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Volume 35 • Number 4 • December 2017

GEOTECHNICAL news

Injection of sodium silicate with setting agent

(see article page 28)

RST Instruments Ltd. offers 2 Wireless Data Collection Systems to quickly get you connected to your data: **RSTAR** and **DT LINK**. Both systems offer **minimum per channel cost, extra long battery life** and **long distance data transmission.**

WIRELESS DATA COLLECTION

for Geotechnical Monitoring Instrumentation

FULLY AUTOMATED COLLECTION (REMOTELY)

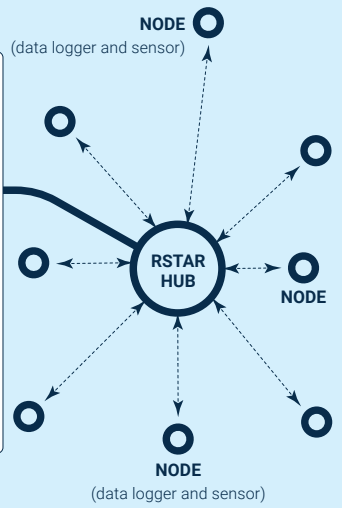
An RSTAR System uses data loggers (nodes) at the sensor level, deployed in a star topology from an active RSTAR Hub containing an RST flexDAQ Data Logger.

rstar ARRAY RADIO SERIES

FEATURES

- Up to 10 years of battery life from 1 lithium 'D' cell.
- Up to 14 km range from Hub to Node in open country. (depending on antenna type)
- Up to 255 nodes per RSTAR Hub.
- Based on 900 MHz , 868 MHz and 2.4 GHz spread spectrum band. (country dependent)

The RSTAR Hub shown left contains a flexDAQ Data Logger System with an antenna and battery. Collected data is saved to the flexDAQ memory where users can access it remotely, either on-site or off-site.



>>> Watch the video for both systems at: www.rstinstruments.com/Wireless-Data-Collection.html <<<

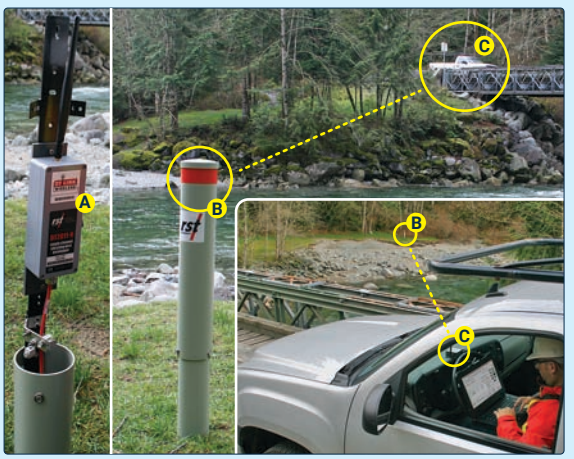
SEMI-AUTOMATED COLLECTION (ON-SITE)

DT LINK is an on-site wireless connection to RST data loggers for quick data collection. Ideal for hard to access areas where the data logger is within line of sight.

DT LINK WIRELESS

FEATURES

- Safely & easily collect data from data loggers that are in areas with poor access, trespass issues and hazardous obstacles.
- Years of battery life from 1 lithium 'D' cell.
- Range up to 800 m (900 MHz) and up to 500 m (2.4 GHz).
- Collect data in seconds with a laptop connected to DT LINK HUB.



Pictured: (A) DT LINK WIRELESS data logger, connected to a vibrating wire piezometer and housed in a (B) protective enclosure, has its data collected from a laptop connected to the (C) DT LINK HUB - all within seconds from the convenience of your vehicle.

DT SERIES DATA LOGGERS

RST's "DT Series" Data Loggers accommodate the RSTAR and DT LINK WIRELESS Systems. Compatible sensor types include:

Vibrating Wire, Potentiometers, MEMS Tilt Sensors, Strain Gauge (full bridge) Sensors, Digitally Bussed Sensors, 4-20 mA Sensors, and Thermistors.

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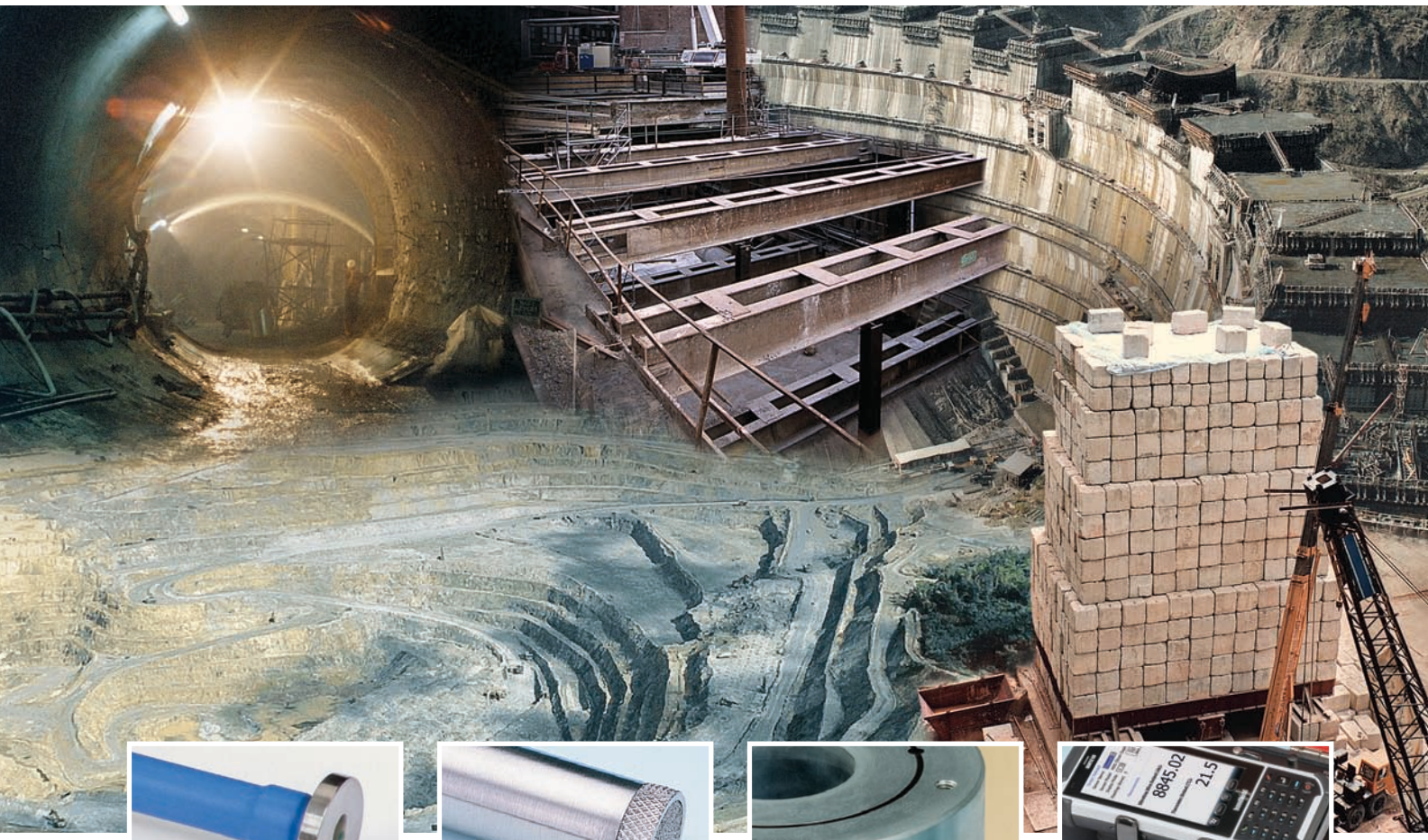

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NOVA METRIX

Message from the President

Dharma Wijewickreme, President of Canadian Geotechnical Society

As we near the end of the Year 2017, I would like to dedicate this message to summarizing some of the many accomplishments of the Canadian Geotechnical Society (CGS) over the past 12 months. It is important for me to note that much of our efforts over the past year have been focused on: member's engagement and involvement (including young professionals), new approaches for general communications and dissemination of technical matter and related topics, enhancement of member experience, and improved relationships with Local Sections. With these in mind, we have started working towards a number of new initiatives through the portfolios of the CGS Executive Committee (EC) and Board of Directors (BOD).

Let me begin by saying that the 70th CGS Annual Conference (GeoOttawa 2017), held October 1st to the 4th, was a highly successful event with more than 900 delegates in attendance,75 booths at the trade show and over 20 sponsors. Sincere thanks are due to the Ottawa Local Organizing Committee (LOC) led by **Mamadou Fall**, Geotechnical Technical Committee Chair **Paul Simms** and Hydrogeology Technical Chair, **Nell van Walsum**. Considering the coincidence of this year with the 150th Anniversary of the Canadian Confederation, the Monday luncheon presentation, along with 29 posters, highlighted past Canadian Geotechnical Achievements (organized by Past President **Doug VanDine**) as one of the key highlights of the conference. In addition, a number of awards were presented during the Banquet to recognize achievements of our members. On Wednesday, we were pleased to recognize our distinguished colleague **Doug Stead** as the 2017 recipient of the most prestigious award of the CGS, the **Legget Medal**.

The annual Board of Directors (BOD) meeting and the annual Business Meeting were held as a usual part of the CGS annual conference, GeoOttawa 2017. At the BOD meeting, a number of important decisions addressing communications and operational aspects were made including approvals: (i) of the Executive Committee's recommendation to accept major revisions to the CGS Conference Manual; (ii) to reform the Membership committee with an expanded mandate; (iii) to add the Chairs of the Committees and Geotechnical Research Board as voting members of the BOD; (iv) of a proposal, so the 73rd Annual Canadian Geotechnical Conference will be held in Calgary, Alberta, in 2020.

The three Vice Presidents (VPs) of the Society, **Suzanne Powell** (VP Technical), **Kent Bannister** (VP Finance), and **Jean Côté** (VP Communications and Member Services) presented summary reports during the BOD meeting on October 1st. Suzanne leads the process to have the Errata of the 4th Edition of the Canadian Foundation Engineering Manual (CFEM, 2006) completed by the end of 2017; she is also aligning alternative options for the next version of the CFEM. Jean is spearheading the formation of a renewed Membership Committee with a wider mandate to promote the CGS to current and future members, survey geoprofessionals and assess members' expectations, explore and analyze new initiatives, increase interest in volunteering and monitor and increase membership renewal. Kent is steering a new Financial Advisory Task Force to examine the ways to best invest the CGS' funds while keeping in line with the government financial/tax regulations. Kent is also in the process of developing policies and guidelines for funding new initiatives to serve the best interests of the membership. Our VPs have led numerous other tasks, and I would invite you to read their reports in the CGS Annual Report for further details. In the meantime, let me take the opportunity to express my gratitude to these three individuals for their unconditional support in contributing to the Society's strength and health.

It is also my pleasure to announce that **Mario Ruel** has been named the CGS President-elect for 2018; in turn, he will become the President of the Society for the period 2019-2020. Mario will be assembling his administration team with three Vice Presidents, and their names will be announced during the 71st CGS Annual Conference to be held in Edmonton in September 2018. This event will be Co-Chaired by **Don Lewycky** and **Seán Mac Eoin**.

Three of our Executive Committee (EC) members **Richard Brachman** (Technical Divisions Representative), **Seán Mac Eoin** (Local Sections Representative), and **Ariane Locat** (Young Professionals Representative) are completing their terms at the end of 2017. I would like to take the opportunity to appreciate the extensive

contributions to the CGS made by these three volunteers over their terms, as well as their valuable and enthusiastic presence that enriched the EC Meetings. I am pleased to welcome **Nicholas Vlachopoulos**, **Andrea Lougheed**, and **Maraika DeGroot** who will be assuming duties for the above positions, respectively, commencing January 2018.

A few of our Board members have also completed their terms; they include the following Division Chairs: **Richard Brachman** (Chair of Geosynthetics Division),**Craig Lake** (Geoenvironmental), **Sam Proskin** (Rock Mechanics), **Alex Baumgard** (Soil Mechanics and Foundations), **Frank Magdich** (Groundwater), and Section Directors: **Sumi Siddiqua** (Interior BC), **Scott McKean** (Calgary), **Seán Mac Eoin** (Section Director Geotechnical Society of Edmonton), **Andrew Stewart** (London), **Andrew Dreviniknas** (Southern Ontario), **Yannic Ethier** (Western Québec), **Benjamin McGuigan** (New Brunswick). Two committee chairs are also completing their assignments: **Paul Simms** (Mining Geotechnique) and **Tim Newson** (Sustainable Geotechnics). It is important for me to acknowledge the valuable and persevering contributions by these volunteer members.

One of our long standing and most popular CGS events, the Cross Canada Lecture Tour (CCLT) is approaching its centennial mark. The 99th CCLT was completed by **Vaughan Griffiths** (Colorado School of Mines) in April 2017. **Jean-Marie Konrad** will have delivered the 100th CCLT by the time you read this report. In a complementary manner to the CCLT, **Greg Siemens** and **Jasmin Raymond** presented their Colloquium Lecture Series at various locations. **Michael Hendry** was the 2017 CGS Colloquium speaker during GeoOttawa 2017. **Matt Lato** was announced as the 2018 CGS Colloquium speaker and will present at GeoEdmonton 2018 next September.

The Society continues to maintain very good relationships with constituent and partner societies and international organizations such as the Engineering Institute of Canada (EIC), the Canadian Society for Civil Engineering (CSCE), the Canadian Federation of Earth Sciences (CFES), the Geo-Institute of ASCE and the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). The CGS active participation in the 19th International Conference on Soil Mechanics and Geotechnical Engineering (19th ICSMGE) held in Seoul, Korea in September 2017 is noteworthy: **Alex Baumgard** and **Angela Küpper**, reviewed the 23 abstracts and 18 final papers on behalf of our Canadian members. The Sixth International Young Geotechnical Engineers' Conference (iYGEC6) which was held in association with the ISSMGE in Seoul, Korea had eleven abstracts from our CGS members. These were reviewed by **Ariane Locat** and her team to select 2 candidates that the CGS & the Canadian Foundation for Geotechnique (CFG) co-sponsored. **Andrea Lougheed** and **Jeffrey Oke** were the successful candidates to attend the iYGEC6. It is also of importance to highlight the duties assumed by our CGS member **Tim Newson** as Vice President North America (VP-NA) for the ISSMGE (2017-2021).

As a part of our focus on communications, some additional enhancements to the CGS website is also underway. Moreover, CGS News (edited by **Don Lewycky**) continues to be published in Geotechnical News (GN).

The promotion of research activities conducted by our members form an

important part of the CGS organization. I would like to thank the Geotechnical Research Board (GRB) led by **Bruno Bussiere** for selecting the Colloquium speaker, organizing a Specialty Session for New Academics and Experienced Researchers in GeoOttawa 2017, and reporting to the National Research Council to obtain a financial support.

The CGS has a unique relationship with the Canadian Geotechnical Journal, a high quality geotechnical publication available to all our members. I take the opportunity to congratulate the team of Editors **Ian Moore**, **Craig Lake**, and **Daichao Sheng** and Associate Editors on the success of the Canadian Geotechnical Journal (CGJ) and to express our appreciation to our members who devote their time to the Journal.

The role of the National Office in the operation and administration of the CGS is immense. In this regard, I must thank and acknowledge the relentless support of our enthusiastic administration team: **Michel Aubertin** (Executive Director), **Wayne Gibson** (Director, Administration and Finance) and **Lisa McJunkin** (Director, Communications and Member Services). As I have said before, their experience and familiarity with the CGS organization is one of the keys to our success.

The CGS continues to be solid and strong due to the extensive volunteering by our members. As you may have noted, 2017 has been a busy year for the CGS and we have accomplished many things as a community, and I am pleased to state that the Society is marching on the right track with excellent membership strength as well as solid financial health.

If you are interested in details related to the CGS activities, I invite you to visit the CGS website (*www.cgs.ca*) that contains the full Annual Report. As member engagement and involvement is one of our key focus elements, we always welcome your ideas; I am hoping that you will return your thoughts by writing to us at *admin@cgs.ca.*

Once again, thank you for reading this message and consider offering feedback. I wish you and yours a very happy holiday season and New Year 2018!

Dharma Wijewickreme
President - 2017/2018

Message du président

Alors que nous approchons de la fin de l'année 2017, j'aimerais résumer quelques-unes des nombreuses réalisations de la Société canadienne de géotechnique (SCG) des 12 derniers mois dans ce message. Je tiens à noter qu'une grande partie des efforts que nous avons faits au cours de la dernière année ont été axés sur l'engagement et la participation des membres (y compris les jeunes professionnels), les nouvelles approches pour la communication et la diffusion générale de questions techniques et autres thèmes connexes, de même que l'amélioration de l'expérience des membres et les relations avec les sections locales. C'est dans cette optique que nous avons commencé à travailler à un certain nombre de nouvelles initiatives par l'entremise des dossiers relevant du Comité exécutif (CE) et du Conseil d'administration (CA) de la SCG.

Permettez-moi de commencer en disant que la 70e conférence annuelle de la SCG (GéoOttawa 2017), qui s'est déroulée du 1er au 4 octobre, a été un évènement très réussi, avec plus de 900 délégués présents, 75 kiosques au salon professionnel et plus de 20 commanditaires. Je remercie sincèrement le comité organisateur local (COL) d'Ottawa dirigé par **Mamadou Fall**, le directeur du Comité géotechnique **Paul Simms** et la directrice du Comité sur l'hydrogéolie **Nell van Walsum**. Considérant la coïncidence de cette année avec le 150e anniversaire de la fédération canadienne, la présentation de réalisations géotechniques canadiennes marquantes (organisée par l'ancien président **Doug VanDine**) lors du dîner du lundi, ainsi que des 29 affiches, a été l'un des faits saillants de la conférence. De plus, un certain nombre de prix ont été décernés durant le banquet pour souligner les réalisations de nos membres. Le mercredi, nous avons eu le plaisir de reconnaître notre distingué collègue **Doug Stead** à titre de lauréat 2017 du prix le plus prestigieux de la SCG, **la Médaille Legget**.

La réunion annuelle du CA et l'assemblée annuelle ont été tenues comme à l'habitude dans le cadre de la conférence annuelle de la SCG, GéoOttawa 2017. Lors de la réunion du CA, un certain nombre de décisions importantes concernant les communications et des aspects opérationnels ont été prises, y compris des approbations: (i) de la recommandation du CE d'accepter d'importantes révisions au Manuel des conférences de la SCG; (ii) de réformer le Comité des membres en lui attribuant un mandat élargi; (iii) d'ajouter les directeurs des comités et du Conseil de recherche en géotechnique (CRG) à titre de membres votants du CA; (iv) d'une proposition faisant en sorte que la 73e conférence canadienne de géotechnique annuelle aura lieu à Calgary, en Alberta, en 2020.

Les trois vice-présidents (v.-p.) de la Société, **Suzanne Powell** (v.-p. technique), **Kent Bannister** (v.-p. aux finances) et **Jean Côté** (v.-p. aux communications et services aux membres), ont présenté des rapports sommaires durant la réunion du CA, le 1er octobre. Mme Powell dirige le processus visant à produire l'erratum de la 4e édition de la version anglaise du Manuel canadien d'ingénierie des fondations (CFEM, 2006) d'ici la fin de 2017; elle est également en train d'évaluer d'autres options pour la prochaine version du Manuel. M. Côté gère la formation d'un Comité des membres remanié ayant un mandat élargi pour promouvoir la SCG auprès

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des membres actuels et futurs, sonder les professionnels en géotechnique et évaluer les attentes de nos membres, explorer et analyser de nouvelles initiatives, accroître l'intérêt pour le bénévolat et suivre la progression des adhésions. M. Bannister est à la tête d'un nouveau Groupe de travail consultatif sur les finances chargé d'examiner les façons de mieux investir et utiliser les fonds de la SCG tout en se conformant à la réglementation financière et fiscale du gouvernement. Il est également en train d'élaborer des politiques et des lignes directrices pour financer de nouvelles initiatives afin de servir au mieux les intérêts des membres. Nos v.-p. ont mené de nombreuses autres tâches, et je vous invite à lire leurs rapports dans le Rapport annuel de la SCG pour en savoir plus. Entretemps, permettez-moi de profiter de l'occasion pour exprimer ma gratitude à ces trois personnes pour leur soutien inconditionnel qui contribue à la solidité et à la santé de la Société.

J'ai également le plaisir d'annoncer que **Mario Ruel** a été nommé président désigné de la SCG pour 2018; à son tour, il deviendra président de la Société pour 2019-2020. M. Ruel réunira son équipe administrative composée de trois vice-présidents, et leurs noms seront annoncés lors de la 71e conférence annuelle de la SCG qui aura lieu à Edmonton en septembre 2018. Cette conférence sera coprésidée par **Don Lewycky** et **Seán Mac Eoin**.

Trois membres de notre CE, **Richard Brachman** (représentant des divisions techniques), **Seán Mac Eoin** (représentant des sections locales) et **Ariane Locat** (représentante des jeunes professionnels) terminent leur mandat à la fin de 2017. J'aimerais profiter de l'occasion pour remercier ces trois bénévoles pour leur importante contribution à la SCG au cours de leur mandat, ainsi que pour leur présence précieuse et enthousiaste qui a enrichi les réunions du CE. Je suis heureux d'accueillir **Nicholas Vlachopoulos**, **Andrea Lougheed** et **Maraika DeGroot** qui entreront en fonction pour les postes susmentionnés, respectivement, à compter de janvier 2018.

Quelques-uns des membres de notre CA ont également terminé leur mandat; mentionnons les directeurs de division **Richard Brachman** (géosynthétiques), **Craig Lake** (géoenvironnement), **Sam Proskin** (mécanique des roches), **Alex Baumgard** (mécanique des sols et fondations), **Frank Magdich** (eaux souterraines); et les directeurs de section **Sumi Siddiqua** (intérieur de la C.-B.), **Scott McKean** (Calgary), **Seán Mac Eoin** (Société géotechnique d'Edmonton), **Andrew Stewart** (London), **Andrew Devininkas** (Sud de l'Ontario), **Yannic Éthier** (Ouest du Québec) et **Benjamin McGuigan** (Nouveau-Brunswick). Deux directeurs de comité technique terminent aussi leur mandat cette année: **Paul Simms** (géotechnique minière) et **Tim Newson** (géotechnique durable). Il est important pour moi de souligner la contribution précieuse et inlassable de ces membres bénévoles.

L'un des évènements historiquement les plus populaires de la SCG, la Tournée de conférences transcanadienne (TCT), approche de son centenaire. La 99e TCT a été effectuée par **Vaughan Griffiths** (Colorado School of Mines) en avril 2017. **Jean-Marie Konrad** aura présenté la 100e TCT lorsque vous lirez ce rapport. En complémentarité avec la TCT, **Greg Siemens** et **Jasmin Raymond** ont présenté leur série de conférences du Colloquium à différents endroits. **Michael Hendry** a été le conférencier du Colloquium 2017 de la SCG durant la conférence GéoOttawa 2017. On a aussi annoncé que **Matt Lato** sera le conférencier du Colloquium 2018 de la SCG lors de la conférence GéoEdmonton 2018 en septembre prochain.

La Société continue d'entretenir de très bonnes relations avec d'autres sociétés et partenaires ainsi qu'avec des organisations internationales, comme l'Institut canadien des ingénieurs (ICI), la Société canadienne de génie civil (SCGC), la Fédération canadienne des sciences de la Terre (FCST), le Geo-Institute de l'ASCE et la Société internationale de mécanique des sols et de la géotechnique (SIMSG). La participation active de la SCG à la 19th International Conference on Soil Mechanics and Geotechnical Engineering (19th ICSMGE) qui a eu lieu à Séoul, en Corée, en septembre 2017, mérite d'être soulignée; **Alex Baumgard** et **Angela Küpper** ont révisé les 23 résumés et les 18 articles soumis par nos membres canadiens à cette Conférence. De plus, 11 résumés des membres de la SCG ont été soumis dans le cadre de la Sixth International Young Geotechnical Engineers' Conference (iYGEC6), qui s'est déroulée en association avec l'ICSMGE, à Séoul, en Corée. Ils ont été révisés par **Ariane Locat** et son équipe, notamment afin de sélectionner deux candidats que la SCG et la Fondation canadienne de géotechnique (FCG) ont cocommandités. **Andrea Lougheed** et **Jeffrey Oke** ont été retenus pour participer à l'iYGEC6. Il est également important de souligner les fonctions assumées par **Tim Newson**, membre de la SCG, à titre de vice-président pour l'Amérique du Nord (v.-p.-AN) de la SIMSG (2017-2021).

Compte tenu de l'accent que nous mettons sur les communications, des améliorations supplémentaires au site Web de la SCG sont également en cours. De plus, la section CGS News (préparée sous la direction de **Don Lewycky**) continue d'être publiée dans Geotechnical News (GN).

La promotion des activités de recherche menées par nos membres fait partie intégrante de la raison d'être de la SCG. J'aimerais remercier le CRG dirigé par **Bruno Bussière** pour avoir sélectionné le conférencier du Colloquium, avoir organisé une session spécialisée pour les nouveaux universitaires et les chercheurs chevronnés dans le cadre de GéoOttawa 2017 et pour le rapport soumis au Conseil

national de recherche pour obtenir un appui financier.

La SCG entretient une relation privilégiée avec la Revue canadienne de géotechnique (RCG), une publication géotechnique de haute qualité offerte à tous nos membres. Je profite de l'occasion pour féliciter l'équipe de rédaction composée de **Ian Moore**, **Craig Lake** et **Daichao Sheng** et les rédacteurs adjoints pour le succès de la RCG ; j'exprime aussi notre reconnaissance aux membres de la SCG qui consacrent leur temps à la Revue.

Le rôle du Bureau national dans le fonctionnement et l'administration de la SCG est immense. À cet égard, je tiens à remercier et à souligner le soutien indéfectible de notre équipe administrative enthousiaste: **Michel Aubertin** (directeur général), **Wayne Gibson** (directeur, Administration et finances) et **Lisa McJunkin** (directrice, Communications et services aux membres). Comme je l'ai déjà dit, leur expérience et leur connaissance de la SCG sont l'une des clés de notre succès.

La SCG continue d'être solide grâce au travail bénévole de plusieurs de nos membres. Comme vous l'avez peut être remarqué, 2017 a été une année bien remplie pour la SCG, et nous avons accompli beaucoup en tant que communauté. De plus, je suis heureux de constater que la Société avance sur la bonne voie avec la contribution des membres et une solide santé financière.

Si vous désirez obtenir des renseignements sur les activités de la SCG, je vous invite à consulter son site Web (*www.cgs.ca*) sur lequel vous trouverez le Rapport annuel intégral. Étant donné que l'engagement et la participation des membres représentent un de nos éléments clés, nous accueillons toujours vos idées avec plaisir; j'espère que vous nous ferez part de vos réflexions en nous écrivant à *admin@cgs.ca*.

Encore une fois, merci d'avoir lu ce message et pensez à nous faire part de vos commentaires. Je vous souhaite, à vous et à votre famille, de joyeuses fêtes et une bonne année 2018!

Dharma Wijewickreme
Président – 2017/2018

From the Society

Canadian Geotechnical Society – Awards and Honours for 2017

R.F. Legget Award – Doug Stead, Simon Fraser University

R.M. Quigley Award - Peter Robertson, "*Cone Penetration Test (CPT) Based Soil Behaviour Type (SBT) Classification System – An Update*"

Honourable Mentions – Louis Le Pen, **David Milne**, **David Thompson**, **William Powrie**, "*Evaluating Railway Track Support Stiffness from Trackside Measurements in the Absence of Wheel Load Data*"

C.W.W. Ng, **C.E. Choi, A.Y. Su**, **J.S.H. Kwan**, **C. Lam**, "*Large-scale Successive Boulder Impacts on a Rigid Barrier Shielded by Gabions*"

G. Geoffrey Meyerhof Award – Arvid Landva, BGC Engineering Inc.

Thomas Roy Award – Erik Eberhardt, University of British Columbia

John A. Franklin Award – Ming Cai, Laurentian University

Robert N. Farvolden Award (Joint award with IAH-CNC) – Mike Wei,

Water Protection & Sustainability – BC Ministry of Environment

Robert Schuster Medal (Joint award with AEG) – Abdul Shakoor, Kent State University

Graduate Student Paper Award

1st Prize - Zhong Han, *"Modeling Stiffness and Shear Strength of Unsaturated Soils"*, Civil Engineering, University of Ottawa, Dr. Sai K. Vanapalli

2nd Prize - Haley Schafer, *"Freezing Characteristics of Fluid Fine Tailings and their Relation to Unsaturated Soil Properties"*, Civil and Environmental Engineering, University of Alberta, Dr. Nicholas Beier

Undergraduate Student Report (Individual)

1st Prize - Dylan Stafford, "*Shear Strength of Soils under Frozen and Thawed Conditions Using Large Direct Shear Box*", Civil and Environmental Engineering, University of Manitoba, Dr. Marolo Alfaro

2nd Prize - Guillermo Alexander Riveros, "*Static Liquefaction Triggering Analysis of the Fundao Dam Contrasting the Behaviour of Iron and Gold Mine Tailings*", Civil and Environmental Engineering, The University of Western Ontario, Dr. Abouzar Sadrekarimi

Undergraduate Student Report (Group)

1st Prize - Erik Cernik, **Lea Johnston**, **Takako Miyoshi**, **Eric Zhou**, *"Feasibility Geotechnical Evaluation: Slope Design Criteria for the Phase III Bafour Open Pit Project"*, Earth, Ocean & Atmospheric Sciences, University of British Columbia (Vancouver), Susan W. Hollingshead

2nd Prize - Cormac Foster, **Kristyn Fanstone**, **Chenyang Zhao**, **Tanishq Verma**, *"Evaluation of the Proposed Geothermal-Cold System Design for Prevention of Permafrost Thawing Beneath Structures in Northern Climates"*, Biosystems Engineering, University of Manitoba, Dr. Kris Dick

Canadian Foundation for Geotechnique Michael Bozozuk National Graduate Scholarship

Jordan Aaron, University of British Columbia

A.G. Stermac Awards

Andrea Lougheed - BGC Engineering Inc.

Mustapha Zergoun - Thurber Engineering Ltd.

Alex Baumgard - BGC Engineering Inc.

CGS R.M. Hardy Keynote Address – Richard Bathurst, GeoEngineering Centre at Queen's - RMC

Canadian Geotechnical Colloquium – Michael Hendry, University of Alberta

Cross Canada Lecture Tours

Dr. Vaughan Griffiths (Spring 2017)

Dr. Jean-Marie Konrad (Fall 2017)

Awards from the Engineering Institute of Canada (EIC)

Julian C. Smith Medal - Michel Aubertin, Polytechnique Montreal

K.Y. Lo Medal - Bryan Watts, Klohn Crippen Berger

Canadian Pacific Railway Medal - D. Jean Hutchinson, Queen's University

Fellowship of the Institute (FEIC) - Bruno Bussière, Université du Québec en Abitibi-Témiscamingue

Fellowship of the Institute (FEIC) - Richard Chalaturnyk, University Alberta

Fellowship of the Institute (FEIC) - Paul Dittrich, Golder Associates

Fellowship of the Institute (FEIC) - Jocelyn Grozic, University of Calgary

Fellowship of the Institute (FEIC) - Catherine Mulligan, Concordia University

Fellow of the Royal Society of Canada - Richard Bathurst, GeoEngineering Centre at Queen's-RMC

Provided by Lisa McJunkin, Director, Communications and Member Services/
Directrice, Communications et services aux membres

70th Canadian Geotechnical Conference and the 12th Joint CGS/IAH-CNC Groundwater Conference Ottawa, Ontario

The **GeoOttawa 2017** Conference was another successful event for CGS/IAH-CNC. The 70th Canadian Geotechnical Conference and 12 Joint CGS/IAH-CNC Groundwater Conference, GeoOttawa 2017, closed on October 4 after hosting over 900 delegates, sponsors, exhibitors and guests to four days of plenary and technical sessions, workshops, short courses, business meetings, social events and the 10th Annual Awards Gala. The Conference Chair **Mamadou Fall** and the Local Organizing Committee did an excellent job making this a first-rate technical and social meeting.

Milestones achieved this year include the oral presentation of just under 400 plenary and technical session papers and the involvement of a record 75 firms as exhibitors in the trade show. Our thanks go out to all sponsors, exhibitors and delegates who supported GeoOttawa 2017!

2017 CGS Corporate Sponsors

The CGS would like to thank all of its 2017 Corporate Sponsors.

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Naviq Consulting Inc.
Reinforced Earth Company
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SoilVision Systems
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Thurber Engineering
Trek Geotechnical

If you would like to renew your sponsorship for 2018, or like to become a CGS Corporate Sponsor, please contact **Lisa McJunkin** (*admin@cgs.ca*).

CGS Membership Registration for 2018

It is time to renew your Canadian Geotechnical Society membership for 2018. Please visit *www.cgs.ca* and renew online. We are happy to report that there are no increases in membership fees for 2018.

Membership benefits include:

- online access to the monthly Canadian Geotechnical Journal, including all past issues, and special price for the printed and mailed Canadian Geotechnical Journal
- online and printed copies of the quarterly Geotechnical News, including CGS News
- the monthly electronic CGS Geotechnical Information Net
- online access to all past CGS Conference proceedings and some special lectures
- special member price for all CGS conferences
- early information about the spring and fall CGS Cross Country Lecture Tours
- membership in one or more of 7 CGS technical divisions and associated international societies
- involvement in one of 20 CGS local sections
- involvement in any of the 8 CGS standing committees
- involvement in THE Society for all Canadian geotechnical professionals

We welcome all new and renewing members and look forward to your participation in 2018!

Adhésion à la SCG pour 2018

Si vous n'avez pas encore renouvelé votre adhésion à la Société canadienne de géotechnique pour 2018 ou désirez y adhérer pour la première fois... c'est le temps de le faire. Consultez la section <Devenir membre> du site *http://www.cgs.ca/index.php?lang=fr*. Il n'y a pas d'augmentation des cotisations pour 2018.

Les avantages de l'adhésion comprennent :

- un accès en ligne à la Revue canadienne de géotechnique mensuelle, y compris à ses numéros précédents, et à un tarif spécial pour sa version imprimée;
- des versions en ligne et imprimée de la publication trimestrielle Geotechnical New, qui comprend CGS News;
- le bulletin électronique mensuel Réseau de l'information géotechnique de la SCG;
- un accès en ligne à tous les comptes-rendus des précédentes conférences de la SCG et à certaines conférences spéciales;
- des prix spéciaux pour toutes les conférences de la SCG;
- de l'information sur les Tournées de conférences transcanadiennes du printemps et de l'automne de la SCG;
- une adhésion à une ou à plusieurs des sept divisions techniques de la SCG et aux sociétés internationales associées;
- une participation dans l'une des 20 sections locales de la SCG;
- une participation à l'un des sept comités techniques de la SCG;
- une participation dans LA Société pour tous les professionnels en géotechnique canadiens.

Nous souhaitons la bienvenue à tous les nouveaux membres ainsi qu'à ceux qui renouvellent leur adhésion et sommes impatients de vous voir participer en 2017. Nous vous encourageons également à recommander la SCG à un ami ou à un collègue. Nous continuons à améliorer les avantages que la SCG offre à notre profession.

Call for Nominations for the 43rd CGS Colloquium Deadline January 31, 2018

Established in 1977, the CGS Colloquium is an annual commissioned presentation and paper. Along with the honour comes a $5,000 honorarium provided by **Canadian Foundation for Geotechnique**. It is targeted towards a younger CGS member to provide information of particular interest to the geotechnical community on topics of importance to the Canadian geotechnical field. A younger CGS member is typically regarded as being less than 40 years of age, with preference given to candidates 33 to 38 years at time of age at time of nomination.

Nominations can be made by any CGS member. The nominations for the **43rd CGS Geotechnical Colloquium**, which will be presented at the CGS conference in **St. John's, NL** in the fall of 2019, are due by J**anuary 31, 2018**. The selection will be made by the CGS Geotechnical Research Board in April 2018, 18 months prior to the presentation.

- The nomination submission should include:
- a nomination letter that introduces the nominee with his/her main accomplishments
- an extended abstract of the proposed talk (approximately 2000 words), including a statement of the importance of the topic to the Canadian geotechnical community;
- the originality of the nominee's contribution, and
- the nominee's resume including practical experience relevant to the topic and publication record

The 42nd Colloquium will be presented at **GeoEdmonton 2018** by **Matt Lato** in Edmonton.

Contact CGS Headquarters at *admin@cgs.ca* or 1-800-710-9867 for more information or to send in your nomination.

Appel de candidatures pour le 43e Colloquium de la SCG Date limite : 31 janvier 2018

Établi en 1977, le Colloquium de la SCG consiste en une présentation et un article annuels commandités. Cet honneur est accompagné d'une rétribution de 5 000 $ offerte par la **Fondation canadienne de géotechnique**. Il vise à ce qu'un jeune membre de la SCG donne de l'information présentant un intérêt particulier pour la communauté géotechnique sur des sujets d'importance pour le domaine géotechnique canadien. On considère ici qu'un jeune membre de la SCG est habituellement considéré comme étant âgé de moins de 40 ans, avec une préférence pour les candidats âgés de 33 à 38 ans au moment de leur candidature.

Les candidatures peuvent être somises par tout membre de la SCG. Les candidatures pour le **43e Colloquium géotechnique de la SCG**, qui sera présentée à **la conférence** canadienne de géotechnique de **St-John T-N** à l'automne 2019, doivent être reçues d'ici le **31 janvier 2018**. La sélection sera faite par le Conseil de recherche en géotechnique de la SCG en avril 2018, 18 mois avant la présentation.

Les candidatures doivent comprendre :

- une lettre de candidature présentant le/la candidat(e) ainsi que ses principales réalisations;
- un résumé détaillé de la conférence proposée (environ 2 000 mots), y compris un énoncé sur l'importance du sujet pour la communauté géotechnique canadienne;
- l'originalité des contributions du/de la candidat(e);
- le curriculum vitae du/de la candidat(e) comprenant l'expérience pratique pertinente au sujet et le dossier de publication.

Le **42e Colloquium** sera présenté à la conférence **GéoEdmonton 2018** par le **Matt Lato**.

Pour obtenir de plus amples renseignements ou soumettre une candidature, communiquez avec le siège social de la SCG à admin@cgs.ca ou au 1-800-710-9867.

Upcoming Conferences and Seminars

71st Canadian Geotechnical Conference and the 13th Joint CGS/IAH-CNC Groundwater Conference September 23 to 26, 2018, Edmonton, Alberta, Canada

The **Geotechnical Society of Edmonton** and the **Canadian Geotechnical Society (CGS)** in collaboration with the **Canadian National Chapter of the International Association of Hydrogeologists (IAH-CNC)**, invite you to **GeoEdmonton 2018**, the 71st Canadian Geotechnical Conference and the 13th Joint CGS/IAH-CNC Groundwater Conference. The conference will be held at the **Shaw Conference Centre** in **Edmonton, Alberta**, Canada from Sunday, **September 23 to Wednesday, September 26, 2018**. This spectacular facility is one of Canada's premier conference venues and is itself a geotechnical achievement, being constructed on the flank of an active landslide overlooking Edmonton's beautiful river valley in the heart of downtown.

Edmonton was founded on the banks of the North Saskatchewan River and served as a Hudson's Bay Company trading outpost that grew to become Canada's Gateway to the North and is Alberta's Capital City. With a metro population of over 1.3 million people, Edmonton has an open and welcoming atmosphere. Also known as the Festival City, Edmonton showcases its local and international talent and diversity through various festivals like its annual Heritage Festival and the second largest Fringe Theatre Festival in the world. Boasting the longest stretch of connected urban parkland in North America and just steps from the conference venue, Edmonton is also a wonderful place to enjoy nature without leaving the city's limits.

The theme for GeoEdmonton 2018 is **Transportation Géotechnique Moving Forward**. Much of Canada's prosperity is founded on its vast network of railways, pipelines, highways, and waterways. This conference intends to highlight recent achievements in transportation development and their associated geohazards. The technical program will cover a wide range of geotechnical and hydrogeological topics, including specialty sessions that are of local and national relevance. In addition to the technical program and plenary sessions, the conference will include a complement of distinguished keynote speakers, high calibre short courses, social events, and techni-

cal tours. The official languages for the conference will be English and French.

The GeoEdmonton 2018 conference organizing committee invites members of the Canadian and international geotechnical and hydrogeological communities to contribute papers for presentation at the conference. Of particular interest are submissions highlighting recent research developments and advancements in their respective fields of practice, as well as case histories dealing with the challenges of geotechnical or hydrogeological problems.

Authors are invited to submit abstracts (French or English, maximum 300 words) by **December 31, 2017** through the **Online Submission** page of the conference website at *http://www.geoedmonton2018.ca*. Abstracts should generally align with the following topics, but sessions may be added for groups of abstracts which share a common theme not listed below:

- Geotechnical themes
  - ◊ Soil Mechanics and Foundations
  - ◊ Rock Mechanics and Engineering Geology
  - ◊ Landslides and Geohazards
  - ◊ Mining Geotechnics and Hydrogeology
  - ◊ Geoenvironmental Engineering
  - ◊ Transportation Geotechnics
  - ◊ Geosynthetics
  - ◊ Cold Regions and Permafrost Geotechnics
  - ◊ Sustainable Geotechnics
  - ◊ Professional Practice
  - ◊ Special Themes:
  - ▫ Peats and Soft Soils
  - ▫ Light Rail Transit
  - ▫ Tunnelling in Urban Environments
  - ▫ Geohazards in Linear Infrastructure
  - ▫ Remote Sensing and Monitoring
  - ▫ In-situ Testing
  - ▫ Trenchless Technology
  - ▫ Risk Management in Geotechnical Projects
  - ▫ Reliability Analysis for Geotechnical Design
  - ▫ Dam Safety
  - ▫ Shallow Geothermal Energy Exchange
- Hydrogeological themes
  - ◊ Mining, Energy Development and Groundwater
  - ◊ Groundwater and Climate Change
  - ◊ Watershed Resilience and Source Water Protection
  - ◊ Groundwater Dependent Ecosystems
  - ◊ Regional Characterisation
  - ◊ Hydrostratigraphy and Geological Modelling
  - ◊ Hydrogeophysics
  - ◊ Geostatistical Methods for Mapping and Modelling
  - ◊ Isotopic and Geochemical Fingerprinting
  - ◊ Approaches to Groundwater Management
  - ◊ Transboundary Water Resources
  - ◊ Outreach and Education
  - ◊ General Hydrogeology
  - ◊ Contaminant Hydrogeology:

For the latest information about the conference, please visit the conference website at *http://www.geoedmonton2018.ca*.

See you in Edmonton!

2018 Geohazards 7 Conference June 3 to 6, 2017 Canmore, Alberta

The CGS Geohazards Committee's specialty conference, **Geohazards 7**, will be held **June 3 to 6, 2018** at the **Coast Canmore Hotel & Conference Centre** in Canmore, Alberta and the call for abstracts is well underway.

Geohazards 7 will touch on the full range of hazards and risks associated with floods, debris flows, landslides, snow avalanche, earthquakes, volcanic eruptions, degrading permafrost and more, and will be of interest to engineering and geoscience students and consultants, industry, and government agency representatives who are involved in planning, approval, construction and operation of infrastructure and residential development in areas prone to geohazards.

More information about the conference can be found by visiting the conference website at *http://www.geohazards7.ca/*

Members in the News

Richard J. Bathurst

Dr. Richard J. Bathurst elected to Fellow of the Royal Society of Canada

We are delighted to announce that **Dr. Richard J. Bathurst** of the Civil Engineering Department at RMC has been elected **Fellow of the Royal Society of Canada**.

Election to the academies of the Royal Society of Canada is the highest honour a scholar can achieve in the Arts, Humanities and Sciences.

The citation reads: *Professor Bathurst has made innovative and impactful*

contributions to the advancement and understanding of modern civil engineering geosynthetic reinforced earth retaining structures and slopes. His work demonstrates a multi-disciplinary approach to the design, analysis and sustainability of these structures. His many acclaimed contributions also include themes related to earthquake geotechnical engineering, probabilistic design, full-scale model earth structure testing, materials testing, soil-structure interaction, transparent surrogate granular soils and granular particle mechanics.

Dr. R.J. Bathurst joins over 2000 Canadian scholars, artists, and scientists, peer-elected as the best in their field. The fellowship of the RSC comprises distinguished men and women from all branches of learning who have made remarkable contributions in the arts, the humanities and the sciences, as well as in Canadian public life.

This recognition is the most recent of many other national and international accolades that Professor Bathurst has received over his distinguished career at RMC.

Dr. Richard J. Bathurst a été élu membre de la Société royale du Canada

Nous sommes ravis d'annoncer que **M. Richard J. Bathurst**, du Département de génie civil du CMR, a été élu **membre de la Société royale du Canada**.

L'élection à la Société royale du Canada constitue le plus grand honneur qui puisse être accordé à un universitaire qui travaille dans les domaines des arts, des lettres et des sciences.

Le témoignage : *Richard Bathurst a apporté des contributions novatrices et percutantes à l'avancement et à la compréhension des ouvrages de soutènement et des pentes renforcés de géosynthétiques. Son travail démontre une approche multidisciplinaire pour la conception, l'analyse et la durabilité de ces structures. Ses nombreuses contributions saluées par ses pairs comprennent également des travaux sur l'ingénierie géotechnique sismique, la conception probabiliste, l'étude à pleine échelle des ouvrages géotechniques, les essais sur matériaux, l'interaction sol-structure, les sols granulaires transparents de substitution et la mécanique des particules granulaires*.

M. R.J. Bathurst se joint à plus de 2 000 érudits, artistes et scientifiques canadiens remarquables élus par leurs pairs. Les femmes et les hommes membres de la SRC sont issus de toutes les disciplines intellectuelles. Ils se sont distingués par leur contribution aux arts, aux lettres, à la science et au service de la population canadienne.

Cette reconnaissance est la plus récente de nombreuses autres accolades nationales et internationales que le professeur Bathurst a reçu durant sa carrière éminente au CMR.

Submitted by Guy Gosselin, FCSCE, FEIC, P.Eng
Executive Director - Engineering Institute of Canada
and Canadian Society for Mechanical Engineering

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2017 R.F. Legget Medal Award - le médaillé R.F. Legget 2017 Awarded to Professor Doug Stead

Introduction of 2016 R.F. Legget Medal Winner by Marc-André Brideau

C'est avec le plus grand plaisir que j'ai l'honneur de présenter le **médaillé R.F. Legget de 2017**. It is my great pleasure and honor to introduce the recipient of the 2017 **Legget Medal Award: Professor Doug Stead**.

Doug has been the FRBC chair in Resource Geoscience and Geotechnics at Simon Fraser University since September 2000. His research has brought significant advances to three fundamental components of engineering geology and geotechnical engineering; field characterization (LiDAR, photogrammetry), laboratory testing (acoustic emission), and numerical modelling (DEM, FEM, hybrid, lattice-spring). Doug is also one of the few academics that has contributed in equal amounts to the investigation of natural slopes, open pits, and underground mines.

J'ai eu la chance de faire la connaissance de Doug en 2001. En premier lieu comme étudiant dans sa classe d'introduction à la mécanique des sols et des roches à l'Université Simon Fraser. Par la suite j'ai complété ma maîtrise et mon doctorat sous sa supervision. Suite à mes études universitaires, nous avons continué à collaborer sur des projets de recherche et sur les comités de thèse de ses étudiants.

Doug is a prolific author and co-author having penned approximately 300 technical publications with approximately 200 different co-authors over his career. He has an extensive network of collaborators in Canadian universities, government agencies, and in industry. De plus, Doug a un réseau bien établi de collaborateurs Européens en Angleterre, en Italie, et en Suisse. L'étendue de ses intérêts de recherche couvre non seulement le génie géologique et la géotechnique mais aussi la géomorphologie et les sciences de la terre. Doug à publier dans plus de 15 journaux scientifiques différents depuis les dix dernières

années ce qui reflète l'étendue de ses intérêts de recherche.

En plus de ses nombreux accomplissements académique, Doug a fait des contributions importantes afin d'encourager le transfert d'idées et de connaissances entre les ingénieurs et les géoscientifiques universitaire, ceux en industrie, et les experts-conseils. Doug has contributed to the transfer of ideas and knowledge by offering professional development workshops to practitioners, providing external expert reviews on large consulting projects, and leading joint research projects with mining companies and consulting firms. He has also been the co-chair of three very successful conferences over the last 10 years. These included the 2007 Canada-US Rock Mechanics Symposium, 2011 International Symposium on Rock Slope Stability in Open Pit Mining, and Civil Engineering, 1st International Conference on Discrete Fracture Network Engineering (DFNE) in 2014. The 2014 DFNE conference is a great example of integrating academics and practitioners from a wide range of specialties (petroleum, mining, infrastructure, and geohazards) and providing them with a forum to present their work and exchange ideas.

Pour réaliser tous ces accomplissements, il faut bien sûr être un travaillant infatigable mais aussi avoir une curiosité insatiable et une grande imagination. Doug is constantly looking at new techniques and approaches to tackle fundamental and applied problems in engineering geology and geotechnical engineering. As an example of his insatiable curiosity, Doug has recently started to investigate the additional insights that radar, thermal, and hyperspectral imagery can bring to the remote sensing tools used for characterising rock outcrops in natural slopes, open pits, and underground mines. Keeping at the forefront of integrating technology into science and engineering, he has also recently been involved in projects investigating ways to harness virtual reality applications to display and analyze multiple complex three-dimensional engineering geology and geotechnical engineering datasets.

Sans plus attendre, veuillez-vous joindre à moi pour accueillir et féliciter le médaillé R.F. Legget de 2017: Without further ado, please join me in welcoming and congratulating the recipient of the 2017 Legget Medal Award: Professor Doug Stead.

Marc-André Brideau
October 4, 2017

2017 R.F. Legget Medal Award Acceptance Speech Professor Doug Stead - Simon Fraser University

Doug Stead

Thank you, Marc-Andre, for your very kind introduction. Mesdames et messieurs, je suis très honoré de recevoir la médaille Legget pour deux mille dix-Sept. It is a very great honour for me to be selected as the recipient of the 2017 Legget Medal. I would first like to thank those who nominated me, the Canadian Geotechnical Society Committee for selecting me, the Canadian Foundation for Geotechnique and finally the GeoOttawa Local Organising Committee for making it possible for me to receive the medal in person. Looking through the 47 previous recipients of the Leggett Award since 1970 I am particularly honored and humbled to have been selected.

It was in the early 1970's when I was first introduced to the field of engineering geology during undergraduate lectures by **Dr. F.G. Blyth**, author of the text "*Geology for Engineers*". In my undergraduate year at the University of Exeter were **David Wood** and **Len Murray** both of whom were to become highly Canadian consultants. I recall my first exposure to landslides through case studies such as the Frank Slide which I have been very fortunate to work on during my career. In 1975-6, I was accepted by **Dr. Alistair Lumsden**, into the MSc. Engineering Geology and Geotechnics at Leeds University – looking back, without doubt, the most important opportunity to arise in my career. I remember reading Dr. Legget's "*Cities and Geology*" at the start of this course and knowing then that I had made the right career choice.

My MSc. dissertation was my first real introduction to Canadian geotechnical engineering focussing on a comparison between Canadian and Scandinavian quickclays under the supervision of **Dr. Ian Smalley**. On graduation, my wife Sally and I left for Zambia where I worked for two years as an open pit geotechnical engineer at Nchanga open pit, Chingola. This was a particularly important time in my career when I saw through the example of several outstanding mine consultants the potential synergies

between applied research and practice. I was put in charge of the mine's soil testing laboratory, an experience which was to prove invaluable in my future career. The mine consultants included Oscar Steffen a founder of SRK, **Dick Stacey**, **Allan Moss** and **Professor Jeremiah Jennings** of the University of Witwatersrand. This is when I was first introduced to unsaturated soils, unloading tests, cave mechanics and importantly rock slope stability, step-paths and rock bridges. The late Canadian engineering geologist, **Doug Piteau**, (Piteau and Associates) had previously worked at this mine so there was a strong connection with Canadian geotechnics which was, at that time, at the forefront of open pit geomechanics with publication of the CANMET open pit manuals. One of the important experiences learned during this period was the need to understand the important relationships between the geology, structure, hydrogeology and geotechnics of the pit.

After leaving Zambia, my career involved periods as a soils engineer working on site investigation projects for motorways in the UK (Midland Road Construction Unit) and in Hong Kong working as an engineering geologist with consultants **Scott Wilson Kirkpatrick** on rock slopes and foundation projects. During my time in Hong Kong I attended several short courses by Canadian engineers including a course on tunneling by a previous Legget winner, **Professor K.Y. Lo**. It was at this time I decided to go back to university to obtain a PhD. Following on the rock slope stability theme of my early career, my doctoral research at the University of Nottingham was to focus on slope stability in UK surface coal mines under the supervision of **Professor Malcolm Scoble**, now at UBC Mining.

At that time, there were very few commercial software codes available and it was necessary to develop one's own software from first principles. It was then that I became keenly aware of the leading role of Canadian geotechnical engineers in the development of limit equilibrium methods including yet again several previous Legget award recipients. I still recall as a new PhD student receiving a large package of papers in the mail from **Professor Fredlund** at the University of Saskatchewan in a response to a letter.

After completing my PhD, I immediately left to take up an appointment as a Lecturer in Applied Geology at the University of Papua New Guinea in Port Moresby where I continued to work on slope stability along highways and in open pits. The importance of intense weathering, high precipitation (up to 8m per year), geomorphology and geological structure on slope stability were all keenly apparent.

In 1986, I moved to Canada to join the Geological Engineering program at the University of Saskatchewan teaching rock mechanics, site investigation and structural geology. During ten years at the U of S, I was very fortunate to teach first year "Geology for Engineers" to many hundreds of engineers, possibly to some of you in the audience now. My research over this 10-year period was wide-ranging including surface and underground rock engineering, experimental rock mechanics, and landslides. Underground potash mine geomechanics was a major focus of our research working with **Professors Malcolm Reeves** and **Don Gendzwill**; this is also when I first met Past CGS President, **Michel Aubertin**. I look back on daily research discussions with my colleague and friend **Zig Szczepanik** rock mechanics technician at U of S as a major source of inspiration over this time. As an Associate member of the U of S Geotechnical Group, I obtained a great appreciation of unsaturated soils and soil slope analysis from **Professors Fredlund** and **Barbour** and also fondly remember spending time in the field with the late **Professor Karl Sauer.** It was during this period of time I was very fortunate to teach and supervise my long-time friend and colleague **Dr. Erik Eberhardt** from a 1st year student, through his MSc and PhD. In the following 25 years, we have continued to collaborate on a wide variety of rock engineering projects, something I hope will continue for some time with my recent appointment as an Affiliate Professor at UBC. Early research at the University of Saskatchewan was to highlight the importance of considering progressive brittle fracture in rock engineering and also the important need to consider time-dependent constitutive criteria.

In 1996, I commenced a position as Chair of Geotechnical Engineering at the University of Exeter, UK, based at Camborne School of Mines, CSM. Research between 1996 and 2000 focussed on experimental acoustic emission, characterisation of altered granites, three-dimensional modelling of soil and rock slopes, coastal slope instability, risk analysis, quarry slope stability and longwall coal mining. Research at CSM in 1999, showed the significant future potential of ground-based LIDAR in rock slope characterisation and the need to move to brittle fracture modelling of slopes. At this time, I began a long time working collaboration with my colleague and friend **Associate Professor John Coggan** of CSM which continues to this day through my appointment as an Honorary Visiting Professor at the University of Exeter.

In 2000, I returned to Canada as Forest Renewal of BC, FRBC Chair and Professor in Forestry Geotechnics in the Department of Earth Sciences, Simon Fraser University. This position initially focussed on the influence of forest harvesting on slope stability. With a change of government and the termination of FRBC, the mandate of the chair was changed to Resource Geotechnics. Over the last 17 years I have been fortunate to be involved in the application of new engineering geology, remote sensing and numerical modelling technologies to natural slopes, open pits and underground mines both in Canada and internationally. A particular focus of research at

SFU has been the integrated use of characterisation, monitoring and modelling methods in geomechanics.

As numerical modelling increases in sophistication, the need to improve characterisation of the rock mass becomes ever more important. The advances in monitoring technologies including ground and satellite based methods brings with it the potential for not only improved model constraints but also improved rock mass characterisation. The advent of these new technologies has led to the challenges of "big data" storage, interpretation and visualization – an area in which geotechnical engineers will need to be increasingly involved.

I would like to take this opportunity to thank many people without whom, this award would have not been possible. Firstly, I would like to acknowledge the critical role of my graduate students who have come from all parts of the world and enriched my research program. I would like to thank all my post-doctoral fellows and in particular my colleagues and friends **Davide Elmo** from UBC, Mining and **Mirko Francioni** from the University of Exeter. I have particularly enjoyed working with you, **Erik Eberhardt** and **John Coggan** on developing brittle fracture-DFN modelling methods and remote sensing approaches. I would like to thank my colleagues at Simon Fraser University, **John Clague**, **Brent Ward**, **Diana Allen** and **Glyn William-Jones** who I have enjoyed working with on many numerical modelling, engineering geomorphology and remote sensing projects. I would also like to thank all my international colleagues and friends that I have worked with over the last 20 years, in particular **Monica Ghirotti** and **Lisa Borgatti** from Italy, **Michel Jaboyedoff** and **Simon Low** from Switzerland and more recently **Jim Griffiths** and **Nick Rosser** in the UK.

There are too many industry collaborators over the years to acknowledge individually, but to all of you, I thank you for the opportunity to keep my research industry-focussed with practical applications. I would like to acknowledge the contributions of SRK. Golder Associates, Itasca and in particular BGC Engineering whose support of my graduate program and undergraduate teaching has been a major benefit to my students.

I first went to a CGS conference in 1987 in Regina some 30 years ago and it has been a very positive influence on my career. I would strongly recommend young geotechnical engineers and geoscientists today to get involved with CGS. As a member and Chair of the Rock Mechanics and Engineering Geology Divisions and Vice President Technical of CGS I have enjoyed working with numerous CGS colleagues who are present today, many of whom, I have known for over 20 years.

Most importantly I would like to thank my wife **Sally**, my daughter **Rosalind**, and my sons **Alistair** and **Philip** who over the years have been dragged along to numerous landslides in Canada, the US and overseas. My wife Sally a long time ago left the UK to go with me on long term contracts in Zambia, Hong Kong and Papua New Guinea before we eventually came to Canada. She supported me during my MSc and when I decided to leave a well paying consultancy job in Hong Kong to go back to university to do a PhD; she was always one hundred percent behind me – without you my career would not have been possible and I certainly would not be here today.

I am very pleased and honoured to accept the Legget Medal not only as an engineering geologist who moved from the UK to Canada some 30 years ago but equally as someone whose father was a 6th generation Newfoundlander and whose family came from Little Catalina, Bonavista Bay. En terminant je remercie la société Canadienne de Géotechnique et le comité de sélection pour cet honneur. Thank you et Merci

Doug Stead
October 4, 2017

Introduction by Richard Guthrie, Editor

Summer 2017

Summer's verdant greens stumbled over themselves in a race to try on the reds and golds of autumn this year. In Alberta, we even tried on the mantle of snow, but decided we weren't quite ready. The bulk of the field work wrapped up safely in gorgeous sun dappled vistas as shorter days drew closer.

I know that many drilling programs will continue through the winter, and for our snow avalanche colleagues, the season is only just beginning, but fall always seems to me to be a resetting of the clock and a time to reflect, if momentarily, on the year.

I was asked to give a talk to the EGBC AGM this year and what started in my head as a technical talk, ended up being a philosophical piece about the challenges of risk assessments, liability, and geotechnical work in general. The paper that follows is reproduced (with permission) from an article published this fall in Innovation. GN has been good enough to provide the full set of references in case you want to dig further into some of the ideas. Hopefully, you find something in the article that resonates with you.

By the time you read this, your winter program will have begun. Report writing, field work, analysis. I wish you success in your endeavors, and hope you have time this winter to enjoy the season.

7th Canadian Geohazards Conference – Geohazards 7: Engineering Resiliency in a Changing Climate http://www.geohazards7.ca/

The Canadian Geotechnical Society (CGS) is pleased to announce the 7th Canadian Geohazards Conference – Geohazards 7 – to be held June 3-6, 2018 at the Coast Canmore Hotel & Conference Centre in Canmore, Alberta. The CGS's Geohazards conferences are the premiere forums in Canada for the sharing and dissemination of scientific and engineering knowledge related to geohazard assessment and risk management.

Canmore is ideally situated for hosting Geohazards 7. It is located within easy travel distance from the Calgary International Airport, and is less than a 30-minute drive from Banff National Park. Heavy rainfall in June 2013 resulted in the worst floods in Alberta's history. Landslides, debris floods and debris flows cut off highway and rail access to Banff and Canmore, and many homes constructed on alluvial fans were destroyed. Municipal governments, the Province and the engineering and geoscience community have since carried out aggressive programs to quantify geohazard risk, increase public awareness of hazards, and are constructing mitigation measures to reduce future risk. Canmore is a terrific venue to showcase the results of some of these initiatives, which will feature in the conference program and fieldtrip.

This conference will be of interest to engineering and geoscience students and consultants, industry, and government agency representatives who are involved in planning, approval, construction and operation of infrastructure and residential development in areas prone to geohazards. The conference will touch on the full gamut of hazards and risks associated with floods, debris flows, landslides, snow avalanche, earthquakes, volcanic eruptions, degrading permafrost and more. Arming participants with greater awareness of methods for quantifying geohazard magnitude and frequency for risk assessment and mitigation design, quantifying uncertainty in a changing climate, and communicating with the public about geohazard issues, are key objectives of the conference.

Closing Notes

Thank you for your letters! If you have a paper or project related to Geohazards that you think would be interesting to GN readers, please send me note at *Richard.guthrie@stantec.com.*

Until the spring,

Rick

Courting Disaster: The Increasing Challenge of Risk Assessments

(A version of this article first appeared in the Sep/Oct 2017 edition of Innovation Magazine)

R.H.Guthrie, M.Sc., Ph.D., P.Geo.

Introduction

On April 6, 2009, at approximately 3:32 AM, a magnitude 6.3 earthquake devastated the medieval Italian town of L'Aquila, about 90 km east of Rome, killing more than 300 and leaving thousands homeless (Roberts, 2014; Cartlidge, 2014). Ultimately, it wasn't just the devastating human toll that made this event newsworthy, but the legal consequences to a group of Italian scientists that formed part of the Italian National Commission for Forecasting and Preventing Major Risks (the Major Risks Commission). Those six scientists (three seismologists, a volcanologist and two seismic engineers) were tasked with estimating the risk of a major earthquake to the town in light of several small and medium sized events that occurred in previous months (Cartlidge, 2014) and local prognosticators and scaremongers predicting a major event. The Major Risks Commission estimated that there was little risk of a large earthquake. The earthquake occurred despite the prediction, and in 2012, the scientists were sentenced to 6 years in prison and € 9,000,000 (Cartlidge, 2012). The ruling was overturned 2 years later, but the impact to the global scientific community was sobering.

As geotechnical scientists and engineers, we are called upon to make judgements about the conditions and characteristics of the earth and earth processes. Those judgements are intended to guide development; to contribute to the understanding of environmental, economic, or societal safety; to advise civil design, and to prevent catastrophic outcomes of the human footprint. All too often we are expected to perform Herculean leaps of knowledge based on very limited data for a litigious society that relies on our expertise.

And let's be clear. The public does rely on our expertise, and as a self-regulating profession that claims expert knowledge about the workings of the earth, we encourage and promote that model.

We owe ourselves, and the public, a duty of care to limit our own liability by being aware of, and communicating, what we know, and conversely what we don't know. We also owe it to ourselves and the public to clearly communicate the notion of residual risk and uncertainty, and how that residual risk can change as a result of changing conditions (including development).

Definitions

Definitions of hazard and risk may be superfluous; however, they are still widely misused in geotechnical engineering and warrant reviewing in light of the present topic.

Hazard

Hazard is widely-used to describe threats to humans and what they value including life, well-being, material goods and the environment (Perry, 1981). Ambiguity arises wherein the term hazard is used as both a colloquialism and as a specialist term with different meanings or levels of precision for different disciplines (Nadim, 2013). In geotechnics, hazard should be limited where practical to the probability, within a specific time and area, that an event or events (geotechnical, geological or geomorphological processes) will adversely affect humans or the things humans value. Other conditions can be described as threats, dangers or susceptibility.

Risk

Risk is also widely-used to describe threats to humans and what they value. Geotechnical engineers and the public frequently misuse the word risk to mean hazard, or indeed, any measure of probability (such as susceptibility). In reality, risk must embody both the probability of a hazard (or the sum of hazards) occurring, and the consequence(s) of that event. The most general risk equation is given as:

$$R = H \times C$$

Where R=risk, H=hazard and C=consequence.

In reality, the basic risk equation is normally divided into component parts including: spatial and temporal probability of a hazard, or a probabilistic model of hazards, and the magnitude (volume, area, intensity, runout etc…), the elements at risk and the vulnerability, exposure and value of those elements.

A more refined equation therefore looks something like the following:

Where R_S = specific risk, P=probability, $H_{T,S}$=temporal and spatial likelihood of a hazard of a given magnitude respectively, E_V, V and E_X is the value, vulnerability and exposure respectively of a given element at risk.

It shouldn't surprise the reader to learn that many of these terms can be

$$R_s = P\left(H_{TS}\right) x \sum \left(E_v x V x E_x\right)$$

further broken down.

Residual Risk

Residual refers to the risk that remains following an event, assessment, or mitigation. It reflects our uncertainty about the stochastic nature of the physical world, the potential for even low probability events to occur at any time, and our knowledge and identification of more likely events that remain following an assessment or mitigation.

In the L'Aquila case, the knowledge of the day was that small earthquake swarms were not statistically correlated with a major earthquake (this assumption is being rigorously re-examined globally as a result of the outcome). The residual risk of a major earthquake remained but was inadequately communicated.

Increasing risk and increasing challenges of risk assessments

While credible arguments can be made for a decreasingly risky world (increased lifespans, wealth and general human health, earthquake resistant infrastructure, better land use zoning, emergency management applications and increased medical care), there are objective measures whereby geotechnical risk has increased substantially. With a global population at more than 7.5 billion and growing, humans have disrupted natural systems and imposed themselves on the landscape (Guthrie, 2015). Obvious examples include climate change and subsequent changes to sea level, slope stability, distribution of permafrost, flooding and storm intensity, as well as geotechnical risks that result from a systematic intrusion into, and occupation of, higher hazard areas.

The assessment of geotechnical risk cannot rely unquestioningly on standards and practices developed by those pioneers of the discipline. We must continue to use our best understanding and judgement in a world where the rate of change, and our role in it (as both drivers of change and those effected by change) is increasing, and our assessments should in some manner, account for that change. Errors in judgement are assured (Nasmith, 1986), but hopefully through the careful and judicious application of our knowledge, training and experience, and clear communication to our clients, we do indeed serve the public good.

Abdulahad et al. (2010) reviewed 41 legal cases involving geotechnical practice in Canada between 1982 and 2006. While not strictly risk assessments, risk is implicit in each example. Of those cases, more than 50% were based on different soil conditions and recommendations than expected from the geotechnical report. The courts allowed the actions based on a provision of reasonable evidence to expect different soil conditions (about 40% of the time).

Nasmith (1986) stated similarly that incorrectly located boreholes are among the most common errors in geotechnical engineering.

In addition, slope stability and landslide risk assessments are inherently high-risk for the practitioner. They rely on uncertain knowledge, changing ground conditions, and constantly changing driving forces (such as the weather, manipulation of the slopes, and re-direction of water among other things).

The questions remain: How do we, as a discipline, increase our predictive accuracy in an increasingly complex world. How do we communicate effectively to our clients both the legitimacy and the uncertainty in our work? How do we provide practical, useful advice that decreases geotechnical risk?

Answers in the code

Geotechnical scientists and engineers conducting hazard and risk assessments perform a valuable public service. The Engineer's and Geoscientist's code of ethics is designed to protect the public, but simultaneously offers protection to the practitioner. In this case, answers to the above questions are framed in the context of the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). This has been renamed to Engineers and Geoscientists British Columbia (EGBC).Code of Ethics: (Author's note: other Codes have similar clauses).

Code Bullet 2: Undertake and accept responsibility for professional assignments only when qualified by training or experience

It is a human condition to overestimate our knowledge or the accuracy of our own judgement (Kahneman, 2011). We're simply not very good at knowing what we don't know. An antidote to this is, ironically, training and experience. The more we learn, the more we are exposed to the exceptions to the rule, to the rare black swans, to solutions arrived at through an entirely different mechanism. We have a duty therefore, to recognize when independent or senior review is helpful (almost always), to cross-pollinate and discuss our ideas with peers and colleagues, to mentor junior and intermediate staff and to approach other disciplines with humility and respect.

Another antidote to the training and experience issue occurs when a problem is approached by an engineering geologist or geomorphologist and a geotechnical engineer working together. Each has a comprehensive background that is not likely to be fully realized by the other, but together can dramatically improve the results of an assessment. These advantages have been made clear by others (Redlich, Terzaghi, & Kemp, 1929; Fookes & Vaughan, 1986; VanDine, Nasmith, & Ripley, 1992; PRCI, 2009) but this approach remains under-utilized.

Code Bullet 3: Provide an opinion on a professional subject only when it is founded upon adequate knowledge and honest conviction

Similar to the previous bullet and subject to the same solutions, this one also speaks to a tension that frequently arises between a client looking for a conclusive answer from a specialist

who has insufficient data. Adequate knowledge is a judgement call, and a practical balance between effort spent and diminishing returns is often necessary. Nevertheless, there is a clear and logical relationship between increased data gathered through additional samples, boreholes, field work, LiDAR or similar means, and the accuracy of the result. Indeed, increased data was the first recommendation of Abdulahad et al. (2010) aimed at reducing legal claims against the geotechnical engineer, and it is the basis for the at least some of the changes in the new Canadian Highway Bridge Design Code (CSA, 2014), the upcoming seismic guidelines, and in general, reliability assessments in geotechnical engineering (Duncan, 2000).

Where knowledge is insufficient, the uncertainty should be clearly communicated in such a manner that the client knows and understands what has been provided, but also what has not been provided in the assessment. Geotechnical baseline reports (GBR) are sometimes used to communicate the level of knowledge and reliability of geotechnical assessments (ASCE, 2007; Parnass & Staheli, 2010). Baseline statements may be in conflict with the actual information gathered, but may be a more accurate description of what actual ground conditions could be. GBR's are not accepted by some clients, however, we can still provide clear communication about how our studies are to be used or interpreted.

Finally, where residual risk is known or assumed, that risk should be communicated as part of the information provided to a client.

Code Bullet 6: Keep themselves informed in order to maintain their competence, strive to advance the body of knowledge within which they practice and provide opportunities for the professional development of their associates

For the first time in history, as professionals, we are limited not so much by a lack of information as by an excess of it. Part of the corollary to the knowledge and training discussed under Bullet 2 above, is the ongoing need to continue to advance our understanding, to learn what new applications, tools, knowledge and software is available to us to adequately perform our jobs.

This is formalized through associations as professional development hours and opportunities to expand one's knowledge and understanding will substantially improve one's ability to correctly assess hazard and risk.

In addition, where specialization continues to occur, it behooves us to learn what others can do, how it differs from our own skill sets, and to work in teams insofar as it is possible. This helps us reduce the famous "not knowing what we don't know" portion of the knowledge pie.

Code Bullet 8: Present clearly to employers and clients the possible consequences if professional decisions or judgments are overruled or disregarded

The human mind is notoriously bad at understanding very large or very small numbers. Further, we are inherently drawn to a compelling narrative, sometimes drawing completely false conclusions about hazard and risk, and we are subject to inherent biases based on repeated experiences (Kahneman, 2011). For all these reasons and more, humans in general are very poor judges of actual risk, even when it is explained to us.

Unfortunately, hazard and risk assessments are routinely working with abstractions of probability, while individual human experience relates better to the repeated instances where nothing happened better than the possibility that something unlikely will occur. We are like the proverbial thanksgiving turkeys the week before the harvest, secure in our understanding about the benign and caring nature of the two legged creatures that bring us daily food. There is a substantial challenge communicating credible risk scenarios to clients in a way that is not a scare tactic, but represents instead a genuine communication of probability, uncertainty, and residual risk.

Moving away from statements that discuss probabilities strictly in terms of return intervals (1:100 years, 1:10,000 years) and toward the percent probability of occurrence over a given period (design life, 50 years or similar) frames these numbers in a way that is more meaningful.

Similarly, we can articulate the ways that infrequent probabilities accumulate to better inform clients that manage large areas, long linear infrastructures or intend to build facilities with a long design life.

Case studies or examples help illustrate the credible consequence scenarios for rare events that don't normally occur.

Ultimately, we have an obligation not to make a risk decision on behalf of the client, but to help the client understand what that risk really entails, and allow him or her to make an informed decision.

Conclusion

An argument can be made that the analysis of geotechnical risk is increasing worldwide. Consequences increase as the human footprint extends further into marginal lands, intersecting more hazards. Hazards increase, in part, due to new interactions between geomorphological and anthropomorphic systems that modify the surface of the planet and change the processes that form it. Our knowledge and understanding about geotechnical, geological, or geomorphological systems continues to increase, but requires increased specialization and training to use, and considerable effort to remain current.

The issues are not new, just increasingly complex. Possible solutions should be taken seriously as part of the service we provide, and to reduce our own liability that may arise through a failure of communication. Our Codes of Ethics are intended to provide a

framework for at least some of the answers within which geoscientists and geotechnical engineers can look for ways to provide reliable, transparent results, while helping clients understand how to best use and interpret them. The main points identified above are as follows:

- Get independent review of your work, solicit advice, mentor young staff;
- Respect specialization and work in teams, use engineering geologists/geomorphologists and geotechnical engineers together where possible (this may be a river hydrologist/civil engineer combination for rivers);
- Find adequate balance and communicate clearly the benefits of increased data and the risks associated with insufficient information. This is particularly true for locations where variability and the consequences are high (BC for instance);
- Provide language that helps clients understand how reports should be used and what other conditions might be expected;
- Communicate as applicable: confidence, uncertainty and residual risk;
- Increase your knowledge base and work with other specialists in complimentary fields;
- Recognize the inherent difficulty in understanding probabilities and find ways to communicate them such a manner that a client is able to make knowledge-based decisions.

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Recap of 2017 Tailings and Mine Waste Conference

Vivian Giang, Nicholas Beier, Dave Sego and G. Ward Wilson

Between November 5 and 8, 2018, over 350 mine waste managers, engineers, regulators and researchers gathered at the Banff Springs Hotel in Banff, Alberta, for the 21st International Conference on Tailings and Mine Waste. The University of Alberta Geotechnical Centre and Oil Sands Tailings Research Facility (OSTRF) hosted the conference, which provided attendees an opportunity to discuss the latest developments in tailings and mine waste management.

The University of Alberta is one of three hosting universities for this conference, which began in 1978 at Colorado State University. Participants representing 18 countries presented new ideas and made professional contacts with others who have mutual interests and goals. Thirty-seven exhibitors were also present at the conference to showcase their technologies and services.

The conference featured seven keynote presentations on a variety of topics. Presenters included:

Henry Brehaut, President, Global Sustainability Services Inc. – Catastrophic Tailings Dam Failures – Path Forward

John Cunning, Principal and Geotechnical Engineer, Golder Associates; and **Mark Hawley**, President and CEO, Piteau Associates Group of Companies – Introducing Guidelines for Mine Waste Dump and Stockpile Design

Terry Eldridge, Principal, Golder Associates – Advances in Tailings Management in South America

Henry Brehaut addresses the audience during the opening Keynote Presentation (courtesy of Jen Stogowski Photography).

Richard Davidson, Senior Principal and Vice President, AECOM – The State of Mining Geotechnics

Tamara Giles, Senior Technical Advisor, Tailings, Canada's Oil Sands Innovation Alliance – Update on Oil Sands Tailings Research

Dr. Gord McKenna, President and Geotechnical Engineer, McKenna Geotechnical Inc. – Density and Strength Requisites for Capping and Reclaiming Soft Tailings to Meet Land-Use Goals

Luke Russell, VP External Affairs, Hecla Mining Company – Filtered Tailings: A Silver Bullet?

Special to this year, the Mining Association of Canada (MAC) held a workshop on "Updates to the Tailings Management Component of the Towards Sustainable Mining® (TSM) Program". Dr. Michael Davies (Senior Advisor, Tailings & Mine Waste, Teck Resources, and Chair of MAC's Tailings Working Group) and Charles Dumaresq (Vice President, Science and Environment Management, Mining Association of Canada) provided an overview of MAC's TSM program. The workshop also detailed revisions to the TSM Tailings Management Protocol, which describes performance measurement indicators for tailings management, and officially launched the third edition of *Guide to the Management of Tailings Facilities.*

Prior to the conference, Four short courses were offered, including "A Step by Step Guide to Risk Informed Decision Making for Mining Projects and Operations", "Cover Design and Construction for Tailings, Waste Rock,

and Heap Leach Pad Closure", "Tailings Dam Failure, Hazard Evaluation and Tailings Dam Safety Practices" and "Terrain Analysis". Additionally, Canada's Oil Sands Innovation Alliance (COSIA) made a special presentation on "Tailings Funding Opportunities through IOSI and COSIA".

With 22 sessions over three days, the presentations covered an array of topics related to the engineering and management of tailings and mine waste, including case histories; the design, operation and disposal of mine waste; geotechnical considerations; mine waste/tailings modeling; liners, covers and barriers for waste control; acid mine drainage; reclamation and remediation of mine impacted sites; oil sands issues; surface water and groundwater management and geochemistry; and policies, procedures and public safety. The conference proceedings are composed of 77 technical papers, and presentations will be available for viewing online (*see www.ostrf.com/TMW*).

The University of Alberta Geotechnical Centre and OSTRF would like to thank the following organizations for their invaluable sponsorship of the conference:

Platinum Sponsors:

ConeTec and BASF

Gold Sponsors:

Alpha Laval Inc., BGC Engineering, Golder Associates, Hayward Baker Wick Drains, Minebridge, Norwest Corporation, Stantec and Tetra Tech

Silver Sponsor:

SNF Mining

The next Tailings and Mine Waste Conference will be held in Keystone, Colorado, September 30 – October 2, 2018.

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Conference delegates enjoying the ice breaker (courtesy of Jen Stogowski Photography).

Conference delegates enjoying the ice breaker (courtesy of Jen Stogowski Photography).

Paolo Gazzarrini

Overture

49th episode of the Grout Line and for this issue an article related to research on sodium silicates. The article is related to the application of a new type of sodium silicate for grouting (or for "squeezing" – which grouting is affectionately referred to as in this particular industry) mainly in the Oil Industry.

Authors of the research and article are Michael McDonald, Xianglian Li & Timothy Evans, Julie Qiulin Shang, Yu Guo & Bingfeng Xue.

Chemical grouting using a newly developed form of sodium silicate

Michael McDonald, Xianglian Li, Timothy Evans, Julie Qiulin Shang, Yu Guo, Bingfeng Xue

Introduction

Sodium silicate has been a major class of chemical grouts over several decades for soil stabilization and water control. Over this span, a wide variety of sodium silicate-based formulations have been developed to best meet geotechnical conditions and end-use requirements. Properties of silicate-based grouts have been adjusted by selection of setting agent and/or the use of additives. With few exceptions, the choice of sodium silicate has been confined to one particular grade. Conventional manufacturing of sodium silicate has restricted the choice of products. Recently, a novel and cost effective process was developed to produce a lower alkalinity with larger, more reactive silicate molecules. Compared to conventional sodium silicate, the proposed silicate has a much higher ratio of silica to alkali and will be described as a "high ratio silicate" and more specifically, a 4.5 ratio sodium silicate.

To investigate the suitability of high ratio silicate for chemical grouting of geomaterials an in-depth study was performed at the University of Western Ontario Geotechnical Research Centre (GRC). The study modelled the reaction kinetics of the high ratio sodium silicate with two different setting agents. i.e. triacetin and citric acid. These setting agents were chosen because they have a successful track record as well as excellent HS&E characteristics. The researchers at the Geotechnical Research Centre evaluated grouts formulated with high ratio sodium silicate in terms of the strength gain, durability, permeability reduction. The results were benchmarked against conventional sodium silicate. The premise that a lower alkalinity would have better durability was confirmed in the lab studies. Testing also indicated other performance enhancements such as higher compressive strength.

The early adopters for evaluation of high ratio sodium silicate have been the petroleum industry. The industry commonly uses sodium silicate to modify the reservoir permeability, block fractures, shutoff water and gas migrating to the surface of the well. At the time of this article, over 20 wells have used sodium silicate to remediate cement and block gas migration. Field results show a high success rate at blocking gas on the first treatment and providing substantial cost savings.

Brief description of the chemistry

The manufacturing of sodium silicate provides a starting point to understanding the chemistry as well as the limitations in types of sodium silicate. The "Ratio" is the critical parameter that governs sodium silicate chemistry and refers to the proportion of sand to alkali or more precisely the weight ratio SiO2:Na2O. The vast majority of grout treatments have used a 3.2 ratio sodium silicate. Compared to lower ratio sodium silicates, the 3.2 ratio sodium silicates system is easier to polymerize and set. Upon setting and forming a silica gel,

the system has higher compressive strength and improved durability , as well as a reduced level of syneresis (i.e. shrinking). A logical question is if a 3.2 ratio is better than a 2.2 ratio, why not use a 4.2 ratio or higher? The answer is manufacturing limitations; once the ratio of sand to soda begins to exceed 3.2 there is a rapid increase in temperature requirements to make molten sodium silicate as well as a corresponding increase in molten glass viscosity. Assuming a high ratio glass was produced in a furnace using ordinary means, the material would have limited solubility and stability in water. Upon aging, it would be prone to separation and formation of a gel.

To move to a lower alkali, i.e. more siliceous product, the end-user needs to jump from sodium silicate to colloidal silica. This takes the user from using a solution of silicate molecules to an aqueous suspension of discrete, nonporous particles of amorphous silicon dioxide. Colloidal silica or sometimes under the banner of "nano particles", is used in grouting applications. This form of silica has several desirable performance properties such as longer, more controlled gelation times and the produced gels tend to be less prone to syneresis. The trade-offs are the produced silica gel has less strength, and a higher starting concentration than for sodium silicate is required. Further, colloidal silica is a considerably more expensive chemical.

A cost-effective procedure has been developed to produce polysilicates for subterranean applications. A 4.5 ratio was selected as the focus ratio for comparative study with conventional sodium silicate. Table 1 provides a comparison of the 4.5 ratio vs. 3.2 ratio vs. colloidal silica.

Formulation development & experimental procedures

Silicate-based grouts are generally considered one of the safest types of chemical grouts. Any concerns related to environmental impact are usually related to the choice of setting agent and/or potential leaching of sodium. The move to a lower alkalinity sodium silicate addresses concerns with sodium levels. Care was taken in selection of setting agents so as to maximize overall HS&E characteristics of the grout system. Triacetin was selected as a proven setting agent and is environmentally safe. Citric acid is not commonly used in grouting applications but is a preferred setting agent for oilfield applications. Similar to triacetin, it is approved as a food additive. Citric acid had the further appeal of being a lower cost chemical vs. triacetin. The other checkmark in favor of citric acid is that it comes as an easy to dissolve powder. Depending on location and temperature, the use of powder provides definitive handling advantages over a liquid.

The 4.5 ratio sodium silicate was benchmarked against traditional sodium silicate using ASTM methodology to study the feasibility and performance metrics for stabilizing soils. The study at GRC was conducted using liquid sodium silicates diluted with tap water to concentrations ranging from 30 to 60%. These concentrations would be considered typical for most geotechnical applications. Sands used in this study were medium to fine Barco silica sand. The use of just sand represented a worst case scenario since the presence of clays and metals are known to improve strength and water resistance. Formulations were developed to provide set times of approximately ~4hrs at room temperature. As noted earlier, the presence of dissolved metals such as calcium are known to improve the performance of the silicate grout. Testing later included the performance of conventional and high ratio silicate with a hardener.

Silica gel durability

As anticipated, the move to a less alkaline form of sodium silicate produced silica gels with greater durability vs. conventional sodium silicate. This was quantified using ASTM D559/D559M, "standard test methods

Table 1. Physical properties of colloidal silica vs. 3.2 ratio vs. 4.5 ratio

	Colloidal Silica*	3.2 ratio	4.5 ratio
SiO_2:Na_2O	52	3.22	4.5
% SiO_2	30	28.7	21.1
% Na_2O		8.9	4.7
% Solids	30	37.6	25.8
pH	10.2	11.3	11.0
Density (g/cm^3)	1.22	1.38	1.22
Viscosity (centipoise)	5	180	50
Average size (nm)	7	1	3
*represents colloidal silica that has been used in the past for water blocking			

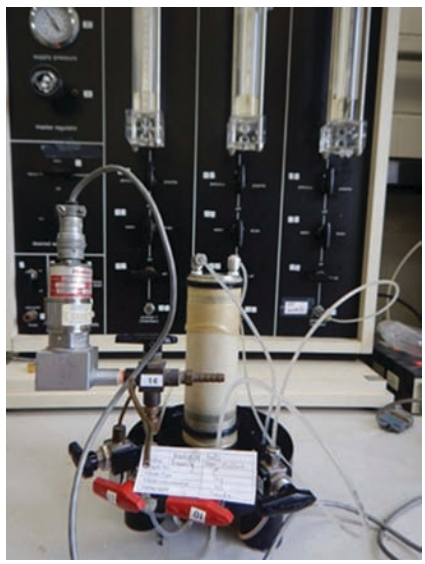

Figure 1: Permeability test set up.

for wetting and drying compacted soil-cement mixtures". This test method calls for consolidated sand to be oven-dried for 43 hours and then submerged in water for 5 hours. Measurements are taken over 12 cycles. Barco silica sand was consolidated with a 4.5 ratio sodium silicate diluted 1:1 with water and then polymerized using citric acid or triacetin. Table 2 summarizes the loss of weight after each cycle. The 4.5 ratio set with triacetin showed only a slightly loss of weight over the 12 cycles, while the sample set with citric acid had good durability until the 6th cycle: after that a crack developed in the consolidated sand. No samples formulated with conventional sodium silicate were able to pass a 12 cycle test. It should be noted that samples formulated with citric acid passed 12 cycles when a small amount of hardener (i.e. soluble calcium) was included in the formulation.

Testing of sample permeability was restricted to 4.5 ratio sodium silicate using the same formulations as durability testing using ASTM D5084–16a, "Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter". The test set-up is shown in figure 1 and test results are summarized in Table 3. Applying the Darcy's law, the permeability of the sand was reduced by 4 to 5 orders of magnitude and the final permeability of samples would be in-line with silt.

Table 2. Durability of consolidated sand after curing 14 days with 4.5 ratio silicate using citric acid and triacetin

4.5 ratio - 50%	Setting agent			
	Citric acid		Triacetin	
Test cycle	Remaining weight, g	Cumulative weight loss	Remaining weight, g	Cumulative weight loss
Original oven dry mass	325.6	N/A	321.8	N/A
1	324.5	0.3%	320.0	0.6%
2	323.8	0.6%	319.1	0.8%
3	323.7	0.6%	318.9	0.9%
4	322.7	0.9%	318.7	1.0%
5	316.8	2.7%	318.9	0.9%
6	238.6 (Cracked)	26.7%	318.5	1.0%
7	218.7	32.8%	318.0	1.2%
8	215.3	33.9%	317.7	1.3%
9	210.7	35.3%	317.6	1.3%
10	200.9	38.3%	317.3	1.4%
11	200.6	38.4%	317.6	1.3%
12	194.3	40.3%	314.4	2.3%

Field trials

Upon completion of an oil or gas well, cement is pumped and placed in the annular space between the casing the wellbore. In a perfect world, the cement would form an impermeable barrier that would isolate geological zones and prevent the flow of fluids or gas to other zones or the surface. In reality, a significant percentage of wells have a nuisance level of methane leaking to the surface. It is open to debate on the exact number of wells in Western Canada that are leaking gas but it is agreed that it is 10, 000's. Western Canada and globally there is increasing regulatory and public pressure for the oil industry to remediate wells leaking nuisance levels of gas. Figure 2 is a commonly referenced diagram taken from the Alberta Energy Regulator that shows the different gas pathways. These pathways can develop during the cementing process and/or over time as the cement is subject to thermal cycling, geological movement and production.

As repairs are non-revenue generating, operators are looking for long term solutions that are simple, environmentally acceptable and cost effective. The default method for blocking gas migration is to squeeze cement. (Note of the Editor: I didn't change the term "squeeze" here and below, that I learned is the equivalent of grouting in the Oil Industry). Class G cement and micro fine cement are effective at filling and blocking medium to large micro annuli however, as the diameter of micro annuli and fractures gets tighter, physical limits of viscosity and particle size make it progressively more difficult to squeeze cement. This leads to limited penetration and bridging in channels. Conventional sodium silicates as well as the 4.5 ratio sodium silicate have the advantage of being a low viscosity, solids free solution of smaller molecular weight molecules. This allows the silicate to be squeezed closer to the gas source and therefore provide a more effective, long term seal. Over the last 7 years conventional sodium silicate has had good success in Western Canada remediating wells venting gas. The interest in evaluating the 4.5 ratio material was driven by a few factors:

- achieve a higher success rate on the 1st squeeze (vs. multiple squeezes)
- avoid the use of setting agents

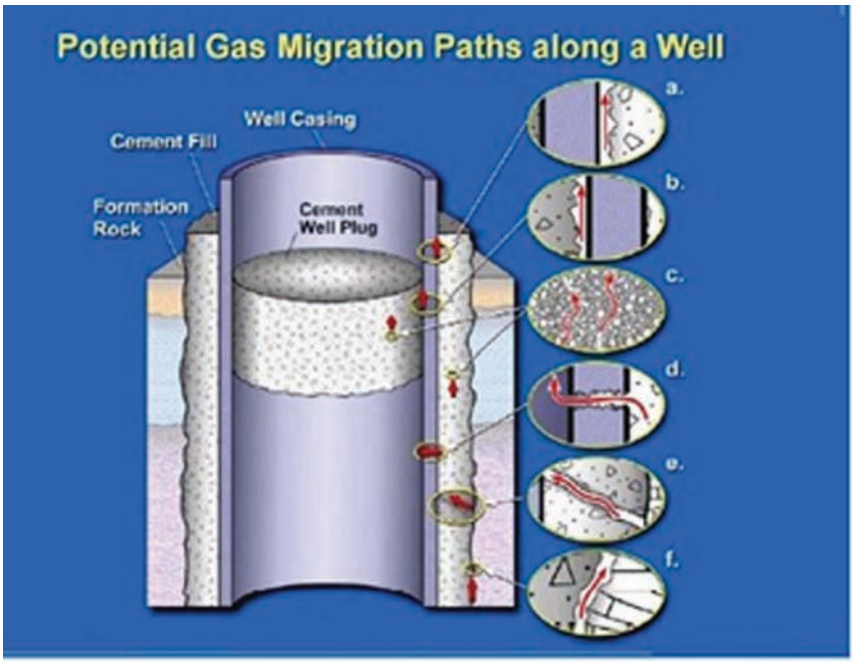

Figure 2: gas pathways in cement.

Table 3. Permeability of pure sand vs. consolidated sand with 4.5 ratio and citric acid

Sample	Curing time	Permeability
Control, quartz sand	N/A	2.30×10^{-4} m/s
50% S45-Citric	7 days	2.73×10^{-8} m/s
50% S45-Citric	14 days	7.55×10^{-8} m/s

- greater insurance for long term blockage
- act as a stepping stone for more challenging treatments

The majority of the trials with 4.5 ratio sodium silicate has been as a compliment to a cement squeeze. The 4.5 ratio material was diluted 1:1 with water for a total volume of 500 to 1000 litres. This material was squeezed using a pressure pumping unit. (see figure 3). Typically, the setting process would begin as the squeezed silicate was exposed to calcium rich environment of the microchannels. As injection pressure increased a small volume of fresh water would be pumped behind the silicate to act as a spacer for the cement. Field trials showed a high first-time success rate using the 4.5 ratio but more trials would be necessary to determine if success rate was statistically higher vs. conventional silicate.

The 4.5 ratio sodium silicate has also been used as a standalone product to block gas migrating inside and outside of the casing. It should be noted that successful blocking of gas or water is not just about having an effective sealant, success is dependent on good diagnostics to pin point the source(s) of gas and their pathways. Once communication is established with gas pathways then proper placement of the treatment chemical is critical to success. Trials have been equally split between using the high ratio material by itself or with a setting agent. Placements of the silicate have been done with a pressure pumping unit or with chemical injection pumps (see figures 3). The advantage of chemical injection pumps is it allows for low pump rates over long period times. The other advantage is it is a low cost pumping technique. For well abandonment, success requires that venting gas be reduced to zero. Based on the limited number of trials the success rate at achieving total blockage on the first squeeze is ~66%. In cases where the volume of venting was reduced but not eliminated it is felt there were secondary sources of gas and not all pathways were available for entry.

Conclusions

The experimental study at GRC provided a good starting point to assess the performance of cementation of clean quartz sand by 4.5 ratio silicate vs. conventional sodium silicate. The setting agents used in the study were citric acid and triacetin. The next phase of study will look at longer gela

Figure 3: Silicate squeeze with cement.

Figure 4: Injection of sodium silicate with setting agent.

tion times and the impact of harden-ers. Data was sufficiently encouraging that the study has been quickly moved to the trial phase for oilfield applica-tions. Field trials are on-going but early results have indicated a higher first-time success rate and allow for the placement of the high ratio sodium silicate without a setting agent.

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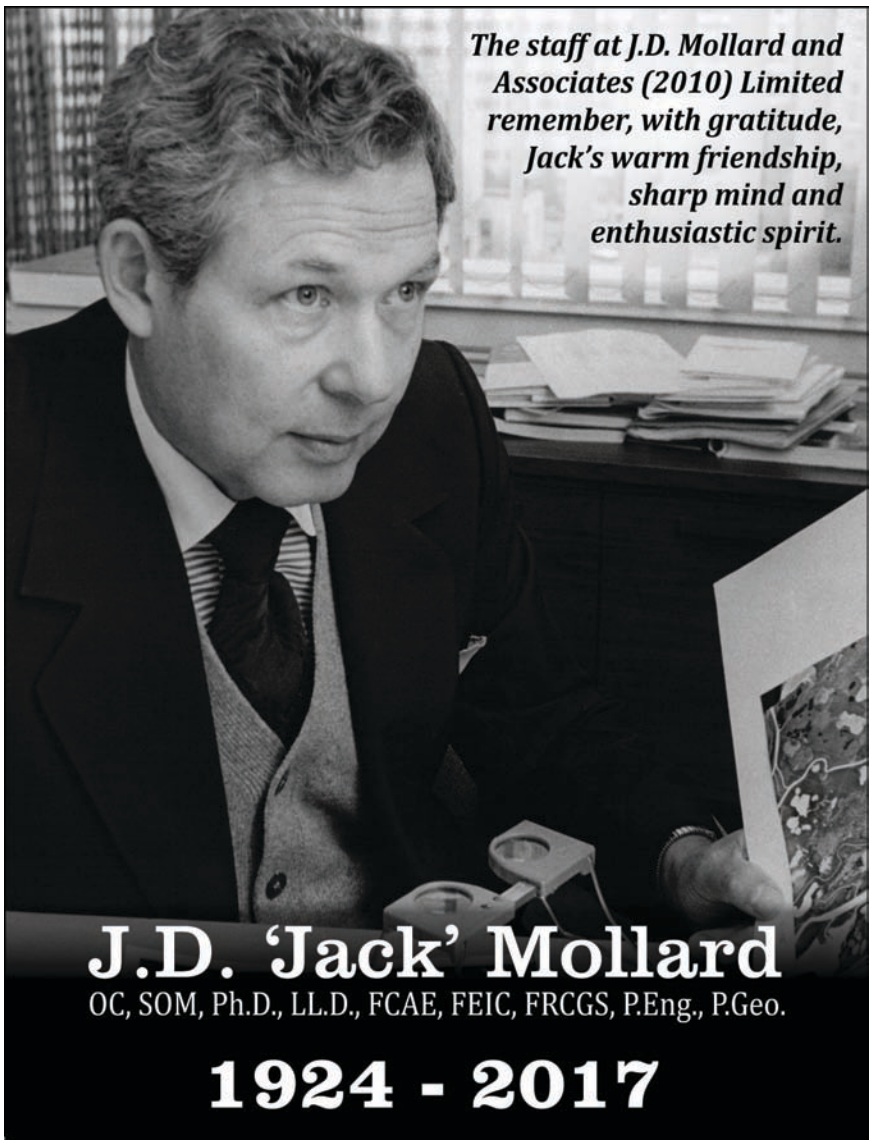
Grouting Fundamentals Course

Only 2 months until the Grouting Fundamentals Course in Austin, TX! *https://www.youtube.com/watch?v=dbm-D_Nu20A*

And, please don't forget that in 4 months we will celebrate the 50th issue of the Grout Line with the same request, asking you to send me your grouting comments or grouting stories or case histories. My coordinates remain:

Paolo Gazzarrini, paolo@paologaz.com , paologaz@shaw.ca or paolo@groutline.com.

Ciao! Cheers!



Mining and Sustainability – the State of Play

R. Anthony Hodge

Introduction

Just over 15 years ago in May 2002, the Global Mining Initiative (GMI) reported out after 2 years of intensively reviewing mining's social and environmental practices. GMI activities spanned the world through its flagship initiative, Mining, Minerals and Sustainable Development (MMSD). Some 50,000 people participated from all corners of society – mining companies, consultants, suppliers, communities, civil society, indigenous people, and academia.

The 1990s had seen a high and increasing level of criticism levelled at the industry, something that has continued until today. When the waves of public criticism coincided in the mid-1990s with depressed prices and a low in the boom–bust cycle, investors reduced their focus on mining in favour of investment in clean, green, and innovative information technology which offered more profitable and socially acceptable options. Ian Thomson and Susan Joyce, who have worked on community-mine relationships across the Americas point out (2006) that by the late 1990s:

> mining was an industry whose role and contribution to society was in question in many parts of the world with well-organized grass roots opposition to mineral exploration projects and new mine developments. A series of high profile tailings dam failures and an explosion of conflicts around mining projects in Latin America had cast the industry in a very negative light.

In short, a significant gap had opened in the social and environmental values of society and those reflected in mining industry practices. The turn of the millennium found the mining and metals industry reeling from the combined effects of public criticism, investor hesitation, unfavourable economic conditions, and changing laws and regulations, all of which added significant complications to the process of mine planning, financing, and decision-making.

It was a perfect storm. And the industry faced increasing regulation and public scrutiny for which is was ill-prepared. Many industry leaders felt discomfort and expressed an attitude of hostile resistance, adopting a black-and-white, 'us–them' position. This attitude of resistance only served to fuel the strong sense of 'unfairness' that already existed outside the industry. By 2005, resource nationalism, spawned at least partly by this sense of unfairness linked to the high commodity processes characterizing the 2002 – 2012 super cycle, was high on the list of 'risks' facing the extractives industry. Meanwhile, on-the-ground conflict between operations and host communities was on the rise.

The August 2014 tailings failures at Imperial Metal's Mount Polley mine, near Likely, British Columbia and Southern Copper's Buenavista del Cobre mine, Sonora, Mexico, and the November 2015 failure at Samarco's (jointly owned by BHP and Vale) Germano mine in Brazil once again cast doubt on the integrity of the industry and its regulators.

In an October 2017 report, "Mine Tailings Storage: Safety Is No Accident" the United Nations Environment Programme reviewed 40 tailings accidents in 15 countries since 2008 (UNEP, 2017). Since 2014 alone there have been eight failures significant enough to make global news. These occurred in Canada, Mexico, Brazil (twice), China, USA and Israel. The report estimates that since 2008, mine waste failures have killed several hundred people, damaged hundreds of kilometres of waterways, affected drinking water sources, wiped out fish populations, destroyed heritage sites and monuments and jeopardized the livelihoods of many communities. In their assessment, Canada stands second only to China as the worst performer. In their report, UNEP urges governments and the mining industry to improve safety, accountability and oversight.

Over the past 50 years, societal values related to people and the environment have greatly evolved. With a time-lag, rules (some formal, some voluntary) have also evolved. There is no doubt that leading mining companies have sensed this change and worked hard to improve their social and environmental practices. But in some ways, it seems that the sum of societal value changes and overall reality of mining industry practices leaves us not a lot farther ahead than 20 years ago – if at all. And often a refrain arises that the financial and legal framework that governs the industry and that entrench the dominant role of shareholder value, production rates, and rate-of-return, stand as the major barrier to the

kind of improved environmental and social practices that society expects.

However, such a conclusion is only a small part of the story. Like society, the industry itself is a complex web of interconnected but very different parts. It has a deep history and for some change doesn't come easily. Now at a time when contemporary society has more need for the commodities produced by mining more than ever before (as a small example, an electric car requires four times the copper used by a traditional car), finding a way forward to bring greater alignment between industry practices and society's values is more important than ever.

The complex nature of the mining industry

There are likely about 10,000 mining companies in the formal mining industry across the world employing 2-3 million people. There is also an informal mining industry (artisanal and small scale) that employs some 15 – 20+ million people. Rules and practices governing the formal industry are different than the informal industry. In addition to the mining companies, there is a rich mix of other interests including the financial services industry (investors, banks, insurance companies), providers of a broad range of services, equipment and supplies, host communities, governments, and a vast maze of civil society organizations.

A majority of companies within the formal industry are listed in public stock markets. There are also a significant number of state-owned companies, and an unknown number of privately held companies. Table 1 below offers a profile of the companies in the formal part of the industry.

These companies operated in countries across the world. Vast variations in culture serve as hosts, cultures that are often little respected and poorly understood by the mining company. Skill at intercultural communications within mining companies slowly improves, but only slowly.

Like any part of society, there are leaders and laggards when it comes to performance. Figure 1 captures this range elegantly. To bring change, each part of this spectrum must be treated differently. For the leading edge, the opportunity to bring innovative improvement to not only themselves but also to society speaks to their desire for creativity. Their best comes through facilitating voluntary action; setting hard rules may in fact drive their performance down to a least common denominator. For hostile avoiders, only hard rules will make any difference. They will volunteer nothing that they see as beyond their personal interest.

Table 1. Company profile within the formal part of the complex mining industry ecosystem.

Company category	Portion of industry	employees	comment
Global giants	1% or less	Tens of thousands	• Global giants and seniors control the majority of available capital, they have multiple operations • they can be vertically integrated to some extent with activities extending from exploration through production and into manufacturing; • their focus is on the industry
Seniors	1.5 %	Thousands	
Intermediates	6 %	Hundreds	• types: producers (focus on growing reserves) and management groups (technically skilled, produce for others); • often growing and expanding
Production juniors	17 %	Tens to hundreds	• small (often one mine) producers • some growing, some shrinking • their focus is on their mine
Exploration juniors	34 %	A few to 50	• a number of different "types": site accumulator, one site, one state, regional niche, focus on a particular geology • volatile and market dependent • they are finders, not producers • their focus is on their exploration project(s)
Investment juniors	42 %	a few to 10s	• volatile and market dependent • their focus is on accessing venture capital and growing their stock price

Source: McDonald, 2002

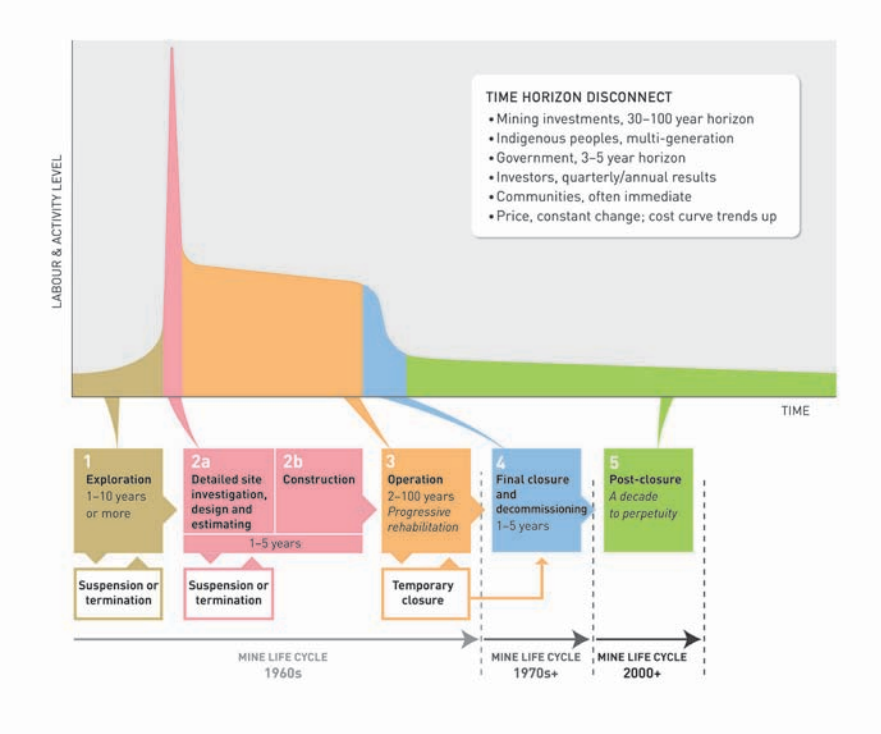


Figure 1. Spectrum of corporate behaviour. (After John Gadsby (2000), Hodge 2011; personal communication, ICMM 2012).

Seeing the full project life-cycle

A particularly important challenge plagues the mining industry. Figure 2 shows the mine life cycle by phases and level of activity. Note the lower time line plot. Until the late 1960s, little attention was given by companies or governments beyond the operations phase. In the 1970s, closure came into the industry and regulators radar. Only about the year 2000 was the importance of the post-closure phase recognized. Note also the box on the upper right which lists the time horizons of typical concern for various interests and how they vary significantly.

Very few interests see and address the mine life cycle as a "whole" continuing process. Within a company, exploration, construction, operation, closure and post-closure are undertaken by different teams of employees. Within government, a whole-project regulatory perspective simply doesn't exist. And amongst civil society organizations, almost always the focus is on a crisis or a single-point issue (like licencing). Only rarely is the idea of a full life-cycle used as the basis of design courses in academia. Lacking such integrative thinking, it is not surprising that mine designs are weak on long-term integration. Though ideas of design for closure were first introduced by leading edge thinkers in the 1980s, design and implementation for closure is only now entering the mainstream of thinking.

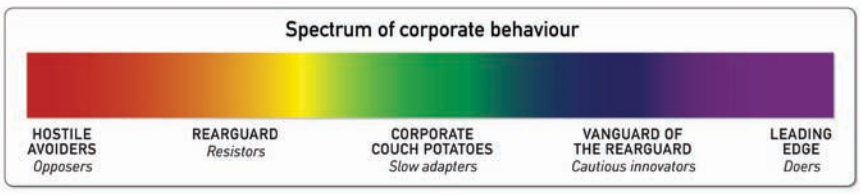


Figure 2.The mine project life cycle by activity level; approximate dates when the mining industry and regulatory perspective expanded to include each phase; time horizon disconnects between interests. NRTEE, 1993.

Actions for the Geotechnical Engineer

In summary, contemporary society needs the commodities produced by mining but carries little understanding of what it takes to produce those commodities. At the same time, society continues to call for an industry that seeks and attains a positive contribution to both human and ecosystem well-being.

In fact, what we find is an industry that:

1. consists of many components with companies that are tiny to huge and characterized by a broad variation in objectives, interests and behaviours;
2. operates across many cultures, but does not always demonstrate effective intercultural communications;
3. is often (but not always) distrusted and criticized for taking too much, giving too little, and expressing good intentions while not following through with performance on the ground;
4. is regulated by a system of governance that is equally complex, disjointed, and not carrying the respect of either industry or the public.

In the high-level maze described above, what does this mean for the geotechnical engineer and geoscientist in terms of their day-to-day practice? The following five concrete actions will contribute greatly to strengthening the alignment between society's values and industry practices.

Action 1. Champion the long term. Those trained in the geosciences understand natural process in terms of geological time; you understand the long term and need to be its champion amongst others who don't, be they technical

people or the general public. Never lose sight of the full mine project life cycle and use a time horizon for design that spans the full life cycle, even if it means butting heads with your client.

Action 2. Use language with integrity. Be aware that a safety factor of 2 (which sounds great to the public) translates to a failure rate of 1 failure per 1000 years for leachate collection systems. This means that a tailings impoundment engineered with an overall factor of safety of 2, will on average fail once in a thousand years – or that one in a thousand tailings impoundments will fail every year. It also means that the facility is designed to eventually fail. Saying this is not pessimistic – it is honest and realistic and it is something that the public need to understand if they are to support good decision-making (see Freeze, 2000 for a clear discussion of this topic).

Action 3. Integrate citizen values into technical decision-making. There are some geotechnical engineers who believe their role is to deal with risk by "assuring people that we can deal with it, not raising their concerns." People see through this approach. Rather, in today's world there needs to be a shift from the above perspective to one where risks are acknowledged along with the inability of responsible parties and the technical community to eliminate those risks. We need to share that reality with the public and build approaches which effectively combine the facts, judgments, and probabilities provided by technical experts with value judgments provided by stakeholders. Doing so is not an admission of weakness, but of strength.

Action 4. Let ethics trump poor company behaviour. Ask yourself what is right – and do it. It's always worth it.

Action 5. Work to the high ground . . . it's almost always found in the middle. In working with different cultures – within a company, in a community, in a country, no one party is always right, and almost always each party has insight to offer. The best way forward is almost always one that combines good from each, an anathema to those who would proclaim "it's either my way or the highway."

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Peter Michael Byrne (1936 - 2017)

Peter Byrne was born in Dun Laoghaire, County Dublin and gained his first engineering degree from University College, Dublin. He completed post-graduate studies at the University of British Columbia and was a Professor of Civil Engineering there from 1967 until his retirement in 2001. He continued his association with the University as Professor Emeritus of Civil Engineering.

Peter was highly regarded as a geotechnical consultant. In 2014 he was awarded the prestigious R.F. Legget Medal by the Canadian Geotechnical Society. The R.F. Legget Medal is the Society's highest honour and is presented to an individual for 'outstanding life-long contributions to geotechnique'. In 2009, Peter was presented with the Julian C. Smith Medal by the Engineering Institute for 'Achievement in the Development of Canada'. The Canadian Geotechnical Society noted at the time that his achievements were demonstrated by a wide range of projects on which he had been consulted, including bridges, tunnels, dams, rapid transit projects, airports and a wide variety of other facilities in seismically active areas in Canada and around the world. Peter gained further professional recognition by winning the Geoffrey Mayerhoff Award from the Canadian Geotechnical Society.

Peter also built a reputation as a researcher, having written many papers in his area of expertise while pioneering many new procedures. He was also much in demand at national and international conferences as a consultant on several projects.

To the Vancouver sailing fraternity Peter Byrne was well known as a competitive sailor. His passion for sailing led to his winning a Bronze Medal for Canada in the Flying Dutchman class at the 1967 Pan American Games and being selected as a member of Canada's Olympic sailing team at the 1972 Munich Olympic Games. In 1973, with his wife Jane as crew, he won the Enterprise Class World Championship, held that year in Vancouver.

Peter was a popular and respected member of the Royal Vancouver Yacht Club for over fifty years. Jane, Sean and Craig, along with many friends and family members, will forever cherish the memories of summer sailings with Peter along the coast of British Columbia.

He leaves behind his loving wife Jane, sons Sean (Elen) and Craig (Alessandra), granddaughters Rebecca and Greta, brother Donald (Shirley), sister Dr. Marie Arnall, special niece Miriam (Wayne) and numerous nephews and nieces in Canada, England and Ireland.

John Douglas Ashton (Jack) Mollard (1924 – 2017)

Dr. J.D. (Jack) Mollard, OC, SOM, Ph.D., LL.D., FCAE, FEIC, FCRGS, P.Eng., P.Geo., died peacefully in his home surrounded by family on September 13, 2017. Jack was well known to the local, national and international engineering and geoscience community, and his achievements and contributions in the fields of engineering, geoscience, teaching, writing and consulting are truly remarkable.

A Saskatchewan native, Jack grew up on a farm near Xena, a short distance west of Watrous. Jack completed high school in Watrous before moving to Saskatoon where he obtained a Bachelor of Civil Engineering from the University of Saskatchewan in 1945. After a brief time with the Saskatchewan Highways Department in 1946, Jack moved on to obtain a Master's of Science in Civil Engineering from Purdue University in 1947 and then a Doctor of Philosophy from Cornell University in 1952. While at Purdue and Cornell, Jack studied under Dr. Donald Belcher, a pioneer in terrain interpretation using stereoscopic aerial photographs.

Following completion of his doctorate degree, Jack joined the Prairie Farm Rehabilitation Administration (PFRA) in Regina. As PFRA's chief air surveys engineer, Jack conducted airphoto and site investigations for

the many dams and water resource development projects constructed by PFRA in western Canada at that time. Among other projects, he made a significant contribution to geological and engineering studies to locate Gardiner Dam, which was completed in 1966. From 1953 to 1956, Jack served as an advisor to the Shaw Royal Commission on Newfoundland agriculture and as a technical advisor on aerial resource mapping to the governments of Ceylon and Pakistan.

Jack started his consulting firm, J.D. Mollard and Associates Limited, in 1956. Located in Regina throughout its history, the firm undertook more than 5,000 consulting assignments in applied airphoto and satellite image remote sensing under Jack's leadership. Those projects covered a wide range of applications -- exploring for aggregates, hydrocarbons and minerals, conducting geoenvironmental studies, mapping natural hazards, selecting route and site locations, and conducting groundwater studies -- in a wide range of terrain. Jack completed studies on all continents and even Mars.

Jack generously shared his knowledge and experience in over 100 short courses and workshops across Canada and in the USA, and published over 125 technical and scientific papers. Early in his career he was invited by Dr. Karl Terzhagi to lecture at Harvard. He holds the record for longevity at the University of Alberta extension department, having lectured there for over 40 years. Jack's also recognized the important role that universities play in preparing future engineers and geoscientists and gave generously to the universities of Saskatchewan and Regina. This vision was exemplified when, at 89 years of age, he joined a group of engineering students for the inaugural "Sensing the Earth" field tour which he helped found at the University of Saskatchewan.

Jack's work has been widely recognized over the years. In 2002 he was named an Officer of the Order of Canada and he received the Lieutenant-Governor of Saskatchewan's Meritorious Achievement Award. In 2010 he received the Saskatchewan Order of Merit. He has also received the Julian Smith Medal from the Engineering Institute of Canada (EIC) for achievements in the development of Canada, the Sir John Kennedy Medal, the highest honour of the EIC, the Allied Arts Medal from the Royal Architectural Institute of Canada, the Massey Medal from the Royal Canadian Geographical Society, an honorary Doctor of Laws from the University of Regina plus many other major awards.

These achievements not withstanding, Jack was perhaps best known for his passionate interest in interpreting the Earth's physical geography, geoenvironment and natural resources from airphotos and satellite images, and for his warm personality and infectious enthusiasm. He will be dearly missed by family, friends and colleagues.

Oldrich Hungr (1947 - 2017)

Footnote from Oldrich's family: *Since Oldrich's passing, we have been flooded with personal and sincere messages of condolence from all over the world. We are moved by this overwhelming response that clearly shows how Oldrich touched so many people, not just professionally but personally. We would like to thank the geotechnical community for the home they created for Oldrich. His passion for his work infused itself into our family life in so many wonderful ways. He taught each of his children to pursue life with the same level of integrity and fervour. To extend Oldrich's efforts, we have opened for contributions a scholarship fund through the University of British Columbia to help students in the same line of research. For more information, please see https://memorial.support.ubc.ca/oldrich-hungr/.*

See September 2017 issue of Geotechnical News (page 43) for In Memoriam for Oldrich

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