multi-layer soil profiles were tested in a specially designed rainfall simulator apparatus. Simulated precipitations of different intensities on different initial conditions were conducted. Runoff volumes were measured simultaneously with rainfall volumes. In addition, a number of instruments were installed to monitor changes in matric suction and volumetric moisture content as the wetting fronts propagated.



Results suggest that rainfall runoff rate is primarily governed by the applied rainfall intensity and saturated hydraulic conductivity in the case of saturated soil surfaces, whereas it is governed by the applied rainfall intensity and infiltration capacity for unsaturated soil profiles.

#### **444 - CONSTANT-HEAD PERMEABILITY TESTS PERFORMED IN MONITORING WELLS AT LABORATORY SCALE**

Lu Zhang (1), Robert Chapuis (1), Vahid Marefat (1)  
(1) *Ecole polytechnique de Montreal (Montreal, Canada)*

Permeability tests are regularly done in monitoring wells. Two types of tests have been performed in ten wells monitoring a confined aquifer, installed in a large sand box. Electronic transducers have been used to register total pressure and atmospheric pressure versus time. The paper presents first the method used to calibrate the sensors, in order to assess their zero offset and its influence on the test data. Then, it presents the results of the variable-head tests and those of constant-head tests performed using a peristaltic pump, thus as constant flow rate tests until stabilization of the water level in the well pipe. In addition, several types of constant-head tests have been performed: (i) single flow rate as for groundwater sampling; (ii) different flow rates, with or without rest periods between the periods of constant flow rate. The paper presents and discusses the hydraulic conductivity values that have been obtained from the field data for each type of test.

#### **365 - EXPERIMENT SETUP FOR SIMPLE SHEAR TESTS IN A TRIAXIAL CELL: TXSS**

Mohamed Chekired (1), Réjean Lemire (1), Mourad Karray (2), Mahmoud Hussein (2)  
(1) *Hydro-Québec (Varenes, Canada)*; (2) *Université de Sherbrooke (Sherbrooke, Canada)*

This paper documents the development of a new combined triaxial simple shear (TxSS) apparatus. The TxSS system consists of a simple shear apparatus incorporated in a triaxial cell for the measurements of static and dynamic characteristics of soil samples. A general description as well as some applications and advantages of the TxSS systems over the traditional apparatus are given in this paper. The key application of TxSS is the evaluation of liquefaction potential of soil under regular or irregular excitations. Sample results in terms of static and dynamic characteristics obtained using the TxSS device on different cohesive and cohesionless soil samples are presented to illustrate its capabilities, and they are successfully compared to those obtained using reliable design charts available in the literature as well as those from rigorous numerical analyses using the computer code FLAC.

#### **393 - EVALUATION OF DSS TEST RESULTS ON GRANULAR SOILS BASED ON TXSS RESULTS**

Mahmoud Hussien (1), Mourad Karray (1), Mohamed Chekired (2)  
(1) *Université de Sherbrooke, Sherbrooke (Sherbrooke, Canada)*; (2) *Hydro-Québec (Montréal, Canada)*

Although DSS tests represent quite well the cyclic shear mode of the soil under seismic loading conditions, one of its main flaws is its lack to monitor the change of confining stress of the tested specimen. Accordingly, the complete stress state of the soil sample is typically not defined, and in turn, this limits the use of DSS test results, in particular, for the calibration of soil constitutive models. In this paper, the new combined triaxial simple shear (TxSS) apparatus is employed to evaluate DSS test results on granular soils. The



TxSS system consists of a direct simple shear system incorporated in a typical triaxial cell for the purpose of applying and monitoring the lateral confinement as well as the pore water pressure generation during strain-controlled loading. Parallel monotonic and cyclic TxSS tests on different saturated Baie-Saint-Paul sand specimens with (DSS) and without (TxSS) stacks of annular plates at different confining pressures and draining conditions were conducted to evaluate the performance of DSS results against the results obtained from the TxSS. The results corroborate the practical recommendations that stress the use of DSS to investigate the shearing behavior of sands at small strains, but less so for evaluating large-strain behavior.

### **130 - EVALUATION OF EQUIVALENT CYCLE LIQUEFACTION CONCEPT BASED ON TXSS TEST RESULTS**

Marwan Khashila (1), [Marwan Khashila](#) (1), Mahmoud Hussien (1), Mourad Karray (1), Mohamed Chekired (2)

(1) *Sherbrooke University (Sherbrooke, Canada)*; (2) *Hydro-Québec, Montréal (Montréal, Canada)*

The concept of equivalent number of cycles is that, an irregular earthquake load can be replaced by uniform cycles that have the same damage effect on the soil to trigger liquefaction. In this paper, uniform and non-uniform cyclic strain-controlled tests have been carried out using the new combined triaxial simple shear (TxSS) apparatus on different saturated reconstituted samples of Ottawa C-109 and Baie-Saint-Paul sands. An empirical expression developed to estimate the buildup of pore pressure,  $R_u$  that has been later used in this study as damage metric for computing the equivalent number of cycles,  $neq$ . The estimated  $neq$  based on the experimental results has been compared successfully with those computed by the well-established P-M and R-N damage hypotheses.

## **Session/Séance : Foundations II / Fondations II**

**Tuesday, September 22, 13:45 - 15:15 / Mardi 22 septembre, 13 h 45 - 15 h 15**

Room / Salle : **207**

Chair / Présidente de séance : **Pooneh Maghoul**

### **598 - DESIGN AND CONSTRUCTION OF A THREE-STOREY CONCRETE BUILDING ON LIQUEFIABLE SOILS IN VICTORIA, BC**

J. Suzanne Powell (1), Kevin Sterne (2)

(1) *Thurber Engineering Ltd. (Victoria, Canada)*; (2) *Thurber Engineering Ltd. (Victoria, Canada)*

The foreshore in Victoria has undergone a number of changes over the years with large areas of fill having been placed to increase the land surface within much of the foreshore area. One such reclaimed land site was selected for the construction of a new three-storey concrete building. The field investigation consisted of both Becker Penetration tests (BPT) and Standard Penetration Tests (SPT) followed by bedrock probing with an air track percussion rotary drill. The soil conditions generally consist of a variable thickness of gravelly sand to sand and gravel fill material overlying a thick deposit of firm to soft marine clay. The design level earthquake for this structure is the 1:2,475 year event which results in a peak horizontal firm ground acceleration (PGA) of 0.6g for this site. Estimated liquefaction induced lateral displacements within the fill were up to 6 m and



vertical settlement estimates varied from about 0.1 m to 0.3 m. The final design of the building foundations consisted of rock-socketed caissons designed to resist the seismic deformations. Additional challenges included planning and executing a geotechnical investigation within a congested active work site and meeting the environmental requirements for working adjacent to the ocean within contaminated

#### **604 - COMPARISON OF PILE CAPACITY ESTIMATED BY SIGNAL MATCHING (CAPWAP®), ICAP® AND CASE METHOD OF DRIVEN STEEL PILES INSTALLED AT AN INDUSTRIAL SITE NEAR EDMONTON, ALBERTA**

Renato Clementino (1), Yonggeng Ye (1), Robin Tweedie (1), Yonggeng Ye (1)  
(1) *Thurber Engineering Ltd. (Edmonton, Canada)*

The standard approach used to estimate the pile capacity from high-strain dynamic testing (HSDT) is by signal matching technique using commercial software programs such as CAPWAP®. This approach is relatively time consuming and requires an experienced person to properly interpret the results. A faster approach is the use of the Case Method, which is a closed form solution, but requires a selection of a damping constant, not always adequately known for the subject site. A new alternative is the iCAP® method, which is an automated signal matching procedure that provides a fast signal matching solution to estimate the pile capacity for uniform driven piles under simple pile-soil interaction conditions. As part of the quality control for driven steel pile installation at an industrial plant site near Edmonton, Alberta, 187 driven steel pipe piles were dynamically tested on pile sizes ranging from 254 mm to 762 mm and depths ranging from 10 m to 24 m. The HSDT were performed at the End of Drive and at the Beginning of Restrike. This paper provides a comparison of the estimated pile capacities from the 187 piles using CAPWAP® software, the automated signal matching iCAP® program and also with the Case Method.

#### **511 - OPENSEES SIMULATIONS OF AXIAL BEHAVIOUR OF SINGLE-HELIX PILES**

Weidong Li (1), Lijun Deng (1)  
(1) *University of Alberta (Edmonton, Canada)*

Helical piles are widely used in Western Canada for many engineering applications. Soil-helical pile interactions are important for the helical pile industry and have been conventionally investigated using continuum finite element analyses, which require sophisticated modeling of soils and piles. The present research conducted simplified numerical modeling of soil and single-helix pile systems on the platform of the Open System for Earthquake Engineering Simulation (OpenSees). The numerical model adopts the beam-on-nonlinear-Winkler-foundation (BNWF) method for simulating soil-pile interactions. Soil reactions to piles are simulated by a series of q-z, t-z, and p-y springs. The numerical modeling is used to calibrate the performance of in-situ helical piles under axial loads and to understand the load-transfer mechanism during in-situ loading tests. Cone penetrometer tests (CPT) results of each test site are used as the input to parameters of the numerical models. Preliminary results showed that the BNWF method could properly simulate the capacities and load-displacement behavior of single-helix piles.

#### **751 - NUMERICAL STUDY FOR SOIL-SPRING STIFFNESS OF PILE GROUP**

Lassaad Hazzar (1), Mourad Karray (1), Admir Pasic (2)  
(1) *Université de Sherbrooke (Sherbrooke, Canada); (2) Dessau Inc. (Québec, Canada)*

Many approaches have been developed to determine the soil-spring stiffness and typical values have been proposed for different types and densities of soil. However, these typical





values ignore the effect of the depth and the degradation of elastic parameter ( $G$  or  $E$ ) as a function of strain. In this paper, a series of 3D numerical analyses are conducted to compute the equivalent soil-spring stiffness's according to pile distortion for a pile group located under the central pier of bridge structure above the river Sault-au-Mouton (Longue-Rive, Québec) and subjected to multi-loading conditions. In these simulations the degradation of the shear modulus is incorporated in order to account for soil nonlinearity. The idea is to develop equivalent springs that can be adapted to the lateral deformation of the pile. The stiffness of these springs thus varies depending on the distortion and may be adapted in an iterative process according to the pile deformation at each depth. This method can be compared to the linear equivalent method used in dynamic analysis where an equivalent shear modulus is adapted according to the shear distortion. In fact, This type of linear equivalent spring is very useful for structural engineers who want to incorporate the effect lateral capacity of soil in their models.

## 25 - 3D MODELING LATERALLY LOADED BATTERED PILES IN SAND

Lassaad Hazzar (1), Mahmoud Nasser Hussien (1), Mourad Karray (1)  
(1) *Université de Sherbrooke (Sherbrooke, Canada)*

A series of three-dimensional finite difference analyses have been carried out to investigate the lateral capacity of battered piles under lateral loads. Analyses were performed in homogenous sandy soils. Numerical results show that the lateral capacity of the battered piles is influenced by the value and the sign of the pile batter angle as well as the sand density. For negative batter angles, when lateral load acts opposite to the direction of pile inclination, the lateral capacity of the battered piles increases substantially with batter angle and with soil density. However, for positive batter angles, when the lateral load acts in the direction of the pile inclination, the lateral capacity is slightly decreased to moderately increased all dependent to the value of batter angle and the sand density.

## 21 - LATERAL PERFORMANCE OF HELICAL TAPERED PILES IN SAND

Ahmed Fahmy (1), Mohamed Hesham El Naggar (1)  
(1) *The University of Western Ontario (London, Canada)*

A novel piling system is proposed in this study to support solar energy panels in solar farm projects. It involves a spun-cast ductile iron (SCDI) tapered pile fitted with a lower helix. The proposed pile offers higher lateral capacity, and represents a sustainable foundation system. The monotonic lateral performance of the proposed system is investigated herein. Five SCDI tapered and two steel straight shaft piles were installed using mechanical torque in silty sand. The piles were laterally tested and their ultimate capacities were evaluated. The effect of prior axial and cyclic lateral loading on the piles' lateral performance was assessed. The tapered piles generally possess a stiffer response and higher ultimate capacity. The fixation provided by the helix had a positive effect on the lateral performance of short piles.



## Session/Séance : Contaminated Sites and Remediation / Sites contaminés et réhabilitation

161

Tuesday, September 22, 13:45 - 15:15 / Mardi 22 septembre, 13 h 45 - 15 h 15

Room / Salle : 2102B

Chair / Président de séance : Craig Lake

### 271 - INCORPORATING GEOTECHNICAL INVESTIGATIONS TO SUPPORT RECLAMATION ON RESOURCE PROJECTS

Victoria Stevens (1)

(1) *Stantec Consulting Ltd. (Victoria, Canada)*

Integration of geotechnical drill logs and drill data into terrain and soils mapping provides a powerful tool in reclamation planning for industrial development. For large resource projects such as pipelines and mines, reclamation planning commonly includes baseline soil and terrain mapping to inform reclamation aspects such as soil salvage and terrain stability planning, and geotechnical drill logs provide detailed information on soil depths and assist refinement of terrain mapping in terms of depth to bedrock and surficial materials. Geotechnical drill logs are imported into geographic information systems (GIS) and cross-referenced to terrain maps. Surficial material depths are modelled across the project development area and soil salvage volumes are calculated using drill log depths. Quantifying permafrost and accurate hazard mapping in areas of permafrost can rely heavily on both fieldwork and geotechnical drill logs to identify areas of potential permafrost geohazards and their potential impact on resource infrastructure and reclamation. Examples of project work that uses geotechnical logs for data and model verification are presented for areas of complex geohazards, permafrost hazards and deep organic soils.

### 265 - ON THE EFFECT OF SOPHOROLIPIDS ON DIFFERENT FRACTIONS OF MINE TAILING AND THE SPECIATION OF ARSENIC

Fereshteh Arab (1), Catherine Mulligan (1)

(1) *Concordia University (Montreal, Canada)*

Mine tailings produced after extracting gold from its ore, contain high levels of arsenic and heavy metals. As a result, mine tailings are one of the main environmental contamination sources. The objective of the present study was to investigate the effects of sophorolipids on the speciation and mobilization of arsenic, as well, on the morphology and composition of the mine tailings. The result from the sequential extraction of untreated and treated sample showed that in a continuous setting, a solution of 1% sophorolipids at pH 5 was able to change the morphology of the sample and mobilize arsenic associated with all fractions of the mine tailing sample. By using the soil washing in the continuous setup the total removal of 99% of iron and 98.8% of arsenic was achieved. The results drawn from these investigations will be used to develop an efficient, environmentally friendly, and economically feasible system for the treatment of mine tailings.

Mardi / Tuesday

GEOQuébec2015



### **370 - EFFECT OF CEMENTITIOUS AMENDMENT ON THE GEOCHEMICAL BEHAVIOR OF A SURFACE PASTE TAILINGS DISPOSAL**

Ichrak Hadimi (1), Mostafa Benzaazoua (1), Abdelkabar Maqsoud (1), Bruno Bussière (1)  
(1) *Université du Québec en Abitibi-Témiscamingue (Rouyn-Noranda, Canada)*

Laboratory study of the long term geochemical behavior of paste sulfidic tailings (SPD) and the cement amendment used to the control acid mine drainage (AMD), was performed using an instrumented physical model test. This model was filled initially with nine layers of paste tailings. After 27 months, a 10th layer of cemented tailings (with 2wt.% of cement) was deposited on top of the tailings stack. The tailings were submitted to wetting/drying cycles until the 34th cycle. The collected water during each cycle was analysed for its chemistry and its volume measured. Investigation results showed that the pH of leached collected water remained around neutrality. The evolution of the concentration of metals in the leachates did not change much after the addition of the 10th layer. While the calcium concentrations increased slightly. The projection of the oxidation-neutralization curve of the physical model has shown that the uncemented paste in time becomes AMD generator however the behaviour of the cemented paste is uncertain.

### **163 - THE HYDROCHEMICAL BEHAVIOR OF THE ALDERMAC ABANDONED MINE SITE AFTER ITS REHABILITATION**

Abdelkabar Maqsoud (1), Mamert Mbonimpa (1), Bruno Bussière (1), Mostafa Benzaazoua (1), Jean Dionne (2)  
(1) *Université du Québec en Abitibi-Témiscamingue, Institut de recherche en mines et en environnement (val-d'or, Canada)*; (2) *MERN – Direction de la Restauration des sites miniers (Québec, Canada)*

Before its reclamation Aldermac was considered as one of the most problematic abandoned mine site in Québec due to the high production rate of acid mine drainage (AMD) by sulphidic mine tailings. This site was reclaimed between 2008 and 2009 to control tailings oxidation, and future production of AMD. For that purpose, the site was reclaimed using a monolayer cover combined with an elevated water table for the north zone and using low saturated hydraulic conductivity HDPE geomembrane cover for the south zone. The reclamation of the mine tailings impoundment should gradually improve the groundwater quality at the site. To evaluate this aspect, sampling campaigns from 2011 to 2013 were performed on site to assess the evolution of groundwater quality of the reclaimed Aldermac mine site. Hydrochemical results were interpreted with principal components analysis. Results show that the groundwater quality is improving and that the reclamation is helping to reduce groundwater contamination at the site.

### **13 - CARACTÉRISATION ENVIRONNEMENTALE DES SOLS ET DU REMBLAI CONTENANT DES MATIÈRES RÉSIDUELLES À L'ENDROIT D'UN ANCIEN DÉPÔT PÉTROLIER SUITE À LA CESSATION DE SES ACTIVITÉS**

LAMINE BOUMAIZA (1)  
(1) *Stantec Experts-conseils Ltée (Saint-Laurent, Canada)*

Suite à la cessation d'activités d'un dépôt pétrolier, des travaux de caractérisation environnementale ont été effectués afin de vérifier la qualité environnementale des sols et du remblai contenant des matières résiduelles aux endroits où des sources potentielles et des enjeux environnementaux ont préalablement été identifiés lors d'une étude d'évaluation environnementale. L'objectif de cette étude était de délimiter les enclaves des sols affectés et celles du remblai contenant des matières résiduelles, afin d'en évaluer les volumes respectifs. À cette fin, les résultats de la présente étude ont été combinés



à ceux obtenus lors des études réalisées antérieurement sur le site. De l'ensemble des résultats, cinq enclaves des sols affectés par des hydrocarbures pétroliers ont été délimitées. Par ailleurs, quatre zones présentant un remblai contenant moins de 50 % de matières résiduelles ont été localisées dans la partie ouest de la propriété, alors que trois zones présentant un remblai contenant plus de 50 % de matières résiduelles ont été localisées dans la partie est de la propriété. Le modèle conceptuel de la répartition des sols affectés et les zones où le remblai contenant des matières résiduelles représente un outil relativement pertinent lors de l'élaboration d'un plan de réhabilitation.

### **18 - INFLUENCE OF EXTREME EVENTS AND HYDROGEOLOGICAL PROPERTIES ON THE RELEASE CAPACITY OF STORE-AND-RELEASE COVERS IN A SEMIARID CLIMATE**

Bruno Bossé (1), Bruno Bussièrè (1), Abdelkadir Maqoud (1), Rachid Hakkou (2), Mostafa Benzaazoua (1)

(1) IRME-UQAT (Rouyn-Noranda, Canada); (2) Faculté des Sciences et Techniques, Université Cadi Ayyad (Marrakech, Morocco)

The transient unsaturated hydrogeological behaviour of four store-and-release (SR) cover systems made with different fine-grained materials was simulated using the HYDRUS-1D code under extreme rainfall conditions typical of a semiarid climate. Numerical predictions indicated higher release rates for coarser SR materials (0.3 mm/d), whereas finer SR materials (0.03 mm/d) accumulated water above the interface of the cover systems and did not prevent water percolation with the reactive mine wastes under consecutive extreme rainfall events. Coarser SR materials (i.e., silty sands), which recover their full storage capacity more rapidly, proved more suitable to ensure the long-term performance of these systems under natural and extreme climatic conditions. The surface evaporative fluxes, the thickness of the SR layer and the hydrogeological properties of the fine-grained material are the main parameters that affect the release capacity of such cover systems.

## **Session/Séance : Earthquakes and Geohazards II / Séismes et géoaléas II**

**Tuesday, September 22, 13:45 - 15:15 / Mardi 22 septembre, 13 h 45 - 15 h 15**

Room / Salle : **2104AB**

Chair / Président de séance : **Maxime Bolduc**

### **127 - FAILURE MECHANISMS OF UNDERGROUND STRUCTURES DURING EARTHQUAKE: AN OVERVIEW**

Ahmed Mahmoud (1), Mahmoud Hussien (1), Mourad Karray (1), Mohamed Chekired (2), C. Bessette (2), L. Jinga (2)

(1) Sherbrooke University (Sherbrooke, Canada); (2) Hydro-Québec (Montréal, Canada)

Geotechnical structures buried near the ground surface have a wide range of applications, from small-scale pipelines such as means of gas transmission, telecommunications, water supply, and sewerage pipelines, to large-scale structures including tunnels for various transportation systems. This paper provides an overview of the current understanding of the failure mechanisms of these structures due to earthquake loadings. Based on post-earthquake investigations, experimental laboratory data as well as numerical simulations of underground structures conducted in the current study by means of computer



code, FLAC, it was found that movement of ground at seismic load may cause serious damage to those infrastructures. These serious damage is represented in two main types of failure has been occurred. First, stress-strain failure of the underground structure due to extra-stress and extra-deformation which as a result of soil movement at seismic. Second, state the stress failure of soil which lead to an uplift of underground structures and collapse of surround soil then disconnection of pipe joints between buried structure and tubes.

### **278 - THE BENEFICIAL AND DETRIMENTAL EFFECTS OF ROCKING SHALLOW FOUNDATIONS ON SUPER STRUCTURE DURING SEISMIC LOADING**

Partheeban Selvarajah (1), Sivapalan Gajan (2)

(1) Student (Raleigh, United States); (2) Associate Professor (Fargo, United States)

Generally, modern seismic design codes prohibit relative movement between the foundation and the soil beneath, which demands the structural elements of the superstructure to dissipate seismic energy. The primary benefit of appropriately reducing the size of the footing in shallow foundation is the partial isolation of the structure from the soil beneath (uplift and rocking). The rocking behavior caused by the seismic loading can occur around the footing base, subsequently dissipating the seismic energy and reducing the ductility demands transmitted to the superstructure. In this study, several centrifuge and shake table experiments on rocking shallow foundations have been analyzed to investigate the following beneficial and detrimental effects in an attempt to come up with a balanced design methodology: reliability and predictability of the moment capacity of the soil-foundation system, rocking induced energy dissipation and the resulting permanent settlement of the foundation, and the reduced ductility demands (maximum and permanent tilt of the structure) transmitted to the super structure.

### **484 - A PROCEDURE FOR ESTIMATION OF LATERAL SPREADING DISPLACEMENT USING RESULTS OF PROBABILISTIC SEISMIC HAZARD ASSESSMENT**

Hamid Karimian (1), Roy Mayfield (2), Pete Quinn (3)

(1) Ph.D., P.Eng. (Vancouver, Canada); (2) Ph.D., P.E. (Seattle, United States); (3) Ph.D., P.Eng., P.Geo. (Ottawa, Canada)

Empirical and semi-empirical regression models are widely used to estimate liquefaction-induced lateral spreading displacements. These models were developed from case histories with the seismic hazard defined in a deterministic fashion. A difficulty arises when using these models with results from a probabilistic seismic hazard assessment (PSHA) which are made up of contributions from a range of magnitude and distance combinations. There is little guidance on the selection of appropriate values of magnitude and distance from a PSHA for use in these models, and the commonly used mean or modal values may result in misrepresentation of lateral spreading displacements and do not provide information regarding the probability of exceedance of the estimated values. This paper introduces an approach to estimate the annual probability of exceedance of significant lateral spreading displacements (i.e.  $\geq 0.3$  m) using conventional PSHA output. The ground displacement threshold of 0.3 m was selected based on the review of a published database and is considered as a potential threshold to separate inconsequential and consequential ground displacements to some important structures including buried steel pipes and highways. Suggestions are also provided for application of this approach for displacement values other than 0.3 m.



## 561 - LIQUEFACTION SUSCEPTIBILITY MAPPING DERIVED FROM TERRAIN MAPPING; EXPERIENCE ON A LINEAR PROJECT IN BRITISH COLUMBIA, CANADA

Pete Quinn (1), Martin Zaleski (1), Roy Mayfield (1), Hamid Karimian (1), Betsy Waddington (1)  
(1) *BGC Engineering (Ottawa, Canada)*

Earthquake-triggered liquefaction and its attendant ground-movement hazards (e.g. buoyancy, subsidence, lateral spreading) may threaten linear infrastructure. Such infrastructure often traverses a range of physiographic, geologic and seismic settings, with varying liquefaction potential. Liquefaction susceptibility maps and the distribution of seismic hazard are typically combined to screen areas for more detailed geotechnical investigations of liquefaction potential. We applied several liquefaction susceptibility classification systems, including Youd and Perkins (1978), to airphoto-based, medium-scale (1:20,000) terrain maps completed in general accordance with Howes and Kenk (1997) for a proposed natural gas pipeline corridor across northern British Columbia, Canada. We compare these maps against site-specific geotechnical and geophysical data to generate statistics relating liquefaction susceptibility categories to the expected thickness of loose, saturated, cohesionless soil. We conclude that medium-scale mapping is reliable for preliminary design level screening, with potential for improvement through larger scale mapping and the compilation of additional subsurface and mapping data.

## 567 - COMPARAISON EXPÉRIMENTALE DES MÉTHODES MASW ET H/V BRUIT DE FOND DANS L'ESTIMATION DES EFFETS DE SITE LITHOLOGIQUE DANS LE BASSIN DE DAMIEN

Berthoumieux Junior Jean (1), Sadrac St Fleur (2)  
(1) *Université d'Etat d'Haïti / Laboratoire National du Bâtiment et des Travaux Publics (Port-au-Prince, Haïti)*; (2) *Géozur, Université Nice Sophia Antipolis, CNRS, OVA (Nice, France)*

L'objectif de cet article est de comparer les résultats obtenus lors des campagnes d'essais sismiques par les méthodes MASW et H/V bruit de fond, réalisées dans la plaine de Damien (Port-au-Prince, Haïti). Ces deux méthodes utilisent la propagation des ondes dans les couches superficielles et permettent d'identifier les interfaces entre les couches présentant des contrastes d'impédance et/ou de vitesse plus ou moins importants. Ces contrastes sont souvent à l'origine des effets de site lithologiques. Un rapprochement entre le contenu fréquentiel des ondes indiqué par la méthode H/V et la vitesse de cisaillement indiquée par la méthode MASW, est fait en fonction de l'épaisseur des couches. La confrontation de ces deux types de résultats dans la plaine de Damien (fréquences fondamentales et vitesses de cisaillement), contribue ainsi à l'amélioration du choix des techniques d'estimation d'effets de site lithologique, dépendamment des caractéristiques géophysiques des sols.

## 608 - MICROZONAGE SISMIQUE DE LA VILLE DES CAYES À HAÏTI

Betegard Jeudy (1), Mourad Karray (2), Patrick Paultre (2)  
(1) *Département de génie civil de l'Université de Sherbrooke / LNBTP (Port-au-Prince, Haïti)*; (2) *Département de génie civil de l'Université de Sherbrooke (Québec, Canada)*

Durant un tremblement de terre, on constate que les dégâts enregistrés dépendent non seulement de l'énergie libérée et de la typologie des constructions, mais aussi du sol. La connaissance du sol est un des moyens permettant de réduire le risque sismique. Cet article, portant sur le microzonage sismique de la ville des Cayes dans le sud-ouest d'Haïti, vise la détermination de la nature des sols en vue de mitiger les conséquences des séismes. Dans cette étude, des essais d'analyse spectrale des ondes de surface (SASW) ont été exécutés pour déterminer les profils de vitesse des ondes de cisaillement (Vs). Des essais SPT, de pénétromètre dynamique (PD) ont été collectés et des corrélations entre



leurs valeurs et Vs ont également servi à établir des profils de vitesse. La catégorisation des sols, sur la base du paramètre Vs30, fait ressortir trois classes de sols : C en région montagneuse, D en région plaine et E à proximité des côtes.

## **Session/Séance : Permafrost Considerations in Design / Considérations du pergélisol dans la conception**

**Tuesday, September 22, 13:45 - 15:15 / Mardi 22 septembre, 13 h 45 - 15 h 15**

Room / Salle : **2105**

Chair / Président de séance : **Niu Fujun**

### **349 - A PRACTICAL GUIDE TO PERMAFROST VULNERABILITY FOR YUKON'S NORTH ALASKA HIGHWAY**

Fabrice Calmels (1), Louis-Philippe Roy (1), Cyrielle Laurent (1), Maude Pelletier (1), Lacia Kinneer (1), Bronwyn Benkert (1), Brian Horton (1), Joel Pumple (2)

(1) Yukon Research Centre - Yukon College (Whitehorse, Canada); (2) University of Alberta (Edmonton, AB, Canada)

Northern Climate ExChange (NCE) has partnered with the Highways and Public Works (HPW) to develop a field guide to inform climate change adaptation along the northern 200 km of the Alaska Highway from Burwash Landing to the Yukon/Alaska border. The project examines the potential sensitivity of the permafrost along the highway to present and future climate variability. The project team used a multi-disciplinary approach that included permafrost coring, geocryological analyses, ground temperature and climate monitoring, Electrical Resistivity Tomography (ERT), and remote sensing techniques. Results indicated that the regional glacial history has influenced permafrost distribution and characteristics. Sites underlain by permafrost located within a few square kilometers of each other exhibit a wide range of ages, ground temperatures, thicknesses, and ground ice content and nature. The resulting product of the survey is a field guide that will facilitate the development of appropriate maintenance and remediation strategies, ensuring the highway's continued viability.

### **341 - CONSIDERING PERMAFROST IN THE DESIGN OF LINEAR INFRASTRUCTURE THROUGH MOUNTAINOUS TERRAIN**

Lukas Arenson (1), Katherine Johnston (1), Pete Quinn (1), Pablo Wainstein (1)

(1) BGC Engineering Inc. (Vancouver, Canada)

Traditionally, only a 500 - 2000 meter corridor width is considered and assessed when linear infrastructure, such as a road, pipeline or transmission line is planned. As such, hazards that originate from the periglacial belt at high elevations outside the corridor, which are often controlled by climatic parameters, may not be considered. Rapid climate change and variations in climate extremes can have a significant impact on the permafrost degradation and deglaciation in mountainous terrains of the Canadian Rockies and the Coast Mountain Range and change the geohazard potential with time. In order to assess such potential hazards for linear infrastructure projects through northern British Columbia, the role of permafrost must be addressed. This is best carried out in a systematic way, where direct and indirect hazards are assessed by using a scenario based approach that may also consider future climate change.



## 744 - METADATA TEMPLATE FOR GROUND TEMPERATURE RECORDS IN THE NORTHWEST TERRITORIES

Kumari Karunaratne (1), Steven Kokelj (1), Michael Palmer (2), Stephen Wolfe (3), Stephan Gruber (4)

(1) *Northwest Territories Geological Survey (Yellowknife, Canada)*; (2) *Cumulative Impact Monitoring Board, Government of the Northwest Territories (Yellowknife, Canada)*; (3) *Geological Survey of Canada (Ottawa, Canada)*; (4) *Department of Geography and Environmental Studies, Carleton University (Ottawa, Canada)*

In northern Canada, ground temperatures are measured for a number of reasons including permafrost research and infrastructure development. A template for reporting metadata on ground temperature datasets will allow data to be easily shared between various users, and is a necessary step towards a permafrost database. We outline a metadata template for ground temperature measurements developed through collaboration with both users and collectors of ground temperature measurements. Our collaborators are typically involved with: permafrost research and modelling, geotechnical engineering, and infrastructure performance monitoring. Our metadata template is divided into seven sections: (1) Project Details; (2) Location of Ground Temperature Measurements; (3) Installation of Ground Temperature Cable; (4) Ground Temperature Record; (5) Site Conditions; (6) Permafrost Conditions; and (7) Related Publications and Data.

## 112 - COORDINATION AND COMPLETION OF MULTI-YEAR GEOTECHNICAL INVESTIGATION IN THE CANADIAN ARCTIC: CHALLENGES AND LESSONS LEARNED

Yves Cormier (1), Olivier Piraux (1)

(1) *Stantec (Edmonton, Canada)*

The Northwest Territories Department of Transportation (NWTDOT) is constructing an all season highway connecting the Hamlet of Tuktoyaktuk with the Town of Inuvik and the Dempster highway. The Inuvik to Tuktoyaktuk Highway (ITH) consists of over 140 km of two lane, gravel surfaced highway requiring close to 10 million m<sup>3</sup> of material.

The execution of the borrow investigation program required the development of risk management strategies with an emphasis on project team roles focusing on the logistical aspects and the associated challenges while maintaining technical oversight and quality. A significant effort was spent on planning the program, including the identification of areas deemed most probable to contain suitable borrow. This included a significant effort and cooperation between geotechnical and terrain staff using new technologies to complete an initial desktop study of the proposed alignment area in order to identify and prioritize areas of interest. Close to 700 boreholes were drilled in less than 80 days spread over three winter seasons.

This paper present the overall approach, planning, and execution strategy utilized to achieve the overall objective, which was to locate the required volume of borrow material along the proposed highway alignment prior to the start of construction.

## 372 - IMPROVING WATER CONTENT DESCRIPTION OF ICE-RICH PERMAFROST SOILS

Marcus Phillips (1), Chris Burn (1), Stephen Wolfe (2), Peter Morse (2), Adrian Gaanderse (1), Brendan O'Neill (1), Dan Shugar (3), Stephan Gruber (1)

(1) *Carleton University (Ottawa, Canada)*; (2) *Geological Survey of Canada (Ottawa, Canada)*; (3) *University of Washington Tacoma (Tacoma, United States)*

The standard expression for soil gravimetric water content is on a dry basis (mass of water per unit mass of dry soil). In ice-rich soil, this method may produce extremely high values





that are difficult to interpret. Alternatively, the wet-basis gravimetric water content (mass of water per unit mass of field-moist soil) may be used. Until now, this method has not been evaluated for use with ice-rich soils. We compare dry- and wet-basis gravimetric water contents, and find wet-basis to be a reliable and readily interpretable alternative to dry-basis for ice-rich mineral soils. However, it offers no clear advantage in organic soils or unfrozen mineral soils.

### **105 - PIPE-LAYING TECHNOLOGY IN A SUBARCTIC PERMAFROST REGION – A CASE STUDY FOR THE CHINA-RUSSIA CRUDE OIL PIPELINE FROM MO'HE TO DAQING, NORTHERN NORTHEAST CHINA**

Yongping Wang (1), Huijun Jin (1), Jiaqian Hao (1), Guoyu Li (1), Yongjun Cai (2), Shusheng He (2)

(1) *State Key Laboratory of Frozen Soils Engineering, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (Lanzou, China)*; (2) *PetroChina Pipeline Company (Langfang, China)*

This paper summarized some pipe-laying technology experiences and lessons of the China-Russia Crude Oil Pipeline (CRCOP). The main principle on frost hazards mitigation and pipeline route selection is “bypassing” and “protection” of permafrost with mitigative measures. Another supplementary principle is pre-thawing or clearance of permafrost. The mitigative measures mainly include the increase of pipe wall thickness, external thermal insulation, drainage control, re-vegetation, and refilling with the thaw-stable (or non-frost-susceptible) soils. Numerical simulations, field investigations and ground-penetrating radar surveys have provided many key parameters and characteristics of the pipeline and its foundation soils. A strain-based pipeline design and a modified conventional burial were proposed and adopted for the CRCOP.

## **Session/Séance : John Ross Mackay Symposium - Permafrost III / Symposium John Ross Mackay - Pergélisol III**

**Tuesday, September 22, 16:00 - 17:15 / Mardi 22 septembre, 16 h - 17 h 15**

Room / Salle : **204AB**

Co-Chairs / Coprésidents de séance : **Don Hayley & Hugh French**

### **234 - METEOROLOGICAL AND GEOLOGICAL INFLUENCES ON ICING DYNAMICS IN SUBARCTIC NORTHWEST TERRITORIES, CANADA**

Peter Morse (1), Stephen Wolfe (1)

(1) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*

In this study, we test the significance of identified meteorological forcing variables against a long-term dataset of icing dynamics and distribution developed for the Yellowknife region, Northwest Territories. Overall, 28% of icing density interannual variation is explained by winter warming periods ( $>=5^{\circ}\text{C}$ ) and autumn rainfall. Interannual icing density variation and significant meteorological forcing variables differ among ecoregions where varied geological permafrost conditions influence the hydrological regime.



#### **429 - TOPOCLIMATIC CONTROLS ON ACTIVE-LAYER THICKNESS, ALASKAN COASTAL PLAIN**

Frederick Nelson (1), Melanie Schimek (2)

(1) *Northern Michigan University (Milwaukee, United States)*; (2) *University of Delaware (Newark, United States)*

Although many studies of active layer development address spatial variations in soil thermal properties and moisture conditions, few have attempted to isolate topoclimatic influences on active-layer thickness. Observed patterns of thaw depth on various facets of an anthropogenic thermokarst landform near Prudhoe Bay, Alaska show systematic variation with slope orientation. This study demonstrates that aspect has a strong control on active-layer thickness, even at 70°N latitude, with south-facing slopes thawing to greater depth than north-facing slopes and northern exposure compensating even for the absence of an insulating layer of vegetation.

#### **422 - GEOCHEMISTRY OF THE ACTIVE LAYER AND PERMAFROST IN NORTHWESTERN CANADA: FROM MEASUREMENTS TO QUATERNARY STRATIGRAPHY**

Denis Lacelle (1), Marielle Fontaine (1), Steve Kokelj (2)

(1) *Department of Geography, University of Ottawa (Ottawa, Canada)*; (2) *Northwest Territories Geological Survey, Government of the Northwest Territories (Yellowknife, Canada)*

The amount and distribution of soluble ions and salts in active layer and permafrost provide a tool to assess present and past changes in active layer thickness, and chemical weathering regimes in a given landscape. This short paper summarizes various methodologies used for the extraction of soluble salts and ions in the active layer and permafrost, and then tests two methods from two sites in northwestern Canada. The results are discussed with respect to the extraction techniques and the timing of permafrost aggradation following sediment deposition (i.e., syngenetic vs epigenetic permafrost).

#### **248 - THE THERMO-MECHANICAL BEHAVIOR OF FROST-CRACKS OVER ICE WEDGES: NEW DATA FROM EXTENSOMETER MEASUREMENTS.**

Denis Sarrazin (1), Michel Allard (1), Michel Allard (2)

(1) *Centre d'études nordiques (Québec, Canada)*; (2) *Centre d'études nordiques, Université Laval (Québec, Canada)*

Specially adapted extensometers were deployed across eight frost cracks over ice wedges on Bylot Island in order to measure the timing of cracking and width variations of the open cracks over the winter. The cracking-contraction-expansion data were correlated with atmospheric and ground thermal temperature data acquired by automated meteorological stations and thermistor cables. Analysis of the data shows that narrow, sub-millimeter-size cracks first open abruptly early in winter when the active layer is frozen back. The cracks abruptly expand later when permafrost temperature falls below -10 °C. They keep enlarging over the winter, reaching widths between 6.8 and 18.2 mm by the end of March when permafrost temperatures oscillate around -18 to -20 °C. Short and small width variations in winter are associated with warmer spells of a few days duration. The cracks narrow by the end of the winter with warming ground and air temperatures. But they stay open at about half of their maximum width for several weeks in May-June, at the time of snowmelt.



Christopher Burn (1), Brendan O'Neill (1)  
(1) *Carleton University (Ottawa, Canada)*

Ice-wedge polygons are characteristic features of unconsolidated sediments in the continuous permafrost zone. They commonly have a well-defined surface expression in lowland basins, but are also ubiquitous on hill slopes. The polygons are outlined by a network of primary ice wedges, in places subdivided by secondary wedges, and even tertiary features. The evolution of ice-wedge networks was thought to be the result of winter climate variation. Three sets of observations suggest that, instead, the development of secondary and tertiary wedges may be due to growth of the primary ridges and troughs influencing snow depth. (1) J.R. Mackay showed that smaller, secondary wedges may crack more frequently than primary wedges. (2) Hill slope polygons are not characteristically subdivided by secondary ice wedges. (3) Thermal contraction cracks expand over winter, responding to cooling of the ground as the season progresses.

## **Session/Séance : Barriers and Geosynthetics / Barrières et géosynthétiques**

**Tuesday, September 22, 16:00 - 17:15 / Mardi 22 septembre, 16 h - 17 h 15**

Room / Salle : **205A**

Chair / Président de séance : **Éric Blond**

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### **806 - THE PRACTICAL LIMITS OF COLD TEMPERATURE GEOMEMBRANE INSTALLATION IN NORTHERN CANADA**

Andrew Mills (1), Brian Fraser (2), Deepaksh Gulati (2)  
(1) *Layfield Canada Ltd (Edmonton, Canada)*; (2) *Layfield Canada Ltd. (Edmonton, Canada)*

Many industry specifications for geomembranes call for a low temperature installation limit of 0C. These limits were set up for US installations and are rarely practical for more northern Canadian installations. Short Canadian summers inevitably see projects extend into the fall where any day can slip below 0C. In recent years liner installations have been extended so that now it is common for geomembranes to be installed in all months of the year. If 0C is no longer a suitable low temperature limit then what is a suitable guideline for Canadian geomembrane installations?

This paper will look at a project completed in the winter of 2014. This triple-lined pond was installed in temperatures well below -30C. Cold temperature cracking of materials occurred during handling and deployment and one area of cracking developed in a unique area of the pond. Material samples were removed and tested by the manufacturer and were found to meet all project specifications. Comparing field experience with the recorded temperatures allowed us to establish reasonable guidelines for northern Canadian low temperature installations. The paper also discusses the use of newer generation flexible polyolefin geomembranes which help to reduce the amount of field welding and overall installation costs.



## 27 - EFFECT OF BRINE SOLUTION ON ANTIOXIDANTS OF HDPE GEOMEMBRANES

MOHAMAD SHOAI B (1), Kerry Rowe (2)

(1) *Queen's University, Kingston, Canada (KINGSTON, Canada)*; (2) *Queen's University Kingston, Canada (KINGSTON, Canada)*

(HDPE) geomembranes (GMBs) are used as the primary bottom liner for brine storage and evaporation ponds. The brine arising from the processing of waters recovered from shale or coal gas extraction often contains sodium chloride (NaCl), sodium carbonate (NaHCO<sub>3</sub>) and sodium bicarbonate (Na<sub>2</sub>CO<sub>3</sub>) at very high concentrations. This paper describes an experimental examination of the ageing of four different GMBs immersed in brine solution at four different temperatures to monitor the depletion rate of antioxidants/stabilizers added to the GMB formulation to protect the GMB both during manufacturing and subsequently when deployed in the field. The depletion rate of antioxidants depends on several factors, including the amount and type of antioxidants/stabilizers, temperature, the GMB exposure conditions, the diffusion/extraction of antioxidants from the GMB, and the chemical composition of the fluids with which the GMB is in contact. There is a paucity of published research examining the chemical compatibility of HDPE GMB with brine solution. The tests are intended to provide insight regarding the antioxidant depletion rate and its impact on the time to nominal failure of HDPE GMB and therefore will help to provide an estimate of the service life of four different HDPE GMBs immersed in a brine solution.

## 775 - ADVANCES IN GEOMEMBRANES: LEAK LOCATION LINER: GEOMEMBRANE BARRIER SYSTEMS WITH INCREASED INTEGRITY

Boyd Ramsey (1), Vincent Diviacchi (2), Vincent Diviacchi (2)

(1) *Chief Engineer (Houston, United States)*; (2) *Technical Manager - Canada (Elmhurst, United States)*

In recent years, several developments and advances have been made in geosynthetic barriers, particularly barriers in exacting difficult and high risk applications. These developments have advanced the capabilities of geosynthetics and improved the performance of barrier systems. In particular, two applications have changed significantly. On December 19, 2014 the US EPA published the regulations that will be imposed on the storage of coal ash and coal combustion residuals in the United States. In the two years prior to that, a series of advances in leak detection methods and efficiency, leak location techniques and equipment and the materials that facilitate more accurate and rapid leak detection surveys have been fully commercialized and successfully applied to multiple installations around the world. This includes the ability to easily provide continuous monitoring for leakage through geosynthetic systems. This combination of regulations and technology has significantly improved the performance capabilities and potential for geosynthetic barriers. These technologies are reported, case history examples are presented, and projections are made for current and future usage of these materials and techniques.

## 601 - BEHAVIOR OF DRAIN TUBES PLANAR DRAINAGE GEOCOMPOSITE UNDER EXTREME COLD TEMPERATURES

Stephan Fourmont (1), Pascal Saunier (2)

(1) *Texel (Sainte-Marie, Canada)*; (2) *Afitex- Texel (Vancouver, Canada)*

Drainage is a critical component of every construction in civil, environmental and mining engineering. Natural drainage material like gravel or sand is widely used but starts to be replaced by drainage geocomposites, more efficient in term of installation



and environmental footprint. However, these solutions are not always adapted to the extreme climate of northern Canada. Indeed, the structure of the product and its chemical composition have a strong influence on its behavior under cold temperatures and some geocomposites can exhibit an important stiffness making them difficult to install. Their mechanical and hydraulic properties may also be affected. The use of drain tubes planar drainage geocomposites allow for the avoidance of these issues. This paper shows the main characteristics of this type of geocomposite, the lab tests results on its mechanical behavior under cold conditions and presents two case studies of a pond construction and a mine site rehabilitation in northern Canada.

### **280 - FIELD TESTING LARGE SAND-FILLED GEOTEXTILE CONTAINERS USED AS A TEMPORARY FLOOD PROTECTION SYSTEM**

Steven Harms (1), James Blatz (1), Shawn Clark (1)  
(1) *University of Manitoba (Winnipeg, Canada)*

The effectiveness of temporary flood protection is highly variable depending on the location, application, and the nature of flood events. This paper evaluates sand-filled interconnected geotextile containers used as flood protection products within a framework of standardized tests. Two single-layer configurations and two stacked configurations were tested under a variety of flood conditions while seepage rates and product displacements were measured during each test. Researchers implemented a modified version of the US Army Corps of Engineers Standardized Testing Protocol for the Evaluation of Expedient Floodfight structures at an outdoor test facility constructed at the University of Manitoba. Each product configuration was evaluated under hydrostatic loading, wave-induced hydrodynamic loading, overtopping and debris impact conditions. This allowed for informed decisions to be made regarding appropriate applications for each temporary flood protection product configuration, and identifies areas for product improvement and development.

## **Session/Séance : Laboratory Testing III / Essais en laboratoire III** **Tuesday, September 22, 16:00 - 17:15 / Mardi 22 septembre, 16 h - 17 h 15**

Room / Salle : **205BC**

Chair / Président de séance : **Sai Vanapalli**

### **812 - NOVEL EVALUATION OF BENDER RESPONSE IN SAND SPECIMENS USING A LASER VIBROMETER**

Muhammad Irfan (1), Giovanni Cascante (1), Dipanjan Basu (1), zahid khan (2)  
(1) *University of Waterloo (Waterloo, Canada)*; (2) *american university of sharjah (sharjah, United Arab Emirates)*

Bender elements (BE) are used to measure the shear-wave velocity of soils in many geotechnical laboratories worldwide. Despite its popularity, the method remains without a standard procedure, mainly because of the difficulties in controlling the actual behavior of BE inside the soil specimen. Previous studies have monitored and/or simulated the behavior of BE, finding evidence that the actual transmitter movement is not equal in shape and frequency content of the electrical signal used as excitation. However, this is not supported by any direct measurements of BE transmitter vibrations. In this study, a transparent soil is used in conjunction with a laser vibrometer to obtain actual BE transmitter movements in the transparent soil. Measurements of transmitter BE are



obtained in air and in transparent soil under five different stresses. Results show that the BE response in air with a sine pulse excitation resembles the response of a single-degree-of-freedom (SFOD) system. However, the BE response in soil is significantly different with the same excitation. Moreover, the BE response in the transparent soil shows an unexpected variation in amplitude with increase in stress; whereas, there is an increase in frequency of vibration that is consistent with the increase in the medium stiffness.

### **586 - IMPROVEMENT OF THE PIEZO-ELECTRIC RING ACTUATOR TECHNIQUE (P-RAT) USING 3D NUMERICAL SIMULATIONS**

Ahmed Mhenni (1), Mourad Karray (1)

(1) *Université de Sherbrooke (Sherbrooke, Canada)*

Shear wave velocity of soil is commonly measured in the laboratory using piezoelectric elements such the bender elements (BE). These techniques, however, are associated with several difficulties including the mixed radiation of both primary and shear waves, near-field effects, boundary effects, and uncertain detection of first arrivals. A new technique, piezoelectric ring-actuator technique (P-RAT) has been developed in the geotechnical laboratory at the Université de Sherbrooke to minimize/eliminate the difficulties associated with other techniques, in particular, the penetrating of the used sensors into the tested specimens that may be inescapable in BE technique. This paper presents a brief description of the P-RAT technique as well as the results of 3D numerical simulations conducted using the computer code, COMSOL in order to study the interaction between the P-RAT components and the tested sample (soil or solid). This study demonstrate the effectiveness of the P-RAT technique and shows that the 3D simulations can be used in order to improve the reliability and/or the performance of the P-RAT to expand its applicability in the field of civil engineering.

### **121 - MINIMIZING SCALING EFFECT ON THE MEASURED VS USING THE P-RAT**

Mohamed Ben Romdhan (1), Mohamed Ben Romdhan (1), Mahmoud N. Hussien (1), Mourad Karray (1)

(1) *Sherbrooke university (Sherbrooke, Canada)*

Contrairement à la plupart des paramètres géotechniques (par exemple, N-SPT et qc-CPT) qui peuvent être mesurés que sur terrain, la vitesse des ondes de cisaillement,  $V_s$  peut être évaluée insitu ou en laboratoire en utilisant des techniques traditionnelles telles que BE et RC. Ces techniques peuvent être utilisés efficacement pour étudier et quantifier les effets de divers paramètres sur  $V_s$ . Ils ont prouvé leur polyvalence, et l'utilité en particulier pour augmenter les données de terrain limitées. Cependant, le nombre de questions augmente de la même manière que le nombre des essais BE augmente et il pourrait être la raison pour laquelle BE n'est pas encore normalisé. De nombreuses explications et hypothèses ont été faites, mais peu ont signalé que la géométrie de l'échantillon peut affecter la propagation des ondes de cisaillement. Cet article porte sur une étude expérimentale sur l'effet de la taille de l'échantillon sur le  $V_s$  mesurée en utilisant la technique d'anneau actionneur piézo-électrique (P-RAT). Cette technique est incorporé dans l'appareil oedométrique pour obtenir des valeurs  $V_s$  sur des sol granulaire ayant différentes géométries. Les résultats expérimentaux montrent que l'utilisation du P-RAT dans la détermination de  $V_s$  peut minimiser l'effet d'échelle.



#### **449 - MEASURING THE SMALL-STRAIN ELASTIC MODULUS OF GAP-GRADED SOILS USING AN EFFECTIVE-MEDIUM MODEL AND THE RESONANT COLUMN APPARATUS**

Jesús González-Hurtado (1), Timothy Newson (1)

(1) *Geotechnical Research Centre, Department of Civil Engineering, Western University, London, Ontario, Canada (London, Canada)*

Many natural soils are composed of a wide range of different sized particles. Soils such as sandy silts or sandy clays can be considered to be a combination of two poorly graded soils with different grain size distributions. These types of soils are usually known as "gap-graded soils". Although there is a lack of mechanical knowledge of gap-graded soil mechanics in the literature, some work has been conducted on binary mixtures, which provide a reasonable representation of this type of soil. The main focus of this work was to investigate the elastic properties of binary mixtures through the application of an effective-medium model used in rock mechanics. Results from resonant column test experiments on sand-glass bead mixtures were used in this study. Amongst the findings, it was possible to determine a threshold value where the mixture properties abruptly changes and how the elastic moduli of the binary mixtures is affected by this sudden change.

#### **736 - VISUALIZATION OF HEAT TRANSFER TO CHARACTERIZE ENERGY FOUNDATIONS**

Jonathan Black (1), Alireza Tatari (1), Manouchehr Hakhamaneshi (1)

(1) *University of Sheffield (Sheffield, United Kingdom)*

Limited information exists about the thermo-dynamic interactions of geothermal structures and soil owing to practical constraints of placing measurement sensors in proximity to foundations. An alternative experimental method is explored using transparent soil to enable internal visualisation of heat flow in soil. Advocating the loss of optical clarity as a beneficial attribute of transparent soil, this paper explores the hypothesis that temperature change will alter its refractive index and therefore progressively reduce its transparency becoming more opaque. The development of the experimental methodology is discussed and a relationship between pixel intensity and soil temperature is defined and verified. This relationship is applied to an energy pile example to demonstrate heat flow in soil. The heating zone of influence is observed to extend to a radial distance of 1.5 pile diameters and is differentiated by a visual thermal gradient propagating from the pile.

### **Session/Séance : Foundations III / Fondations III**

**Tuesday, September 22, 16:00 - 17:15 / Mardi 22 septembre, 16 h - 17 h 15**

Room / Salle : **207**

Chair / Président de séance : **Hany El Naggar**

#### **633 - EVALUATION OF PREDICTION ACCURACY OF ULTIMATE BOND STRENGTH OF SOIL NAILS BY THE EFFECTIVE STRESS METHOD**

Peiyuan Lin (1), Richard Bathurst (2), Jinyuan Liu (1)

(1) *Ryerson University (Toronto, Canada); (2) Royal Military College of Canada (Kingston, Canada)*

This paper presents a statistical evaluation of the accuracy in predicting the ultimate bond strength of soil nails using the effective stress method (ESM). A total of 113 data points from field nail pullout tests taken to failure in Hong Kong were collected from the



literature. After removing outliers, the data were used to estimate the accuracy of the current ESM. Based on the available data, the current ESM pullout model is found to be excessively conservative (on average) by a factor of three or more and the spread in prediction accuracy is large. In addition, the accuracy of the current model for prediction of nail bond strength is shown to be dependent on the magnitude of predicted ultimate bond strength. This undesirable dependency is traced to a strong correlation between model accuracy and vertical effective stress computed at the elevation of the soil nail anchor embedment length.

#### **149 - ESTIMATION OF UPLIFT SHAFT FRICTION FOR A SINGLE PILE IN EXPANSIVE SOIL USING THE MECHANICS OF UNSATURATED SOILS**

Yunlong Liu (1), Sai Vanapalli (1)  
(1) *University of Ottawa (Ottawa, Canada)*

Pile foundations that are installed in unsaturated expansive soils are subjected to uplift forces along the pile shaft due to the swelling of the expansive soils upon infiltration. This leads to the redistribution of the pile axial force and possible upward movement of the pile body. For this reason, it is necessary to take into account of uplift shaft friction by determining or estimating the uplift shaft friction along the shaft in the rational design of piles in expansive soils considering the influence of lateral swelling pressure. In this paper, the conventional  $\beta$  method for calculating pile lateral friction is modified to estimate the uplift shaft friction for a single pile in expansive soils upon infiltration considering the influence of lateral swelling pressure and matric suction. The proposed method is successfully validated using the experimental data by Fan (2007).

#### **75 - INNOVATIVE DEEP FOUNDATION SUPPORT USING DUCTILE IRON PILES**

Mark Tigchelaar (1), Jason Brown (1), Brenan FitzPatrick (2)  
(1) *GeoSolv Design/Build Inc. (Vaughan, Canada)*; (2) *DuroTerra LLC (Braintree, United States)*

Working in urban environments presents unique logistical challenges beyond those typically associated with traditional geotechnical analysis and design. This paper describes the construction, design and quality control details including load testing of Ductile Iron Piles - an innovative piling system used in Europe for decades. Project applications and system benefits are also described. The paper presents practical examples of North American projects where the system provided economic, construction and technical advantages.

#### **23 - EVALUATION OF SEISMIC KINEMATIC AND INERTIAL FORCES IN PILES**

Mahmoud Hussien (1), Mourad Karray (1), Tetsuo Tobita (2), Susumu Iai (2)  
(1) *Université de Sherbrooke, Sherbrooke (Sherbrooke, Canada)*; (2) *Kyoto University (Kyoto, Japan)*

Parametric analyses are carried out by means of nonlinear two-dimensional (2D) finite element (FE) analyses, focusing on normalized seismic forces in piles supporting structures as affected by typical characteristics of structures and piles. The results of the study provide a new interpretation of the interplay between pile kinematic and inertial seismic forces. It is found that for relatively short/stiff piles; the kinematic interaction can be the prime contributor to the seismic forces in the pile provided that the excitation frequency is not close to the natural frequency of the coupled soil-pile-structure system, f<sub>SSI</sub>. The results show also that maximum kinematic seismic force does not always occur





at the fundamental frequency of the deposit. For certain relative soil-pile stiffness and excitation amplitudes, the largest peak of the kinematic seismic forces in piles can be occurring at the second mode.

## 72 - TOTAL VERSUS DIFFERENTIAL SETTLEMENT OF DEEP FOUNDATIONS

Farzaneh Naghibi (1), Gordon A. Fenton (1), D. V. Griffiths (2)  
(1) *Dalhousie University (Halifax, Canada)*; (2) *Colorado School of Mines (Golden, CO, United States)*

This paper investigates the probabilistic nature of differential settlement between two identical piles founded in a spatially variable linearly elastic soil. A theoretical model is developed, and validated by simulation, which is then used to calculate the probability of excessive differential settlement. The theoretical model can be employed in the design of individual piles to avoid excessive differential settlements.

## Session/Séance : Geotechnical Education Challenges / Défis de la formation en géotechnique

**Tuesday, September 22, 16:00 - 17:15 / Mardi 22 septembre, 16 h - 17 h 15**

Room / Salle : **2102B**

Chair / Président de séance : **Serge Leroueil**

## 742 - POURQUOI PAS UN BACCALURÉAT EN GÉNIE GÉOTECHNIQUE ?

Jean Lafleur (1), Pierre Montès (1)  
(1) *École Polytechnique (Montréal, Canada)*

La géotechnique devient une discipline de plus en plus étendue avec des outils de conception qui se multiplient tant au niveau des logiciels de calcul disponibles que des techniques de mesures en laboratoire et sur le terrain. Du côté amont, le financement de la formation universitaire s'avère de plus en plus restreint et les pressions pour former un ingénieur dans les plus brefs délais sont de plus en plus grandes. D'autre part dans l'état actuel, il faut consacrer au minimum plus d'une année à des études supérieures pour pratiquer la géotechnique. N'est-il pas temps de changer la situation? Il serait possible de conserver au départ de ce nouveau programme les notions scientifiques et professionnelles de base indispensables tout en insistant davantage sur l'impact de la géologie dans la conception des ouvrages et la conduite des travaux de génie. À cause de ce manque de connaissances, les ingénieurs débutant dans la pratique sont souvent mal outillés pour formuler des hypothèses réalistes de calcul de fondations alors que c'est là le propre de l'ingénieur géotechnicien qui souvent ne bénéficie pas de toute l'information nécessaire pour prendre les décisions appropriées.

## 145 - PERSONAL REFLECTION OF TEACHING ADVANCED FOUNDATION DESIGN COURSE

Jinyuan Liu (1)  
(1) *Ryerson University (Toronto, Canada)*

This paper presents course development and lessons learned from teaching Advanced Foundation Design at Ryerson University. This graduate level course considers practical design of shallow and deep foundations for various structures. The topics cover subsurface



investigation, foundation type and selection, design principles, shallow foundations, pile design for axial and lateral loads, and pile group. This course was developed eight years ago and modified over the years. So far it has been offered four times to graduate students, on an average of 20 students each time. The tasks for students include attending regular lectures and guest talks, conducting personal readings and individual and team projects, critical reviewing of a research paper, making a presentation, and finishing a final exam. The results from the last four offers will be discussed based on statistical analyses of student compositions, student performance, and feedback. In the end, how to improve the quality of teaching and enhance the students' learning experience for future teaching will be discussed.

## **752 - BLENDED TRAINING AND COLLABORATIVE LEARNING FOR SOFTWARE USERS IN THE GEOSCIENCES.**

Efrosyni-Maria Skordaki (1), Susan Bainbridge (2)

(1) *Royal Military College of Canada (Kingston, Canada)*; (2) *Centre for Distance Education, Athabasca University (Athabasca, Canada)*

Geoscientists and geo-engineers use scientific software in applications that can directly affect public safety. Water quality geochemical assessments, modeling of contaminant transport in the environment or geological hazard risk assessments, all involve the use of scientific software (i.e. numerical modeling programs). Although training on this type of software is necessary to ensure correct scientific decisions, literature indicates that it is currently conducted without the backing of supportive theory. This study examines the delivery of scientific software training, in blended learning settings, through the eyes of software users in their natural setting of practice. Preliminary data reveal that scientific software users perceive training on this type of software as the process wherein the users inform their practices by developing their conceptual skills. This depends on their participation in knowledge mobilization activities within an online/onsite community of practice, ability to develop risk management strategies (i.e. checking their software assumptions) as well as the profile of the user (background/strengths, motivation regarding distance/self-directed learning or willingness to openly share information).

## **759 - REDESIGNING FIELD SCHOOL: E-PARTICIPATION IN GEOTECHNICAL FIELD EXERCISES.**

Efrosyni-Maria Skordaki (1), Nicholas Vlachopoulos (2)

(1) *Centre for Distance Education, Athabasca University (KINGSTON, Canada)*; (2) *Civil Engineering Department, Royal Military College of Canada (KINGSTON, Canada)*

There is much academic debate in terms of what to include in undergraduate and graduate programs for GeoEngineering students at Canadian Universities (and abroad) in order for a student to gain fundamental knowledge and become fully prepared for the challenges associated with the workforce. In determining the proper balance of methods and tools to be utilized within a Geological / Geotechnical Engineering graduate program, a number of factors need to be considered. The most prevalent of these factors are: The current state of industry and their requirements, technological improvements, sustainable development as well as the advancement of educational tools and techniques. This paper highlights the use of blended, synchronous/asynchronous interactions for the purposes of enhancing geological field exercises; not limiting the experience to those physically on the field exercise. This proof of concept case study demonstrates that field exercises, related assignments and real world learning do not have to be limited to those that can afford to participate in such excursions. The paper will underscore the relevance of the inclusion of such activities, technologies and associated teaching methods balanced against the very real time, fiscal and technology constraints and a need to optimize these efforts.



### **390 - A LONGITUDINAL SURVEY OF EXPERIENTIAL FIELD-BASED LEARNING IN GEOLOGICAL SCIENCES AND GEOLOGICAL ENGINEERING (GS&GE) AT QUEEN'S UNIVERSITY USING STUDENT ASSESSMENT OF LEARNING GAINS (SALG)**

Vicki Remenda (1), Douglas Archibald (1)  
(1) Queen's University (Kingston, Canada)

Field-based learning, in site investigation and geological mapping, is essential to the education of geological engineers because it develops the habit of mind of integrating sparse, disparate observations into meaningful conceptual models and helps students transition from learner to expert. To investigate students' field experiences and learning gains, we initiated a long-term on-line survey of students in Years 2 to 4. The SALG instrument consists of 4 sections each using Likert-like items to assess gains in: 1) thinking and working like a geoenvironmentalist, 2) skills development, 3) confidence in fieldwork, and 4) changes in attitudes. Item scores show year-to-year increases indicating that students are progressing in developing skills and are moving from emerging to mastery of the learning outcomes.

### **Session/Séance : Landslides and Slope Stability IV / Mouvements de terrain et stabilité des pentes IV**

**Tuesday, September 22, 16:00 - 17:15 / Mardi 22 septembre, 16 h - 17 h 15**

Room / Salle : **2104AB**

Chair / Président de séance : **Michael Porter**

### **373 - MONITORING GEOHAZARDS NEAR PIPELINE CORRIDORS WITH AN ADVANCED INSAR TECHNIQUE AND GEOMECHANICAL MODELLING**

Jayanti Sharma (1)  
(1) MDA Systems Ltd. (Richmond, Canada)

Surface displacements derived from Interferometric Synthetic Aperture Radar (InSAR) for the monitoring and risk assessment of geohazards near pipeline corridors are presented. The InSAR results are integrated with GIS analyses and field data to define geologic and preliminary geomechanical models using the InSAR-derived displacements and GIS-derived geological features as a constraint. Geohazard monitoring is demonstrated over the Fels Glacier in Alaska, which is bordered by active, deep-seated, slowly deforming slopes with the potential for generating large landslides that could damage the nearby Trans-Alaska Pipeline and Richardson Highway.

### **513 - 3D DATA COLLECTION FOR RAPID ROCK FALL RESPONSE SITUATIONS**

Matt Lato (1), Dave Gauthier (2), Pete Quinn (1), Jean Hutchinson (3), Ryan Kromer (3), Tom Edwards (4), Jose Riopel (5)  
(1) BGC Engineering Inc. (Ottawa, Canada); (2) BGC Engineering (Kingston, Canada); (3) Queen's University (Kingston, Canada); (4) CN Railway (Edmonton, Canada); (5) QNS&L Railway (IOC) (Sept-Îles, Canada)

Linear infrastructure corridors in rugged terrain are typically vulnerable to rockfall and rockslide type natural hazards. Once a hazardous event has occurred that warrants investigation in relation to the safety of the site it is critical to collect detailed information quickly. The Railway Ground Hazard Research Program has invested in the development



of remote sensing techniques that can be deployed in a rapid response scenario. Oblique Helicopter Photogrammetry (OHP) is a technique that enables the generation of 3-dimensional (3D) point cloud data from photos using Structure from Motion (SfM) photogrammetry. This paper discusses two case studies in which the operator of a single track railway line experienced a rockslide event that required an immediate engineering response. The first case study is located along a CN railway line 1 km northeast of Vancouver, BC where a rockslide activated a slide detector fence. The second site is located along a QNS&L railway line 20 km north of Sept-Îles, QC where a rockslide covered the tracks and forced the temporary closure of the railway. An immediate response was undertaken by both railways. In both instances the time between data collection and initial model development was less than 24 hours.

#### **492 - ROCKFALL PROTECTION ALONG HIGHWAY 403 IN HAMILTON, ON: A RECENT RE-ASSESSMENT AND APPLICATION OF EMERGING SITE INVESTIGATION METHODS.**

*David Wood (1)*

*(1) David F. Wood Consulting Ltd. (Sudbury, Canada)*

The Niagara escarpment is a unique area of high relief and exposed bedrock in Southern Ontario between Niagara in the south, and Tobermory in the north. Ontario King's Highway 403 transects the escarpment with a long approach along the toe of an active talus slope, and directly adjacent to exposed bedrock near to the crest of the escarpment, within the limits of the City of Hamilton. Engineered rockfall hazard protection extends for approximately 1.5 km through this area, with a combination of a 500 kJ capacity rigid catchment fence and a narrow ditch/clear zone. Following a number of rockfall events in 2012, some of which impacted the fence and reached the shoulder of the eastbound lanes, a detailed assessment of the efficacy of the existing protection was undertaken. In this paper we report on the application of traditional and emerging site investigation methods employed in this assessment. We focus on the use of oblique aerial photogrammetry to generate a detailed 3D terrain model of the 1.5 km long slope, from crest to road, and report on the use of that information in a number of novel ways to evaluate the protection provided, and recommend further risk management measures.

#### **356 - SOME FACTORS AFFECTING RETROGRESSIVE FAILURE OF SENSITIVE CLAY SLOPES USING LARGE DEFORMATION FINITE ELEMENT MODELING**

*Chen Wang (1), Biswajit Saha (2), Bipul Hawlader (2)*

*(1) Memorial University of Newfoundland (St. John's, Canada); (2) Memorial University of Newfoundland (St. John's, Canada)*

Many landslides in sensitive clay slopes near the riverbank in Eastern Canada and Scandinavia have been reported in the literature. Some of them extended over a large horizontal distance from the river bank. Traditional limit equilibrium methods cannot explain such failure because the failure surfaces develop progressively. Finite element (FE) modeling of such failure is also very challenging because significant strain localization occurs along the failure plane (shear band) that results in unacceptable mesh distortion. Moreover, the failed soil mass might displace a very large distance.

The process of failure of sensitive clay slopes due to toe erosion is simulated using a large deformation FE modeling technique. Post-peak degradation of undrained shear strength and its effects on progressive failure surface development are examined. The effects of some factors, such as the amount of toe erosion, initial stress conditions (KO) and height of the slope, are examined. It is shown that these factors could change the failure patterns of sensitive clay slopes near the river bank.



## **650 - NOUVELLE INVESTIGATION GÉOTECHNIQUE DU GLISSEMENT DE TERRAIN DE 1971 LE LONG DE LA RIVIÈRE DE LA NATION SUD, ONTARIO**

Alain Durand (1), Ariane Locat (1), Serge Leroueil (1), Pascal Locat (2), Denis Demers (2)  
(1) Université Laval (Québec, Canada); (2) Ministère des Transports du Québec (Québec, Canada)

Un très grand glissement de terrain d'une superficie d'environ 28 hectares s'est produit dans la nuit du 16 au 17 mai 1971, le long de la rivière de la Nation Sud près du village de Casselman, Ontario. L'analyse des débris à l'intérieur de la cicatrice du glissement révèle la présence de horsts et de grabens, typique des étalements dans les argiles sensibles. Le Ministère des Transports du Québec et l'Université Laval collaborent à la réalisation d'une investigation géotechnique afin de caractériser les propriétés géotechniques des sols impliqués dans ce glissement. La campagne comprend deux forages, trois profils d'essais au scissomètre et cinq sondages au piézocône situés à l'extérieur du glissement. De plus, 11 sondages au piézocône et deux forages ont été réalisés à l'intérieur de la cicatrice du glissement afin de détecter la position de la surface de rupture et de caractériser les débris du glissement. Les principaux résultats de cette campagne d'investigation sont présentés.

## **Session/Séance : Geophysical Investigation in Cold Regions / Investigations géophysiques en milieu nordique**

**Tuesday, September 22, 16:00 - 17:15 / Mardi 22 septembre, 16 h - 17 h 15**

Room / Salle : **2105**

Chair / Président de séance : **Michael Angelopoulos**

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### **205 - SEISMIC STUDIES OF FROZEN GROUND IN RUSSIAN ARCTIC AREAS**

Marat Sadurtdinov (1), Andrey Skvortsov (1), Andrey Tsarev (1), Maria Sudakova (1)  
(1) Earth Cryosphere Institute SB RAS (Moscow, Russia)

This report shows the results of a study of permafrost conditions in the coastal and nearshore areas of the Russian Arctic seas that was carried out through seismic methods. For this study, the researchers developed a new technique for using seismic methods on the floor or shallow waters, combining bottom and downhole surveys. In order to more reliably identify frozen state deposits, Poisson's ratio was used as an added seismic criterion. The results obtained show that in seismic surveys on the sea bottom, SH-waves are preferable to P-waves.

### **336 - GEOPHYSICAL MONITORING OF ENGINEERING CONSTRUCTIONS IN WESTERN YAKUTIA AND STUDY OF COUPLED PROBLEM OF TEMPERATURE AND SEEPAGE FIELDS IN PERMAFROST NEAR HYDRO UNIT**

Svet Milanovskiy (1), Sergey Velikin (2), Alexey Petrunin (3), Istratov Vyatcheslav Istratov Vyatcheslav (4)  
(1) Institute Physics of the Earth RAS (Moscow, Russia); (2) Vilyui Permafrost Station of the Permafrost Institute SB RAS (Chernishevskii, Russia); (3) GeoForschungsZentrum (Potsdam, Germany); (4) Radionda Ltd Company (Moscow, Russia)

For the last two decades on a number of Hydro Units in Western Yakutia, we observe seepage process compromising their secure. We present geophysical methods for verification of permafrost state near Sitikan and Vilyui Hydro Units. Complex includes



electric, electromagnetic, ground penetrating radar, hydro location, thermal and radiowave (down-hole) measurements. Ground level and down-hole geophysical survey focused on detecting thawing zones (talik) in dam, its flank and tail-water zone. Long-term geophysical monitoring shows up spatial-temporal permafrost evolution and talik development in the flank shore of Sitikan dam. Detecting of inflow zone and seepage velocity performed for right-bank contiguity of Vilyui HPS-1. Alongside with field studies the numerical evaluations of conditions of originating permeable talik-zones (thawing) in a board zone of dam, was down. Numerically analyzed conditions causing origin and development of talik near reservoir: annual air temperatures, snow cover, annual water temperature in storage basin with depth, permeability evolution in frozen soil. Proposed model can be used for analyzing more complex situation.

### **396 - INVESTIGATIONS OF DISCONTINUOUS PERMAFROST IN COASTAL LABRADOR WITH DC ELECTRICAL RESISTIVITY TOMOGRAPHY**

*Robert Way* (1), *Antoni Lewkowicz* (1)

(1) *Department of Geography, University of Ottawa (Ottawa, Canada)*

Investigations of ground conditions within the coastal Labrador communities of Cartwright (54°N) and Nain (57°N) revealed occurrences of discontinuous permafrost. The characteristics of permafrost bodies were examined using a combination of standard field methods and DC electrical resistivity tomography (ERT). In Cartwright, local climate is unfavourable for permafrost with mean annual air temperatures exceeding 0°C in recent years. Consequently, permafrost is thin (<6 m) and restricted to small palsa fields in raised bogs at exposed coastal locations. In the more northerly field area in Nain, permafrost was inferred to be present at numerous sites under both fine and coarse surficial covers. Permafrost up to 18 m thick was inferred in marine deposits at the coast and up to 9 m at a forested site. Despite challenges, a combination of standard field based methods and ERT can discriminate between frozen and unfrozen ground at these sites.

### **283 - CHARACTERIZING PERMAFROST VALLEY FILLS ALONG THE ALASKA HIGHWAY, SOUTHWEST YUKON**

*Joel Pumple* (1), *Duane Froese* (1), *Fabrice Calmels* (2)

(1) *University of Alberta (Edmonton, Canada)*; (2) *Yukon Research Centre (Whithorse, Canada)*

In the Beaver Creek area of southwest Yukon, the Alaska Highway traverses both glaciated and non-glaciated terrain from the last glacial maximum. In this area permafrost characteristics are strongly influenced by regional glacial history including the distribution of relict Pleistocene permafrost. Here we characterize the distribution and history of permafrost in a valley fill along the Alaska Highway between Beaver Creek and the Alaska border using a multidisciplinary approach. Our surveys include Electrical Resistivity Tomography (ERT), permafrost drilling, cryostratigraphy, and geochemical analyses to define the boundaries and characteristics of the valley fill. Using ERT data we are able to map the distribution of relict syngenetic permafrost from the late Pleistocene within the valley fill, from areas where similar sediments have degraded and have been subsequently overlain by organic-rich sediment through the Holocene. Radiocarbon dating and stable isotope analyses of  $\delta^{18}O$  and  $\delta D$  combined with detailed cryostratigraphy confirm that much of the ground ice is relict syngenetic ground ice from the late Pleistocene.



**318 - GEOPHYSICAL IMAGING OF PERMAFROST CONDITIONS ALONG THE NORTHERN YUKON ALASKA HIGHWAY**

Greg A. Oldenborger (1), Anne-Marie LeBlanc (1), Anne-Marie LeBlanc (1), Chris W. Stevens (2), Jason Chartrand (1), Benoit Loranger (3)

(1) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*; (2) *SRK Consulting Inc. (Anchorage, United States)*; (3) *Université Laval (Québec, Canada)*

Three sections of the northern Yukon Alaska Highway have been identified for testing the usefulness of geophysical surveys for understanding permafrost degradation and assisting with highway management. Results from capacitive resistivity and ground-penetrating radar surveys are analysed and interpreted along with surficial maps, geotechnical borehole records, and surface observations of highway roughness and distress. Observed damage appears to be associated with a variety of ground ice conditions. The geophysical results help elucidate the terrain conditions and support the conclusion that multiple subsurface processes contribute to highway degradation. Several geophysical signatures are interpreted as indicative of terrain conditions involving ice-rich ground, frozen ground, thaw-susceptible sediments and shallow groundwater.







# WEDNESDAY TECHNICAL PROGRAM / PROGRAMME TECHNIQUE DU MERCREDI

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## Poster Sessions / Séances d'affiches

### General Geotechnique and Engineering Geology / Géotechnique générale et géologie de l'ingénieur

Wednesday, September 23, 10:00 - 10:30 and 15:00 - 15:30 /  
Mercredi 23 septembre, 10 h - 10 h 30 et 15 h - 15 h 30

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#### 50 - EFFECTS OF SPATIAL VARIABILITY OF SOIL PARAMETERS ON THE DIFFERENTIAL SETTLEMENT AND THE INTERNAL FORCES OF A FRAME STRUCTURES

Mohamad Nazieh Jililati (1)

(1) *Widener University (Chester, United States)*

One of the distinguishing features of geotechnical reliability analysis, compared to other structural reliability analysis such as concrete and steel structures is material properties are different from site to site. The sources of uncertainties in reliability analysis are usually classified in four categories, namely physical uncertainty, model uncertainty, statistical uncertainty and gross error.

The purpose of this study is to quantitatively evaluate the impact of physical uncertainty of soil on the differential settlement of circular shallow foundations on statistically homogeneous elastic ground and the stresses in a 1<sup>st</sup> degree indeterminate frame structures. The settlement and the differential settlement were predicted; the stresses had not exceeded 1.2% increment of the homogenous conditions in the studied frame structure.

#### 96 - PERFORMANCE ANALYSIS OF A SOIL NAIL WALL OF A DEEP EXCAVATION

Emad Zolqadr (1), Shahab Yasrebi (2), Hadi Momeninoshari (1)

(1) *P.O.R. Consulting Engineers Company (Tehran, Iran)*; (2) *Enskon Ltd (Toronto, Canada)*

This study surveys the performance of a temporary soil nail wall with maximum height of 30.6m in Amirkabir complex project, located in Tehran. The water table located 15m under natural ground surface. Some numerical models were developed using a Finite Element software, based on results of field and laboratory tests. Simulation construction process of the soil nailed wall was carried out considering the sequence of construction stages. The modeling results were analyzed and compared with the in-situ monitored data. The results demonstrate, the model's horizontal deformations are generally greater than In Situ monitored values. Therefore the parameters of soil layers were back analyzed to narrow the differences between the results of models and monitored data. As it was an EPC project, the results of monitoring and back analysis are applied to optimize system design during construction.



### 131 - ÉVALUATION EN LABORATOIRE DES CARACTÉRISTIQUES THERMIQUES DU BASSIN SÉDIMENTAIRE DES BASSES-TERRES DU SAINT LAURENT

Maheer NASR (1), Jasmin Raymond (1), Michel Malo (1)

(1) Institut National de la recherche scientifique (INRS), Centre Eau-Terre-Environnement (Québec, Canada)

Une évaluation des propriétés thermiques en laboratoire a été effectuée sur une cinquantaine d'échantillons de surface des principales formations de la plateforme des Basses-Terres du Saint-Laurent. Cette étude fait partie d'un plus vaste projet destiné à évaluer la possibilité de produire de l'électricité à partir de la géothermie profonde dans la province de Québec. Les échantillons ont été ramassés dans la portion québécoise du bassin sédimentaire et forment une collection quasi représentative de toute la colonne stratigraphique de la plateforme des Basses-Terres du Saint-Laurent. Les analyses de conductivité thermique ont été réalisées avec une sonde à aiguille sur des échantillons majoritairement secs et parfois humides.

Les résultats démontrent que les formations argileuses à l'instar des groupes d'Utica et de Sainte-Rosalie sont les plus isolantes, avec une conductivité thermique de l'ordre de 2.5 W/(m.K), une capacité thermique massique de près de 850 J/(kg.K). En revanche, les formations gréseuses se présentent comme les meilleures unités conductrices de chaleur. Les grès de Potsdam par exemple montrent une conductivité thermique allant jusqu'à 6 W/(m.K), une chaleur massique de 700 J/(kg.K).

### 159 - MÉTHODOLOGIE DE CARACTÉRISATION ET DE VALORISATION DES SÉDIMENTS MARINS EN TECHNIQUE ROUTIÈRE

Raouf Achour (1), Patrice Rivard (2), Nor-Edine Abriak (1), Rachid Zentar (1), Pascal Grégoire (3)

(1) École des Mines de Douai (Douai, France); (2) Université de Sherbrooke (Sherbrooke, Canada); (3) Grand Port maritime de Dunkerque (Dunkerque, France)

La valorisation des sédiments marins non-immérgeables du Grand Port Maritime de Dunkerque comme un nouveau granulat présente une solution alternative aux granulats conventionnels. Cet article se focalise sur l'étude de valorisation de sédiment marin en technique routière (en laboratoire et insitu). L'objectif est de démontrer la faisabilité de la valorisation des sédiments marins en technique routière. On vise à proposer une méthodologie de valorisation sur la base d'évaluation de paramètres, physiques, chimiques et mécaniques des sédiments de dragage. Une valorisation des sédiments marins en couche de fondation est envisagée avec un mélange d'un 1/3 de sédiments marins et 2/3 de sable de dragage traité à la chaux vive et au liant hydraulique. Un second objectif de ce travail en laboratoire consiste à prévoir le comportement mécanique et l'aspect environnemental de la formulation proposée à base des sédiments non-immérgeable à court et à long terme. La formulation caractérisée en laboratoire a été appliquée sur le terrain en réalisant une première route expérimentale en France au Freycinet 12 à Dunkerque. Les résultats en laboratoire et sur site ont montré la viabilité de l'approche proposée.



## 243 - GEOTECHNICAL AND GEOPHYSICAL CHARACTERISTICS OF SOILS IN MAHOTIERE (KENS COFF-HAITI)

Berthoumieux Junior JEAN (1), Dominique Boisson (2), Jean-François Thimus (3), Christian Schroeder (4)

(1) *Laboratoire National du Batiment et des Travaux Publics / Université d'Etat d'Haiti (Port-au-Prince, Haiti)*; (2) *Université d'Etat d'Haiti (Port-au-Prince, Haiti)*; (3) *Université Catholique de Louvain (Louvain-la-Neuve, Belgium)*; (4) *Université Libre de Bruxelles (Bruxelles, Belgium)*

A geological study based on bibliographic data found on Kenscoff-Mahotiere area revealed that this region is part of "Massif de la Selle System" and is constituted mainly of two sedimentary dating from the Eocene (ei - limestone) and Paleocene (ep - clay). The geotechnical analysis (physical, mineralogical and chemical identification tests) carried out in the laboratory has allowed to classify the soil samples collected in Mahotiere as calcareous sand and plastic clay, especially in the presence of smectite, chlorite and kaolinite. The geophysical survey carried out In Situ (electrical sounding, electrical tomography and refraction seismic) confirms the geological nature of the soil and also describes its geophysical behavior. We made a comparative study between these two approaches to obtain the final characterization of the soil and to determine in the study area the different soils profiles such as: plastic swelling clay and limestones.

## 354 - REMEDIAL MEASURES INCORPORATING JET GROUTING AND MICROPILES FOR THE CONSTRUCTION OF A NEW BACK FLOW PREVENTER

Naresh Gurpersaud (1), Naresh Gurpersaud (1), Jim Bruce (2), Mark Redden (2)  
(1) *Geo-Foundations (Acton, Canada)*; (2) *Geo-Foundations Contractors Inc. (Acton, Canada)*

A new back flow preventer (BFP) was constructed as part of Toronto's West Don Lands (WDL) redevelopment in preparation for the 2015 Pan Am Games. Movement of three adjacent existing bridge piers early during conventional construction necessitated an embargo on dewatering, a change from conventional to innovative techniques as well as remedial measures to construct the new backflow preventer. The site is located within the flood plain of the Don River and is underlain by over 30 metres of weak organic deposits. Overlapping jet grouted columns were installed using the double fluid process to create both a low permeability base plug and a vertical cut-off. Rock-socketed micropiles were installed through the jet grout base plug to support and tie-down the new chamber. Several challenges were encountered during remedial works, namely revisions to the method and sequence required to mitigate further movement of the adjacent bridge piers. Eventually additional micropiles were installed as part of a foundation retrofitting scheme to permanently transfer the foundations of the three existing bridge piers to rock. Details of the jet grouting, backflow preventer micropiles and bridge micropiles, including test programs and challenges encountered during construction are outlined in this paper.

## 376 - PREDICTION OF GROUND TEMPERATURE FOR SOUTHERN PORTION OF PRAIRIE PROVINCES

Entzu Hsieh (1)  
(1) *Amec Foster Wheeler (Calgary, Canada)*

Prediction of the mean annual and seasonal ground temperatures at 1.5 m depth were carried out for the southern portion of the Prairie Provinces. The study area is characterized with various soil types, differing climate zones and agricultural lands with different planting and harvesting dates. One-dimensional geothermal analyses were conducted to predict the ground temperatures at shallow depth. Various sets of boundary conditions including



air temperature, ground vegetation, and snow thickness were considered in the model. Sensitivity analyses were conducted to evaluate the impact of soil heat capacity, thermal conductivity, and climate parameters on predicted ground temperature.

### **394 - ARSENIC REMOVAL FROM CONTAMINATED WATER AND ITS STABILIZATION IN SOIL USING IRON/COPPER NANOPARTICLES**

Yassaman Babae (1), [Catherine Mulligan](#) (1), Catherine Mulligan (1), Md Saifur Rahaman (1)  
(1) *Concordia University (Montreal, Canada)*

Arsenic contamination of water has become a crucial water quality problem in many parts of the world considering the fact that the source of pollution is mostly contaminated soils. To overcome this problem many new technologies are being developed, among them using nanoparticles as a new class of adsorbents is becoming attractive because of their high specific surface area and higher surface reactivity due to their extremely small size. In this research, iron/copper bimetallic nanoparticles were used to remove arsenic from aqueous solutions as well as to stabilize arsenic in an industrial contaminated soil. Results of this study show that Fe/Cu nanoparticles are effective for removing arsenic from aqueous solutions and have the potential for developing a simple process for field applications to stabilize arsenic in soil.

### **504 - ÉTUDE DE CAS : SITE MINIER NEW CALUMET, VALIDATION D'UN RECOUVREMENT AVEC GÉOMEMBRANE BENTONITIQUE**

[Jean-François St-Laurent](#) (1), Nathalie Chevé (1), Martine Paradis (2)  
(1) *WSP Canada (Québec, Canada)*; (2) *DRSM, MERN (Québec, Canada)*

L'activité minière a engendré de nombreuses aires d'accumulation de résidus miniers sur le territoire québécois. L'ancien site minier New Calumet a le statut de site minier abandonné et est actuellement restauré par l'État. Les résultats des campagnes de caractérisation indiquent que les résidus sont lixiviables à risque élevé et potentiellement générateurs d'acide. Les mesures in situ de la qualité de l'eau montrent la présence d'un drainage neutre contaminé. Basée sur les conditions topographiques du site et sur les conditions hydrologiques et hydrogéologiques du système, la méthode de restauration sélectionnée est un recouvrement avec géomembrane bentonitique (GMB). Dans le processus d'approbation et de validation du concept d'ingénierie, une revue de littérature a été effectuée de même que des essais en laboratoire afin d'évaluer la performance à long terme du recouvrement proposé. Les essais de laboratoire ont permis d'évaluer l'impact combiné des cycles de gel-dégel et de mouillage-séchage sur la conductivité hydraulique des GMB et l'effet de transfert ionique entre différents fluides et la bentonite.

### **645 - INFLUENCE OF CHOICE OF SMALL- AND LARGE-STRAIN MODE IN FLAC ON SOIL-GEOSYNTHETIC INTERACTION PROBLEMS**

[Richard Bathurst](#) (1), Yan Yu (1), Lin Bo-Hung (2)  
(1) *Royal Military College of Canada (Kingston, Canada)*; (2) *National Chi Nan University (Taipei, Taiwan)*

Soil-geosynthetic interaction plays a major role in the performance of mechanically stabilized earth structures such as reinforced soil walls, steep slopes and embankments. Program FLAC is now used routinely by engineers for the design and analysis of these structures. Accurate numerical modelling requires the use of appropriate constitutive models which has been the subject of much research. However, numerical outcomes may also be sensitive to geometric nonlinearity which is detectable when numerical simulations are carried out



in both small- and large-strain modes in program FLAC. The paper examines two examples of soil-geosynthetic interaction problems using FLAC. The cases are: 1) horizontal pullout of a geosynthetic layer in a pullout box; and 2) a reinforced soil layer over a void. FLAC simulations are carried out both in small-strain mode (i.e., without numerical grid updating) and in large-strain mode (i.e., with numerical grid updating). N Examples of numerical results are demonstrated by comparing numerical outcomes using both approaches with physical test results available in the literature. This paper will assist engineers to identify those conditions where numerical simulations of geosynthetic-reinforced soil structures should be carried out in large-strain mode in order to avoid unreasonable numerical outcomes.

#### **646 - CARACTÉRISATION PRÉLIMINAIRE DE LA RÉSISTIVITÉ ÉLECTRIQUE DE L'ARGILE SENSIBLE À BROWNSBURG, QUÉBEC**

Karine Bélanger (1), Ariane Locat (2), Richard Fortier (2), Denis Demers (1), Majid El Baroudi (2), Andrée-Anne Fortin-Rhéaume (1)

(1) *Ministère des Transports du Québec (Québec, Canada);* (2) *Université Laval (Québec, Canada)*

La vallée du ruisseau des Vases dans la région de Brownsburg au Québec est constituée d'argile sensible et ses berges sont parsemées de nombreuses grandes cicatrices de glissements de terrain. De concert avec l'Université Laval, le Ministère des Transports du Québec a entrepris récemment une investigation détaillée dans cette région afin d'étudier la possibilité d'utiliser la mesure de la résistivité électrique des sols pour caractériser les zones exposées aux glissements de terrain fortement rétrogressifs. Une tomographie de résistivité électrique a été effectuée sur une longueur de 1,6 km, le long d'une ligne de levé transversale à la vallée. Six essais de pénétration au piézocône électrique, incluant la mesure de la résistivité électrique, ont été réalisés le long de cette ligne. Les résultats préliminaires montrent que les mesures de résistivité électrique permettent d'identifier les zones d'argile lessivée. La tomographie de résistivité électrique est une méthode prometteuse pour caractériser les secteurs vulnérables aux grands glissements.

#### **656 - RECYCLING WASTE GYPSUM IN SOIL STABILIZATION APPLICATIONS**

ALY AHMED (1), M. H. M. H. El Naggar (2), Hafiz Ahmad (3), Takeshi Kamei (4)

(1) *Western Ontario University (London, Canada);* (2) *Western Ontario University, London, Ontario, Canada (London, Canada);* (3) *Orbit Engineering Limited, Mississauga, Ontario, Canada (Mississauga, Ontario, Canada);* (4) *University of Miyazaki, Miyazaki, Japan (Miyazaki, Japan)*

Solid waste management is a serious problem worldwide as amounts of produced wastes are increasing annually. For example, the disposal of gypsum waste-plasterboard, widely used as dry-wall across North America, represents a serious environmental issue. Therefore, attention is focused on using and recycling such waste as an alternative material in construction applications. This can reduce the amount of wastes that are sent to landfills, and hence leads to environmental and economic benefits. This study examines the potential of reusing gypsum wastes as a stabilizer material for earthwork projects. Recycled gypsum, mixed with cement or lime at different ratios, was used as a stabilizer for soft-fine-grained soil. Compressive strength, secant moduli, unit weight, water content and Atterberg limits tests were conducted to evaluate the improvement in stabilized soil properties. The results indicate that the inclusion of gypsum-cement or gypsum-lime admixtures improved the mechanical properties of the stabilized soil, with higher admixture concentrations leading to greater improvement. Moreover, the soil specimens stabilized using gypsum-lime admixture exhibited higher strength gain rate and reduction in plasticity index and water content than those stabilized by gypsum-cement admixture. It is concluded that the proposed stabilizing technique can be advantageous for both waste management and construction industries.



## 710 - AFFAISSEMENT D'UNE CHAUSSÉE CONSTRUITE SUR ARGILE À MONTRÉAL

Martin Tremblay (1), Jocelyn Lavoie (1), Sébastien Dubeau (1)  
(1) *Ville de Montréal (Montreal, Canada)*

L'aménagement d'un territoire entraîne un changement drastique dans le bilan hydrique qui prévalait avant la construction des infrastructures urbaines. L'augmentation du ruissellement causé par les surfaces minéralisées et les toitures diminue la quantité d'eau qui s'infiltré dans le sol. Lorsque le sol d'infrastructure est constitué d'argile, ces changements combinés à des périodes de sécheresses prolongées peuvent provoquer son assèchement. Cela cause une diminution de la teneur en eau du sol par altération de l'argile, entraînant des tassements qui déforment les chaussées. Les facteurs qui contribuent à ce phénomène sont examinés. Un cas d'affaissement de chaussée, documenté sur plusieurs années est analysé. Les propriétés du sol, l'ampleur des déformations, les variations de teneur en eau et les facteurs qui peuvent accentuer la progression de l'assèchement sont présentés. Différentes solutions pour remédier à ce problème sont discutées, incluant la réinfiltration d'eau dans le sol et la reconstruction sur une assise granulaire épaisse. L'observation du comportement, plusieurs années après les travaux de réparation, permet de formuler des commentaires et des mises en garde à prendre en compte dans la conception des infrastructures urbaines sur sol argileux.

## 712 - EFFECT OF VOIDS ON THE BENDING RESPONSE OF BURIED FLEXIBLE UTILITY PIPES

Heather Sales (1), Jonathan Black (2), Richard Collins (2)  
(1) *Cementation Skanska (Doncaster, United Kingdom)*; (2) *University of Sheffield (Sheffield, United Kingdom)*

Buried pipe infrastructure is of critical importance for the provision of fresh water supply and disposal of waste water. Pipe performance is sensitive to initial ground burial conditions and subsequent changes during serviceable life. Voids are frequently reported as a possible factor that accelerates deterioration of the pipe condition leading to ultimate premature failure in flexure or cracking. This study considers the effect of voids on a 0.3 m prototype flexible pipe using centrifuge model tests for fully supported and unsupported conditions buried in sand. Pipe stiffness and bending response for spherical void geometries 2 to 5 times that of the pipe diameter are evaluated when subjected to vertical surface loading. Digital image correlation was used to capture soil-pipe interaction mechanics. Increased pipe deformation and bending moment were observed with increased void size confirming that void formation may contribute in the overall failure of pipe infrastructure.

## 740 - REPRÉSENTATIVITÉ DE L'ÉCHANTILLONNAGE D'UN SOL CONTAMINÉ EN PILE : EFFETS DE L'HUMIDITÉ, DE LA CONCENTRATION DU CONTAMINANT ET DE LA TECHNIQUE D'ÉCHANTILLONNAGE

Mirela Sona (1), Jean-Sébastien Dubé (1), François Duhaime (1)  
(1) *École de technologie supérieure (Montreal, Canada)*

La caractérisation des sols contaminés demeure un défi, entre autre, car il n'y a pas de directives précises concernant l'obtention d'échantillons représentatifs sur le terrain. L'objectif de cette étude a été de quantifier la représentativité de l'échantillonnage d'un sol lâche en pile. L'échantillonnage a été réalisé à l'échelle du laboratoire sur un sol contaminé artificiel, ce qui a permis de quantifier le biais, la variance et la représentativité de deux méthodes d'échantillonnage, soit le grappillage et une méthode alternative développée au



LG2. Les effets de l'humidité du sol et de la concentration initiale de l'analyte (contaminant) sur la représentativité de l'échantillonnage ont aussi été étudiés. Les résultats ont montré que la méthode alternative permet de réduire le biais et la variance des mesures de concentrations, donc d'obtenir des résultats plus représentatifs que le grappillage. Les résultats ont également montré que la variabilité des résultats est moins grande lorsque le sol est humide que lorsqu'il est sec et ce, pour les deux méthodes d'échantillonnage.

### **807 - EFFECTIVENESS OF JUTE GEOTEXTILE FOR HILL SLOPE STABILIZATION IN ADVERSE CLIMATIC CONDITIONS**

Pradip Kumar Choudhury (1), Tapobrata Sanyal (2)

(1) *Indian Jute Industries' Research Association & National Jute Board (Kolkata, India)*; (2) *Chief Consultant - National Jute Board (Kolkata, India)*

Efficacy of Jute Geotextiles (JGT) in hill slope management stands substantiated as a result of its unique attributes such as its bio-degradability, hydrophilic properties, and ability to moderate temperature extremes have few parallels among ecofriendly natural fibres. The mechanism of containment of top soil erosion is the resultant effect of velocity of surface run-off propelled by gravity, ground friction, hydraulic conductivity of the slope fill, absorption of a portion of run-off by jute yarns of open weave JGT, and barrier effect posed by them on the other. JGT also acts as mulch creating a microclimate that fosters quick growth of vegetation on biodegradation. JGT plays an important role in bioremediation of slope-erosion problems. The paper delineates climatic factors, types of JGT used, and the prevailing site conditions of various trial sites, with an attempt to analyze the mechanism of functioning of JGT in low temperature zones.

## **Poster Sessions / Séances d'affiches**

### **Landslide and Slope Stability / Mouvements de terrain et stabilité des pentes**

**Wednesday, September 23, 10:00 - 10:30 and 15:00 - 15:30 /  
Mercredi 23 septembre, 10 h - 10 h 30 et 15 h - 15 h 30**

### **139 - ANALYSE ET MODÉLISATION DES GLISSEMENTS DE TERRAIN DANS LA RÉGION D'ALGER: CAS D'EL ACHOUR**

Mira Filali (1), Ammar Nechnech (2)

(1) *Université Djilali Bounaama (Khemis miliana, Algeria)*; (2) *USTHB Alger (Alger, Algeria)*

Les glissements de terrain représentent une menace majeure pour la population, les bâtiments et les différentes infrastructures. Ils sont très fréquents dans la région d'Alger, dont fait partie notre site d'étude et où a été observé diverses signes d'instabilités te que; fissurations des murs, rupture de canalisations, glissements de terrain,...etc. Cette étude est faite sur le parc Dounia qui s'étend sur plus de 1000 hectares dans le sahel marneux et dont la majeure partie se trouve dans la commune d'El Achour. On procèdera à une analyse et interprétation des paramètres géotechniques des marnes plaisanciennes qui couvre une large surface du sahel d'Alger et représentent le substratum, sur lequel, le développement de cette ville se dirige, ainsi qu'une approche de modélisation de ce phénomène par le code de calcul par éléments finis, nous permettant d'analyser la stabilité du site en prenant en considération différents facteurs.



## 224 - NUMERICAL ANALYSIS OF SLOPE STABILITY IN EXPANSIVE SOIL: A CASE STUDY OF FIELD TEST IN HENAN PROVINCE, CHINA

Shunchao Qi (1), Sai Vanapalli (1)  
(1) *University of Ottawa (Ottawa, Canada)*

To investigate stability of expansive soil slope under the rainfall condition, a field study conducted by Zhang et al. (2010) in Henan Province, China, is analyzed using a comprehensive numerical procedure that involves the hydraulic Finite Element Analysis, followed by Factor of Safety (FS) calculation based on Limit Equilibrium Analysis. Several hydraulic properties functions; including the unimodal SWCC and permeability functions with increased saturated permeability and bimodal SWCC with its permeability functions are used to consider effects of cracks developed within the shallow layer. The results suggest that the bimodal hydraulic properties can better represent the hydraulic behavior of cracked expansive soils, and result a close match between the predicted and measured pore water pressure change over time. The calculated FSs illustrates the importance of selecting shear strength parameters under lower confining pressure from laboratory studies in the stability analysis of expansive soil surficial layer.

## 368 - INVESTIGATION ON THE BEHAVIOR OF ROCKFALL FLEXIBLE BARRIERS BY NUMERICAL SIMULATION

Massoud Palassi (1), Saeed Askar (1)  
(1) *University of Tehran (Tehran, Iran)*

One of the commonly protective measures against rockfall in roads and railways is flexible barrier kits. In this paper, the finite element method is used to study the behavior of flexible rockfall barriers. The effect of various parameters such as angle of collision and location of impact on mesh and number of spans is investigated. It is noted that such analyses can be very useful in proper design of rockfall barriers.

## 505 - INVESTIGATIONS COMPLÉMENTAIRES DU GLISSEMENT DE TERRAIN DE 1993 SUR LA RIVIÈRE DE LA NATION SUD, À LEMIEUX, ONTARIO.

Pascal Locat (1), Denis Demers (1), Ariane Locat (2), Serge Leroueil (2)  
(1) *Ministère des Transports du Québec (Québec, Canada)*; (2) *Département de génie civil, Université Laval (Québec, Canada)*

Le 20 juin 1993, un glissement de terrain d'une superficie de 16,9 hectares et d'une distance de rétrogression de près de 600 mètres s'est produit en rive droite de la rivière de la Nation Sud, dans le secteur de Lemieux, en Ontario. Ce glissement de terrain présente la particularité que certaines de ses portions se sont rompues sous la forme de horsts et de grabens, à la façon d'un étalement dans les argiles sensibles, alors que d'autres portions se sont totalement remaniées à la manière d'une coulée argileuse. Des investigations ont été effectuées récemment afin de préciser les caractéristiques du glissement de terrain, de façon à pouvoir mieux étudier les mécanismes de rupture impliqués. Cet article présente une revue des travaux antérieurs réalisés par d'autres auteurs, et les travaux d'investigation complémentaires réalisés à l'été et à l'automne 2014, ainsi qu'à l'hiver 2015.





## 507 - ÉTABLISSEMENT DE SCÉNARIOS D'ACCÉLÉRATION ET DE VITESSE DE GRANDS GLISSEMENTS ROCHEUX ACTIFS : LE CAS DE BLACK LAKE

Dominique Turmel (1), Jacques Locat (1), Jonathan Leblanc (1), Jacques Locat (1), Martin Grenon (1)

(1) *Université Laval (Québec, Canada)*

Dans les dernières années, au pourtour de la mine LAB d'Amiante du Canada (LAC) (Thetford Mines, Québec, Canada), de multiples glissements de terrain sont survenus. En 2010, un glissement affecta le mur Ouest de la fosse principale. Au mois de juillet 2012, des glissements se sont produits dans la partie Sud-Est de cette même fosse.

Le glissement de 2012 est encore en mouvement, et un volume maximal de 50 millions de m<sup>3</sup> pourrait être mobilisé. De plus, la mine n'étant plus en opération actuellement, le niveau d'eau dans la fosse augmente au fil du temps. Si une accélération soudaine du glissement survenait, une vague pourrait en résulter. Afin de modéliser une telle vague, et d'en évaluer les impacts, divers scénarios de vitesse et d'accélération de la masse ont dû être élaborés. Une analyse sommaire de la géométrie du glissement sera faite dans cet article, ainsi que l'élaboration de scénarios de vitesse et d'accélération à partir de cas documentés et de modélisations numériques.

## 570 - INFLUENCE DE LA COHÉSION APPARENTE SUR LA STABILITÉ DES PENTES À VIVY MITCHELL (HAÏTI)

Berthoumieux Junior JEAN (1), Sadrac St Fleur (2), Dominique Boisson (3), Jean-François Thimus (4), Christian Schroeder (5)

(1) *Université d'Etat d'Haiti / Laboratoire National du Batiment et des Travaux Publics (Port-au-Prince, Haiti)*; (2) *Géozur, Université de Nice-Sophia Antipolis, Centre National de Recherche Scientifique (Nice, France)*; (3) *Université d'Etat d'Haiti (Port-au-Prince, Haiti)*; (4) *Université Catholique de Louvain (Louvain-la-Neuve, Belgium)*; (5) *Université Libre de Bruxelles (Bruxelles, Belgium)*

L'objectif de cet article est d'analyser la stabilité des pentes sur le site de Vivy Mitchell en tenant compte de la cohésion apparente. Dans notre travail, nous nous intéressons plus particulièrement à l'étude de modélisation de ce site, basée sur les caractéristiques expérimentales des échantillons prélevés. Pour compléter cette étude de modélisation, une étude semi-paramétrique sera menée pour les caractéristiques incertaines de ces échantillons. En ce sens, des paramètres mécaniques seront modifiés tour à tour afin de modéliser leur influence sur cette stabilité. Cette modélisation a été accomplie avec le logiciel GEOSLOPE utilisant les méthodes d'équilibre limite couplées avec les méthodes des éléments finis afin d'analyser le rôle de la cohésion apparente sur cette stabilité. Les applications effectuées à partir des différentes approches examinées dans nos modèles ont permis de comprendre l'influence de la cohésion apparente sur la stabilité au niveau du glissement de Vivy Mitchell.

## 614 - DISCONTINUITY ORIENTATION IN JIGSAW CLASTS FROM VOLCANIC DEBRIS AVALANCHE DEPOSITS AND IMPLICATIONS FOR EMPLACEMENT MECHANISM

Marc-Andre Brideau (1), Jonathan Procter (2)

(1) *BGC Engineering Inc. (Vancouver, Canada)*; (2) *Massey University (Palmerston North, New Zealand)*

Jigsaw fractures in clasts have been noted in the deposit of large (>1 Mm<sup>3</sup>) volcanic debris avalanches and non-volcanic rock avalanches at numerous locations around the world but they have rarely been systematically studied. This project applied terrestrial photogrammetry techniques to characterize the discontinuity orientation of jigsaw clasts found in the debris



avalanche deposits around Mt. Taranaki. Mt. Taranaki is a stratovolcano located on the North Island of New Zealand. The orientation of 355 discontinuities was obtained from clasts at 7 stations on the west side of Mt. Taranaki. The constant discontinuity orientation in clasts from stations separated by approximately 10 km has implications on the landslide debris transport and emplacement mechanisms. Two emplacement mechanisms that could result in a consistent orientation pattern in the jigsaw clasts at all 7 stations are discussed and compared with the field observations at Mt. Taranaki.

## Poster Sessions / Séances d'affiches

### Permafrost and Cold Regions Geotechnology / Pergélisol et géotechnologie des régions nordiques

Wednesday, September 23, 10:00 - 10:30 and 15:00 - 15:30 /

Mercredi 23 septembre, 10 h - 10 h 30 et 15 h - 15 h 30

#### 183 - PERMAFROST THERMAL REGIME AT NORTH AND SOUTH ASPECTS, KUNLUN MOUNTAIN, QINGHAI-TIBET PLATEAU

Zhanju Lin (1), Fujun Niu (1), Jing Luo (1), Minghao Liu (1), Guoan Yin (1)

(1) State Key Laboratory of Frozen Soil Engineering, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences (Lanzhou, China)

Ground temperatures from 0.5 to 15 m depth were measured for six years (2008-2013) at south and north aspects in Kunlun Mountain, Qinghai-Tibet Plateau, to characterize the ground thermal regime and determine if the variations in ground temperature were associated with the slope aspect. Climate conditions at north slope close to south slope, but the ground temperatures were greatly diverse. At the near-surface, about 50 cm depth, the mean annual ground surface temperature (Ts) at north slope was approximately 0.6 °C colder than that at south slope, resulting in an 1-m increase in active layer thickness (ALT) at south slope. As a result, the mean annual ground temperature at permafrost top (Tps) was about 1 °C colder at north slope than that at south slope, and 0.2 °C colder of the mean annual ground temperature at 15 m depth (Tg). The significantly different ground temperature showed an important effect of slope aspect to permafrost, especially in shallower layer permafrost.

#### 239 - THE GEOCRYOLOGICAL BIBLIOGRAPHY OF J. ROSS Mackay (1915-2014)

Christopher Burn (1)

(1) Carleton University (Ottawa, Canada)

For more than four decades Professor J. Ross Mackay was the Canadian authority in permafrost science, and was internationally recognized for his contributions to geocryology. This paper presents the research bibliography of J.R. Mackay with respect to the permafrost environment, and also his contributions on the hydrology of Mackenzie River and his studies of needle ice and snow in southern British Columbia.



## **289 - MONITORING OF CRYOGENIC GEOSYSTEMS IN THE EUROPEAN NORTH, THEIR CURRENT CONDITION AND DYNAMICS**

Galina Malkova (1), Marat Sadurtdinov (1), Marat Sadurtdinov (1), Andrey Skvortsov (1), Andrey Tsarev (1)  
(1) *Earth Cryosphere Institute SB RAS (Moscow, Russia)*

This paper provides results of monitoring of cryogenic (permafrost-affected) geosystems at the permafrost monitoring stations Bolvansky, Kashin, and Shapkina, in region of the European North of Russia. The interannual dynamics of permafrost temperatures, and of the seasonal thawing depth have been studied. The trends in increase of ground temperature ( $T_{ground}$ ) in various cryogenic geosystems lag behind trends in air temperature ( $T_{air}$ ). The  $T_{air}$  trend for the 30-year period shows an increase of  $0.07^{\circ}\text{C}/\text{year}$ , while for  $T_{ground}$  it varies from  $0.01$  to  $0.03^{\circ}\text{C}/\text{year}$ . In the last two years, the active layer thickness has reached its maximum value, and the closed taliks began to form at the hilltops underlain by ice-poor permafrost.

## **385 - DÉVELOPPEMENT D'UN MODÈLE MÉCANISTE-EMPIRIQUE DE PRÉDICTION L'UNI DES CHAUSSÉES FLEXIBLES**

Youdjari Djonkamla (1), Guy Doré (1), Jean Pascal Bilodeau (1)  
(1) *Université Laval (Québec, Canada)*

Pour développer le modèle de prédiction de l'uni mécaniste-empirique, quatre rigoureuses hypothèses ont été posées. L'essentiel de ces hypothèses est que la variation de l'uni est due à la déformation permanente et au soulèvement au gel de sol d'infrastructure. De ces hypothèses, une fonction mathématique a été dérivée. La fonctionnalité du modèle a été évaluée avec des données des essais de laboratoire et les résultats obtenus sont réalistes.

## **480 - LOAD TRANSFER OF PILE FOUNDATIONS IN WARMING FROZEN GROUND**

Abdulghader Abdulrahman (1), Mohammad Rayhani (2)  
(1) *Carleton University (Ottawa, Canada)*; (2) *Carleton University (Ottawa, Canada)*

An experimental research program has been undertaken to investigate the response of pile foundations to frost thawing and adfreeze bond in Leda clay. Field pile load tests were conducted at the Canadian Geotechnical Research Site No. 1 located in Gloucester, Ontario. The results of static pile load tests in frozen and unfrozen Leda clay showed dramatic reduction in pile capacities upon frost degradation. Load-displacement relationships for tested piles and theoretical estimation of long-term adhesion of frozen and unfrozen Leda clay are presented and discussed.

## **585 - SYNTHESIS RESEARCH ON THE PERMAFROST CARBON FEEDBACK: EVALUATING THE ROLE OF THERMOKARST AND THERMAL EROSION AT CIRCUMPOLAR SCALES**

Merritt Turetsky (1), E.A.G. Schuur (2), C. Schädel (2), A.D. McGuire (3), D. Olefeldt (4), G. Hugelius (5)  
(1) *Department of Integrative Biology, University of Guelph (Guelph, Canada)*; (2) *Center for Ecosystem Science and Society, Northern Arizona University (Flagstaff, United States)*; (3) *U.S. Geological Survey, Alaska Cooperative Fish and Wildlife Research Unit, University of Alaska Fairbanks (Fairbanks, United States)*; (4) *Department of Renewable Resources, University of Alberta (Edmonton, Canada)*; (5) *Department of Physical Geography, Stockholm University (Stockholm, Sweden)*

Permafrost thaw, and carbon released via the microbial decomposition of previously frozen soil organic matter, is considered one of the most likely positive feedbacks from terrestrial



ecosystems to the atmosphere in a warmer world. The rate and form of permafrost carbon release is highly uncertain but crucial for predicting the strength and timing of this carbon cycle feedback during this century and beyond. The main objective of the Permafrost Carbon Network is to use data synthesis and modeling to link biological carbon cycle research with well-developed networks in the physical sciences focused on the thermal state of permafrost.

### **634 - INFLUENCE OF SNOW COVER ON THE GROUND THERMAL REGIME ALONG AN EMBANKMENT BUILT ON PERMAFROST: IN-SITU MEASUREMENTS**

Florence Lanouette (1), Guy Doré (1), Daniel Fortier (2), Chantal Lemieux (1)  
(1) *Département de génie civil et Centre d'études nordiques, Université Laval (Québec, Canada);* (2) *Département de Géographie, Université de Montréal; Centre d'études nordiques, Université Laval (Montréal, Canada)*

Snow accumulation along linear transportation infrastructures prevents heat to be extracted from the ground in winter. Consequently, the permafrost underneath is degrading and the structural properties of the roadway can be significantly affected. During the winter of 2014-2015, the thermal regime through the snowpack and the ground underlying were monitored at two study sites in Canada. The data collected shows that the ground surface temperature reduction is more important for the first centimeters of snow, then progressively diminishes as the snowpack get thicker and denser. The relationship between the n-factor and the snow thickness that can be explain by a power equation can quantify this observation. This paper is part of a bigger project whose purpose is to counteract the insulating effect of snow accumulation along transportation infrastructure embankments by adapting the angle of the slopes in the design.

### **199 – How reliable is the mass variation in the Siberian permafrost region as observed by GRACE?**

Akbar Shabanloui, Jürgen Müller  
*Institute of Geodesy – University of Hannover, Hannover (Lower Saxony, Germany)*

Permafrost generally and in Siberia (Russia) especially plays a key role for global hydrological mass transport, climate change and the eco-system of the Earth. In this study, surface and sub-surface massvariations in the Siberian permafrost region based on the gravitational approach (i.e. from GRACE mission) are estimated, and investigated to what extent the mass transport estimates are reliable and realistic. On the other hand, hydrological mass variations in this region are determined based on the geometrical approach using satellite (radar/laser) altimetry re-tracking data (e.g. Jason-2, ICESat) and satellite imagery (e.g. LandSat). In addition, hydrological surface mass variations are extracted from global hydrological water cycle models based on various in-situ hydrological observations, e.g. precipitation, evapotranspiration and run-off data. In this study, we quantify and asses the signal errors and its contributions to the integral mass variations in Siberia including error bars and determine to what extent GRACE results can provide mass variations which are caused by permafrost changes.



## Session/Séance : Foundations IV / Fondations IV

Wednesday, September 23, 10:30 - 12:00 / Mercredi 23 septembre, 10 h 30 - 12 h

Room / Salle : 204AB

Chair / Président de séance : Tim Newson

### 750 - FULL-SCALE PILE LOADING TESTS ON INSTRUMENTED CONCRETE PILES IN CLAY TILL, IN EDMONTON, ALBERTA

Xiaobo Wang (1), Robin Tweedie (1), Renato Clementino (1)  
(1) *Thurber Engineering Ltd. (Edmonton, Canada)*

Full-scale pile loading test on instrumented piles not only verifies load-carrying behavior and performance of the piles but also allows for the break-down of shaft and toe resistances for the pile design. Based on the results of the pile loading test, an increase of geotechnical resistance factor from 0.4 to 0.6 can be applied in the geotechnical resistance design. For projects with a large number of piles required, the overall benefit gained from the increase in design reliability and the reduction in total piling costs can be substantial. This paper presents the results of three full-scale pile loading tests on instrumented cast-in-place concrete belled piles constructed in three separate project sites in the downtown area of Edmonton, Alberta. The shaft diameters of the test piles ranged from 0.9 m to 1.2 m, bell diameters from 1.8 m to 2.7 m, and test loads were up to 9,000 kN. Embedded strain gauges and tell-tales were installed in the test piles, which provided a reliable assessment on the shaft and toe resistances. Considerable variability in the test results was identified at the test sites and the design implications are discussed in the paper.

### 510 - IN-SITU LOADING TESTS OF SMALL-DIAMETER HELICAL PILES AND EVALUATION OF DESIGN METHODS

Weidong Li (1), Lijun Deng (1), Richard Schmidt (2), Baocheng Li (2)  
(1) *University of Alberta (Edmonton, Canada)*; (2) *Almita Piling Inc. (Edmonton, Canada)*

The present research investigated the behaviour of three types of single-helix piles. The research conducted axial loading tests of helical piles installed in cohesive and cohesionless soils located in Alberta. Subsurface conditions of testing sites were investigated using cone penetration tests (CPT). Correlations between the axial capacity and final installation torque were proposed based on the testing results. It was observed that, for the two smaller piles, the torque factor varied with the amplitude of axial capacities while the biggest piles had relatively stabilized torque factor values. In addition, CPT-based method and several indirect methods were used to predict the pile capacities. It is shown that the CPT-based method provides adequate agreement with the test results despite that modified end bearing coefficients for helical piles were adopted for capacity prediction. It is therefore recommended that CPT-based method could be used directly to predict the pile axial capacity.

### 155 - IN-SITU AXIAL LOAD TESTS OF DRILLED DISPLACEMENT STEEL PILES

Fazli Shah (1), Lijun Deng (1), Lijun Deng (1)  
(1) *University of Alberta (Edmonton, Canada)*

Drilled Displacement Steel Pile (DDSP) is an innovative pile type that fully displaces the soil during installation. DDSP consists of a conical tip with steel blades and a steel tubular pipe. Compared to conventional drilled displacement piles, this pile type has many advantages that include rapid installation, immediate usability, and greater pile capacities. Consequently, DDSP has recently been widely used in varieties of engineering applications in Western



Canada. However, the axial behaviour of DDSP has not been well understood due to the lack of research, and a design guideline has not been developed. A series of in-situ load tests of full-scale piles were conducted at two testing sites in Alberta. Three axial compression and two tensile tests were conducted on heavily instrumented piles. The paper evaluates the axial capacities and the load-transfer mechanisms during axial loading tests and compares the existing design methods adopted for other pile types.

### **793 - EVOLUTION OF PILE SHAFT CAPACITY OVER TIME IN SOFT CLAYS (CASE STUDY: LEDA CLAY)**

Mohammadamin Hosseini (1), Mohammad Rayhani (1)  
(1) Carleton University (Ottawa, Canada)

This paper presents a comprehensive experimental investigation to examine the evolution of pile shaft capacity over time. This phenomenon is observed in pile foundations that are driven into soft clays, and is referred to as pile set-up. In this research, a series of pile load testing was performed on steel and concrete piles driven into Leda clay in Gloucester, Ontario. The piles were tested immediately after driving to measure their initial bearing capacities, and were tested repeatedly over different elapsed time to study the change in pile shaft capacity over time. The excess pore water pressure around the pile was also monitored by a piezometer. The average pile capacity measurements for steel and concrete piles indicate that there is approximately an 80% increase in the pile capacity after 30 days from the initial day.

### **227 - NUMERICAL MODELLING TECHNIQUE TO PREDICT THE LOAD VERSUS SETTLEMENT BEHAVIOR OF SINGLE PILES IN UNSATURATED COARSE-GRAINED SOILS**

Mohammed Al-Khazaali (1), Sai Vanapalli (1)  
(1) University of Ottawa (Ottawa, Canada)

The load-settlement behavior of three model piles with 38.3, 31.75, and 19.25 mm base diameter tested with different capillary suction values of 0, 2, and 4 kPa in two coarse-grained soils are presented. A simple finite element analysis technique using PLAXIS 2D is proposed to estimate the load versus settlement behavior of the model piles using the information of the predicted stiffness and the shear strength behavior of unsaturated soils derived from the information of saturated soil properties and the soil-water characteristic curve (SWCC). There is a good comparison between the numerical modeling results and the experimental results. The results of the study highlight the contribution capillary suction towards load-settlement behavior of pile foundations in coarse-grained soils. The proposed numerical modeling methodology is encouraging for implementing the mechanics of unsaturated soils into engineering practice.

### **325 - ENVIRONMENTAL IMPACTS OF DRILLED SHAFT DESIGN IN SAND**

Mina Lee (1), Dipanjan Basu (1), Dipanjan Basu (1)  
(1) University of Waterloo (Waterloo, Canada)

A variety of methods are available for design of drilled shafts based on different assumptions and input parameters. Whilst all these design methods ensure safety and/or serviceability of drilled shafts, difference in drilled shaft dimensions ensues for the same design problem if different design methods are used. Consequently, there is a difference in material use depending on the choice of the design method, and this impacts the environment. In this study, life cycle analyses (LCA) are performed to quantify the consumption of resources required to construct drilled shafts designed using different available methods and to



estimate the emissions as a consequence of the construction. Different available design methods are selected and compared based on the results of LCA for several different subsurface profiles consisting of sand layers.

## **Session/Séance : Landslides and Slope Stability V / Mouvements de terrain et stabilité des pentes V**

**Wednesday, September 23, 10:30 - 12:00 / Mercredi 23 septembre, 10 h 30 - 12 h**

Room / Salle : **205A**

Chair / Président de séance : **Jacques Locat**

### **153 - SLOPE OBSERVATIONS AND FIELD MAPPING TO VERIFY THE STABILITY OF SLOPES NEAR KITIMAT, BC**

Ali Khalili (1), Jason Pellett (2), Brian Hall (2), Jack Price (2)

(1) *Tetra Tech EBA Inc. (Vancouver, Canada)*; (2) *Tetra Tech EBA Ltd. (Vancouver, Canada)*

Landslides and slope instabilities have previously occurred in the vicinity of Kitimat, British Columbia in sensitive or quick clays of glaciomarine origin. The assessment of slope stability has been one of the key challenges in this area due to the difficulty in reliably estimating the shear strength parameters as well as other factors that influence slope stability. Future developments along in this area, necessitate the prediction of slope performance. As an alternate verification approach, reconnaissance of the slopes along some of the Forestry Service Roads was performed and detailed notes of the slope configuration along with signs of instability or distress were recorded at numerous locations. The collected data from the site is reduced and presented graphically to provide insights into the anticipated performance of the slopes.

### **17 - EUREKA RIVER LANDSLIDE, HWY 726:02 NEAR WORSLEY, ALBERTA: DESIGN AND CONSTRUCTION OF REMEDIAL MEASURES**

Barry Meays (1), Don Proudfoot (1), Roger Skirrow (2), Ed Szmata (3)

(1) *Thurber Engineering Ltd. (Edmonton, Canada)*; (2) *Alberta Transportation - Geotechnical and Materials Section (Edmonton, Canada)*; (3) *Alberta Transportation - Construction Branch (Peace River, Canada)*

A number of landslides are affecting Highway 726 through the Eureka River valley in northwest Alberta, Canada. One of these sites required immediate attention. The site investigation revealed a deep-seated landslide in a weak, high plastic clay layer that toed out into the River 15 m below the highway. Remediation in 2012/2013 consisted of two lines of concrete piles constructed downslope of the highway spanning the landslide. The upper pile wall was tied back with two rows of grouted anchors. The lower, cantilever design pile wall was installed which acts to maintain lateral soil pressure against the upper wall. Other measures, such as EPS lightweight fill, were implemented in order to further reduce driving forces on the upper wall. This paper summarizes the geotechnical investigation, design, and repair measures, including instrumentation monitoring results at the remediated site.



## 215 - INSTRUMENTING AND MONITORING A SLOW MOVING LANDSLIDE

Matthew Schafer (1), Renato Macciotta (1), Michael Hendry (1), Derek Martin (1), Chris Bunce (2), Eddie Choi (2), Tom Edwards (3)  
(1) *University of Alberta (Edmonton, Canada)*; (2) *Canadian Pacific Railway (Calgary, Canada)*; (3) *Canadian National Railway (Edmonton, Canada)*

The performance of instrumentation in moving landslides has always been a challenge in the geotechnical industry. Movements can cause issues relating to shearing of cables or the breaking of grout used for installation. The Ripley Landslide near Ashcroft, B.C., Canada has been previously investigated using sand-pack piezometers and slope inclinometers. An investigation and monitoring program was carried out in April 2013. Grouted-in piezometers and a Shape Accel Array was installed during this investigation. The river elevations were derived from a rating curve. Pore pressures were compensated for the effect of barometric variation. The displacement and pore pressure values were validated to ensure that the values recorded could be used for further analysis.

## 616 - ENGINEERING GEOLOGY, ELECTRICAL RESISTIVITY TOMOGRAPHY AND DISPLACEMENT MONITORING OF THE DAWSON CITY LANDSLIDE, YUKON.

Marc-Andre Brideau (1), Alexandre Bevington (2), Antoni Lewkowicz (3), Doug Stead (4)  
(1) *BGC Engineering Inc. (Vancouver, Canada)*; (2) *BC Ministry of Forests, Lands and Natural Resources Operations (Prince George, Canada)*; (3) *University of Ottawa (Ottawa, Canada)*; (4) *Simon Fraser University (Burnaby, Canada)*

The Dawson City landslide is a pre-historic slope failure located at the northern city limit of Dawson City, Yukon. The landslide occurred at the faulted contact between an older ultramafic rock unit that is thrust on top of a younger metasedimentary rock unit. The fault damage zone results in the very blocky nature (five main discontinuity sets) of the failed rock mass and led to an initial pseudo-circular slope failure mechanism. The landslide deposit is composed dominantly of ultramafic rocks. A series of split trees, disturbed soil exposing stretched roots, and trenches, all indicate movement in both the headscarp and deposit. Monitoring since 2006 confirms annual surface displacement rates in these areas in the cm to decimetre range. A 200 m long electrical resistivity tomography profile conducted in the lower part of the deposit is interpreted as a thick active layer over permafrost, suggesting that ongoing deformation is due to the creep of permafrost containing ground ice. As such, the lower part of the landslide can be regarded as a rock glacier.

## 326 - TEMPORARY SLOPE STABILIZATION AT THE AIRPORT TRAIL UNDERPASS EXCAVATION, CALGARY INTERNATIONAL AIRPORT

Bronwen Kelley (1), Paul Xu (2), Ognian Gubev (2), Laura Normore (2), Tara Rihn (2), Lee Nichols (2), Kelly Illerbrun (3)  
(1) *Terracon Geotechnique Ltd (Calgary, Canada)*; (2) *Terracon Geotechnique Ltd. (Calgary, Canada)*; (3) *PCL (Calgary, Canada)*

The City of Calgary identified Airport Trail as a key East-West Corridor providing connection from Deerfoot Trail to Stoney Trail. The Calgary International Airport expansion project resulted in a need to develop a tunnel to accommodate east-west traffic under the new runway and taxiways. This tunnel was constructed as a cut and cover tunnel requiring excavation up to 19 metres deep in the local tills and Tertiary soft rocks. This paper describes the rock slope issues and mitigating measures to allow safe construction to proceed.





**514 - USE OF NATIVE SOIL IN THE MSE STRUCTURES**

Daniel Huang (1), [David Fuerth](#) (2), David Fuerth (2), Abe Choi (2)

(1) *TerraFix (Toronto, Canada)*; (2) *TerraFix Geosynthetics Inc. (Toronto, Canada)*

Applying native soils as the reinforced fill material in the Mechanically Stabilized Earth (MSE) structures could be problematic if the native soils contain large percentage of fines ( $d < 0.075\text{mm}$ ) and are poorly graded. Several case histories of TerraSteep retaining wall, a welded-wire-form faced MSE structure using such native soils in the Greater Toronto Area (GTA) have been reviewed and discussed in this paper with respect to their design, construction and performance during and after installation of the walls based on monitoring data.

## **Session/Séance : Transportation and Linear Infrastructure I / Transports et infrastructures linéaires I**

**Wednesday, September 23, 10:30 - 12:00 / Mercredi 23 septembre, 10 h 30 - 12 h**

Room / Salle : **205BC**

Chair / Président de séance : **Mario Ruel**

### **749 - INTEGRATED FRAMEWORK IN SUPPORT OF PIPELINE ENGINEERING DESIGN FOR GEOHAZARDS**

[Shawn Kenny](#) (1), Pijush Debnath (2), Kenton Pike (2), Bipul Hawlader (2)

(1) *Carleton University (Ottawa, Canada)*; (2) *Memorial University (St. John's, Canada)*

Energy pipelines are critical elements of the national infrastructure for the transportation of oil and gas resource. These pipeline systems may extend hundreds of kilometers in length, traverse across terrain units with varied geotechnical properties and may be impacted by geohazards. The relative ground movement imposes forces on the buried pipeline that may cause local damage and impair the mechanical performance with respect to serviceability or strength limits. The current state-of-practice for the engineering design and integrity assessment of a buried energy pipeline is based on structural pipe/soil interaction models idealized using beam and spring elements. This approach can be deficient when analyzing complex pipeline/soil interaction events that need to account for complex boundary conditions, load transfer processes and failure mechanisms. Continuum finite element methods can address these deficiencies but require an integrated framework including experienced numerical analysts, laboratory tests to define input parameters for soil constitutive models and physical data to verify simulation procedures. In this paper, the framework for integration of these technical approaches in support of pipeline engineering design is discussed with reference to recent studies. The potential for improving current pipeline engineering practice is also explored.

### **713 - HAZARD IDENTIFICATION AND EVALUATION USING UAV PHOTOGRAMMETRY FOR PIPELINE ROUTING**

[Matt Lato](#) (1), Alex Baumguard (1), Jon Foster (1), Dennis Kim (1), Dave Gauthier (1)

(1) *BGC Engineering Inc. (Ottawa, Canada)*

The geotechnical engineering aspect of pipeline route selection is a multifaceted process involving detailed studies of ground conditions, geohazards, and geological history. Assessing ground conditions typically involves preliminary desktop based



terrain evaluation tools, boots-on-the ground field investigations, drilling/sampling/testing, and remote sensing data collection and interpretation. Recent advancements in the field of Structure-from-Motion (SfM) 3-dimensional (3D) photogrammetry eliminate the onerous requirements of ground control and enable the generation of high resolution digital terrain models at variable resolutions. Photographs can be taken from a variety of aerial platforms or terrestrial locations. In this project we demonstrate the use of Oblique Aerial Photogrammetry from a UAV (OAP-U) for the generation of a detailed terrain models for the evaluation of a pipeline route crossing a deep valley 200 km from Vancouver, British Columbia. The resultant data was used to map slope angles, geological structure, rockmass conditions, thereby allowing for the optimisation of the pipeline route, and to establish a baseline 3D model of the site that could be used for future comparisons to assess ground changes. The incorporation of OAP-U techniques into field mapping projects has greatly increased the information obtained in the field and resulted in a greater understanding of the terrain.

### **610 - SECANT PILED SHAFT CONSTRUCTION AND MICROTUNNELLING IN SAND**

Aiden Horan (1), Scott Peaker (2)

(1) *Ward and Burke Microtunnelling Ltd. (Mississauga, Canada)*; (2) *SPL Consultants Ltd. (now WSP Canada) (Toronto, Canada)*

This paper outlines the installation of three 18m deep shafts up to 8.2m internal diameter, and two tunnels with an internal diameter of 1.2m in sand with the water table near the ground surface. The shafts were constructed using the secant piled method while the tunnels were constructed via microtunnelling. The challenges and problems associated with these difficult installations are presented, as well as the solutions used to overcome and mitigate the issues encountered.

### **334 - SOIL FAILURE MECHANISM FOR LATERAL AND UPWARD PIPELINE-SOIL INTERACTION ANALYSIS IN DENSE SAND**

Kshama Roy (1), Bipul Hawlader (1), Shawn Kenny (2)

(1) *Memorial University of Newfoundland (St. John's, Canada)*; (2) *Carleton University (Ottawa, Canada)*

Finite element (FE) simulation of the response of buried pipelines due to lateral and upward relative displacements is presented in this paper. Analyses are performed using the Arbitrary Lagrangian-Eulerian (ALE) approach available in Abaqus/Explicit FE software adopting a modified Mohr-Coulomb model (MMC) where pre-peak hardening, post-peak softening, density and confining pressure dependent friction and dilation angles are considered. The calculated peak dimensionless force with the MMC model is consistent with the available design guidelines for shallow burial depths. However, at deep burial conditions FE simulations with the Mohr-Coulomb (MC) model give higher peak resistance than the simulations with MMC model. The simulations with the MMC model appeared to be consistent with the trend of model test results. The role of strain-softening on soil resistance and failure pattern is also critically examined.



## **795- NUMERICAL MODELING OF STRESS REDUCING EFFECTS OF RIGID INCLUSIONS ABOVE BURIED FRP PIPES**

Dahlia Hafez (1), M. Hesham El Naggar (2), Alper Turan (3)  
 (1) Cairo University, Egypt (Windsor, Canada); (2) University of Western Ontario, Canada (London, Canada); (3) Geotechnique, Burlington, ON, Canada (Burlington, Canada)

Buried fibreglass reinforced-plastic (FRP) pipes are widely used in process industry, where they are often subjected to large hauling loads. Few traditional protection approaches are in use. The inclusion of a reinforced concrete (RC) structural element above the crown of the pipe is a commonly adopted procedure. This paper presents a series of numerical analyses that parametrically study the interaction between the FRP Pipe-Soil-Rigid Inclusion system. Finite Element (FE) stress/deformation analyses of buried FRP pipes subjected to truck loads and protected by a rigid RC slab-on-grade are performed. The effect of using a RC slab-on-grade on the deformation of pipes is investigated considering different axle loading scenarios and different RC slab widths and thicknesses. The results show that the use of a RC slab-on-grade significantly reduces pipe deformation. Increasing the width of the slab yielded better practical benefits than increasing the slab thickness.

## **577 - ON THE NUMERICAL MODELING OF BURIED STRUCTURES WITH COMPRESSIBLE INCLUSION**

Mohamed Meguid (1), Mahmoud Hussein (1), Jim Whalen (2)  
 (1) McGill University (Montreal, Canada); (2) Plasti-Fab Ltd. (Calgary, Canada)

Expanded polystyrene (EPS) geofoam has been successfully used as a lightweight fill material in geotechnical engineering applications due to its low density and high compressive strength. In this study a 2D nonlinear finite element analysis is conducted to investigate the role of embedding a layer of geofoam within the backfill soil around a buried rigid box on the earth loads reaching the box walls. The earth pressure distribution acting on the box is investigated for varying several parameters including geofoam density, thickness, width and location. The numerical model is first validated by comparing the calculated pressures with experimental data and then used to understand some soil-structure interaction aspects of the problem. Conclusions are made regarding the effectiveness of placing the EPS inclusion on the earth pressure distribution around the structure as well as the resulting soil movement near the soil surface.

## **Session/Séance : In Situ Testing and Instrumentation I / Essais insitu et instrumentation I**

**Wednesday, September 23, 10:30 - 12:00 / Mercredi 23 septembre, 10 h 30 - 12 h**

Room / Salle : **206A**

Chair / Président de séance : **Mamadou Fall**

## **606 - EFFECT OF SOIL STRUCTURE ON IN-SITU FIELD VANE AND SEISMIC PIEZOCONE TESTS IN CHAMPLAIN CLAY**

Mark Styler (1), Will McQueen (1), John Howie (2)  
 (1) ConeTec Investigations, Ltd. (Richmond, Canada); (2) University of British Columbia (Vancouver, Canada)

In this paper we report on the interpretation of field vane shear testing at the National Canadian Geotechnical Research site in Gloucester, Ontario. Previously published



investigations of the Champlain/Leda clay that underlies this site have observed cemented particle aggregates. We examined three different techniques for estimating the yield-stress ratio from field vane test results in the Champlain/Leda clay that underlies this site. We observed that all three vane interpretation methods provided similar results that were larger than laboratory reported values. We performed a seismic piezocone test and calculated the ratio of the shear stiffness to net tip resistance. For this soil, it appears that strength is a better indication of cemented particle bonds than stiffness.

### **35 - EVALUATION OF THE UNDRAINED SHEAR STRENGTH OF CHAMPLAIN SEA CLAYS (LEDA CLAY) IN OTTAWA USING CPT**

Raymond Haché (1), Athir Nader (2), Simon Gudina (3), Mamadou Fall (4)  
(1) *M.Sc., P.Eng., ing. (Ottawa, Canada)*; (2) *M.A.Sc., E.I.T. (Ottawa, Canada)*; (3) *Ph.D., P.Eng. (Ottawa, Canada)*; (4) *Ph.D., Dipl.Eng., Dipl.Eng. (Ottawa, Canada)*

An evaluation of the empirical cone factors,  $N_{kt}$ , which are used to define the undrained shear strength ( $s_u$ ) profile of a deposit on the basis of cone penetration test (CPT) has been carried out for eleven Ottawa Leda clay sites. Both CPT and field-vane tests were carried out at each site as part of the evaluation of the  $N_{kt}$  values. The field-vane apparatuses used were friction compensated digital and Nilcon vanes.  $N_{kt}$  values presented in the literature typically range from 10 to 20 with recommended values of 14 to 16 in the cases where site specific information is not available. The Ottawa Leda clay sites investigated mostly produced  $N_{kt}$  values in the range of 8 to 12. The practice of using SPT N-values to estimate the undrained shear strength is also briefly discussed and it is demonstrated to be unsuitable for use within Leda clay deposits.

### **251 - INTERPRETATION AND CORRELATION OF CPTU AND VANE SHEAR TESTS FOR VERY SOFT VARVED SILTY CLAYS – A CASE STUDY**

Lincar Pedroni (1), Denise Leahy (2)  
(1) *SNC-Lavalin (Montreal, Canada)*; (2) *SNC-Lavalin (Montreal, Canada)*

A geotechnical testing program has been carried out for site characterization for the design of an earthfill dyke. The preliminary program involved piezocone testing (CPTu) and field vane shear testing (VST) associated with sampling of the very soft varved silty clay foundation. The undrained shear strength profiles estimated from the VST tests were much lower than expected, based on the CPTu tests results. The  $N_{kt}$  coefficient used to compare the VST and CPTu results were in the typical range for the clay present on site.

Additional VST tests were carried out with a manual vane apparatus in several locations down to a depth of about 6 m. The results of the second field test program did not correlate with the CPTu results, even if the additional vane tests seemed to be more representative. As a result, a new testing program was recommended in order to obtain high quality measurements along the dyke alignment. This third testing program has been made taking into account the difficulties and uncertainties of the previous testing programs: therefore vane tests were carried out with care in order to eliminate any remoulding of the soft clay and CPTu tests were performed using an accurate probe.

### **355 - GEOTECHNICAL INVESTIGATIONS OF A LARGE LANDSLIDE SITE AT QUYON, Québec**

Baolin Wang (1), Gregory Brooks (1), James Hunter (1)  
(1) *Natural Resources Canada (Ottawa, Canada)*

Geotechnical investigations were conducted at a large landslide site near Quyon, Québec. Previous studies concluded that the landslide was triggered by an earthquake about a



thousand years ago. The current study continues the previous work to confirm the slope failure mechanism and the earthquake magnitude. This paper presents the results of the first year's study. Cone Penetrometer Tests (CPT), field Vane Shear Tests (VST) and laboratory tests were conducted. The CPT bearing factor  $N_{kt}$  is determined to be a constant 10.5. The CPT pore water bearing factor  $N_{du}$  is dependent on the pore pressure parameter  $B_q$ . The soil undrained shear strength ( $S_u$ ) ranged from 30 kPa to about 250 kPa. A clay layer of  $S_u$  lower than 100 kPa exists at all the undisturbed locations, but is either absent or dislocated within the landslide zone.

### **9 - PIEZOCONE TESTING APPLICATIONS FOR SAFETY ANALYSES OF DAMS ON STRATIFIED DEPOSITS**

Valérie Michaud (1), Pierre-Alain Konrad (1), Marc Smith (2), Éric Péloquin (2),  
Pierre-Alain Konrad (1)

(1) *Groupe Qualitas Inc. (Saguenay, Canada); (2) Hydro-Québec (Montréal, Canada)*

Piezocene testing is largely used for dam foundation investigations. This sounding technique has shown satisfactory result in stratified deposit. For dam safety analysis, the main challenge remains the understanding of the groundwater conditions within the stratified deposits. The latter is assessed from dissipation test achieved within the sounding. This article presents two cases studies where piezocene testing (including dissipation tests) were performed in order to determine an accurate stratigraphy not only based on soil behavior but also on units having similar total head pressure.

### **503 - EGT SAMPLING METHOD; TOWARD UNDISTURBED SAND SAMPLE**

Jean-François St-Laurent (1), Jean-Marie Konrad (2)

(1) *WSP Canada (Québec, Canada); (2) Université Laval (Québec, Canada)*

Numerous publications showed and described the impact of sampling technique disturbance effects over cohesionless soil samples and behavior. This paper presents a new sampling technique for fine granular soils in a saturated state, called EGT sampling technique. The EGT sampling technique stabilizes the soil by using a gelatin solution. As the gelatin solution temperature decrease, hydrogenous bridges are created between gelatin molecules to form a dissolvable elastic gel. Undrained triaxial tests were conducted to establish the viability of the technique. Obtained results suggest that the developed method maintains the soil grain to grain structure. Observed divergence between behaviors are associated to system saturation difference. In order to support and assist the EGT technique, an advanced and unified thermo fluid-mass flow numerical model, based on 11 equations was developed. The finite element model, allowed determining the stabilized soil volume under various boundaries conditions.



## Session/Séance : Groundwater / Eaux souterraines

Wednesday, September 23, 10:30 - 12:00 / Mercredi 23 septembre, 10 h 30 - 12 h

Room / Salle : 2102B

Chair / Président de séance : Lee Barbour

### 529 - PUMPING TEST IN A CONFINED AQUIFER: HOW TO DETECT A POORLY SEALED MONITORING WELL

Robert P. Chapuis (1), Djaouida Chenaf (1)

(1) CGS (Montreal (Québec), Canada)

When a well is monitoring a confined aquifer, its riser pipe must be perfectly sealed against the borehole wall. A poor seal produces a hydraulic short-circuit and preferential seepage in it. Then, the static water level in the monitoring well is not the aquifer piezometric level, which is unknown. During a pumping test, a poorly sealed monitoring well yields incorrect drawdown and recovery data. This paper explains how to detect short-circuiting and obtain the correct drawdown data, using the example of a test near Moncton, NB. The usual methods for interpreting the drawdown and recovery data ignored the possible short-circuiting: they yielded close values for transmissivity  $T$ , but storativity  $S$  values differing by 500%. The proposed method found that because of short-circuiting the static water level in the riser pipe was 124 cm below the aquifer piezometric level. Then, drawdown and recovery data were corrected and reanalyzed, which yielded new and close values for  $T$  and  $S$ , thus supporting the diagnosis of hydraulic short-circuiting.

### 508 - A NUMERICAL STUDY OF THE INFLUENCE OF GROUNDWATER FLOW ON HEAT LOSS FROM RESIDENTIAL FOUNDATIONS

Dominique Beaulieu (1), Jean Côté (1)

(1) Université Laval (Québec, Canada)

This paper aims at determining the relative effects of groundwater flow (heat convection) on the total heat loss towards surrounding soils using a finite elements method to solve coupled heat and mass transfer in porous media. Three different soils were studied: clay, silt and sand. The results show that the flow of groundwater under the foundation has a significant influence on the total foundation heat loss if the surrounding soil is made of coarse grained soil such as pervious sands. As expected, the high water conductivity of sand has a strong influence on total heat loss due to varying pore-water velocities (hydraulic gradient). On the other hand, the results also show that low permeability soils such as silts and clays have insignificant influence on the total heat loss. Very low pore-water velocity does not allow for noticeable heat extraction under any water table or hydraulic gradients conditions.

### 286 - THE EFFECT OF FLOW REVERSAL ON PERMEABILITY MEASUREMENT IN ROCKS

Adrian Glowacki (1), A.P.S. Selvadurai (1)

(1) McGill University (Montreal, Canada)

This paper presents the results of an experimental evaluation of flow reversal on the alteration of "permeability" in both saturated and unsaturated rock samples subjected to constant flow tests. Cylindrical samples of the rock (Indiana limestone, Stanstead granite and Rudna Sandstone measuring 50 mm in diameter and 20 mm in length) were tested. The samples were epoxy coated on the cylindrical surfaces and capped with acrylic disks, allowing only one-dimensional flow. A constant flow rate was applied at the upstream and



the downstream was kept at atmospheric pressure. The inlet fluid pressure response was recorded with time. The samples were tested under different conditions: initially dry, initially saturated and flow reversal all using distilled de-aired water. The pressure response due to flow reversal was noted to be significant and dependent on the rock type. Sandstone was the least influenced by flow reversal, whereas granite and limestone showed an increase in pressure due to flow reversal.

## **725 - INTERPRETING PUMPING TEST IN STRATIFIED CONFINED AQUIFER USING THE EQUIVALENT MODEL**

Djaouida Chenaf (1), Afaf Moumin (1), Sarah Boukemidja (2), Afaf Moumin (1)  
(1) *Royal Military college, Department of Civil Engineering (Kingston, Canada)*; (2) *LRS EAU, École Nationale Polytechnique (Algérie, Algeria)*

Aquifer tests are commonly used to determine the hydrodynamic characteristics and boundary limits of stratified confined aquifers. However, the interpretation of the resulting data is made based on very simplistic assumptions lacking real-world validation. Heterogeneous and anisotropic layered aquifers are frequently treated using homogeneous anisotropic equivalent models whose neither spatial nor temporal validity have been assessed. This paper proposes a new approach to allow for a more reliable and appropriate application in such conditions, thus, overcoming the shortcomings of these models.

## **11 - ESTIMATION DE LA CONDUCTIVITÉ HYDRAULIQUE ET LA POROSITÉ DES LITHOFACIÈS IDENTIFIÉS DANS LES DÉPÔTS DU PALÉODELTA DE LA RIVIÈRE VALIN DANS LA RÉGION DU SAGUENAY**

LAMINE BOUMAIZA (1), ALAIN ROULEAU (2), PIERRE A COUSINEAU (2)  
(1) *Stantec Experts-conseils Ltée (Saint-Laurent, Canada)*; (2) *Université du Québec à Chicoutimi (Chicoutimi, Canada)*

Dans le cadre de travaux de caractérisation hydrogéologique des aquifères granulaires du paléodelta de la rivière Valin au Saguenay (Québec), des essais d'estimation de la conductivité hydraulique et de la porosité ont été réalisés sur les différents lithofaciès identifiés sur les faces de sablières sélectionnées dans la zone d'étude. Ces essais, tant pour la conductivité hydraulique que la porosité, ont été réalisés insitu et en laboratoire. Les résultats issus des essais de porosité selon les méthodes utilisées semblent bien concorder, avec un écart observé de moins de 5% pour 75% des cas, entre les résultats obtenus insitu et ceux obtenus en laboratoire. La variabilité des valeurs estimées de la conductivité hydraulique semble rattacher à trois facteurs distincts qui sont : 1) l'hétérogénéité des dépôts meubles du paléodelta de la rivière Valin, 2) les différentes méthodes d'estimation qui ont été utilisées pour le même lithofaciès et au même endroit, et 3) des causes d'erreur identifiées lors de la réalisation des essais effectués dans le cadre de cette étude. Par ailleurs, des analyses granulométriques et sédimentométriques sur les échantillons de sol, représentant les lithofaciès, permettent une interprétation plus exacte des résultats portant sur la conductivité hydraulique et la porosité.

## **216 - PERFORMANCE OF FULLY GROUTED PIEZOMETERS SUBJECTED TO TRANSIENT FLOW CONDITIONS**

Vahid Marefat (1), François Duhaime (2), Robert P. Chapuis (2)  
(1) *PhD candidate (Montreal, Canada)*; (2) *Professor (Montreal, Canada)*

Piezometers can be installed within clay layers with either the fully grouted or traditional method. With fully grouted piezometers, there is no sand filter around the piezometer



and the borehole is grouted completely after having positioned the transducer. Advocates of this method claim that it has the following advantages: no risk of failure for the sand pack of deep wells, ease of installation, and reduced installation costs, especially from the opportunity to install several piezometers and geotechnical instruments within the same borehole. This paper presents a numerical model using the finite element code SEEP/W to assess the performance of a fully grouted piezometer under transient flow condition. The results indicate that the fully grouted transducer provides representative pore pressure data, without producing a significant piezometric error, when the permeability contrast between grout and surrounding clay is between 0.1 and 10. For a grout with a much lower permeability than the surrounding clay, the cement-bentonite grout should be stiffer than the clay to provide representative pore pressure data.

## **Session/Séance : Problematic Soils and Ground Improvement I / Sols problématiques et amélioration du comportement I**

**Wednesday, September 23, 10:30 - 12:00 / Mercredi 23 septembre, 10 h 30 - 12 h**

Room / Salle : **2104AB**

Chair / Président de séance : **Régis Bouchard**

### **670 - SITE PREPARATION FOR VANCOUVER AIRPORT DESIGNER OUTLET CENTRE, RICHMOND, BC**

Mustapha Zergoun (1), Ivan Rivera Cruz (1), Gunther Yip (1)  
(1) *Thurber Engineering Ltd. (Vancouver, Canada)*

This paper presents a case history of the site preparation for a large commercial retail development near the Vancouver International Airport, Richmond, British Columbia. The low elevation of the site required filling to achieve flood protection from the Fraser River. The subsurface conditions included compressible deep deltaic deposits that can generate large settlement under fill loads and loose sand that can liquefy under the design earthquake. The site investigation and analysis concentrated on estimating the expected post-construction settlement and assessing the soil liquefaction under the national building code seismic event. A preload treatment was carried out to reduce post-construction settlement to within acceptable limits. In-depth soil densification using the vibro-replacement method was selected to mitigate the risk of soil liquefaction and foundation shear punching failure. The site preparation was complicated by the proximity of a recently built and active airport light rail transit and a vital jet fuel pipeline. The paper describes the settlement analysis and calibration undertaken using historical field monitoring data available from a nearby highway overpass approach embankment. The paper also describes a comparative interpretation of both Static Cone Penetration Tests (CPT) and Standard Penetration Tests (SPT) for soil liquefaction assessment and mitigation.

### **486 - ASSESSMENT OF COMPATIBILITY BETWEEN EXISTING LIQUEFACTION CHARTS IN EASTERN REGIONS OF NORTH AMERICA**

Mourad Karray (1), Mahmoud Nasser (1), Mohamed Chekired (2)  
(1) *Université de Sherbrooke (Sherbrooke, Canada)*; (2) *IREQ (Varenne, Canada)*

A comprehensive set of seismic (regular and irregular) loading tests on granular soil samples have been conducted using the new combined triaxial simple shear (TxSS) apparatus in order to evaluate the applicability/performance of the available seismic chart used in Eastern





regions of North America and in Eastern Canada in particular. The TxSS system consists of a simple shear apparatus incorporated in a triaxial cell for the measurements of dynamic characteristics of soil samples. With TxSS, it is possible to conduct simple shear tests under control confining pressure, undrained conditions, and using arbitrary seismic loadings. In this study, different granular soil samples extracted from different sites in Québec are subjected to seismic loading obtained from response analyses using the computer code, FLAC on soil deposits subjected to earthquakes compatible and incompatible with the Eastern seismicity. The experimental and the computed results are compared, and the comparison confirmed the accuracy and the reliability of the TxSS test results as well as the adopted numerical model, and demonstrated that liquefaction charts used in the Eastern regions of North America, based on traditional tests, should be revisited.

### **206 - LIQUEFACTION MITIGATION USING RAPID IMPACT COMPACTION AND A COMPARISON OF SPT AND CPT CONFIRMATION TESTING**

Jason Brown (1), [Jason Brown](#) (1), Nicolas LeBlanc (2), Serge Bourque (3), Mark Tigchelaar (1)  
(1) *GeoSolv Design/Build Inc. (Vaughan, Canada)*; (2) *Golder Associates Ltd. (Ottawa, Canada)*; (3) *Houle Chevrier Engineering Ltd. (Ottawa, Canada)*

The East Quadrant Water Distribution System in Kemptville, Ontario was expanded in 2014 to include a new pump station and at-grade water silo. The geotechnical investigation for the expansion identified a 2.3 m to 3.4 m thick layer of potentially liquefiable sand. Rapid Impact Compaction (RIC) was specified to densify the sand layer, thereby increasing the factor of safety against liquefaction to be confirmed using Standard Penetration Testing (SPT). After completing the SPT confirmatory testing, the resulting SPT N60 values were found to have a wide range of results. Cone Penetration Testing (CPT) was carried out to supplement the SPT results. This paper discusses the use of RIC to densify the sand layer within a 5 m radius of the new structures and compares the results of both the SPT and CPT confirmatory testing.

### **609 - FINITE ELEMENT MODELLING OF STONE COLUMN INSTALLATION: REVIEW OF MODELLING PRACTICES AND CASE STUDY WITH PLAXIS 2D**

[Olivier Hurley](#) (1), Mathieu Nuth (2), Mourad Karray (1)  
(1) *Université de Sherbrooke (Montreal, Canada)*; (2) *Université de Sherbrooke (Sherbrooke, Canada)*

This article discusses the different numerical modelling practices for the stone column installation and establishes a comparative review of the numerical techniques and constitutive laws used in the literature. Furthermore, taking advantage of the best practices in numerical modelling of stone column installation, a numerical model was created with PLAXIS 2D in axisymmetric geometry to reproduce the lateral expansion of stone in sand. The host material is modelled with a hardening soil constitutive relation to represent the repetitive loading and unloading of the sand during expansion. The results are presented in terms of lateral to vertical stress ratio and variation in void ratio and are then calibrated with two experimental stone column tests carried out at an intermediate scale in our laboratory.



Amir Poshnejad (1)

(1) EllisDon (Mississauga, Canada)

In this paper, two building projects of EllisDon Corporation are studied to compare the design and construction challenges involved in expansive soils. The first building is a hospital in Winnipeg, Manitoba which is a six-storey building with a large column spacing of 9-m. The second building is an agricultural building in Vancouver, BC. This building is a lightweight building. Both of the buildings are founded on expansive soil.

Different foundation solutions are studied for both cases. The solutions are designed based on the available geotechnical report. The geotechnical differences of the two expansive soils are also highlighted. The feasibility of the solutions is then investigated based on parameters like constructability, cost, and schedule. Final recommendations are provided for the foundation type for each project.

**202 - STABILITY DESIGN OF A TAILINGS DAM ON A GLACIOLACUSTRINE CLAY FOUNDATION**

Jérôme Lapierre (1), Desheng Deng (1), Gilles Bouclin (1), Luciano Piciacchia (1)

(1) AMEC Foster Wheeler (Dorval, Canada)

As part of a tailings management mandate, new tailings must be stored in an inactive, existing tailings pond situated in Abitibi, Québec. In order to confine the hydraulically deposited tailings, several dams will be built on soft, varved clays of glaciolacustrine origin. Field vane tests have revealed undrained shear strengths as low as 13 kPa. In order to ensure the timely delivery of the dams and to meet the design factors of safety at all times, the use of stability berms is proposed in conjunction with an observational design approach. As construction is done in stages, monitoring of pore pressures and consolidation will provide the field data required to update the numerical models and the design, if required.

**Session/Séance : Geocryology I / Géocryologie I**

**Wednesday, September 23, 10:30 - 12:00 / Mercredi 23 septembre, 10 h 30 - 12 h**

Room / Salle : **2105**

Chair / Présidente de séance : **Hanne Christiansen**

**352 - CRYOSTRATIGRAPHY OF NEAR-SURFACE PERMAFROST IN UNIVERSITY VALLEY, MCMURDO DRY VALLEYS OF ANTARCTICA**

Caitlin Lapalme (1), Denis Lacelle (1), Alfonso Davila (2), Wayne Pollard (3), Christopher McKay (4)  
(1) *University of Ottawa (Ottawa, Canada)*; (2) *Carl Sagan Center at the SETI Institute (Mountain View, United States)*; (3) *McGill University (Montreal, Canada)*; (4) *NASA Ames Research Center (Moffett Field, United States)*

The presence and origin of ground ice in cold and hyper-arid regions defies the conventional understanding of ground ice forming processes. This study investigates the amount, distribution and origin of ground ice in a sand-wedge polygon in University Valley, McMurdo Dry Valleys of Antarctica. Analysis of computed tomodensitometric scans revealed three types of cryostructures: structureless, suspended, and crustal. Excess ice distribution in two permafrost cores revealed greater ice content in the center of the polygon. Water



isotope analysis suggests that the ground ice was emplaced by vapour deposition, similar to two nearby polygons. The higher ground ice content in the center of the polygon is likely related to the stability of the ground surface, with a less stable surface near the shoulder of the polygon as sediments fall into cracks. The results presented in this study enhance our understanding of ground ice and the processes, including environmental factors, which form the ice-cemented permafrost in cold arid regions.

#### **641 - CRYOFACIES AND CRYOSTRUCTURES OF MASSIVE ICE FOUND ON BYLOT ISLAND, NUNAVUT**

Stephanie Coulombe (1), [Daniel Fortier](#) (2), Yuri Shur (3), Mikhail Kanevskiy (3), Denis Lacelle (4)  
 (1) *Département de Géographie - Université de Montréal (Montreal, Canada)*; (2) *Département de Géographie - Université de Montréal (Montreal, Canada)*; (3) *Institute of Northern Engineering - University of Alaska Fairbanks (Fairbanks, United States)*; (4) *Department of Geography - University of Ottawa (Ottawa, Canada)*

Permafrost can contain massive ground ice of different origin. Identifying the origin and nature of massive ice is a challenge for permafrost science since the different types of massive ice remain difficult to distinguish on the sole basis of field observations. This paper uses different approaches to accurately characterize a massive ground-ice exposure observed on Bylot Island (Nunavut) in order to highlight its origin. Combined with the analysis of the ice crystallography, the massive-ice cores were described according to the cryostratigraphic approach. These techniques allowed for detailed descriptions of the stratigraphy, the ice crystals (shape, size, orientation) and patterns of gas/sediment inclusions. Our results suggest that the massive ice body is best interpreted as buried ice of glacial origin.

#### **259 - ORIGIN AND COMPOSITION OF A LITHALSA IN THE GREAT SLAVE LOWLAND, NORTHWEST TERRITORIES**

[Adrian Gaanderse](#) (1), Stephen Wolfe (2), Chris Burn (1)  
 (1) *Carleton University (Westmeath, Canada)*; (2) *Geological Survey of Canada, Natural Resources Canada; Carleton University (Ottawa, Canada)*

Recognition of lithalsas in the Great Slave Lowland, NT, prompted an investigation to determine the geomorphic origin and composition of one lithalsa. Ice-poor conditions occur within the upper 4 m of substrate, with substantial increases in ice content at greater depths within clays. The lithalsa core is composed of layered ice lenses over 0.1 m thick, formed of isotopically-modern meteoric waters. The stratigraphy of clays, silts, and sands is sub-parallel, but domed in accordance with surficial relief of the lithalsa. The estimated differential heave between the lithalsa and an adjacent peatland is approximately 2.8 m, of which 2.17 m is directly accounted for by excess ice lenses within the upper 8.4 m of material. <sup>14</sup>C dating indicates permafrost aggradation within the lithalsa occurred between 700 and 400 cal yr BP.

#### **160 - PERMAFROST PATCH SIZE IN THE SPORADIC DISCONTINUOUS AND ISOLATED PATCHES PERMAFROST ZONES, SOUTHERN YUKON AND NORTHERN B.C.**

[Olivier Bellehumeur-Genier](#) (1), Antoni Lewkowicz (1)  
 (1) *University of Ottawa - Department of Geography (Gatineau, Canada)*

Little is known about permafrost patch size, trends and dynamics from the southernmost limit of discontinuous permafrost through to the boundary of continuous permafrost. This research focused on evaluating permafrost patch size and related variables along a 1400 km



transect between Fort St. John, BC and Whitehorse, YT. Methods used included electrical resistivity tomography (ERT), climate data collection, active layer measurement, analysis of historic aerial photos, and on-site near-vertical aerial imaging. Field observations indicate that discrete permafrost patches are in the order of 101-103 m<sup>2</sup> in area and that permafrost boundaries at a given site are influenced by microtopography, slope, drainage, substrate, and antecedent disturbance. Ongoing data analysis is expected to establish whether spatial trends in permafrost patch size and characteristics exist along the transect or whether local factors are the primary controls.

#### **169 - PERMAFROST IN MOUNTAINOUS REGIONS OF CANADA**

Stephan Gruber (1), Christopher R. Burn (1), Lukas Arenson (2), Marten Geertsema (3), Stuart Harris (4), Sharon L. Smith (5), Philip Bonnaventure (6), Bronwyn Benkert (7)  
 (1) Carleton University (Ottawa, Canada); (2) BGC Engineering Inc. (Vancouver, Canada);  
 (3) British Columbia Ministry of Forests, Lands and Natural Resource Operations (Prince George, Canada); (4) University of Calgary (Calgary, Canada); (5) Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada); (6) University of Lethbridge (Lethbridge, Canada); (7) Northern Climate ExChange, Yukon Research Centre, Yukon College (Whitehorse, Canada)

About one third of the global permafrost region is situated in mountainous terrain, and in Canada, large areas underlain by permafrost have mountainous topography. Although mountain topography and terrain-related mass movements yield a much greater diversity of ground materials and temperatures per unit area than encountered in polar lowlands, the governing physical principles are the same. Permafrost in mountainous regions thereby enriches the variety of permafrost-related phenomena encountered beyond what is typically found in lowland areas. Permafrost thaw in mountains is relevant as it may increase the potential for geohazards such as debris flows, rock falls, rock avalanches, and displacement waves. There are also implications for hydrology, water quality, and ecosystems. We argue for better integration of permafrost research in mountainous regions with mainstream permafrost research and education in Canada.

#### **453 - GROUND ICE DETERMINATIONS ALONG THE YUKON COAST USING A MORPHOLOGICAL MODEL**

Nicole Couture (1), Wayne Pollard (2)  
 (1) Geological Survey of Canada - Natural Resources Canada (Ottawa, Canada); (2) McGill University (Montreal, Canada)

Permafrost in the Canadian western Arctic contains large amounts of ground ice and a geomorphological model is used to estimate ground ice content. The Yukon coastline was divided into 44 different terrain units based on geology, coastal morphology, and the presence of different types of ground ice. The overall volume of ground ice within a terrain unit was assessed based on the stratigraphic relationships between different ice types. Ice volumes in the various terrain units ranged from 0 to 74% and were a function of surficial material. Across the entire study area, ground ice accounts for 46% by volume of all earth materials. Pore ice and thin segregated lenses account for 76% of the total ground ice, massive ice accounts for 21%, and wedge ice for 3%.



## Session/Séance : Foundations V / Fondations V

Wednesday, September 23, 13:30 - 15:00 / Mercredi 23 septembre, 13 h 30 - 15 h

Room / Salle : **204AB**

Chair / Président de séance : **Kent Bannister**

### 55 - CASE STUDY: A SIMPLIFIED EVALUATION OF LOAD TRANSFER FROM A MONOPOLE FOUNDATION

Jamie Schweighofer (1), Kyle Noble (1)  
(1) *Stantec Consulting Ltd. (Calgary, Canada)*

This case study outlines the evaluation of load transfer from a monopole foundation to an earth retention structure (three pile diameters away) and a deep utility (one pile diameter away). In the absence of as-built detail for the existing infrastructure, two design approaches were considered. Initially, a cautious estimate of the anticipated load transfer on each structure was evaluated using a combination of computer modelling and simplified analysis. In the second approach, load transfer within the influence of the existing infrastructure was eliminated with a double casing design approach. The end result was the successful completion of a pile foundation that mitigated risk stemming from unknown design and construction details of surrounding infrastructure. The case study also provides insight on the lessons learned that could be incorporated into future projects.

### 536 - ANALYSIS OF LATERALLY LOADED RIGID MONOPILES

Bipin Gupta (1), Dipanjan Basu (1)  
(1) *University of Waterloo (Waterloo, Canada)*

A continuum-based analysis for laterally loaded rigid monopiles supporting offshore wind turbines in multilayered elastic soil is presented. The principle of virtual work is used to derive the equilibrium equations maintaining appropriate force balance between the pile and soil. The equilibrium equations are solved using an iterative numerical scheme to obtain the pile and soil displacements. Pile responses obtained using this method match well with those of equivalent finite element analysis.

### 594 - RESPONSE OF SHORT MONOPILES FOR OFFSHORE WIND TURBINE FOUNDATIONS: VIRGIN AND POST-CYCLIC CAPACITY

Francisco J. Grajales (1), Ryan D Beemer (1), Madhuri Murali (1), Charles P Aubeny (1), Giovanna Biscontin (2)  
(1) *Texas A&M University (College Station, United States)*; (2) *University of Cambridge (Cambridge, London, United Kingdom)*

Geotechnical centrifuge tests were conducted to examine monotonic behavior of low aspect ratio piles in soft clays. Monopiles with aspect ratio of two were tested in the 150g-ton centrifuge at Rensselaer Polytechnic Institute. Initial pile test results include force-displacement for displacement controlled loading. This paper focuses on ultimate capacity of short aspect ratio monopiles after cyclic loading. Post-cyclic monotonic capacity is compared to virgin monotonic capacity for pure rotational loading over a range of eccentricities.



### **753 - EFFECTS OF LOADING ON STIFFNESS AND CAPACITY OF WIND TURBINE HYBRID FOUNDATION UNDER 1 G MODELING.**

Ahmed Abdelkader (1), [Ahmed Abdelkader](#) (1), hesham el naggar (2)  
(1) *phd candidate (London, Canada); (2) Professor, Vice dean Faculty of engineering, UWO (London, Canada)*

Wind Energy generation from both onshore and offshore wind farms is growing rapidly. Monopile foundations offer construction advantages, and therefore are widely used, especially in North Sea offshore wind energy projects, as an effective foundation option for wind turbines. To further enhance the efficiency of monopile foundations for wind turbines applications, a new hybrid system that combines a monopile and a concrete plate is presented and tested in this work. Measured wind loads from boundary layer wind tunnel tests conducted at Western University on a model 5 MW NREL (National Renewable Energy Laboratory) wind turbine were used. A scaled-down non-dimensional framework of stiff foundation models installed in sand was used to conduct a series of static tests under 1-g. Two model foundations were tested in a laboratory setup. The test results were used to develop an equation to predict the plate effects of the proposed hybrid foundation system as an effective modeling technique in the lab.

### **554 - STATIC AND CYCLIC DESIGN ASPECTS FOR FOUNDATION PILES OF OFFSHORE WIND FARMS**

[Axel Nernheim](#) (1), Andre Stang (2)  
(1) *WTM Engineers GmbH (Hamburg, Germany); (2) THM - University of Applied Sciences (Giessen, Germany)*

Part of the proposed transition of the German energy market to renewable energy will be based on the large-scale development of offshore wind farms. Due to large pile diameters and distinct cyclic loading effects from wind and waves, new challenges arise for the pile design of the foundations. This contribution gives an overview of the specific cyclic pile design aspects with a focus on offshore wind farm installations in the German sector of the North Sea. Three methods are presented: An interaction diagram, an analytical and a numerical approach.

### **109 - THE USE OF THE GEOPIER® INTERMEDIATE FOUNDATION® SYSTEM FOR SUPPORT OF SEVEN WIND TURBINE FOUNDATIONS IN EASTERN ONTARIO**

Serge Bourque (1), [Mark Tigchelaar](#) (2), Neil Isenegger (2), Jason Brown (2), Mike Pockoski (3)  
(1) *Houle Chevrier (Ottawa, Canada); (2) GeoSolv Design/Build Inc. (Vaughan, Canada); (3) Geopier Foundation Company (Dayville, United States)*

The use of wind energy in Ontario has been steadily increasing, and multiple farms of a few to hundreds of wind turbines are being constructed at any given time in Ontario. The need for high stiffness foundations due to large overturning moments, and therefore, large edge pressure acting on the base of the foundation can prove challenging when soft or compressible soils at the turbine site do not provide adequate bearing capacity. The use of Geopier® Intermediate Foundations® has been used to provide increased bearing capacity and foundation stiffness for hundreds of wind turbine foundations around the world.



## Session/Séance : Embankments and Dams in Cold Regions / Remblais et barrages en régions nordiques

Wednesday, September 23, 13:30 - 15:00 / Mercredi 23 septembre, 13 h 30 - 15 h

Room / Salle : 205A

Chair / Présidente de séance : Maude Boucher

### 108 - EVALUATING THE PERFORMANCE OF A FROZEN CORE DAM FOUNDED ON ICE RICH SALINE MARINE SILTS AND CLAYS

Maritz Rykaart (1), Megan Miller (1), John Kurylo (1), Lowell Wade (1)  
(1) *SRK Consulting (Canada) Inc. (Vancouver, Canada)*

A precedent setting frozen core dam was constructed over 30 m thick ice-rich, saline glacial marine silt and clay, and fine sand as part of the tailings management system at the Doris North Project in Nunavut Canada. This water retaining dam was completed in 2012, and two years of monitoring data confirm that the engineered (non-saline) core is maintaining a temperature below  $-2^{\circ}\text{C}$ , whilst the underlying saline permafrost foundation is stabilizing with temperatures trending below  $-8^{\circ}\text{C}$  as per the design. This paper presents this data, demonstrating the viability of this technology even under such challenging foundation conditions.

### 602 - HIGHWAY STRUCTURE STABILIZING THROUGH CONVECTION PIPE COOLING (CPC)

Christian Nesrallah (1), Mamadou Fall (2)  
(1) *University of Ottawa (Vancouver, Canada)*; (2) *Professor at the University of Ottawa (thesis supervisor to Christian Nesrallah) (Ottawa, Canada)*

An experimental research site has been constructed in the Northwest Territories to examine the efficacy of long, narrow, hollow pipes inserted into the ground as a cooling mechanism to stabilize permafrost. The pipes were installed in four different ways in order to achieve a broader picture of the mechanisms at work. The resulting ground temperatures over the winter months are presented. Promising results have been obtained.

### 791 - INVESTIGATION OF CRUSHED ROCK MATERIAL USED IN THE FROST PROTECTION LAYER (NORWAY)

Elena Kuznetsova (1), Henri Giudici (1), Inge Hoff (1), Lars Andreas Solås (2), Marta Marcheselli (3), Ilaria Miranda (3), Claudio Lantieri (3), Valeria Vignali (3)  
(1) *Norwegian University of Science and Technology (Trondheim, Norway)*; (2) *Norwegian Public Road Administration (Trondheim, Norway)*; (3) *University of Bologna (Bologna, Italy)*

Norwegian road construction practice has changed significantly during the last 40 years due to the replacement of gravel by crushed rock materials in the granular layers of the pavements. Knowledge of thermal conductivity of all granular layers is required in order to have adequate calculations of frost penetration depth. This paper presents the results of field and laboratory investigations of crushed rock materials used in the frost protection layer. Field observations did not show direct connection of frost heave of the surface with the amount of fines content in the granular layers. Laboratory experiments on thermal conductivity revealed that increasing the water content from 0 to 7% increases thermal conductivity of granular materials from 1.5-2 to 4-7.5 W/mK in frozen and up to 3-6.2 W/mK in unfrozen states.



### 306 - SURFACE TEMPERATURES CALCULATION METHOD FOR HIGH ALBEDO ROAD SURFACES IN PERMAFROST REGIONS

Simon Dumais (1), Guy Doré (2)

(1) *Département de génie civil et Centre d'études nordiques, Université Laval (Québec, Canada)*; (2) *Département de génie civil, Université Laval (Québec, Canada)*

High albedo road surfaces can be used to reduce heat absorption in order to limit the degradation of the permafrost under paved embankments. A method is proposed to calculate the surface temperature pavements in permafrost regions. First, several practical methods to determine the albedo of the pavement are presented. Second, the required climatic data to use the model are discussed. A method to calculate the incoming solar radiation is presented. Then, an albedo based model using a simplified energy balance at the surface of the pavement is used to calculate the radiation index and surface temperature of the pavement. Finally, an index based on Stefan equation is proposed to assess the effectiveness of high albedo surfaces for the mitigation of permafrost degradation. Two working examples are also presented for Beaver Creek, Yukon and Iqaluit, Nunavut.

### 540 - NON-DARCY AND RADIATIVE EFFECTS ON CONVECTIVE EMBANKMENT MODELING

Marc Lebeau (1), Jean-Marie Konrad (1)

(1) *Laval University (Québec, Canada)*

The design of convective embankments generally hinges on the use of numerical models that describe buoyancy-driven flow and heat transfer in porous media. A review of the literature reveals that most of the models used in the study of convective embankments assume that heat transfer occurs by conduction and convection, and that airflow can be described with Darcy's law. This is inconsistent with recent experimental evidence that suggests that radiative heat transfer is significant, and that Darcy's law does not apply to rockfill materials. In response to these shortcomings, a new model is herein derived to account for both radiative heat transfer and non-Darcy effects. Once validated, the model is used to gain insight into the relative importance of radiative heat transfer and non-Darcy flow on the thermal response of a typical railway embankment. The radiative heat transfer is shown to be greater during the summer months. This increases the temperature at the base of the embankment, which in turn, increases the wintertime convective heat transfer. This additional heat extraction does not counteract the effect of the radiative heat transfer, and the wintertime temperatures below the embankment are shown to be warmer than that computed without radiative and non-Darcy effects.

### 89 - INFLUENCE OF WATER TEMPERATURE AND FLOW ON THERMAL REGIME AROUND CULVERTS BUILT ON PERMAFROST.

Loriane Périer (1), Guy Doré (1), C.R Burn (2)

(1) *Université Laval\_Civil Engineering Department\_Centre d'Etudes Nordiques (Québec, Canada)*; (2) *Carleton University\_Geography and Environmental studies (Ottawa, Canada)*

Embankment instability is frequently observed on the Alaska Highway in Yukon (Canada). Some of these instability problems are close to culverts. Free air and water circulation through the culvert creates a thermal disturbance to the surrounding soil. Two culverts near Beaver Creek were selected and instrumented to document these disturbances. Soil temperatures around culverts were recorded for an entire year while water temperatures and flow were recorded during both spring and summer. These data allow validation of mathematical relations established between the heat flux below the culvert and water





temperature and flow. Some variations in flow and water temperature were applied to the mathematical model to quantify the influence of these two parameters on the heat flux transmitted from the culvert to the ground.

## **Session/Séance : Transportation and Linear Infrastructure II / Transports et infrastructures linéaires II**

**Wednesday, September 23, 13:30 - 15:00 / Mercredi 23 septembre, 13 h 30 - 15 h**

Room / Salle : **205BC**

Chair / Président de séance : **Harpreet Panesar**

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### **804 - TERRAIN ANALYSIS FOR HIGH VOLTAGE TRANSMISSION LINE ROUTING USING REMOTE SENSING TECHNIQUES**

Lynden Penner (1), Shayne MacDonald (1)

(1) *J.D. Mollard and Associates (2010) Limited (Regina, Canada)*

Remote sensing techniques offer cost effective tools for characterizing terrain conditions for geotechnical and environmental assessment of linear infrastructure routes. A routing study for a high-voltage overhead transmission line highlights the utility of remote sensing for evaluating slope stability, flood frequency at a major river crossing, and potential impacts to environmentally sensitive aeolian soils. Remote sensing tools used include black and white stereoscopic air photos, high-resolution colour orthoimagery, and digital elevation data generated from photogrammetric analysis and LiDAR data. Interpretation of these data sets was aided by ground and helicopter field reconnaissance and publically available information including water well logs, soils maps, and hydrologic data. Study results illustrate information that can be gained from remote sensing techniques, the value of integrating this information with other data sources, and examples of specific terrain features that can be studied using remote sensing products.

### **684 - LARGE-SCALE AND LONG-TERM SETTLEMENT MONITORING: THE BENEFITS OF USING REMOTE SENSING FOR MAJOR INFRASTRUCTURE PROJECTS**

Pierre-Jean Alasset (1), Joseph Chamberland (1), John Mulvie (1), Bing Yue (1)

(1) *C-CORE (Ottawa, Canada)*

Through specialized interferometric processing of Synthetic Aperture Radar (SAR) remote sensing data, a technique referred to as InSAR, it is possible to obtain high accuracy infrastructure surface change maps over relatively large regions. Applying InSAR techniques to modern space-based SAR datasets can provide surface change maps every 4 to 23 days with a spatial resolution of 1 to 3 meters. This technique is currently being used to monitor key areas of the Ottawa Light Rail Train (OLRT) construction for surface movement over the duration of the construction. The steps to ensure a successful remote sensing monitoring program include a feasibility study, a proper baseline establishment, and an on-going monitoring period where the monitoring requirements are addressed through proper data planning and processing. The OLRT case is an example of using InSAR tools for large infrastructure projects.



#### 446 - FINITE ELEMENT ANALYSES OF BURIED PIPELINE SUBJECTED TO LIVE LOAD USING ABAQUS

Ahdyeh Mosadegh (1), Hamid Nikraz (2)

(1) *PhD Candidate (Perth, Australia); (2) Professor at Faculty of Science and Engineering (Perth, Australia)*

This paper shows the methodology used for modelling the behaviour of a buried pipeline subjected to traffic load using the finite element method (FEM). Soil behaviour is represented by the elasto-plastic Drucker-Prager model and the pipe material is assumed to be isotropic and linear elastic using FEM software ABAQUS 6.13. For the whole system, the effect of surface pressure amplitude (magnitude of 200 and 550 kPa) on pipe-soil displacement and stress distribution is investigated at different pipe burial depths of 1–5 times the pipe diameter. In addition, the influence of pipe-soil interaction properties, boundary conditions at pipeline ends, pipe material properties and internal pressure are taken into consideration. For all cases, the results are compared with predictions obtained through numerical and experimental research, which shows satisfactory agreement with results from the literature.

#### 19 - SETTLEMENT OF A BRIDGE FOOTING SUPPORTED ON RECLAIMED ASPHALT PAVEMENT BACKFILL

Brian Hall (1), Brian Gummesson (2)

(1) *Tetra Tech EBA (Vancouver, Canada); (2) Senior Technologist (Nanaimo, Canada)*

This paper describes the greater-than-expected settlement of a perched bridge abutment footing supported on a mechanically stabilized earth (MSE) wall. A possible reason advanced for the greater than expected settlement was the presence of reclaimed asphalt pavement (RAP) material in the MSE backfill. This possibility was assessed by reviewing the published literature, and conducting a limited laboratory test program comparing the settlement potential of RAP to conventional MSE backfill. The published literature shows that RAP settlement depends on asphalt cement binder content and performance grade, asphalt age, and aggregate characteristics, and generally cautions against the use of RAP because of concerns regarding creep deformations. The laboratory tests showed settlement increased as both asphalt cement and moisture content increased, and led to the conclusion that the observed settlement may have resulted from the use of RAP backfill.

#### 76 - EFFECT OF CORROSION ON THE SOIL STRUCTURE INTERACTION OF CSP CULVERTS

Alex Campbell (1), Hany El Naggar (2)

(1) *Dalhousie University (Halifax, Canada); (2) Associate Professor, Department of Civil and Resource Engineering, Dalhousie University (Halifax, Canada)*

Adequate long-term performance of buried culvert structures depends in part on the durability of the steel in service. In some cases, culverts may experience degradation when exposed to chloride-contaminated groundwater. This paper presents a three-dimensional finite element model to examine the influence of corrosion on the stability of circular corrugated steel culverts. The geometrical and material details of the backfill, as well as the construction process, culvert geometry, and earth and vehicle loads were considered in the model. A new approach to account for the effects of backfill compaction is introduced. The culvert behaviour was simulated using a non-linear finite element model (FEM) that accounts for soil-structure interaction and the non-linear stress-strain response of the soil and steel. The non-linear FEM was used to calculate structural forces in culverts with local corroded areas and that are subjected to standard truck loads.



## 696 - RESPONSIBLE CULVERT DESIGN, EVALUATING CULVERT DESIGN LIFE FROM A SUSTAINABLE PERSPECTIVE

Jessica Abrahamse (1), Peter Wu (1), Daniel Calatrava (1)  
(1) *Reinforced Earth Company Ltd. (Mississauga, Canada)*

In this paper the relationship between culvert design life and sustainability is analyzed. The design standards that apply to culvert design are AASHTO (American Association of State Highway and Transportation Officials), CHBDC (Canadian Highway Bridge Design Code), and AS/NZS (Australian and New Zealand Standards). These regulatory frameworks are analyzed through the lens of sustainability. Sustainability is addressed from the standpoint of climate change and the effect of storm events and through the four system conditions, created by "The Natural Step", as part of the framework for sustainable development. An analysis of culverts functioning as wildlife crossings is also discussed. Factors influencing design life are often neglected, and as a result can have hidden costs of repeated installation and ecological damage. In this paper based on our research, we have discussed that it is probable that culverts that have a longer design life will have a better sustainable position pertaining to ecological impacts.

## Session/Séance : In Situ Testing and Instrumentation II / Essais insitu et instrumentation II

Wednesday, September 23, 13:30 - 15:00 / Mercredi 23 septembre, 13 h 30 - 15 h

Room / Salle : **206A**

Chair / Président de séance : **Yannic Ethier**

### 452 - STATISTICAL CORRELATIONS BETWEEN PRESSUREMETER MODULUS AND SPT N-VALUE FOR GLACIAL TILLS

Kanagaratnam Balachandran (1), Jinyuan Liu (1), Laifa Cao (2), Scott Peaker (2)  
(1) *Ryerson University (Mississauga, Canada)*; (2) *SPL Consultants Limited (Toronto, Canada)*

This paper presents a correlations between the pressuremeter modulus (EPMT) and standard penetration test (SPT) N-value for glacial tills in the Greater Toronto Area (GTA). This study is based on the results of a comprehensive geotechnical investigations for the Eglinton Crosstown Light Rail Transit (LRT) Project in Toronto. This study focused primarily on the statistical correlations between SPT- N value and EPMT for glacial tills with different textures, such as silty clay, clayey silt, silty sand, sandy silt, sand and silt. The literature review shows that there is only very limited information available about correlations between EPMT and SPT N value for glacial tills. In this paper, correlations between SPT N-value and EPMT is suggested.

### 300 - ESTIMATION OF THE SMALL STRAIN STIFFNESS OF GLACIAL TILL USING GEOPHYSICAL METHODS AND BAROMETRIC LOADING RESPONSE

Ruth Harley (1), Paolo Bergamo (1), David Hughes (1), Shane Donohue (1), Laura Carse (1), Lee Barbour (2)  
(1) *Queen's University Belfast (Belfast, United Kingdom)*; (2) *University of Saskatchewan (Saskatoon, Canada)*

Stiffness values in geotechnical structures can range over many orders of magnitude for relatively small operational strains. The typical strain levels where soil stiffness changes



most dramatically is in the range 0.01-0.1%, however soils do not exhibit linear stress-strain behaviour at small strains. Knowledge of the In Situ stiffness at small strain is important in geotechnical numerical modelling and design. The stress-strain regime of cut slopes is complex, as we have different principle stress directions at different positions along the potential failure plane. For example, loading may be primarily in extension near the toe of the slope, while compressive loading is predominant at the crest of a slope. Cuttings in heavily overconsolidated clays are known to be susceptible to progressive failure and subsequent strain softening, in which progressive yielding propagates from the toe towards the crest of the slope over time. In order to gain a better understanding of the rate of softening it would be advantageous to measure changes in small strain stiffness in the field.

### **353 - NON-DESTRUCTIVE INSPECTION OF THE SURFACE OF UNDERGROUND STRUCTURES BASED ON THE PROPAGATION OF SURFACE WAVE**

Simon-Pierre Tremblay (1), Mourad Karray (2), Mohamed Chekired (3), Carole Bessette (3), Livius Jinga (3)  
 (1) *Université de Sherbrooke - Hydro-Québec (Cowansville, Canada)*; (2) *Département de génie civil (Québec, Canada)*; (3) *Hydro-Québec (Varenes, Canada)*

This article shows how the propagation of surface waves is affected by the presence and the state of degradation of an underground concrete structure. In previous work, the behavior of elastic waves propagating in a soil profile containing an underground concrete structure was modelled using 2-dimensional numerical models. One of the drawbacks of using 2D models to represent 3D structures is that 2D models neglect the effect that out-of-plane discontinuities may have on the propagation of elastic waves. A 2D profile is therefore not fully representative of an underground profile containing a small concrete structure compared to the size of the soil deposit surrounding it. This paper uses a 3D finite difference method implemented in FLAC3D to show how the presence of a manhole and of a discontinuity at the surface of an underground concrete structure affects the propagation of surface waves.

### **174 - SHEAR WAVE VELOCITY ESTIMATION USING MULTICHANNEL ANALYSIS OF SURFACE WAVE AND SMALL SCALE MICROTREMOR MEASUREMENT FOR SEISMIC SITE CHARACTERIZATION**

Md. Zillur Rahman (1), Sumi Siddiqua (2), A. S. M. Maksud Kamal (3)  
 (1) *PhD Student (Kelowna, Canada)*; (2) *Assistant Professor (Kelowna, Canada)*; (3) *Professor (Dhaka, Bangladesh)*

Average shear wave velocity of the near surface materials up to a depth of 30 m (AVS30) has been estimated using Multichannel Analysis of Surface Wave (MASW) and Small Scale Microtremor Measurement (SSMM) methods. MASW and SSMM are non-invasive and the most economic techniques to accurately estimate AVS30. MASW and SSMM have been carried out at 39 points in Chittagong City, Bangladesh. The results of MASW and SSMM data have been combined to estimate AVS30. The AVS30 of the soils of the city varies from 123 to 420 m/sec. According to the National Earthquake Hazards Reduction Program (NEHRP), the soils of the city are classified as site classes C, D, E and F. The amplification factor of the seismic waves within the soils of the city can be estimated from site classes. Therefore AVS30 estimation by MASW and SSMM methods is a promising option for seismic site characterization.



### **36 - FORMATION OF SOIL PLUGS WITHIN H-PILES DRIVEN IN STIFF CLAYEY PORT STANLEY TILL NEAR LONDON, ONTARIO**

Raymond Haché (1), Raymond Haché (1), Simon Gudina (1), Shaun Walker (1), Greg MacNeill (1)  
(1) *Stantec Consulting Ltd. (Ottawa, Canada)*

The formation of soil-setup soil plugs within H-Piles is demonstrated using the results of Pile Driver Analyzer (PDA) tests. Sixteen (16) PDA tests were carried out; six (6) on H-Piles driven continuously to 20 m and ten (10) driven after a 24 hours pause to accommodate pile splicing. Test results on piles continuously driven to 20 m demonstrated shaft resistances that agreed with the pre-construction static analysis and showed virtually no scatter in the measured pile resistances. Test results on all piles driven to further depths after welding demonstrated a severe loss of shaft resistance within the top 20 m indicating that a 24 hour delay provided sufficient soil-setup time for the formation of long soil plugs between the flanges which were subsequently dragged down leaving the upper portion of the pile with no reliable soil contact. This paper also demonstrates the use of PDA equipment to develop site specific soil setup functions for predicting long term resistances of friction piles and to investigate unanticipated pile-soil responses.

### **190 - EFFECT OF LONG-TERM STATIC LOAD ON THE L-SHAPED RETAINING WALL INSTALLED WITH THINNED WOODEN PILE AND FIBER OPTIC GEOGRID USING BOTDR METHOD**

Suman Manandhar (1), Kazuyuki Miyazoe (2), Satoshi Fukuoka (3), Takenori Hino (1), Dennes T. Bergado (4), Tatsuya Koumoto (5)  
(1) *Institute of Lowland and Marine Research, Saga University (Saga, Japan)*; (2) *Kyushu Kohzoh Sekkei Co.Ltd. (Saga, Japan)*; (3) *Asahi Techno Consultants Co. Ltd. (Saga, Japan)*; (4) *Asian Institute of Technology (Bangkok, Thailand)*; (5) *Saga University, Geopolymer Research Laboratory (Saga, Japan)*

In this study, the effect of long-term static load was observed on the pile head together with straining of geogrid using optical fiber carried with an actual vehicle dump truck on the constructed L-shaped retaining wall using BOTDR method. The change in strain measured immediate after the construction was found to be decreased after four months due to stress relaxation on the geogrid. The strain under static live load was checked to a virtual rear portion of the L-shaped retaining wall and at the central portion of the bottom panel width of L-shaped retaining wall. The straining on geogrid is found to be relatively small and can bear the load of the dump truck to some extent.



## Session/Séance : Northern Communities / Communautés nordiques

221

Wednesday, September 23, 13:30 - 15:00 / Mercredi 23 septembre, 13 h 30 - 15 h

Room / Salle : 2102B

Chair / Président de séance : Martin Tremblay

### 338 - DEVELOPMENT OF A NEW CSA STANDARD FOR MODERATING THE EFFECTS OF PERMAFROST DEGRADATION ON EXISTING BUILDING FOUNDATIONS

Antoni Lewkowicz (1), Martin Tremblay (2), Kelly Montgomery (3)  
(1) University of Ottawa (Ottawa, Canada); (2) Aboriginal Affairs and Northern Development Canada (Ottawa, Canada); (3) Standards Council of Canada (Ottawa, Canada)

Northern infrastructure is highly vulnerable to climate change impacts and must contend with issues such as permafrost degradation, coastal erosion, as well as changes in temperatures and precipitation patterns. Adaptable mechanisms that reduce the North's vulnerability are needed and standards are one mechanism that can reduce some of the vulnerability. CAN/CSA-S501-14 – Moderating the effects of permafrost degradation on existing building foundations, a National Standard of Canada, was developed through the collaboration of representatives from territorial governments, the federal government, universities, the private sector, and northern community government organizations. This Standard proposes measures to moderate the effects of permafrost degradation on existing building foundation and mitigation techniques in relation to changing permafrost conditions.

### 434 - CONSTRUCTION POTENTIAL MAPS IN SUPPORT TO CLIMATE CHANGE ADAPTATION AND MANAGEMENT STRATEGIES FOR COMMUNITIES BUILT ON PERMAFROST: CASE STUDIES FROM NORTHERN Québec

Andrée-Sylvie Carbonneau (1), Emmanuel L'Hérault (1), Sarah Aubé-Michaud (1), Diane Frappier (2), Michel Allard (1)  
(1) Centre d'études nordiques - Université Laval (Québec, Canada); (2) Ministère des Affaires Municipales et de l'Occupation du Territoire (MAMOT) (Québec, Canada)

As ongoing climate warming is expected to continue in northern Québec, the thermal regime and the dynamics of permafrost will be altered. Adequate land use planning must take into account the potential loss of bearing capacity and soil instability due to permafrost degradation. To guide residential and industrial development, an integrated and GIS based geoscience approach was developed to assess permafrost geotechnical properties and map permafrost conditions. Using a multicriteria analysis, terrain sensitive to thaw-settlement, mass movements or other risks related to hazards were then identified. The results are presented as construction potential maps where, for any given terrain category, the suitable foundation types according to the existing engineering solution guidelines are proposed. The high variability of the permafrost conditions across the territory and at the community scale raises specific challenges for land use planning. Using as examples the community of Akulivik and Kangiqsualujuaq, this paper illustrates the potential of those maps as a tool to support community adaptation and management strategies under a changing climate.



## 704 - IMPACT OF LAND COVER DISTURBANCE ON PERMAFROST LANDSCAPES: CASE STUDIES FROM YUKON COMMUNITIES

Katerine Grandmont (1), Isabelle de Grandpré (1), Louis-Philippe Roy (2), Daniel Fortier (3), Bronwyn Benkert (2), Antoni Lewkowicz (4)

(1) Northern Climate ExChange, Yukon Research Centre, Yukon College, YT, Canada; Centre d'études nordiques, Université Laval, Québec, QC, Canada; Geocryolab, Département de Géographie, Université de Montréal, QC, Canada (Montréal, Canada); (2) Northern Climate ExChange, Yukon Research Centre, Yukon College, YT, Canada (Whitehorse, Canada); (3) Geocryolab, Département de Géographie, Université de Montréal, QC, Canada; Centre d'études nordiques, Université Laval, Québec, QC, Canada (Montréal, Canada); (4) Department of Geography, University of Ottawa, ON, Canada (Ottawa, Canada)

Using examples from three case studies in Yukon communities, we investigate the role of anthropogenic disturbance on permafrost landscapes. Landscape modifications investigated include alternations to surface vegetation for fire protection adjacent to communities, and land clearing to support economic activities like surface mining and agriculture. In most cases, the removal of protective vegetative cover resulted in permafrost degradation, leading to the development of near-surface taliks over decadal-scale time periods. Conversely, light alteration to vegetative cover (e.g., stand thinning for fire protection) does not appear to have altered permafrost presence or distribution. Results have implications for community-scale land use planning in the context of a changing climate.

## 539 - HOW PERMAFROST THAW MAY IMPACT FOOD SECURITY OF JEAN MARIE RIVER FIRST NATION, NWT

Fabrice Calmels (1), Cyrielle Laurent (2), Ryan Brown (2), Frédérique Pivot (3), Margaret Ireland (4)

(1) Yukon Research Centre - Yukon College (Whitehorse, Canada); (2) Watertight Solution (Edmonton, AB, Canada); (3) Athabasca University (Edmonton, AB, Canada); (4) Jean Marie River First Nation (Jean Marie River, NWT, Canada)

The Jean Marie River First Nation (JMRFN) assembled a project team to exchange traditional, local and scientific knowledge to produce maps showing the vulnerability of traditional use areas near Jean Marie River to permafrost thaw. Landscape changes driven by permafrost thaw have and will have considerable impacts on country food. The vulnerability hazard map resulting from this project is tailored to the needs of the JMRFN community, is culturally oriented and, when overlain with spatial traditional land use information, brings a new, integrated perspective regarding climate change impacts on the JMRFN. This project represents a prototype for future surveys with mapping aimed at identifying and quantifying the impacts of permafrost degradation from a broader and more holistic viewpoint that combines western science and traditional and local knowledge.

## 691 - AGRICULTURAL ADAPTATIONS TO CHANGING PERMAFROST CONDITIONS IN SOUTHERN YUKON

Karen McKenna (1), Kam Davies (2), Scott Smith (3), Pierre-Yves Gasser (3)

(1) CryoGeographic Consulting (Whitehorse, Canada); (2) Agriculture Branch, Energy Mines and Resources, Government of Yukon (Whitehorse, Canada); (3) Agriculture and Agri-Food Canada (Summerland, Canada)

Yukon agriculture is adapting to the challenges caused by existing and changing permafrost conditions. An ongoing study identifies indicators of permafrost and changing permafrost



conditions, documents adaptations farmers are making and uses baseline soil mapping, Agriculture and Agri-Food Canada's Land Suitability Rating System (LSRS) and climate scenario outputs for modelling future land suitability for agriculture in permafrost-affected areas. The presence of discontinuous permafrost near surface and at depth causes problems for agriculture so understanding where permafrost occurs and its condition is important for agricultural decision making. As LSRS does not currently take permafrost into account when rating land suitability for agriculture, we discuss the use of existing permafrost observational data, available detailed soil mapping and expert knowledge to incorporate known and observed permafrost conditions into the modelling.

### 123 - ARCTIC CITIES, PERMAFROST AND CHANGING CLIMATIC CONDITIONS

Dmitry Streletskiy (1), Nikolay Shiklomanov (1), Vasily Kokorev (2), Oleg Anisimov (2)

(1) *The George Washington University (Washington, United States)*; (2) *State Hydrological Institute (St. Petersburg, Russia)*

Climate change has resulted in permafrost degradation in numerous locations across the Arctic. The effects of climate change are exacerbated in areas of intensive human activity, particularly large industrial centers on permafrost. We used a combination of modeling techniques and field observations to evaluate how changes in climatic conditions have affected permafrost geotechnical properties in Russian large urban settlements such as Norilsk, Salekhard, Yakutsk, and Anadyr. The results show that there have been substantial decreases in foundation bearing capacity in all of these cities on permafrost from the 1970s to present. The projected changes under the six selected climate models show further decreases in foundation bearing capacity by the year 2050.

## Session/Séance : Problematic Soils and Ground Improvement II / Sols problématiques et amélioration du comportement II

Wednesday, September 23, 13:30 - 15:00 / Mercredi 23 septembre, 13 h 30 - 15 h

Room / Salle : **2104AB**

Chair / Président de séance : **Mustapha Zergoun**

### 57 - THE SANTANA PORT ACCIDENT: COULD IT BE A SENSITIVE CLAY FLOWSLIDE UNDER THE EQUATOR?

Sandro Sandroni (1), Serge Leroueil (2), Elaine Barreto (3)

(1) *PUC-Rio (Rio de Janeiro, Brazil)*; (2) *Professor Université Laval (Québec, Canada)*; (3) *M.Sc Student PUC-Rio Catholic University of Rio de Janeiro (Rio de Janeiro, Brazil)*

In March, 28, 2013, an abrupt slope movement involving about half a million cubic meters of soil took place at a Port situated in the North margin of the mouth of the Amazon river. Most of the soft clayey silt flowed under water for a distance of about 350 meters. After the accident a site and laboratory geotechnical testing program has been carried out.

This paper is the first publication after the accident and intends to present:

- Basic sequence and mechanism of failure;
- Typical geotechnical characteristics of the soft soil;
- Preliminary analyses of the movement;
- Speculations on the cause of failure and on the factors that may have contributed to the sensitivity soil.





The flow that followed failure is similar to those that occur in Canadian and Scandinavian highly sensitive clays. This kind of behavior in clayey soils does not seem to have precedents on the Brazilian coast or in any other tropical areas.

### **107 - IN-SITU DETERMINATION OF DISINTEGRATION ENERGY FOR SOFT SENSITIVE CLAYS**

Vikas Thakur (1), Anders Gylland (1), Samson Degago (2), Frode Oset (2), Rolf Sandven (3)  
(1) *Norwegian University of Science and Technology (Trondheim, Norway)*; (2) *Norwegian Public Roads Administration (Trondheim, Norway)*; (3) *Multiconsult As (Trondheim, Norway)*

An accurate assessment and prediction of retrogressive landslides in sensitive clays is a complex and demanding task. Still, there have been several attempts to assess flow slide potentials by looking at certain aspects of sensitive clays of which one of them is studying the energy involved in the disintegration of sensitive clays from an intact to a remolded state. This energy is referred to as disintegration energy. Estimation of disintegration energy in the laboratory is not a straightforward task. Moreover, the challenges associated with the sampling of soft sensitive clays complicate the overall picture. Therefore, in this study an effort was made to perform an in-situ measurement of the disintegration process of Norwegian sensitive clays using the electric vane shear apparatus. The significance of the testing procedure and the results are discussed in light of available analytical and laboratory test results. This is also evaluated in light of previous work reported in the literature.

### **192 - ON ENGINEERING CHARACTERISATION OF A LOW PLASTIC SENSITIVE SOFT CLAY**

Helene Alexandra Amundsen (1), Arnfinn Emdal (1), Rolf Sandven (2), Vikas Thakur (1)  
(1) *NTNU (Trondheim, Norway)*; (2) *Multiconsult (Trondheim, Norway)*

In central Norway, the soft clays can be extremely sensitive to disturbance during sampling and preparation for laboratory testing. In this paper a low plastic sensitive soft clay from Klett is presented. It is challenging to retrieve samples from the site and good quality samples are rare.

For this study, two different laboratories participated in testing the samples taken with a downsized (160 mm) Sherbrooke block sampler. The block samples were opened in Lab. 1 and transported to the other laboratory. The observations indicate a reduction in measured preconsolidation pressure and undrained shear strength in the time delayed tests carried out at Lab. 2. The observed differences in the results from the two laboratories may be explained by the transport of samples, stress release due to delayed testing, handling of samples and dissimilarities in laboratory procedures.

### **148 - SOFT CLAY DRAINAGE CONSOLIDATION USING ELECTRICALLY CONDUCTIVE WICK DRAINS (ECWD)**

Wei-lie Zou (1), Yan-feng Zhuang (1), Xie-qun Wang (2), Sai K. Vanapalli (3)  
(1) *Wuhan University (Wuhan, China)*; (2) *Wuhan University of Technology (Wuhan, China)*; (3) *University of Ottawa (Ottawa, Canada)*

Electro-osmosis (EO) methods have not been widely used for the drainage consolidation of soft clay in practice because of two key problems; (i) metal electrode corrosion, and (ii) high electric energy consumption. With the recent advancements in the conductive plastics, there has been interest in using conductive plastic electrodes instead of metal electrodes to accelerate the drainage of soft clay. This paper presents the details of an in-situ EO test using a new patented electrically conductive wick drain (ECWD) and a



specially designed power supply system on a hydraulically-filled sludge ground in Jiangsu Province, China. Field and laboratory tests were conducted to evaluate the improvement effectiveness after performing EO for a period of 21 days. The electric energy consumption for this EO treatment is 5.2 kwh/m<sup>3</sup>. Moreover, prediction models for electric current, and cumulative drainage, Q during EO are also proposed based on the undertaken studies. Investigations to date suggest that the new ECWD presented in this paper is encouraging for consolidating the soft clays with relatively high water content and high plasticity index to achieve favorable conditions with respect to increase in shear strength at a relatively low cost.

#### **547 - LABORATORY SETUP TO EVALUATE THE IMPROVEMENT OF GEOTECHNICAL PROPERTIES FROM POTASSIUM CHLORIDE SATURATION OF A QUICK CLAY FROM DRAGVOLL, NORWAY**

Tonje Eide Helle (1), Rikke Nornes Bryntesen (2), Helene Amundsen (2), Arnfinn Emdal (3), Steinar Nordal (3), Per Aagaard (4)

(1) NTNU (Trondheim, Norway); (2) Norwegian University of Science and Technology and Norwegian Public Roads Administration (Trondheim, Norway); (3) Norwegian University of Science and Technology (Trondheim, Norway); (4) University of Oslo (Trondheim, Norway)

This laboratory study comprises testing of soft leached quick clay samples under three storage conditions; wrapped in plastic, submerged in de-aired water and submerged in a potassium chloride slurry. The main purpose is to reveal the potential of improving the soil strength by introducing salt ions to the soil in order to enable future use of unsafe clay areas. To enhance the precision of the study, the clay samples are taken by use of a miniature version (sample diameter 160 mm) of the Sheerbrooke block sampler to reduce the sample disturbance to a minimum. The clay is tested by index, triaxial and oedometer testing. Adding KCl to the clay, a 25 % increase is found in the undrained shear strength whereas the remolded undrained shear strength dramatically increased from <0.5 to 4 kPa. Further, increase in soil plasticity, preconsolidation pressure and stiffness is noticeable.

#### **63 - ASSESSMENT OF DIFFERENT TREATMENT METHODS BY MICROBIAL-INDUCED CALCITE PRECIPITATION FOR CLAYEY SOIL IMPROVEMENT**

Mohamed Shahin (1), Liang Cheng (1)

(1) Curtin University (Perth, Australia)

Microbial-induced calcite precipitation (MICP) utilises the metabolic pathway of ureolytic bacteria to form calcium carbonate precipitation throughout the soil matrix, leading to increased soil strength and stiffness. MICP has proved to be an efficient technique for treatment of clean sand; however, there is lack of knowledge for MICP treatment of clayey soils. This paper assesses three different MICP methods including injection, premixing and diffusion, for treatment of clayey sand containing up to 20% clay content. The results indicate that the injection method is applicable only of treating sand columns that contain < 5% clay content. The premixing method, on the other hand, allowed a homogeneous placement of the bacteria cells in the sand columns and the subsequent injection of cementation solution under low pressure of 100 kPa enabled an adequate bio-cementation along specimens that contain up to 10% clay, resulting in up to 150% increase in the UCS values. The results also show that sand columns with 20% clay content can be treated using the diffusion method, leading to increased UCS values of up to 200% depending on the treatment duration. The overall conclusion is that bio-cementation of clayey soils is challenging and requires further investigation before field application.



## Session/Séance : Geocryology II / Géocryologie II

Wednesday, September 23, 13:30 - 15:00 / Mercredi 23 septembre, 13 h 30 - 15 h

Room / Salle : **2105**

Chair / Président de séance : **Reynald Delaloye**

### 499 - QUANTIFYING THE SIGNIFICANCE OF THE HYDROLOGICAL CONTRIBUTION OF A ROCK GLACIER - A REVIEW.

Maxime Duguay (1), Alan Edmunds (2), Lukas Arenson (1), Pablo Wainstein (1)  
(1) *BGC Engineering Inc. (Calgary, Canada)*; (2) *BGC Ingenieria Ltda. (Santiago, Chile)*

The role of uncovered glaciers in the hydrological cycle has been well studied and documented in the scientific literature. On the other hand, very little is known of rock glaciers. Despite the lack of data and understanding as to the role of rock glaciers within the hydrological cycle some legislations have recently been implemented to protect them from any human impact, by erroneously including rock glaciers as part of the glacial environment. This paper reviews available literature on rock glacier hydrology and the different positions authors have adopted in order to synthesize available knowledge on the hydrological significance and hydrograph response of these cryoforms. We recommend that rock glaciers should be assessed under a holistic approach; their significant differences in genesis, morphology, dynamics, and energy exchange to glaciers must be acknowledged. Detailed site investigation is required in order to properly determine the role of rock glaciers and the periglacial environment on the hydrological cycle in a mountain watershed.

### 311 - HYPER-SALINE SPRING DYNAMICS AND SALT DEPOSITS ON AXEL HEIBERG ISLAND, NUNAVUT

Melissa Ward (1), Wayne Pollard (1)  
(1) *McGill University (Montreal, Canada)*

On Axel Heiberg Island in the Canadian High Arctic, low temperature perennial saline springs occur despite cold polar desert conditions marked by a mean annual air temperature close to -20°C. Distinct large scale salt deposits are associated with two hyper-saline springs. This research characterises the geomorphology and geochemistry of two hyper-saline springs on Axel Heiberg Island: the first is located at Wolf Diapir (79°07'23"N; 90°14'39"W), the deposit at this site resembles a large conical mound (2.5 m tall x 3 m diameter). The second is located at Stolz Diapir (79°04'30"N; 87°04'30"W). In this case a series of pool and barrage structures staircase down a narrow valley for approximately 800 m (several pools are up to 10 m wide x 3 m deep). A detailed methodology and preliminary results are presented.

### 647 - INCIDENCE OF PLEISTOCENE-HOLOCENE CLIMATE ON THE CONCURRENT LANDSCAPE AND PERMAFROST DEVELOPMENT OF THE BEAVER CREEK REGION, SOUTHWESTERN YUKON, CANADA

Michel Slinger (1), Fortier Daniel (1), deGrandpré Isabelle (1), Lapointe-Elmrabti Lyna (1)  
(1) *Université de Montréal - Département de Géographie (Montréal, Canada)*

The Beaver Creek Region is part of Beringia but is likely to have been glaciated until the Early Wisconsinian (55-50kyBP). It lays on a part of the Mirror Creek recession moraine that has not been eroded by fluvial activity. A lot including 29 boreholes have been analysed in relation to the topography, ecology and pedology. Five cryostratigraphic



units have been defined and characterized under the lower concave topography of the muskeg. They represent a relatively thick (>12m) ice-rich permafrost blanket that is likely to be rather incomplete and/or thinner (<6m) on the higher convex topography of the forest. From this cryostratigraphy, five development stages were interpreted in relation with the late Pleistocene climatic history. All along its evolution since the ice retreat, the site's geomorphology might have tended toward convergence. Thus, the differentiated parts of the landscape might have had opposing progressions; tops were denuding while hollows were filling. The rate of activity of the geomorphic processes remains a topic to be documented. This differentiated geomorphic dynamic is likely to have affected the geosystem evolution also from a geothermal, hydrologic, ecologic, pedogenic and cryogenic perspective and justify a proportionally differentiated tolerance, vulnerability and resilience of the actual landscape to disturbance.

### **377 - EVIDENCE IN FAVOR OF THAT OVER THE PLEISTOCENE CRYODIVERSITY IN NORTHWESTERN SIBERIA DEVELOPED AS INTERACTION OF PERMAFROST AND MOUNTAIN GLACIERS BUT NOT OF ICE SHEETS**

Vladimir Sheinkman (1), Vladimir Melnikov (1)

(1) *Tyumen State and Gas University; Earth's Cryosphere Institute (Tyumen, Russia)*

During the Quaternary, permafrost in Northwestern Siberia fluctuated in size but always occupied a vast space. Nevertheless, some researchers suppose ice sheets covering that terrain, though to explain their combined development with permafrost is impossible. They must transform their frozen bed, whereas the latter occur in the fair preservation. The point is that study of glaciation in Siberia began to carry out on the base of the Alpine model suitable to explain forming the sheets in Europe moistened from the Atlantic; however it is not suitable in Siberia where cold and dry environments prevailed over the Quaternary. It made conditional on the particular glaciers interacted with permafrost. They become a new element of cryodiversity (a set of objects and phenomena produced by cold), and differ from those considered as of the Alpine glaciation model, and obtain properties which are more characteristic for permafrost objects, than for the Alpine-type glaciers.

### **113 - PERMAFROST OCCURRENCE IN SUBARCTIC FORESTS OF THE GREAT SLAVE REGION, NORTHWEST TERRITORIES, CANADA**

Peter Morse (1), Stephen Wolfe (1), Steve Kokelj (2), Adrian Gaanderse (3)

(1) *Geological Survey of Canada, Natural Resources Canada (Ottawa, Canada)*; (2) *Northwest Territories Geological Survey, Government of the Northwest Territories (Yellowknife, Canada)*; (3) *Department of Geography and Environmental Studies, Carleton University (Ottawa, Canada)*

Permafrost in the Great Slave region, Northwest Territories is absent beneath bedrock outcrops, but occurs beneath peatlands. A three-year (2010 to 2013) investigation determined that permafrost also occurs in unconsolidated fine-grained sediments beneath forested sites. Annual mean shallow permafrost temperatures range from -1.4 to 0°C, with spatial variation primarily reflecting organic-layer and soil moisture conditions. Discontinuous permafrost is extensive within Great Slave Lowland, in direct relation to the distribution of forested areas in unconsolidated fine-grained sediments, but is sporadic northward within Great Slave Upland where bedrock outcrops are more extensive.



## 226 - HYDROCARBON SEEPAGE AND FORMATION OF AUTHIGENIC MINERALS IN THE PERMAFROST OF WEST SIBERIA

*Anna N. Kurchatova* (1), Victor V. Rogov (2)

(1) 1 - Tyumen State Oil and Gas University, Tyumen, Russia; 2 - Institute of the Earth Cryosphere, Siberian Branch of the Russian Academy of Sciences, Tyumen, Russia (Tyumen, Russia); (2) 1 - Lomonosov Moscow State University, Moscow, Russia; 2 - Institute of the Earth Cryosphere, Siberian Branch of the Russian Academy of Sciences, Tyumen, Russia (Moscow, Russia)

The first overview of the major hydrocarbon-induced chemical and mineralogic changes affecting permafrost sequences was presented. Long-term leakage of hydrocarbons, either as macroseepage or microseepage, set up near-surface oxidation-reduction zones that favor the bacterial activity and the formation of the authigenic mineral association of carbonates, iron sulfides and oxides and siliceous microspheres.

## Session/Séance : Mining Geotechnique IV / Géotechnique minière IV

**Wednesday, September 23, 15:30 - 16:30 /  
Mercredi 23 septembre, 15 h 30 - 16 h 30**

Room / Salle : **204AB**

Chair / Président de séance : **François Duhaime**

## 755 - SHEAR BEHAVIOUR IN ELEMENT TESTING OF POLYMER AMENDED MATURE FINE TAILINGS

Paul Simms (1), *Gholami Mahsa* (1)  
(1) *Carleton University (Ottawa, Canada)*

Oil sands tailings deposition is regulated by enforcing reduction of the volume of fluid fine tailings over the life of an operation. Fluid fine tailings are defined by a 5 kPa undrained shear strength value. Operators are meeting these targets by improving dewatering and consolidation characteristics of fine tailings through various techniques, often involving addition of polymer or other flocculation-inducing treatment. However, the assessment of the strength performance of these technologies is typically quantified using a field vane. This gives one or two numbers, peak and residual strength. Element testing, while challenging for mature fine tailings, does give a richer description of strength behaviour. We compare shear behaviour of samples consolidated and sheared in simple shear and in triaxial element tests, and compare these findings to available field data on in-line flocculated mature fine tailings. Both un-amended and amended tailings behave as a structured soil, showing very high shear strength to effective stress ratios. Shear strength values as a function of density show values comparable in trend but lower than shear strength measured by field vane at some field trials.



## **688 - MODEL BEARING CAPACITY TESTS IN A LARGE LABORATORY SIMULATION OF POLYMER AMENDED MFT**

Liza Rozina (1), Shabnam Mizani (2), Momin Malek (2), Paul Simms (3)  
(1) Carleton University (Ottawa, Canada); (2) Student (Ottawa, Canada); (3) Supervisor/  
Professor (Ottawa, Canada)

This paper investigates the increase in undrained shear strength and bearing capacity in a laboratory simulation of multilayer deposition of in-line flocculated oil sand mature fine tailings (MFT). Vane shear tests were conducted before the deposition of each new layer. From these tests, the tailings, demonstrated relatively high shear strength in a comparably short period of dewatering time, reaching an undrained shear strength of > 5kPa, once they were dried out to 55-60% solids concentration in the top layer. Plate load tests were performed directly on the tailings, after the top layer was dried to approximately 60% and 70% solids concentrations, with a circular plate with a diameter of 10.5cm. The model bearing capacity tests results were compared to values obtained using the effective stress approach without and with considering the influence of matric suction.

## **501 - IMPLEMENTATION OF TREATED OIL SANDS WASTE IN CONTINUOUS FLIGHT AUGER PILES CONCRETE MIXTURES**

Mahmoud Kassem (1), Ahmed Soliman (2), Hesham El Naggar (1)  
(1) Department of Civil and Environmental Engineering – University of Western,  
London, Ontario, Canada (London, Canada); (2) Department of Civil and Environmental  
Engineering – University of Western, London, Ontario, Canada (on Leave of Ain Shams  
University, Cairo, Egypt) (London, Canada)

Concrete is the major constituent of continuous flight auger (CFA) piles, hence, understanding the concrete mixture behaviour and optimizing its design are essential. A laboratory study was undertaken to evaluate the fresh and hardened properties of CFA concrete mixtures incorporating treated oil sands waste (TCCW). Variation of hardened properties with curing time has been quantified. Results show that TCCW addition had an insignificant effect on the concrete flowability. Strength gaining rates for concrete mixtures incorporating TCCW were near that of the control mixture. Results suggest that TCCW can be used in CFA piles which will lead to both economic and environmental benefits.

## **502 - EFFECT OF TREATED OIL SANDS DRILL CUTTINGS WASTE ON MICROPILES GROUT PROPERTIES**

Moustafa Aboutabikh (1), Ahmed Soliman (2), Hesham El Naggar (1)  
(1) Department of Civil and Environmental Engineering – University of Western,  
London, Ontario, Canada (London, Canada); (2) Department of Civil and Environmental  
Engineering – University of Western, London, Ontario, Canada (on Leave of Ain Shams  
University, Cairo, Egypt) (London, Canada)

A micropile is constructed by drilling a hole, placing a steel reinforcing element, grouting it using neat cement. However, cement production consumes energy and generates carbon dioxide. To develop sustainable and environmentally benign micropile construction, a feasibility study was performed on using treated oil sands drill cuttings waste (TOSW) as a partially replacement of cement in micropiles. Results show that TOSW did not affect the flowability for grout mixtures. Increasing TOSW replacement level reduced the 28-day grout compressive strength slightly, while strength gain rate had increased at later ages. Moreover, the achieved strength was still higher than the required strength by different standards. Results suggest that TOSW can be used in micropiles leading to environmental and economic benefits.



**Wednesday, September 23, 15:30 - 16:30 /****Mercredi 23 septembre, 15 h 30 - 16 h 30**Room / Salle : **205A**Chair / Présidente de séance : **Annick Bigras****485 - DETERMINATION OF SHEAR STRENGTH PARAMETERS OF DAM BODY MATERIAL USING DISTURBED SAMPLING**Esra Nur Tanriseven (1), Hasan A. Bilgin (1), Sebnem H. Duzgun (1)*(1) Middle East Technical University, Mining Engineering Department (Ankara, Turkey)*

The determination of shear strength parameters is the most important part of stability analysis of geotechnical structures. Cohesion and internal friction angle obtained from direct shear test are generally referred to as shear strength parameters of soil. Although there are numerous studies on shear testing of undisturbed samples, there are not many about determination of strength parameters from disturbed samples. In this study, shear strength parameters of soil material from a tailings dam, which was constructed without compaction, is evaluated. Because undisturbed sampling is impossible due to coarse grain size and looseness of the dam material, density of the direct shear test sample was determined according to standard compaction test results. Obtained results are compatible with the values given in the literature.

**518 - MESURES DE RADAR EN PUIITS POUR LA LOCALISATION DU NOYAU IMPERMÉABLE DU BARRAGE ROMAINE 2**Michel Chouteau (1), Ting-Kuei Chou (1), Alain Côté (2)*(1) École Polytechnique (Montréal, Canada); (2) IREQ/Hydro-Québec (Varenes, Canada)*

Des levés radar ont été effectués dans les deux inclinomètres verticaux situés en crête de part et d'autre du noyau bitumineux du barrage Romaine 2, après le remplissage à 95% du réservoir. Les levés de tomographie entre les inclinomètres amont et aval ont permis de déterminer le champ 2D des vitesses radar associées directement à la teneur en eau. Les levés radar en mode réflexion ont mis en évidence deux réflecteurs parallèles aux inclinomètres se situant à ~ 2 m et 3,4 m respectivement. Le premier serait lié à une variation de composition granulométrique entre l'îlot de protection entourant l'inclinomètre et le remblai compacté situé de part et d'autre du noyau. Le second serait attribuable à l'interface remblai/noyau. La faiblesse des réflexions et le bruit important n'ont pas permis de positionner cette interface mieux qu'à 30 cm - 40 cm près. Une forte atténuation du signal radar localisée à la base du barrage a rendu impossible de déterminer la position du noyau au niveau de son assise sur le socle en béton.

Deux réflecteurs parallèles à fort pendage ont été mis en évidence entre 35 et 50 m de profondeur dans l'inclinomètre amont; Ils n'étaient pas présents lors des levés lorsque le réservoir était vide.



Vincent Cormier (1), Jean-Marie Konrad (2)

(1) *Université Laval / WSP (Québec, Canada)*; (2) *Université Laval (Québec, Canada)*

During construction and first impoundment of rockfill dams, significant deformations can occur due to crushing of highly stressed rock particles. In order to improve the general understanding of this phenomenon, short term and long term compressibility of assemblages of rock particles was studied with one-dimensional compression tests in a large oedometer cell. The main results from the test program revealed that short term compressibility tends to be more important for samples with a wide grain size distribution curve, a low density and when the samples were wetted or saturated prior to loading. With respect to long term compressibility, it appears that the ratio between the time-dependent compressibility index and the compressibility index,  $C_{\epsilon,t}/C_{\epsilon,\sigma}$ , tends toward a constant of about 0.02 for dry rock particles and 0.03 for saturated samples. Furthermore, the compressibility was successfully related to a breakage factor, highlighting the importance of particle breakage on deformations of rockfill.

#### **456 - AN EXPERIMENTAL STUDY OF CONTACT EROSION BETWEEN A TILL CORE AND COARSER CREST AND FILTER MATERIALS**

Pierre-Olivier Dionne (1), Jean-Marie Konrad (1)

(1) *Université Laval (Québec, Canada)*

Contact erosion is an internal erosion process found in embankment dams and dikes which can lead to failure. It is defined as the pullout and dragging of fines from a base material through an adjacent coarser material under seepage parallel to the interface. This study intends to understand and to identify the mechanisms that control contact erosion with a well-graded base soil (till) combined with different filter materials. To study the erosion process, a new experimental setup has been developed. It was found that the grading of the base material as an impact on the initiation and progression of erosion as different mechanisms such as paving and clogging can develop to limit or even stop the erosion. A conceptualization of the erosion process depending on the grain size of both filter and base soils and on the hydraulic solicitation is proposed.





## Session/Séance : Transportation and Linear Infrastructure III / Transports et infrastructures linéaires III

Wednesday, September 23, 15:30 - 16:30 /  
Mercredi 23 septembre, 15 h 30 - 16 h 30

Room / Salle : **205BC**

Président de séance : **Roger Skirrow**

### **240 - DESIGN AND CONSTRUCTION OF A GEOSYNTHETIC REINFORCED PAVEMENT ON WEAK SUB-GRADE**

Sam Bhat (1), Venkat Lakkavalli (2), Dr. Jimmy Thomas (3)

(1) *Titan environmental Containment Ltd (Ile des Chenes, Canada)*; (2) *Pavement Engineer-Materials Research Construction Roads - City of Calgary (Calgary, Canada)*; (3) *Sr. Design Consultant - Titan Environmental Containment Ltd (Kochin, India)*

This paper describes the salient features of the design and construction of a geosynthetic reinforced pavement. The project involved rehabilitation of old and damaged roads in the City of Calgary in Canada. Poor sub-grade conditions were indicated to be one of the major causes for the distress in the pavement. It led to reconstruct the pavement as a pilot project. Proposed solution required replacement of the existing distressed pavement with required excavations to accommodate the designed pavement thickness. To minimize the disruption to the road users, it was desirable to minimize the depth of excavation, by minimizing the pavement thickness. It is known that reinforcement of the pavement with geosynthetics enhances the strength and stiffness of the pavement and hence a reinforced pavement of lower thickness can give the same level of performance as an unreinforced pavement. A design in which a fiberglass grid placed at the center of the asphalt concrete layer and a geogrid composite incorporated at the bottom of granular sub-base was adopted for one section and a fiberglass grid alone was incorporated for the other section. The initial assessment of the performance seems encouraging.

### **92 - DESIGN AND CONSTRUCTION OF SHORE LINE FORTIFICATION TO PROTECT MAIN LINE RAILWAY, PORT HOPE, ONTARIO**

Colin Alston (1), Mario Ruel (2), David Howett (2)

(1) *Alston Geotechnical Consultants Inc. (Markham, Canada)*; (2) *CN Rail (Montreal, Canada)*

The shoreline bluffs along the north shore of Lake Ontario at Port Hope have experienced ongoing erosion for a long period of time. When the CN Mainline was constructed in 1856 the distance between the railway right-of-way and the crest of the bluffs was more than 60 m. Ongoing erosion has had reduced this width to a few metres in the late 1990's and would compromise the safety of the railway lines unless arrested.

The bluffs are about 16 m high at the shoreline. The soil profile consists of an upper layer of dense silt to fine sand lying on hard silty clay till. Groundwater movement through the upper layer is from north to south, towards the lake, which was causing internal erosion and the development of large chasms at the slope face. Toe erosion was occurring at the base of the slope.

Stabilization of the slope was accomplished by construction of a soil-bentonite to reduce seepage flow through the upper layer. This was complemented by a dynamic revetment covering the entire height of the slope face to resist the effects of wave erosion and the ice sheet, and to support the oversteepened slope face.



Marco Couture (1), Shahriar Mirmirani (1), Shahriar Mirmirani (2), Marc-André Carrier (1)  
(1) *Terre armée (Sainte-Marie, Canada)*; (2) *Terre Armée (Mississauga, Canada)*

Although the mechanically stabilized earth walls are widely used in the road and civil industry, there are questions by some with this system in railways application, especially for high-speed railroad construction. One of the uncertainties is due to lack of information about the strain on the structures under dynamic and cyclic load with high frequency, mainly for high speed trains. This article will explain the interaction between the soil and the soil reinforcements in this condition and will present the achievements in the latest research program on Reinforced Earth walls in railway application under dynamic loading and discuss the effect of cyclic loads on the steel strip soil reinforcements. In addition, a project will be briefly presented for high speed train application.

**225 - THREE DIMENSIONAL FINITE ELEMENT ANALYSES OF PARTIALLY SUPPORTED WATER MAINS**

Kasuni Liyanage (1), Ashutosh Dhar (2)  
(1) *Graduate Research Student (St. John's, Canada)*; (2) *Assistant Professor, Memorial University of Newfoundland (St. John's, Canada)*

Buried water mains used in water distribution systems are subjected to aggressive environmental conditions and undesirable soil conditions, causing deterioration of the pipelines. As a result, a number of water main break occur every year across the municipalities. Circumferential cracking is a predominant failure mode for water mains that results from excessive longitudinal stresses. The longitudinal stress in pipe wall may be due to non-uniform soil support condition caused through erosion of surrounding soil by the water from any leakages. Localized concentrated supports are also expected on the pipe wall within the erosion voids due to the presence of large rock pieces when the fine soil particles are eroded away. In the current research, three dimensional finite element analyses are used to investigate the effects of erosion voids and localized support on pipe wall stresses. A cast iron water main buried in elastoplastic soil, subjected to soil load and surcharge, is considered. FE results are compared with analytical solutions available in the literature for evaluation. A parametric study is followed up in order to investigate the influence of the void size, geometry and void location around the pipe circumference on the stress development in the pipe wall.



## Session/Séance : Landslides and Slope Stability VI / Mouvements de terrain et stabilité des pentes VI

Wednesday, September 23, 15:30 - 16:30 /  
Mercredi 23 septembre, 15 h 30 - 16 h 30

Room / Salle : **206A**

Chair / Président de séance : **Murray Fredlund**

### **526 - DEVELOPMENT OF SPECTRAL PSEUDO-STATIC METHOD FOR DYNAMIC CLAYEY SLOPE STABILITY ANALYSIS**

Fady Ghobrial (1), Mourad Karray (1), Marie-Christine Delisle (2), Catherine Ledoux (2)  
(1) *Université de Sherbrooke (Sherbrooke, Canada)*; (2) *Ministère des transports du Québec (Québec, Canada)*

The pseudo-static method is considered the simplest approach to evaluate the stability of earth-slopes against shakes. It replaces the action of the earthquake by a constant inertial force proportional or not to the peak ground acceleration of the excitation and applies it to the potential unstable mass of the ground. However, it involves some deficiencies: it ignores the earthquake effect on shear strength and, in addition, masks the dynamic aspect of the problem (site effect, degradation of the modulus, synchronization of the movement, etc.) This study aims to examine the limitations of the pseudo-static method in order to examine the possibility of developing a more effective analysis method that allows keeping the benefits of pseudo-static method. This paper will also present the results of a case among large number of numerical simulations that were used to develop a new method of pseudo-static analysis.

### **560 - CO-SEISMIC LARGE LANDSLIDES IN SENSITIVE CLAY IN EASTERN CANADA, A SEARCH FOR AN INITIATION THRESHOLD**

Pete Quinn (1), Martin Zaleski (1)  
(1) *BGC Engineering (Ottawa, Canada)*

This paper examines the search for a peak horizontal ground acceleration (PGA) threshold for triggering co-seismic landslides in sensitive clay in eastern Canada, with the aim of supporting regional risk assessment using HAZUS. Literature sources document a number of small co-seismic landslides associated with small or moderate earthquakes which produced a PGA between about 0.04 g and 0.15 g at the landslide locations. Two papers describe 46 large, co-seismic, sensitive-clay landslides with measured dates. Many of these are associated with the 1663 Charlevoix M7 earthquake, from which site-specific firm ground PGA can be estimated; these range from about 0.03 g to 0.18 g; the remaining landslides are associated with paleo-earthquakes. A clear PGA threshold for triggering large landslides in sensitive clay cannot be inferred from these available data. Earthquake magnitude and distance appear to provide a somewhat better threshold for co-seismic sensitive clay landslides in the study area.



#### **474 - ANALYSIS OF A BLAST LOADING NEAR SENSITIVE CLAY SLOPE IN LA ROMAINE VILLAGE, Québec**

Sarah Bouchard (1), Serge Leroueil (1), Denis LeBoeuf (1), Pierre-Luc Deschênes (2), Pierre Dorval (2)

(1) *Université Laval (Québec, Canada)*; (2) *Ministère des Transports du Québec (Québec, Canada)*

It is well known that blasting vibrations may be a triggering factor for soil movements and landslides. This paper describes a case history of a large slide caused by blasting in a sensitive clay deposit. The slide occurred on August 1st 2009 in La Romaine village, on the North Shore of the St-Lawrence Gulf. Two types of loading may have affected the slope stability: the blast vibrations themselves and the rapid loading impact stemming from muck-pile formation. The goal of this paper is to provide an analysis of the blast loading characteristics in order to better understand its influence on this slope failure. First, some concepts about blasting vibrations are introduced and landslide case histories involving blasting operations are reviewed. Then, data from La Romaine blast design are presented and the resulting ground motion parameters and the dynamic stresses and deformations are assessed using theoretical and empirical equations.

#### **574 - UNDERSTANDING THE DYNAMIC SOIL PROPERTIES ROLE IN A LANDSLIDE**

Akram Ghossoub (1), Muhsin Elie RAHHAL (1)

(1) *Saint Joseph University (Hazmieh, Lebanon)*

Landslide damages have been numerous on infrastructures and on human lives, and its consequences during an earthquake might be a disaster. The purpose of this study is to evaluate how a slope will behave under seismic loading, with a special attention given to the role of dynamic soil properties in understanding slope instabilities.

### **Session/Séance : Permafrost (Other) / Pergélisol (autre)**

**Wednesday, September 23, 15:30 - 16:30 /**

**Mercredi 23 septembre, 15 h 30 - 16 h 30**

Room / Salle : **2102B**

Chair / Président de séance : **Tim Ensom**

#### **693 - LAKE BOTTOM IMAGERY: A SIMPLE, FAST AND INEXPENSIVE METHOD FOR SURVEYING SHALLOW FRESHWATER ECOSYSTEMS OF PERMAFROST REGIONS**

Frédéric Bouchard (1), Daniel Fortier (2), Michel Paquette (2), Paschale Bégin (3), Warwick Vincent (3), Isabelle Laurion (4)

(1) *Institut national de la recherche scientifique (INRS), Université de Montréal & CEN (Québec, Canada)*; (2) *Université de Montréal & CEN (Montréal, Canada)*; (3) *Université Laval & CEN (Québec, Canada)*; (4) *Institut national de la recherche scientifique (INRS) & CEN (Québec, Canada)*

Widespread and diverse in permafrost landscapes, freshwater ecosystems play a crucial role in maintaining the traditional lifestyle of northern communities as habitats for aquatic plants and wildlife, and many are also biogeochemical hotspots that strongly emit greenhouse gases. Limnological and paleolimnological studies are of great importance for understanding the past, present and future dynamics of such aquatic systems. This paper presents a novel, highly integrated lake-bottom imagery strategy for surveying



lake-bottom water and sediments prior to sampling. It is user-friendly and easily portable, can be implemented rapidly in the field with directly accessible data, and is much less expensive than regular lake basin surveying techniques. The method integrates GPS-assisted sonar technology, underwater HD photo-video camera, and water depth and temperature sensors. Examples from Canadian High Arctic permafrost landscapes, where the method has been recently applied, are reported and discussed.

### **666 - CORING OF UNCONSOLIDATED PERMAFROST DEPOSITS: METHODOLOGICAL SUCCESSES AND CHALLENGES**

Graham Gilbert (1), Hanne H. Christiansen (1), Ullrich Neumann (2)

(1) *The University Centre in Svalbard (Longyearbyen, Norway)*; (2) *Kolibri Geo Services (Risør, Norway)*

This technical note presents three scales of drilling infrastructure for comparison. These three methods include: (1) a small hand-drill designed for retrieving cores down to ca. 5 m depth, (2) the medium-scale UNIS Permafrost Drill Rig (down to ca. 50 m depth), and (3) an industrial drill rig designed for coring to depths of greater than 1 km. All methods vary with respect to maximum drill depth, operational cost, and ease of transport throughout the landscape.

### **564 - N<sub>2</sub>O AND CO<sub>2</sub> DYNAMICS IN A FROZEN PASTURE SOIL**

Sébastien Lange (1), Suzanne Allaire (1), Mario ALberto Cuellar Castillo (1), Pierre Dutilleul (2)

(1) *Université Laval, Dpt sol et génie agroalimentaire (Québec, Canada)*; (2) *McGill University, Dpt. of Natural Resource Sciences (Sat Anne de Bellevue, Canada)*

Since gas dynamics in agricultural soils is mainly studied during plant growth, only few researches have focus on their dynamics in frozen soils covered with snow. Spatio-temporal concentrations of CO<sub>2</sub> and N<sub>2</sub>O have been measured from the pre-freezing to the thawing period in a pasture soil during two cold seasons. Three periods related to gas dynamics were observed during both cold seasons. Both gases behaved differently during pre-freeze and thawing periods and their spatial dynamics depended on the spatial and temporal variability of soil temperature as long as the soil surface temperature was above 0°C. However, both concentrations increased and their spatial variability was independent from temperature as long as the soil was frozen, under which condition their correlation was up to 90%. Two main occurrences of gas release occurred during thawing, one related to trapped gases, similar for both gases, and the other to reactivation of microorganisms, different between both gases.

### **663 - SUCCESSION IN TUNDRA LANDSCAPES AND ITS IMPLICATIONS FOR POLAR RESTORATION EFFORTS: CASE STUDY OF HERSCHEL ISLAND, YT, CANADA**

Heather Cray (1), Wayne Pollard (2), Stephen Murphy (1)

(1) *University of Waterloo (Waterloo, Canada)*; (2) *McGill University (Montreal, Canada)*

This research investigates natural revegetation patterns following permafrost disturbance by retrogressive thaw slumps on Herschel Island, YT. Seven sites were chosen, representing undisturbed areas in addition to 250, 20, and 10 year old stabilized thaw slumps. Species diversity and percent cover of different plant functional groups are presented. Results indicate that distinct vegetation assemblages are associated with each age class, and that changes persist for centuries. Using the natural successional plant communities presented here as a guideline, ecological restoration methods using propagule addition which targets effective natural initial colonizers are suggested. If our



goal is to control erosion, create habitat, and enhance freezeback in these landscapes at an accelerated pace, this type of restoration intervention may be necessary and is thus a promising direction for future research.

## **Session/Séance : Problematic Soils and Ground Improvement III / Sols problématiques et amélioration du comportement III**

**Wednesday, September 23, 15:30 - 16:30 /**

**Mercredi 23 septembre, 15 h 30 - 16 h 30**

Room / Salle : **2104AB**

Chair / Président de séance : **Laifa Cao**

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### **618 - COQUITLAM ULTRAVIOLET DISINFECTION FACILITY GEOTECHNICAL INVESTIGATION, DESIGN AND CONSTRUCTION CHALLENGES**

Anthony Fuller (1), Naresh Koirala (1)

(1) *Golder Associates Ltd. (Vancouver, Canada)*

Metro Vancouver (MV) manages and supplies drinking water for the 2.4 million residents in 21 municipalities of the Lower Mainland. In order to comply with new requirements under Health Canada's Guidelines for Canadian Drinking Water Quality, in 2014, MV upgraded the treatment facilities in The City of Coquitlam with ultraviolet (UV) disinfection. The constraints at site for the new facility included adjacent slopes with a history of instability; the nearby Coquitlam River and an operating chlorination plant, as well as other infrastructure, in close proximity to the proposed facility. The geotechnical design and construction challenges presented by these constraints were significant. The final design had a smaller overall footprint compared to similar facilities, but deeper underground structure. Excavations up to 17 m in depth within a varved, non-plastic silt required careful design, extensive dewatering, and shoring. The paper discusses the geological and physical site conditions, the surface and subsurface investigation completed to characterize the soil and groundwater conditions and the geotechnical design and construction of the works.

### **158 - ESTIMATION OF THE WETTING FRONT DEPTH IN A LOESS SOIL DEPOSIT IN RESPONSE TO ENVIRONMENTAL FACTORS**

Ping Li (1), Sai Vanapalli (1), Tonglu Li (2)

(1) *University of Ottawa (Ottawa, Canada)*; (2) *Chang'an University (Xi'an, China)*

The extent of wetting depth in loess soil deposits associated with environmental factors is the key information that is required for reliable prediction or estimation of collapse settlement. This information is also required for better understanding of rainfall-induced loess landslides. In this paper, case study results of a site in Northwestern China are discussed in greater detail. The moisture content variation of soil within 10 m below the surface was monitored for a period of one year. The wetting front extension was determined graphically by understanding the progressive trends of soil moisture in response to environmental changes at various levels of depth. In addition, VADOSE/W was used to simulate the flow behaviour in loess deposits to predict the variation of the soil water content profile due to the influence of environmental factors. The VADOSE/W is found to be a useful tool for reasonably simulating the flow behaviour corresponding to changes of environmental factors in loess soils.



**175 - STUDY THE BEHAVIOUR OF COLLAPSIBLE SOIL OF OKANAGAN VALLEY**

Amin Bigdeli (1), Sumi Siddiqua (1), Norman Williams (2)

(1) *University of British-Columbia (Kelowna, Canada); (2) Interior Testing Services Ltd. (Kelowna, Canada)*

Problematic soil is divided into dispersive, swelling, and collapsible soil. The latter is the most common type of problematic soil which can be found in vast areas of Okanagan valley. Present study is mainly focused on predicting the collapse potential and analyzing the properties of collapsible soil throughout two case studies. In each case, the collapse potential was obtained in three different ways (densometer, Gibbs theory, and consolidation machine) and compared with each other. This paper has proved that in all case studies the collapse potential of soil measured through different methods are in agreement with each other. Moreover, the collapsibility of the soil is highly dependent on wet density of the soil in a way that samples with lower wet density will face higher collapse.

**185 - DEVELOPED STRENGTH AND ENGINEERING PROPERTIES OF STABILIZED ORGANIC SOIL USING CHEMICAL ADMIXTURE: A LINEAR REGRESSION MODEL**

Md. Rafizul Islam (1), Sumi Siddiqua (2), Md. Assaduzzaman (3)

(1) *PhD student (Kelowna, Canada); (2) Assistant Professor (Kelowna, Canada); (3) Graduate student (Khulna, Bangladesh)*

This study illustrates the developed strength and engineering properties of stabilized soils using chemical admixtures at varying curing periods. Organic soil samples were collected from four selected locations, namely, Teligati, Rangpur, Sonadanga and Khulna University campus, Bangladesh at a depth of 3, 2.5, 2 and 4 m, respectively, from the existing ground surface. Chemical admixtures such as cement, lime and bentonite were added to the organic soil specimens as a percentage of the dry soil mass at 5, 10, 15, 20 and 25 %. To check the validity of unconfined compressive strength ( $q_u$ ) measured in the laboratory, SPSS 16.0 software was used to develop a linear regression model. The reliability and accuracy of the developed model were checked by comparing the predicted  $q_u$  against the measured values. Based on the regression analysis,  $R^2$  values ranging from 0.909-0.984, 0.536-0.930 and 0.726-0.965 were observed for cement, lime and bentonite stabilized soil, respectively. Finally, the predicted  $q_u$  from the developed model was found to be nearly the same as the laboratory measured value and the degree of accuracy was more reliable.



## Session/Séance : Physical and Numerical Modelling in Cold Regions / Modélisation physique et numérique en régions nordiques

Wednesday, September 23, 15:30 - 16:30 / Mercredi 23 septembre, 15:30 - 16:30

Room / Salle : 2105

Chair / Président de séance : **Marc Lebeau**

### 288 - THERMAL MODELLING OF EROSION PROTECTION WITH GESOYNTHETIC CONTAINERS IN COMBINATION WITH LIGHT CLAY AGGREGATE

Magne Wold (1), Arne Instanes (2), Arnstein Watn (1), Katja Werth (3), Lars Vollmert (3)  
(1) SINTEF Building and Infrastructure (Trondheim, Norway); (2) Instanes Polar As (Bergen, Norway); (3) Naue GmbH (Espelkamap-Fiestel, Germany)

The main objective of this study has been to investigate the possibility of using special types of Geosynthetics Clay Liners in combination with Geotextile Soil-filled Containers (GSC) to insulate the slope to reduce the thickness of the active layer and freeze-thaw action on the slope. In this manner the thermo-denudation process can be slowed down and the erosion of the slope can be reduced to acceptable levels during a coastal structure or landfill service lifetime.

The numerical model has been extended in order to investigate the possibility of using similar erosion protection techniques in more fine graded soil (silt). The prediction and modelling of coastal erosion in fine-grained, ice-rich continuous permafrost can be more challenging than in coarser soils, due to the presence of ground ice. Under these conditions, the rate and location of erosion can be highly variable from year to year. The results from the analysis must, therefore, be used with care.

### 722 - HEAT ADVECTION IN THE ACTIVE LAYER OF PERMAFROST: PHYSICAL MODELLING TO QUANTIFY THE IMPACT OF SUBSURFACE FLOW ON SOIL THAWING.

Sabine Veuille (1), Daniel Fortier (2), Manuel Verpaelst (2), Katerine Grandmont (2), Simon Charbonneau (3)  
(1) Univerity of Montreal (Montréal, Canada); (2) University of Montreal, Center for Northern Studies (Montréal, Canada); (3) University of Montreal (Montreal, Canada)

To measure the impact of water flow on permafrost degradation, several experiments of active layer physical models were conducted in laboratory. Eight wooden cells filled with different quasi-saturated soils were subjected, for the first half, to a thawing by conduction and for the other half to a thawing by convection (water flow). The purpose of this protocol is to develop, with experimental data, tools to quantify the efficiency of thawing by conduction in comparison to thawing by convection.





## **720 - NUMERICAL SIMULATIONS OF COUPLED GROUNDWATER FLOW AND HEAT TRANSPORT INCORPORATING FREEZE/THAW CYCLES AND PHASE CHANGE IN A CONTINUOUS PERMAFROST ENVIRONMENT**

Masoumeh Shojae Ghias (1), René Therrien (1), John Molson (1), Jean-Michel Lemieux (1)  
(1) *Département de géologie et de génie géologique, Université Laval (Québec, Canada)*

This study presents a series of numerical simulations to investigate the factors that control permafrost freezing and thawing in the shallow soil zone of the continuous permafrost environment at the Iqaluit Airport in Nunavut, Canada. A simplified conceptual model is first developed to represent the groundwater flow and thermal regime of the soil column and future climate scenarios are prepared based on those proposed by the IPCC (Intergovernmental Panel on Climate Change). A numerical model is then calibrated against ground temperatures. The calibrated model produced an excellent match with observed data and the mean absolute error is estimated to be 0.64 °C, which is 1.6% of the maximum temperature range. Numerical simulations reveal that under climate warming, conductive heat transport is the main driver for permafrost degradation at this site and that advective heat transport plays a minor role. This result can be attributed to the thaw front not migrating deeply enough into the ground to allow significant flow to develop and to the significant extent of low-permeability soil close to surface, which decreases the rate of flow and reduces the possible effects of thaw driven by advection.

## **724 - ASSESSMENT OF A LAND COVER DRIVEN TTOP MODEL FOR MOUNTAIN AND LOWLAND PERMAFROST USING FIELD DATA, SOUTHERN YUKON AND NORTHERN BRITISH COLUMBIA, CANADA**

Alexandre Bevington (1), Antoni G. Lewkowicz (2)  
(1) *Ministry of Forests, Lands and Natural Resource Operations (Prince George, Canada);*  
(2) *Department of Geography, University of Ottawa (Ottawa, Canada)*

Air, ground surface and top of permafrost temperatures (TTOP) were measured at 55 sites in three areas of Yukon and northern British Columbia in order to explore relationships between climate-permafrost transfer functions and environmental variables and to assess and validate the TTOP model (Smith and Riseborough, 1996, 2002). The strongest factors controlling climate-permafrost transfer functions are elevation and land cover, though slope, aspect, topographic position and surficial geology were also investigated. In 1000 iterations of the model using randomly-generated equally possible scenarios, 64% of the TTOP model predictions were within  $\pm 1^{\circ}\text{C}$  of measured values, a result that is 6% better than applying a uniform  $3^{\circ}\text{C}$  total offset to the mean annual air temperature. A sensitivity analysis confirmed that the TTOP model is most sensitive to changes in the freezing n-factor, thermal conductivity ratio of the ground, and summer air temperatures.





GEOQuébec2015

Mercredi / Wednesday

# NOTES



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# NOTES



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**GEOVANCOUVER**  
— 2016 —



History & Innovation | *Histoire & Innovation*

## **69<sup>th</sup> Canadian Geotechnical Conference** **69<sup>e</sup> Conférence canadienne de géotechnique**

Vancouver, British Columbia – October 2<sup>nd</sup>-5<sup>th</sup>, 2016

Mark your calendars and save the dates October 2<sup>nd</sup> to 5<sup>th</sup>, 2016 for the 69<sup>th</sup> Canadian Geotechnical Conference at Vancouver's Westin Bayshore Hotel.

Look for abstract submission details and the conference website launch in late September 2015.

*Vancouver, Colombie-Britannique – du 2 au 5 octobre 2016*

*Réservez les dates du 2 au 5 octobre 2016 à votre agenda pour la 69<sup>e</sup> Conférence canadienne de géotechnique 2016 qui aura lieu à l'hôtel Westin Bayshore.*

*Soyez à l'affut du lancement du site Web de la conférence et des détails sur la soumission des résumés vers la fin septembre 2015.*

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