www.geotechnicalnews.com

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GEOTECHNICAL news

Deep sewer tunnel in South Edmonton

Wireless Data Collection

for Geotechnical Monitoring Instrumentation

2 Wireless Data Collection Systems to quickly get you connected to your data: **RSTAR** and **DT LINK**

+ MINIMUM PER CHANNEL COST + EXTRA LONG BATTERY LIFE + LONG DISTANCE TRANSMISSION

FULLY AUTOMATED COLLECTION (REMOTELY)

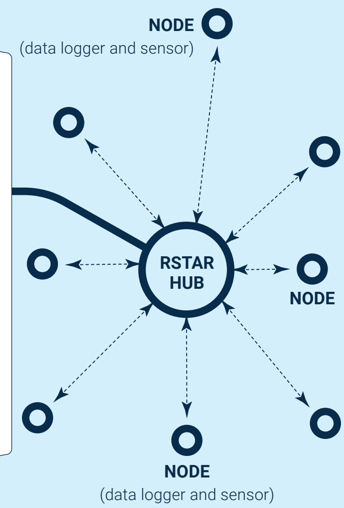
An RSTAR System uses data loggers (nodes) at the sensor level, deployed in a star topology from an active RSTAR Hub containing an RST flexDAQ Data Logger.

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 <<<

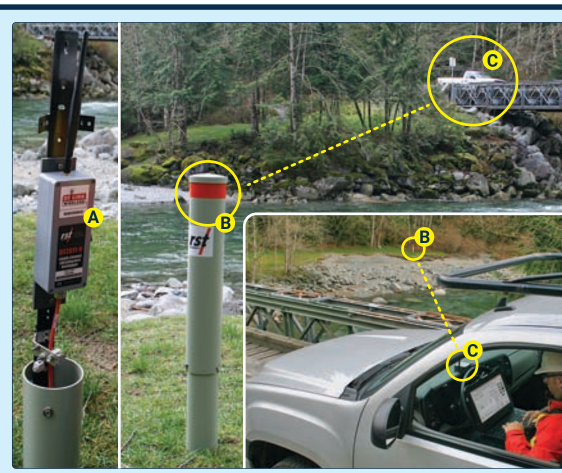
SEMI-AUTOMATED COLLECTION (ON-SITE)

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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Message from the President

Dharma Wijewickreme, President of Canadian Geotechnical Society

It is my pleasure to convey this message as we look forward to another wonderful summer season around the corner. As President of the Canadian Geotechnical Society (CGS), I have the opportunity to observe and appreciate the numerous geotechnical initiatives, activities, and engagements undertaken by our members. With twenty local Sections, from urban to remote geographic regions across six time zones, the membership numbers vary significantly - ranging from several hundred to those with relatively low membership counts. The financial status of the larger Sections is generally strong, whereas some of our smaller Sections experience budgetary challenges from time to time. The Society is mindful of this reality and has been promoting ways to support the members in our smaller sections and provide opportunities for access to and involvement in, CGS activities. Supporting expenses for guest speakers to travel to these areas is one of the examples that come to my mind in this regard. Currently, these types of provisions are funded from the annual CGS budget, typically on a case-by-case basis as an ad hoc expenditure. Knowing well the importance of providing our members with opportunities to engage at different geographic locations, I feel that it is relevant to look towards developing a more formal and streamlined approach to address this consideration. In the first quarter of this year, after consultations with various CGS members, the CGS Executive Committee (EC) established objectives and criteria for the funding of new initiatives – i.e., to help the CGS Sections, Divisions and Committees, organize new activities. Another step may be to establish a dedicated fund so that the Society can provide a well-identified line item in the annual budget to support and encourage activities from the smaller-membership Sections. These are some of my initial thoughts on a topic, I believe, is of relevance country-wide.

I invite you to engage and contribute your comments about this by writing to me c/o admin@cgs.ca or directly conveying your thoughts to the CGS representative of your local Section.

Now, let me present you with some news updates. I expect that **Dr. Thomas O'Rourke** (Cornell University, Ithaca, NY, USA) will have completed the Cross Canada Lecture Tour (CCLT) as the Spring 2018 speaker by the time this magazine reaches your desk. Looking further down the road, I am pleased to inform you that **Dr. Alex Sy** (Klohn Crippen Berger, Vancouver, BC) has accepted the invitation to be the Fall 2018 speaker. We also have the relatively new CGS Colloquium Lecture Series (established in partnership with the Canadian Foundation for Geotechnique). This is offered to the most recent Canadian Geotechnical Colloquium Speaker to cover travel expenses for delivering the Colloquium lecture across Canada; those Sections who wish to have this presentation locally can contact the Colloquium Speaker directly.

Once Again, we have performed very well in relation to CGS members receiving awards and honors from the Engineering Institute of Canada (EIC). In this, our members: **Delwyn Fredlund** and **Catherine Mulligan** were awarded prestigious EIC Medals, with **Kevin Biggar, Richard Brachman, Michel Julien, Robert Kenyon, and Dharma Wijewickreme** each inducted as Fellows of the EIC.

I am pleased to inform you that the planning is well underway for the 71st Annual CGS Conference, GeoEdmonton 2018, to be held September 23 - 26, 2018. The technical sessions for the conference are expected to reflect a high calibre content with over 500 approved abstracts. We again are partnering with the International Association of Hydrogeologists - Canadian National Chapter (IAH-CNC) in organizing the event. Many thanks are due to the **GeoEdmonton** Co-Chairs **Sean MacEoin** and **Don Lewycky** who along with their team are putting in an immense effort organizing this conference. Please visit the conference website (*http://www.geoedmonton2018.ca*) for more details and remember to mark your calendars to join your colleagues in Edmonton in the early days of Fall.

The 72nd CGS annual conference (Geo St. John's 2019) will be held in St. John's, Newfoundland and Labrador. In addition to the technical value, the conference will provide a great opportunity to visit the oldest and most easterly city in North America!

Let me also take the opportunity to congratulate and thank the organizing committee of the Geohazards 7 Conference led by **Michael Porter**, held in Canmore, Alberta, between June 3rd and 6th this year.

We now have the updated Errata for the 4th Edition of the Canadian Foundation Engineering Manual (CFEM) posted on the website. With respect to the new online English and French versions of the CFEM, work is underway on the Limit States Design Chapter, and we are actively pursuing the Seismic Design chapter. Once complete, these chapters will be released as an update/addition to 4th Edition while work continues on the remaining chapters. The existing 4th Edition, updated with new chapters as they become available, will serve as the main platform for the foreseeable future. I would like express my sincere thanks to **Suzanne Powell** (VP Technical) for extensive work on this task in addition her numerous tasks related to the other files on CCLT, Technical Committees, conferences, etc.

As you may recall, a Financial Advisory Task Force was established to examine the ways to best invest the CGS' funds while keeping in line with the government financial/tax regulations; this task force has now finalized their recommendations, and they will be included in the new administration manual after necessary approvals. The intent is to provide incentive for the development of novel ideas that add value to CGS membership. The details on this matter have already been distributed to the membership through the Board of Directors. It is my pleasure to acknowledge the leadership provided by **Kent Bannister** in accomplishing the above tasks in addition to many other items in his portfolio as the VP Finance.

The task force (TF) to develop a solid Communication Strategy for the Society is moving forward with many action items. This important TF is led by **Jean Coté** (VP Communications and Member Services) who has been working very hard with great support from eight other CGS volunteers. The subject of communications has many facets; so, as the first step, the TF defined specifically its objectives and mandate, which are particularly aimed at addressing short-term and long-term CGS needs and members' expectations. The communication topics addressed range from the content/format for the CGS newsletter, *Geotechnical News*, website, and social media portals. Moreover, a new Membership Committee has been formed with **Sumi Siddiqua** serving as the Chair with support from the National Office. More information on these activities can be found in the upcoming CGS reports.

It is also important for me note that **Andrea Lougheed**, **Nicholas Vlachopoulos,** and **Maraika DeGroot** have been making great contributions to the Society as representatives for the Sections, Divisions, and Young Professionals, respectively. I want to welcome and thank these three volunteers for their enthusiasm in their newly assumed roles as the CGS Executive Committee members.

The updated CGS Conference Manual has been finalized, and thanks are due to **Wayne Gibson** and **Michel Aubertin** for their detailed contributions, and our Past President **Doug VanDine** for undertaking a final review.

Our liaison activities with affiliate organizations are moving forward well. In particular, I would like to thank the following individuals for their roles and contributions: **Catherine Mulligan** for serving as the CGS Representative with the Canadian Society for Civil Engineers (CSCE); **Baolin Wang** for attending as the CGS Representative of the conference planning committee of the Engineering Institute of Canada (EIC); **Bruno Bussière** and **Lisa McJunkin** for producing CGS's annual report for the National Research Council (NRC). This new important report is required to receive our annual grant from NRC to pay CGS membership fees to the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE).

Once again, I would like to use this forum to thank our CGS volunteers involved in the Executive, Board, Sections, Divisions, Committees, and external representations; acknowledge the extensive contributions from **Michel Aubertin** (Executive Director), **Wayne Gibson** (Director, Administration and Finance), **Lisa McJunkin** (Director, Communications and Member Services), and **Emily Fournier** (Communications Coordinator) for their respective roles with the CGS National Office.

I must also take the opportunity to thank our CGS Corporate Sponsors: **DownUnder Geotechnical; Geo-Slope International; GKM Consultants; Golder Associates; Insitu Contractors; Klohn Crippen Berger; Knight Piésold Consulting; Mobile Augers and Research; Naviq Consulting; Reinforced Earth; Rocscience; Stantec; Thurber Engineering; Trek Geotechnical; SoilVision Systems and Advanced Construction Techniques.**

As I have said in many instances, your involvement as members is the key to the success of our Society. So, please read this magazine, visit our website (*http://www.cgs.ca/*) and engage in the CGS activities. We always welcome your feedback, so please write to us at *admin@cgs.ca*.

Let me close this message by wishing all of you a fabulous summer, and I look forward to meeting you at GeoEdmonton 2018 in September.

Provided by Dharma Wijewickreme
CGS President 2017 - 2018

Message du président

J'ai le plaisir de vous transmettre ce message alors que nous attendons avec impatience une autre merveilleuse saison estivale qui approche à grands pas. En tant que président de la Société canadienne de géotechnique (SCG), j'ai l'occasion d'observer et d'apprécier les nombreuses initiatives et activités ainsi que les nombreux projets géotechniques réalisés par nos membres. Les vingt sections locales, situées dans des régions urbaines et périphériques distribuées sur six fuseaux horaires, ont une taille très variable allant de plusieurs centaines de membres à un nombre relativement petit. La situation financière des plus grandes sections est généralement solide, alors que certaines de nos plus petites sections font parfois face à des difficultés budgétaires. La Société est consciente de cette réalité et explore différentes façons d'appuyer les membres de nos sections plus petites et de leur offrir des occasions d'accéder et de participer aux activités de la SCG. Un exemple qui me vient à l'esprit à cet égard est celui des frais de déplacement des conférenciers visitant ces sections. Ces déplacements peuvent dans certains cas être financés à partir du budget annuel de la SCG, à titre dépenses ponctuelles. Sachant l'importance d'offrir à nos membres des occasions de s'engager dans différents lieux géographiques, j'estime qu'il est pertinent d'envisager l'élaboration d'une approche plus formelle et simplifiée pour répondre à ce type de besoin. Au cours du premier trimestre de cette année, après avoir consulté des membres de la SCG, le Comité exécutif (CE) de la SCG a établi des objectifs et des critères pour le financement de nouvelles initiatives visant à aider les sections, les divisions et les comités de la SCG à organiser de nouvelles activités. Une autre étape pourrait être d'établir un fonds réservé pour que la Société puisse ajouter un poste bien identifié dans le budget annuel pour soutenir et encourager les activités des sections les plus petites. Ce sont là quelques-unes de mes premières réflexions sur un sujet qui, à mon avis, est pertinent à l'échelle du pays. Je vous invite à enrichir la discussion en me faisant part de vos commentaires à *admin@cgs.ca* ou en transmettant directement vos idées au représentant de la SCG de votre section locale.

Maintenant, laissez-moi vous présenter les dernières nouvelles. Le **Dr Thomas O'Rourke** (Université Cornell, Ithaca, NY, É.-U.) devrait avoir terminé la Tournée de conférences transcanadienne (TCT) à titre de conférencier du printemps 2018 au moment où ce magazine arrivera sur votre bureau. À plus long terme, je suis heureux de vous informer que le **Dr Alex Sy** (Klohn Crippen Berger, Vancouver, C.-B.) a accepté notre invitation, et il sera le conférencier de l'automne 2018. Nous avons aussi la série nouvellement créée de conférences du Colloquium de la SCG (établie en partenariat avec la Fondation canadienne de géotechnique). Cette opportunité est offerte au plus récent conférencier du Colloquium canadien de géotechnique pour couvrir ses frais de déplacement afin de présenter la conférence du Colloquium à divers endroits au pays; les sections qui désirent recevoir cette présentation peuvent communiquer directement avec le conférencier du Colloquium.

A nouveau cette année, plusieurs des membres de la SCG ont reçu des prix et des distinctions de l'Institut canadien des ingénieurs (ICI). Nos membres: **Delwyn Fredlund** et **Catherine Mulligan** ont reçu de prestigieuses médailles de l'ICI, et **Kevin Biggar**, **Richard Brachman**, **Michel Julien**, **Robert Kenyon** et **Dharma Wijewickreme** ont été nommés Fellow de l'ICI.

J'ai le plaisir de vous informer que la planification de la 71^e^ conférence annuelle de la SCG, GéoEdmonton 2018, qui aura lieu du 23 au 26 septembre 2018, va bon train. On s'attend à ce que les sessions techniques de la conférence reflètent un contenu de haut calibre avec plus de 500 résumés approuvés. Nous nous associons de nouveau à la section nationale canadienne de l'Association internationale des hydrogéologues (AIH-SNC) pour l'organisation de cet évènement. Un grand merci aux coprésidents de **GéoEdmonton 2018**, **Sean MacEoin** et **Don Lewycky** qui, avec leur équipe, déploient d'immenses efforts pour organiser cette conférence. Veuillez consulter le site Web de la conférence (*http://www.geoedmonton2018.ca/index.php?lang=fr*) pour obtenir de plus amples renseignements. N'oubliez pas de l'inscrire à votre calendrier pour joindre vos collègues à Edmonton, au début de l'automne.

La 72^e^ conférence annuelle de la SCG (Géo St. John's 2019) se déroulera à St. John's, à Terre-Neuve-et-Labrador. En plus de sa valeur technique, la conférence sera une excellente occasion de visiter la ville la plus ancienne de l'Amérique du Nord, qui est aussi celle située le plus à l'est du continent!

Permettez-moi également de profiter de l'occasion pour féliciter et remercier le comité organisateur de Géorisques 7, dirigé par **Michael Porter**, conférence tenue à Canmore, en Alberta, du 3 au 6 juin cette année.

L'erratum actualisé de la 4^e^ édition de la version anglaise du **Manuel canadien d'ingénierie des fondations** (MCIF) est maintenant disponible sur le site Web. En ce qui concerne les nouvelles versions française et anglaise en ligne du MCIF, nous travaillons actuellement sur le chapitre Calcul aux états limites et nous poursuivons activement la mise à jour du chapitre Conception parasismique. Lorsqu'ils seront terminés, ces chapitres seront présentés sous forme d'une mise à jour/d'un addenda de la 4e édition, tandis que le travail continue sur les autres chapitres. La 4e édition actuelle, actualisée avec de nouveaux chapitres au fur et à mesure qu'ils deviennent disponibles, servira de plate-forme principale pour l'avenir prévisible. J'aimerais exprimer mes sincères remerciements à **Suzanne Powell** (v.-p. technique) pour son travail considérable sur cette tâche en plus de ses nombreuses autres liées à la TCT, aux comités techniques, aux conférences, etc.

Comme vous vous en souviendrez peut-être, un Groupe de travail consultatif sur les finances a été mis sur pied pour examiner les meilleures façons d'utiliser et d'investir les fonds de la SCG tout en respectant les règlements financiers et sur l'impôt du gouvernement. Le comité a finalisé ses recommandations, et celles-ci seront incluses dans la prochaine version du *Manuel administratif* après l'obtention des approbations nécessaires. Un des buts visés est d'encourager le développement d'idées nouvelles qui ajoutent de la valeur à l'adhésion à la SCG. Les renseignements à ce sujet ont déjà été distribués aux membres par l'entremise du Conseil d'administration. J'ai le plaisir de souligner le leadership dont **Kent Bannister** a fait preuve dans l'exécution des tâches susmentionnées, en plus des nombreux autres éléments des dossiers dont il est responsable à titre de vice-président aux finances.

Le groupe de travail (GT) chargé d'élaborer une solide stratégie de communication pour la Société va de l'avant en proposant diverses mesures. Cet important GT est dirigé par **Jean Côté** (v.-p. aux communications et services aux membres) qui a travaillé très fort avec l'appui de huit autres bénévoles de la SCG. Les communications comportent de nombreuses facettes; dans un premier temps, le GT a défini précisément ses objectifs et son mandat, qui visent particulièrement à répondre aux besoins à court et à long terme de la SCG ainsi qu'aux attentes des membres. Les sujets abordés relativement aux communications comprennent le contenu/format du bulletin de la SCG, *Geotechnical News*, le site Web et les portails de médias sociaux. De plus, un nouveau Comité des membres a été formé, et **Sumi Siddiqua** agit à titre de directrice de celui-ci avec l'appui du Bureau national. De plus amples renseignements sur ces activités figureront dans les prochains rapports de la SCG.

Il est également important pour moi de souligner que **Nicholas Vlachopoulos**, **Andrea Lougheed** et **Maraika DeGroot** ont apporté d'importantes contributions à la Société en tant que représentants des divisions, des sections et des jeunes professionnels, respectivement. Je tiens à souhaiter la bienvenue et à remercier ces trois bénévoles pour l'enthousiasme dont ils font preuve dans leur nouveau rôle de membres du Comité exécutif de la SCG.

La mise à jour du *Manuel des conférences de la SCG* est achevée; nos remerciements sont de mise pour **Wayne Gibson** et **Michel Aubertin** pour leurs contributions, ainsi qu'à notre ancien président Doug VanDine pour avoir effectué une dernière révision.

Nos activités de liaison avec nos organisations affiliées vont également bon train. En particulier, j'aimerais remercier les personnes suivantes pour leurs rôles et contributions: **Catherine Mulligan**, qui agit à titre de représentante de la SCG auprès de la Société canadienne de génie civil (SCGC); **Baolin Wang**, qui est le représentant de la SCG au Comité de la planification des conférences de l'Institut canadien des ingénieurs (ICI); **Bruno Bussière** et **Lisa McJunkin** pour la production du rapport annuel de la SCG pour le Conseil national de recherche (CNR); cet important rapport est requis pour recevoir notre subvention annuelle du CNR afin de payer la cotisation de la SCG à la Société internationale de mécanique des sols et de la géotechnique (SIMSG).

Encore une fois, j'aimerais profiter de cette tribune pour remercier les bénévoles de la SCG qui font partie de l'exécutif, du Conseil d'administration, des sections, des divisions et des comités, de même que ceux représentant la Société à l'externe, ainsi que **Michel Aubertin** (directeur général), **Wayne Gibson** (directeur, Administration et finances), **Lisa McJunkin** (directrice, Communications et services aux membres) et **Emily Fournier** (coordonnatrice des communications) pour leur importante contribution dans leurs rôles respectifs auprès du Bureau national de la SCG.

Je dois également profiter de l'occasion pour remercier les commanditaires de la SCG: **DownUnder Geotechnical; Geo-Slope International; GKM Consultants; Golder Associates; Insitu Contractors; Klohn Crippen Berger; Knight Piésold Consulting; Mobile Augers and Research; Naviq Consulting; Reinforced Earth; Rocscience; Stantec; Thurber Engineering; Trek Geotechnical; SoilVision Systems et Advanced Construction Techniques.**

Comme je l'ai dit à maintes reprises, votre participation en tant que membres est la clé du succès de notre Société. Je vous incite donc à lire ce magazine, à visiter notre site Web (*http://www.cgs.ca/index.php?lang=fr*) et à participer aux activités de la SCG. Nous accueillons toujours vos commentaires avec plaisir, veuillez donc nous écrire à *admin@cgs.ca*.

Permettez-moi de conclure ce message en vous souhaitant à tous un été fabuleux, et j'espère vous rencontrer à GéoEdmonton 2018 en septembre.

Fourni par Dharma Wijewickreme
SCG Président 2017-2018

From the Society

Call for Nominations for 2019 Awards and Fellowships Engineering Institute of Canada (EIC)

As a constituent Society of the **Engineering Institute of Canada** (EIC), CGS members are eligible for awards and fellowships of the EIC which are summarized below. CGS members are encouraged to submit EIC nominations of fellow members to CGS Headquarters by **July 15, 2018**.

Nominations must include:

1. a completed EIC Nomination Form which is available from ***http://eic-ici.ca/honours_awards/***)
2. a nomination letter
3. supporting letters from colleagues, preferably Fellows of the EIC (FEIC).

Past CGS member recipients of EIC Awards and Fellowships can be found on the CGS website ***www.cgs.ca/awards.php?lang=en***. It is recommended that nominators review the

Award of Honour	Brief Description/Comments
Sir John Kennedy Medal	For outstanding service to the profession or for noteworthy contributions to the science of engineering, or to the benefit of the EIC. EIC's most distinguished award (awarded every two years)
Julian Smith Medal	For achievement in the development of Canada; up to two medals can be awarded
John B. Stirling Medal	For leadership and distinguished service at the national level within the EIC and/or its member societies
CP Rail Engineering Medal	For leadership and service at the regional, branch and section levels by members of EIC member societies
K.Y. Lo Medal	For significant engineering contributions at the international level, such as promotion of Canadian expertise overseas; training of foreign engineers; significant service to international engineering organizations; and advancement of engineering technology recognized internationally
Fellowship of the EIC	For excellence in engineering and services to the profession and to society
Honorary Member	For non-members of the EIC and its member societies, and on occasion non-engineers, who have achieved outstanding distinction through service to engineering and the profession of engineering in Canada

Prix ou distinction	Courte description/Commentaires
Médaille Sir John Kennedy	En reconnaissance de services exceptionnels rendus à la profession d'ingénieur, ou des contributions remarquables à la science de l'ingénierie, ou au bénéfice de l'Institut. Plus prestigieux prix de l'ICI; décerné tous les deux ans.
Médaille Julian Smith	En reconnaissance des réalisations dans le développement du Canada; jusqu'à deux médailles remises chaque année.
Médaille John B. Stirling	En reconnaissance du leadership et des services rendus à l'échelle nationale à l'Institut ou à ses Sociétés Membres.
Médaille CP Rail Engineering	En reconnaissance de nombreuses années de leadership et de service par les membres des sociétés au sein de l'Institut aux niveaux régional (Direction ou section); jusqu'à deux médailles remises chaque année.
Médaille K.Y. Lo	Pour des contributions remarquables au domaine de l'ingénierie au niveau international, comme la promotion de l'expertise canadienne à l'étranger, la formation d'ingénieurs étrangers, un service exceptionnel rendu à des organisations d'ingénierie internationales et l'‘avancement d'une technologie d'ingénierie reconnu sur la scène internationale.
Titre de Fellow	Pour l'excellence en ingénierie et des services rendus à la profession et à la société.
Membre honoraire	ses sociétés membres, et occasionnellement pour des personnes qui ne sont pas des ingénieurs, qui se méritent cette remarquable distinction en raison de services rendus au domaine de l'ingénierie et à la profession de l'ingénierie au Canada.

awards details and criteria prior to preparing nominations. For more information contact the CGS National Office at:

The Canadian Geotechnical Society
8828 Pigott Road
Richmond, BC
V7A 2C4, Canada,
Fax: (604) 277-7529
E-mail: admin@cgs.ca

Appel de candidatures pour les prix et médailles 2019 Institut canadien des ingénieurs (ICI)

À titre de société membre de l'**Institut canadien des ingénieurs** (ICI), les membres de la SCG sont admissibles aux prix et aux médailles de l'ICI décrits ci-dessous. Les membres de la SCG sont encouragés à soumettre des candidatures de collègues membres pour l'ICI au siège social de la SCG d'ici le **15 juillet 2018**.

Les mises en candidature doivent inclure :

1. un formulaire de candidature de l'ICI dûment rempli qui est disponible sur le site ***http://eic-ici.ca/ honours_awards/***);
2. une lettre de mise en candidature;

3. des lettres de recommandation de collègues, préférablement des fellows de l'ICI.

Il est recommandé que les personnes qui soumettent des candidatures examinent les détails et les critères des prix avant de les préparer. Pour obtenir de plus amples renseignements, communiquez avec le bureau national de la SCG à :

La Société canadienne de géotech*nique*
8828 Pigott Road
Richmond, C.-B.
V7A 2C4, Canada
Télécopieur : 604-277-7529
Courriel : admin@cgs.ca

Les noms des membres de la SCG qui ont déjà reçu des prix et des bourses de recherche de l'ICI sont affichés sur le site Web de la SCG à *www.cgs.ca/awards.php?lang=fr.*

Members in the News

Catherine Mulligan - A Woman of Innovation

Catherine Mulligan, chair of the CGS geoenvironmental division from 2006-2010, vice president of communications from 2013-2016, and A.G. Stermac Award-winner in 2010, was featured in a book that the **Canadian Institute of Mining, Metallurgy and Petroleum** (CIM) published called *Women of Innovation: The Impact of Leading Engineers in Canada*. The book details the stories of 20 inspiring women engineers in Canada who have overcome obstacles and excelled in their fields. Excerpts from each woman's chapter will be posted over the next several months on the CIM Magazine website. Below is the excerpt for Catherine Mulligan which can also be seen on the CIM website at *http://magazine.cim.org/en/voices/catherine-mulligan/*

Catherine Mulligan has a background in chemical engineering and is a world leader and pioneer in research and new solutions for geoenvironmental engineering. In particular, she is a recognized expert in the areas of the decontamination of water, sediments and soils, and bioenergy. Catherine is currently a professor in the Department of Building, Civil and Environmental Engineering at Concordia University and the Concordia Research Chair in Geoenvironmental Sustainability. She is also the director of the Concordia Institute of Water, Energy and Sustainable Systems.

Catherine contributes actively to external communities in her field at the local and international levels. She is a member of numerous technical and scientific committees, including serving in leadership roles with the Canadian Society of Civil Engineering and the Canadian Geotechnical Society. Additionally, Catherine has twice won the Pero-Canada Young Innovator Award and won the Engineering Institute of Canada John B. Sterling Award this year.

What factors influenced your decision to pursue engineering?

I wasn't interested in pure sciences; I couldn't really see the point. My mother made an off-hand remark once, "Here's an ad in the paper for chemical engineering. Maybe that's something that could be of interest to you." I looked into it. I said, "Hey, you can do math. You can do chemistry. You can do physics. It's not pure of anything, it's kind of a mixture of all sorts. Maybe that might be interesting." So that is what I applied for. It was only McGill that was offering chemical engineering, so I went there.

Why did you decide to pursue your Ph.D.?

I was starting to get bored in my job. There weren't a lot of challenges. The boss that I had was not very stimulating. The pilot project that we had was for a mobile unit. We were bringing our wastewater reactor to different places. This particular project was kind of on its last legs. SNC Lavalin really did not want to spend much money on research. I was starting to think, "Where's the challenge here?"

What obstacles did you encounter in your early career and how did you overcome them?

The obstacles were in the lab itself. During my Ph.D., I was looking at the surfactant and whether it had some affinity for metal. I said to my supervisor, "Maybe this is an avenue I would like to explore for my Ph.D. Is there some way I can use these surfactants, these biological products, to actually help remediate contaminated soils and sediments?" This is what I ended up doing. I got some contaminated soil and some contaminated sediments and I used my surfactants to try to see whether there was a way we could do it. At that particular time, surfactants weren't commercially produced so I had to produce my own. My supervisor didn't have the nice little facility like the one I had when I was working at BRI, so I had to fabricate my own. That was the biggest challenge I had at the time.

You work with researchers in Japan and China. What benefits come with international collaborations?

I've been going to China and doing work with biological surfactants. They have a lot of problems with contaminated soil. They don't have the same environmental restraints as we do so there might be an opportunity to try stuff there that I might not do so easily here. I would love to be able to do more field work, especially in surfactants. China is really hungry for solutions, so they say, "Come and help us out here."

What did it mean to you to be appointed the Concordia Research Chair in Environmental Engineering?

It gives you a bit of recognition. At that time, there were very few of these research chairs. To me, it was very special and prestigious to get it.

Do you feel an obligation to mentor female students?

No. I don't favour women to men. I probably draw more female students because I am a woman. I don't go out to recruit them. I have a reputation for being approachable. When other students have problems with their professors, they come to me for help. I do what I can. I wish I could take on more students. I had a large group at one point, around fifteen or sixteen the year before last. I'm trying to reduce that a little bit.

Can you talk about the circumstances leading to the founding of CIWESS?

When I first started going to Japan, I noticed they had a school of global environment at Kyoto University. Seeing that got me thinking, "Maybe this is something that we can do." Before I left to go on my sabbatical, some colleagues and I were discussing forming something like this. We had one person from arts and science, one from fine arts, and one from the John Molson School of Business. We formed this core group. We had a common mindset that this was something important. We talked to our provost. At the time, sustainability wasn't really flying around as much as it is now. I came back from my sabbatical and the group was not really that active. We put it on hold.

Then this program from NSERC came along, CREATE. The whole vision for the program was to be able to train in a new way. I said, "Maybe we can do it from an engineering point of view. Try to train engineers with social and economic perspectives." This to me was something that needed to be done. Engineers are really, really good at the technical side of their job, but they are not always good at talking to people and getting their projects going. From my point of view, engineers don't always think about the social and economic aspects of their work. You need to be able to communicate and to sell what you're doing. I devised this program so that they would have internships to get some experience. At the graduate level, this wasn't something that was done. It was something that I had actually implemented when I was associate dean. I had established a course where students could take an internship. A lot of our students are international so they have no Canadian experience. I also wanted to be able to keep some of our good students. They finish their bachelor's degree and they don't stay for their master's. They want to get experience, to make money. I thought maybe this would be a way to keep them.

What qualities does an innovator need?

You need to be able to think outside the box, think a little bit differently, and more than tweaking things here and there, which is the most common way that people do research. You think, "Okay, there is this but maybe we can make it a little bit better." That's the most common form. You have to be able to break the mold and try to think in a totally different direction.

How do you view yourself as an innovator?

I would call myself a problem solver. I'm very tenacious. I don't let things go. I say, "This is going to happen one way or another." To overcome different things, you really have to have that.

Where have you been most innovative in your work?

The work that I've done with biological surfactants was innovative, especially the work I did when I first started, using biological surfactants to look at all the different types of positively charged metals. I was at the forefront. I think that is a good example of opening up this avenue. It created a whole field. When I started, you could count the number of people working on biological surfactants. It's popularized a lot since then. My research has certainly had an impact. It has created a foundation for necessary knowledge that has helped create companies that are producing these things. That's amazing. Now we are starting to do other things, like looking at negatively-charged metals. The last few years, my students and I have been looking at arsenic. It is negatively charged. Chromium has a negative charge. We've gotten some tailings samples from mines in Yellowknife. We're looking at the use of surfactants for arsenic from two fronts. One, can you look at it for stabilizing? And two, can you look at it for extracting?

Can you think of someone who is particularly innovative that has inspired you?

My old supervisor. He had many patents. He was a very active scientist. He had multiple degrees so he was able to look at things from different points of view. He was at the forefront of the field of geoenvironmental engineering. The whole idea of contaminant transport I attribute to him.

What advice would you give to young people considering pursuing a career in engineering?

I think a lot of them probably have the mindset that engineering is very technical. In reality, it is not. There are many other skills that people can bring and there are many other things that are involved in working in engineering. People think you're just going to sit in your lab or your office drawing and whatnot, but it's not that. You have to sell your ideas. You have to talk to a lot of people. You have to work with different communities. You have to talk to different stakeholders. I deal with a lot of students, graduate students in particular. What I try to get across to them is this. Go for it. Work hard. Be strong. You've got to focus. Do what you have to do to get that project done. There are a lot of life challenges along the way, but you have to keep at it. One of my Ph.D. students just had a baby. It is hard. I told her, "Things will get better."

That's one of my mantras. Things may be bad now, but it will get better, don't worry. Just wait a little bit and it will get better.

Albert Nelson Marquis Lifetime Achievement Award Presented by Marquis Who's Who to John Clague, Ph.D.

Marquis Who's Who, a publisher of biographical profiles, presented **John Clague, Ph.D**., with the **Albert Nelson Marquis Lifetime Achievement Award.** An accomplished listee, Dr. Clague celebrates many years' experience in his professional network, and has been noted for achievements, leadership qualities, and the credentials and successes that he has accrued in his field. As in all Marquis Who's Who biographical volumes, individuals profiled are selected on the basis of current reference value. Factors such as position, noteworthy accomplishments, visibility, and prominence in a field are all taken into account during the selection process.

With 45 years of professional experience to his credit, Dr. Clague has been an emeritus research professor at Simon Fraser University since 2016. Prior to this appointment, and from 1998 to 2016, he was the Gordon M. Shrum Professor in the Department of Earth Sciences at Simon Fraser University. He was the President of Engineers and Geoscientists BC from 2014 to 2015. Dr. Clague began his career as a research scientist with the Geological Survey of Canada in the Earth Sciences Sector of Natural Resources Canada, a position he held from 1973 to 1998.

Before embarking on his professional career, Dr. Clague was educated at Occidental College, earning a Bachelor of Arts, magna cum laude, in 1967. He received a Master of Arts degree in geology from the University of California, Berkeley, in 1969. Dr. Clague concluded his studies at the University of British Columbia, graduating with a Doctor of Philosophy degree in geology in 1973.

Dr. Clague has contributed to numerous endeavors both within and outside of his professional circle. He has been the president of the Canadian Geomorphology Research Group, the International Union for Quaternary Research and the Canadian Geoscience Education Network. Additionally, Dr. Clague was the Canada Research Chair in Natural Hazards Research at Simon Fraser University from 2003 to 2016, and chair of the Engineers and Geoscientists BC Foundation since 2017.

An author of hundreds of earth science journal papers, reports and monographs, Dr. Clague has also been a guest on CBC Newsworld, CBC Radio, and CTV. His work has been featured in such newspapers and magazines as the Vancouver Sun, the Times-Colonist, Equinox Magazine, Westside News and the Westerly News, and in a documentary produced by The Discovery Channel in 1997. Dr. Clague was the former editor-in-chief of the Canadian Journal of Earth Sciences, the author of "Vancouver, City on the Edge" co-author of three editions of the textbook "Natural Hazards," and the co-author of "Destructive Mass Movements in High Mountains".

In light of his exceptional achievements, Dr. Clague has accrued several accolades and honors throughout his impressive career. He was presented with the Bancroft Award from the Royal Society of Canada in 2002, the Christopher J. Westerman Memorial Award from Engineers and Geoscientists BC in 1999, the W.A. Johnston Medal from the Canadian Quaternary Association in 1995, and the E.B. Burwell Junior Memorial Award from the Geological Society of America, Inc., in 1988. He received an honorary doctorate from the University of Waterloo in 2017, and was also awarded the Logan Medal from the Geological Association of Canada, the most prestigious award of that association. A fellow of the Royal Society of Canada, Dr. Clague has been listed in multiple editions of Who's Who in Science and Engineering and Who's Who in the World.

In recognition of outstanding contributions to his profession and the Marquis Who's Who community, Dr. Clague has been featured on the Albert Nelson Marquis Lifetime Achievement website. Please visit *www.ltachievers.com* for more information about this honor.

2017 CGS Award Winners

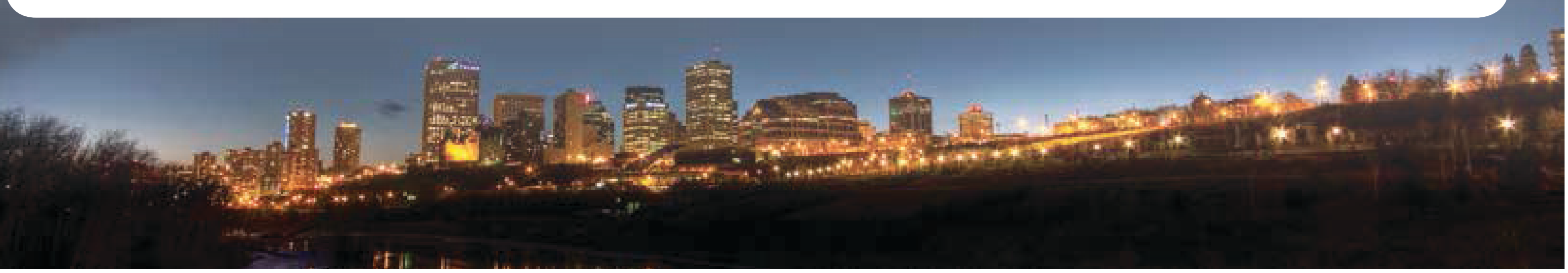
In this issue of Geotechnical News, we again feature more 2017 CGS award recipients. In this issue, we highlight **Mike Wei**, **Dr. Arvid Landva**, **Dr. Ming Cai**, **Alex Baumgard**, **Andrea Lougheed** and **Mustapha Zergoun**.

2017 CGS Awards - Robert N. Farvolden Award Mike Wei

Mike Wei of the BC Ministry of Environment, was presented with the 2017 Robert N Farvolden Award. This joint CGS/IAH-CNC award was established in 2000 and is named to honour Dr. Farvolden (1928-1995) who is credited with beginning the modern era of hydrogeology in Canada in the 1960s.

Mike's citation reads: "BC professional engineer **Mike Wei** is a world class leader in the development of science-based policy and regulation concerning the protection of groundwater resources. As Head of Aquifer and Watershed Science at the BC Ministry of Environment, Mike has been the provincial government expert in developing and implementing the long-awaited Groundwater Protection Regulation, as well as the new Water Sustainability Act and Water Sustainability Regulation. He has helped to develop BC's groundwater science knowledge through careful scientific studies spanning groundwater development through contamination.

His technical contributions have included the development of numerous groundwater protection tools like the BC Aquifer Classification System and the Well Protection Toolkit, which are



used by communities and practitioners across the province. Throughout his career, Mike has worked with a variety of government agencies, regional health authorities, industry, and academia on groundwater resource management projects, striving to achieve balance between science and practicality of solutions. He has steadily and purposefully worked to ensure that all stakeholders in the groundwater industry are engaged and feel that their contributions are recognized.

For his professionalism, leadership, and profound contributions to the protection of British Columbia's and Canada's groundwater resources, the CGS Groundwater Division and the IAH-CNC are pleased to award **Mike Wei** with the 2017 **Robert N Farvolden Award**."

2017 CGS Awards - G. Geoffrey Award Dr. Arvid Lanva

Dr. Arvid Landva was the winner of the 2017 G. Geoffrey Meyerhof Award of the CGS's Soil Mechanics and Foundations Division. Established in 1993, this award honours Professor Meyerhof (1916-2003), the first President of the CGS, for his outstanding life-long contributions to the profession and the CGS, and for his numerous achievements that have received worldwide recognition.

Arvid's citation reads: "A long-time and noted figure in the world of geotechnical engineering, **Professor Arvid Landva** has made extensive and significant contributions towards the advancement of geotechnical engineering, both academically at the University of New Brunswick and as a senior geotechnical consultant with Jacques Whitford.

For nearly three decades, Dr. Landva taught courses in basic and advanced soil mechanics and embankments, mentoring students and bringing critical "out of the box" thinking to his multitude of projects, both inside and outside of academia.

In earlier years, he made major contributions to the classification of peat and the evaluation design and analysis of foundations seated on these difficult materials. In later years, he started ground-breaking research in the area of waste mechanics using large scale laboratory equipment and test fills to characterize these heterogeneous materials. Dr. Landva was one of the first to treat waste fill as a geotechnical material and to develop specialized laboratory and field testing methods for the evaluation of waste materials.

For his many achievements over a long and storied career, the CGS Soil Mechanics and Foundation Division is pleased to honour **Professor Arvid Landva** with the **2017 G. Geoffrey Meyerhof Award**."

2017 CGS Awards - John Franklin Award Dr. Ming Cai

Dr. Ming Cai was the winner of the 2017 John Franklin Award of the CGS Rock Mechanics Division. Established in 1993, this award honours the past President of the International Society for Rock Mechanics (ISRM), John Franklin (1940-2012), for his outstanding contributions to the Canadian and international rock mechanics communities, and to the CGS.

Dr. Cai's citation reads: "Professor Ming Cai, Geomechanics Research Chair at Laurentian University's Bharti School of Engineering, is widely recognized for his outstanding contributions to the study of Canadian and international rock mechanics.

His numerous technical publications include work related to rock support in difficult ground conditions, the interpretation of acoustic emissions and micro-seismic monitoring, and proposed quantitative approaches to estimating the peak and residual rock mass strengths using the Geological Strength Index, to name but a few.

Dr. Cai seeks opportunities for new products that are simple, cost-effective and exhibit superb dynamic capacities – his development of four rockburst products and the granting of five patents illustrates his expertise in this field.

His industrial experience includes work with the Tokyo Electric Power Services Company, and serving as general manager of the Asia Business Group of the Mansour Group of Companies. In addition to his teaching at Laurentian, he includes stints at his alma mater at Beijing's Tsinghua University, the Kunming University of Science and Technology and Zhengzhou's North China University of Water Conservancy and Hydro-Electric Power.

For his exceptional service as a teacher, mentor, author and engineer, **Professor Ming Cai** is a deserving recipient of the CGS Rock Mechanics Division's 2017 **John A. Franklin Award**."

2017 CGS Awards - Stermac Award Winner Alex Baumgard

Alex Baumgard, past-chair of the Soil Mechanics and Foundations Division was a recipient of CGS's **2017 Stermac Award**.

Alex's citation from the October 2017 award ceremony reads: "An active participant in the Canadian Geotechnical Society for many years, Dr. Alex Baumgard's commitment to the organization is marked by his willingness to go the extra mile to support all manner of tasks – many on short notice.

His recent contributions include chairing the Soil Mechanics and Foundation Division of the Canadian Geotechnical Society for more than 4 years. Alex has been directly involved with a number of CGS initiatives, including most recently the selection and review of the papers submitted by CGS members to the 19th International Conference on Soil Mechanics and Geotechnical Engineering held September 2017 in Seoul, Korea.

As a principal engineer in BGC Engineering's Vancouver office, he brings a wealth of experience in the assessment of geohazards, especially related to both onshore and offshore pipelines, as well as traditional geotechnical and geo-environmental areas. Alex is also a member of the Federal Government's Canada Task Force-1 Heavy Search and Rescue team, responding to landslides and other disasters in times of need, including this past summer's landslide near Salmon Arm, BC.

The Canadian Geotechnical Society is pleased to recognize **Dr. Alex Baumgard** with a **2017 A.G. Stermac Service Award**."

2017 CGS Awards - Stermac Award Winners Andrea Lougheed and Mustapha Zergoun

Andrea Lougheed and **Mustapha Zergoun**, co-chairs of GeoVancouver 2016 were both recipients of CGS's **2017 Stermac Award**. Their citation from the October 2017 award ceremony reads: "This year **Andrea Lougheed** and **Mustapha Zergoun** are being honoured for their dedication and outstanding service to the Canadian Geotechnical Society. Andrea currently serves as the CGS Director for the Vancouver Section and Mustapha served in that role from 2006 to 2008.

Most recently, they co-chaired and acted as the driving force on the local organizing committee for the very successful 2016 Canadian Geotechnical Conference – **GeoVancouver 2016**. The conference's theme "History and Innovation", recognized historical achievements and lessons learned while highlighting innovation in the field of geotechnique.

Attracting over 800 registrants, attendees were treated to west coast hospitality and to one of the great CGS annual conferences, punctuated by the inaugural awards for Best Case History paper and Best Student paper.

Leadership and volunteer activities and duties aside, both Andrea and Mustapha are busy working in Vancouver at BGC and Thurber Engineering, respectively, and can now add the Canadian Geotechnical Society's **2017 A.G. Stermac Award** to their impressive list of accomplishments."

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 (GSE)** and the **Canadian Geotechnical Society (CGS)** in collaboration with the Canadian National Chapter of the Inter**national 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, five high calibre short courses, social events, and technical tours. The official languages for the conference will be English and French.

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

See you in Edmonton!

Capital Boulevard & Alberta Legislature.

Rogers Place.

La 71e conférence canadienne de géotechnique et la 13e conférence conjointe SCG/AIH-SNC sur les eaux souterraines Du 23 au 26 septembre 2018, à Edmonton, en Alberta, au Canada

La Société géotechnique d'Edmonton (GSE) et **la Société canadienne de géotechnique (SCG)**, en collaboration avec **la section nationale canadienne de l'Association internationale des hydrogéologues (AIH-SNC)**, vous invite à **GéoEdmonton 2018**, la 71e conférence canadienne de géotechnique et la 13e conférence conjointe SCG/AIH-SNC sur les eaux souterraines. La conférence aura lieu au Centre des congrès Shaw à Edmonton, en Alberta, au Canada, du **dimanche 23 septembre au mercredi 26 septembre 2018.** Cet établissement spectaculaire est l'un des principaux lieux de congrès du Canada et est aussi une réalisation géotechnique, puisqu'il est construit sur le flanc d'une zone de glissement de terrain active qui surplombe la magnifique vallée fluviale d'Edmonton, au cœur du centre-ville.

Edmonton a été fondée sur les rives de la rivière Saskatchewan Nord et a servi d'avant-poste commercial de la Compagnie de la Baie d'Hudson. Elle est devenue la porte d'entrée du Canada vers le Nord et la capitale de l'Alberta. Avec une population métropolitaine de plus de 1,3 million d'habitants, Edmonton a une atmosphère chaleureuse et accueillante. Également connue sous le nom de la ville des festivals, Edmonton met en valeur son talent local et international et sa diversité par l'entremise de divers festivals, comme son Festival du patrimoine annuel et le deuxième plus important festival de théâtre expérimental (Fringe Theatre Festival) au monde. Dotée de la plus longue étendue de forêt-parc urbaine en Amérique du Nord à seulement quelques pas du lieu de la conférence, Edmonton est aussi un endroit merveilleux pour profiter de la nature sans quitter les limites de la ville.

Le thème de GéoEdmonton 2018 est La géotechnique des transports – Ouvrir la voie. La prospérité du Canada repose en grande partie sur son vaste réseau de chemins de fer, de pipelines, de routes et de voies navigables. Cette conférence vise à mettre en lumière les récentes réalisations en matière de développement des transports et les géorisques qui y sont associés. Le programme technique couvrira un large éventail de sujets géotechniques et hydrogéologiques, y compris des séances spécialisées d'intérêt local et national. En plus du programme technique et des séances plénières, la conférence comprendra un éventail d'éminents conférenciers d'honneur et d'activités sociales, ainsi que cinq cours intensifs de haut calibre et une visite technique. Les langues officielles de la conférence seront le français et l'anglais.

Pour obtenir les derniers renseignements sur la conférence, veuillez consulter son site Web, à *http://www.geoedmonton2018.ca/index.php?lang=fr.*

Au plaisir de se voir à Edmonton!

3rd Virtual GeoScience Conference August 22 to 24, 2018 Kingston, Ontario, Canada

We are excited to announce that the **3rd Virtual Geoscience Conference (VGC)** will be held in the beautiful limestone city, **Kingston, Ontario, Canada, August 22 to 24, 2018**. The 3rd VGC will again provide a meeting place for researchers, government, and industry members at the forefront of innovative research and development in close range remote sensing and computer visualization applied to the geosciences. The conference will highlight technological advancements and the latest applications of geomatics and visualization tools to a broad range of geoscience problems.

The conference theme is all about multidisciplinary collaboration at the intersection of geomatics, visualization, computer vision, graphics and gaming, as well as virtual and augmented reality with applications to a range of geoscience subfields, such as geological mapping, geomorphology, geohazards, glaciology, volcanology, tunnelling, and mining.

Virtual Geoscience tools have impacted geoscience research, practice, and education. Geoscientists are increasingly using 3D geological models in favor of 2D GIS maps to better understand and model the scale and scope of projects, to communicate complex geology and engineering designs to clients and to easily inform the public on the impact of infrastructure or mining activities on their community. Tools like augmented and virtual reality are allowing new modes of interaction and with geoscience that are immersive and intuitive to a wide range audiences. Recently, the use of powerful game engines has converged with geoscience research offering exciting geological process modelling opportunities. Additionally, an increasing number of close range remote sensing tools are being used to generate 3D geological models and to monitor geological processes. There are many close range techniques and a wide range of platforms allowing geology to be mapped and monitored at increasingly high spatial and temporal scales. With the increasing number of close range tools and the growth of computer visualization tools, it is of great benefit to meet and discuss the latest developments and applications.

The first two VGC conferences, held in Switzerland followed by Norway, focused on developments and applications of close range remote sensing techniques to a broad range of geoscience research including inputs to geological modelling and have brought together researchers and practitioners interested in a novel 3D technologies. The purpose of the third conference is to again offer a multidisciplinary forum for discussing the latest developments in geomatics tools and visualization in the geosciences.

For additional information, please visit our website at *http://virtualoutcrop.com/vgc2018* or contact us at *vgc2018@virtualoutcrop.com*.

Committee News

Heritage Committee Canadian Geotechnical Society Virtual Archives

There are rich but rarely used resources in Canada that consist of files containing historical information on geotechnical laboratory and field research, geotechnical investigations, work of committees and geotechnical expertise. Ways to identify and use these resources have been developed by the Heritage Committee of the Canadian Geotechnical Society in the form of virtual archives on the CGS web site, where the location and content of accessible historical geotechnical material are given.

CGS members and others are invited to submit candidate material for consideration. The submission should give the location of the material, a description of its nature and content, its historical significance and the conditions under which it can be accessed. Do not submit physical archival material as the Society has no space to store it, however electronic copies of photographs or materials are welcome.

Your contribution to the CGS Virtual Archives web page should be sent to the Chair of the Heritage Committee, Heinrich Heinz, P.Eng. at *hheinz@thurber.ca.*

Corrections and Updates

In the March issue of Geotechnical News, several e-mail addresses for the CGS Board were found to contain errors or have changed. The following are the Board members with their corrected e-mail addresses.

James Blatz - james.blatz@ad.umanitoba.ca

Dylan Hill - hill@malroz.com

Jasmin Raymond - jasmin.raymond@inrs.ca

Editor

Don Lewycky, P.Eng.
Tel.: 780-478-4156
Email: don.lewycky@gmail.com

CGS Professional Practice Committee holds court at GeoOttawa 2017

Among other things, the Canadian Geotechnical Society's Professional Practice Committee (CGS PPC) organizes conference sessions to deliver relevant, practice-related information and guidance to CGS members. The PPC's session held during GeoOttawa 2017 presented some legal considerations when involved in engineering project-related court proceedings and the role of being an expert witness in those proceedings.

The session was led by two of Canada's leading construction lawyers: Neil Abbott, a partner in the Toronto office of Gowling WLG, and Louis-Pierre Grégoire, a partner in the firm's Ottawa office. Louis-Pierre Grégoire created a mock court environment with Neil acting as the 'judge' and Louis-Pierre as the 'lead litigator'. Graeme McPherson from Gowling WLG appeared as the 'expert geotechnical engineering witness' in the case.

'Court' was called to order in the case of the Three Little Pigs v. the Big Bad Wolf. It was alleged that B.B. Wolf had blown down the Three Little Pigs house, valued at $2.5 M, and in so doing destroyed an additional $2.5 M in contents. The Three Little Pigs delivered a statement of claim of $10 M for the value of the house, its contents and their emotional distress. B.B. Wolf filed a statement of defense that the damages were not due to his 'huffing and puffing' but, in fact, were a result of faulty design and construction of the foundation of the house.

Left to right: Louis-Pierre Grégoire, Graeme McPherson and Neil Abbott.

The expert witness, L.R. Riding Hood, was then introduced to the court and the first order of business for the lead litigator, who represented the Three Little Pigs, was to examine the expert's credentials to establish his credibility to provide appropriate expert testimony. This examination is referred to as 'voir dire'. The expert's curriculum vitae was reviewed and he was questioned on the details of his experience. A number of dubious facts were identified in the expert's poorly prepared curriculum vitae. At times, Neil and Louis-Pierre would break from character and explain to the session attendees how the line of questioning was exposing the expert's lack of credibility and how that could potentially affect the judge's reliance on his testimony.

Following the voir dire, the expert witness was reluctantly allowed to testify, but the damage to his credibility had clearly been demonstrated. The litigation then focused on the expert report. During the questioning, it very quickly became apparent that the report was also poorly prepared and the expert's conclusions were systematically called into question. When the questioning ended, it was clear the strength of B.B. Wolf's defence was weak due to the lack of appropriate experience of the expert witness and his poorly prepared report.

The well attended session provided a valuable opportunity for attendees to see, in a mock court environment, what an expert witness could expect to be subjected to. Three key points were made: 1) an expert appears in court to provide an unbiased opinion of the facts of the case; he/she is not there to advocate for either party; 2) the experience of the expert will be tested in court, and one should consider carefully his/her appropriateness to appear as an expert; and 3) all documents presented to the court should be prepared with the utmost care, to ensure that they are complete, correct, understandable to non-technical individuals and without bias towards either party.

If you are attending GeoEdmonton 2018 this fall, look out for another exciting session from the Professional Practice Committee!

Prepared by James Blatz, Chair of the CGS Professional Practice Committee

History of the development of the Canadian Foundation Engineering Manual/ Manuel Canadien d'Ingénierie des Fondations Part 2 of 4

Doug VanDine

Introduction to Part 2 of the Series

In Part 1 of this series, published in the March 2018 issue, the background to, and the '1975 First Draft' of the manual were covered. In this issue, the '1978 First Edition' and the '1985 Second Edition' are chronicled. If you can't wait to read Parts 3 and 4, the entire article is on the CGS website (see *http://www.cgs.ca/engineering_manual_overview.php?lang=en*)

1978 First Edition of the Canadian Foundation Engineering Manual (CFEM)

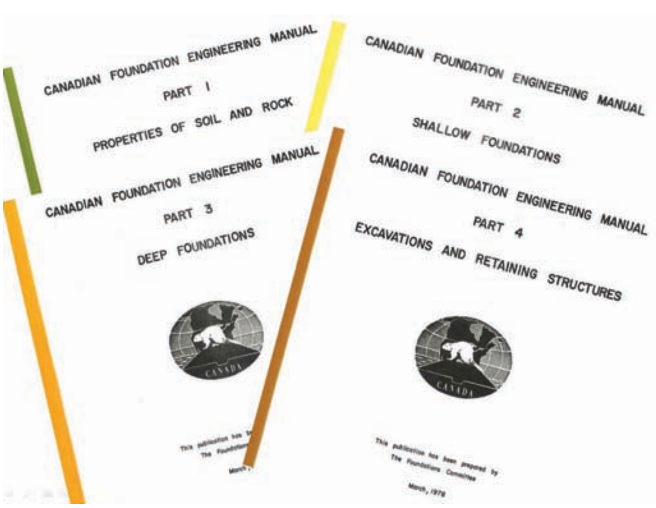


Figure 1. Covers of the stand-alone parts of the 1978 Frist Edition.

In 1976, the Canadian Geotechnical Society (then only in its fourth year as a society) assumed responsibility for the manual. The Society formed a "Foundations Committee" for this purpose that consisted of the following geotechnical engineers, with their identified associations as of 1978:

- W.A. (Bill) Trow (Chair), Trow Group (and also the only member of the early 1970s NRC Subcommittee on Foundations)
- W. (Bill) Birmingham, Birmingham Construction
- J. Burgess, Morrison Hershfield Burgess Huggins
- J.D. (Don) Scott, (Editor) RM Hardy & Associates
- K. (Ken) Shelby, Ontario Ministry of Transportation and Communications
- D.H. (Don) Shields, RM Hardy & Associates (and CGS President 1977-1978), and
- N.E. (Nyal) Wilson, McMaster University.

Between 1976 and 1978, the CGS Foundations Committee revised, updated and reorganized the *1975 Draft Edition* (NRC, 1975) and took "into account the constructive criticism and suggestions that were made of the NRC draft". The result was the CGS Foundations Committee's *Canadian Foundation Engineering Manual (CFEM),* published in 1978 (CGS, 1978; Figure 1). Note the slight change in the title from the 1975 *Draft Edition, the Canadian Manual on Foundation Engineering.*

In its work, the CGS Foundations Committee was assisted by Arthur Heidebrecht, from McMaster University, who contributed significantly to the topic of earthquake resistant design.

The *1978 First Edition* was produced as four stand-alone parts (booklets). The complete manual accompanied by a binder could be purchased, or any of the four booklets could be purchased separately. The document was sold through the, then, CGS office in Montreal, QC.

The four parts consisted of:

Part 1: Properties of Soil and Rock (77 pages)
Introduction; Definitions, Symbols and Units; Identification and Classification of Soil and Rock; Subsurface Investigations; Unusual Site Conditions; Earthquake Resistant Design

Part 2: Shallow Foundations (99 pages)
Introduction; Bearing Pressure on Rock; Bearing Pressure on Soil; Stress Distribution; Settlement; Design Procedure; Swelling and Shrinking Clay; Frost Action

Part 3: Deep Foundations (108 pages)
Introduction; Geotechnical Design; Structural Design and Installation; Load Tests; Inspection; Pile Driving Formulas; Piles Subjected to Horizontal Loads; Vibro Processes, and

Part 4: Excavations and Retaining Structures (68 pages)
Introduction; Theoretical Pressures on Retaining Structures; Excavation Support; Control of Groundwater; Foundation Walls and Retaining Walls.

Among the many differences between the *1975 Draft Edition* and the *1978 First Edition*, the section on "Earthquake Resistant Design" was upgraded from a relatively short "commentary" to a 14-page chapter.

In addition to the statements on limitations and use of experience and judgement, similar to those in the *1975 Draft Edition*, the *1978 First Edition* added:

"While every reasonable effort has been made to insure the validity and accuracy of the information contained in this Manual, the Canadian Geotechnical Society and its members disclaim any legal responsibility for such validity or accuracy; persons using this Manual do so at their own risk."

The 1978 First Edition also stated, "It is the intention of the Society to update the manual from time to time as the need arises".

A French version of this document was not published. It is not known how many copies of this edition were printed, or the price.

1985 Second Edition of the CFEM

In the early 1980s, under CGS Presidents John Adams (1981-1982) and Tony Stermac (1983-1984), the Society presented a series of seminars across Canada on the CFEM and its use. Both in the *1978 First Edition* and during the seminars, comments on and suggestions for revisions and additions to the *1978 First Edition* were solicited. True to the Society's stated intention, in 1983, the CGS requested its Foundations Committee (by then called the Technical Committee on Foundations) to review the comments and suggestions and prepare a revised manual.

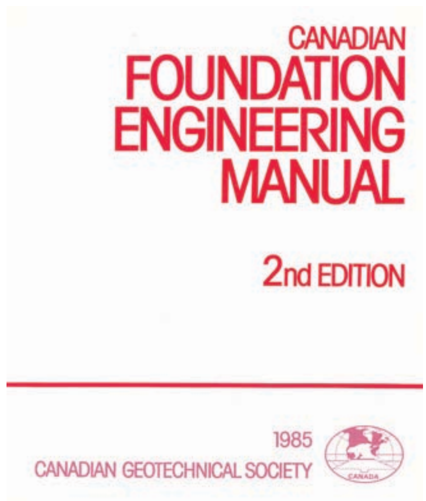


Figure 2. Cover of the 1985 Second Edition.

This task was carried out under the leadership of the following geotechnical engineers (their organizations at that time were not identified, but have been added):

G.G. (Geoffrey) Meyerhof (Editor), Technical University of Nova Scotia (now a part of Dalhousie University)

B.H. (Bengt) Fellenius (co-Editor), University of Ottawa and Chair of the CGS Technical Committee on Foundations

F. (François) Tavenas, Université Laval and CGS Vice President Technical (and a member of the early 1970s NRC Subcommittee on Foundations), and

M. (Michael) Bozozuk, NRC DBR and CGS Vice-President Administrative and Chair of the CGS Committee on Publications.

David Devenny was CGS President (1985-1986) when the *1985 Second Edition* (CGS, 1985; Figure 2) was published.

As stated in the preface of the *1985 Second Edition*:

"The Manual is truly produced by the membership of the Canadian Geotechnical Society. The number of individuals who have contributed to the Manual – first, the preparation of the 1975 draft, then, the 1978 first edition, and, now, the 1985 second edition – is very large. Through the years, there have been about 30 members of the Foundations Committee. In addition, about 100 individual members of the Society have submitted serious comments and suggestions, which have been considered in the revision work. It is impossible to give just credit to all these individuals. The Manual is a manifest of the dedication of the membership at large and owes its existence to the membership."

The *1985 Second Edition*, similar to the *1975 Draft Edition*, was again a single, bound volume. The 456-page document was printed and distributed for the first time with the assistance of BiTech Publishers Ltd. of Vancouver, BC. (Coincidently, John Gadsby, co-owner of BiTech Publishers, was a member of the early-1970s NRC Subcommittee on Foundations that wrote the *1975 Draft Edition*.)

Although a single bound volume, the *1985 Second Edition* was still organized in the same 4 parts as the *1978 First Edition*. The name of Part 1 was changed from "Soil and Rock Properties" to "Fundamentals" to better reflect its content.

There were many changes and additions from the content of *1978 First Edition* to the *1985 Second Edition*. Among them, geotextiles were first referenced; the section on earthquake-resistant design was further enlarged; limit states design was introduced; and the references were compiled at the end of the document. In addition, the Imperial units that were used in the *1978 First Edition* were converted to metric units.

The *1985 Second Edition* was the first edition to be typed using a word processor, as opposed to the typewriter-typed previous editions. Bengt Fellenius recalls that not only was he co-Editor of this edition, but he personally typed the entire manuscript, and the numerous revisions, on his "trusty" Apple computer using WordStar. He then sent the final WordStar file to BiTech who transferred it to MSWord for printing.

With regard to "limit states design", as stated in Chapter 1 "Introduction":

"The introduction of limit states design is intended to make the design of foundations consistent with the design of superstructures, as regulated in the National Building Code of Canada and related Canadian Standards Association (CSA) standards."

The *1985 Second Edition* followed Europe's and Ontario's (first) ultimate limit state and serviceability limit state (ULS-SLS) Bridge Code, in that it applied the partial factor of safety method.

The wording in the preface to the *1985 Second Edition* was also changed from earlier versions to:

"The Manual contains:

1. Acceptable design guidelines for the solution of routine foundation engineering problem, as based on sound engineering practice.
2. An outline of the limitations of certain methods of analysis.
3. Information on properties of soil and rock, including certain conditions encountered in Canada.
4. Comments on construction problems, where these govern the design or the quality of the foundation.

The material in the Manual is presented as a series of suggested rather than mandatory procedures."

The above content description has remained essentially unchanged up to the current *2006 Fourth Edition.*

A second printing of the *1985 Second Edition* was carried out in 1987. This second printing corrected a few minor errors in the previous printing and added two new sections: "Section 4.9 Background Information for Site Investigation" and a "Subject Index" at the end of the document. The CGS Engineering Geology Division was recognized as contributing the new Section 4.9.

Approximately 1,800 copies of the *1985 Second Edition* were printed and they sold for $65, for CGS members, $90 for non-members and $50 for students.

To be continued….

Part 3, the next part of this history, will cover the '1989 French Edition', the '1992 Third English Edition', and the '1994 Second French Edition'.

Acknowledgements

Many individuals assisted the author in locating the older editions of the manual, providing valuable additional information, and providing excellent review comments on numerous drafts of the history. They will be appropriately acknowledged in Part 4. The author, however, accepts responsibility for any errors or misinterpretations of facts. If readers have additional information, or comments, on the history of the development of the CFEM and the MCIF, please send them to *vandine@islandnet.com.*

References for Part 2

Canadian Geotechnical Society (CGS), 1978, Canadian Foundation Engineering Manual, Parts 1 to 4, published by the CGS, Montreal, QC.

Canadian Geotechnical Society (CGS), 1985, Canadian Foundation Engineering Manual, 2nd Edition, published by the CGS c/o BiTech Publishers Ltd., Vancouver, BC, 465 p.

National Research Council (NRC), 1975, Canadian Manual on Foundation Engineering, published by the NRC Associate Committee on the National Building Code, Ottawa, ON, 318 p.

Introduction by John Dunnicliff, Editor

This is the 92nd episode of GIN. Just one article this time, on my favourite subject, Human Factors. In the red book I called these People Issues, but the former is a more common and better term. The article is followed by some discussions by manufacturers of instruments (which I found very interesting) and a closure.

A 'Must Read' Manual for Anyone Using an Inclinometer

"Use of Inclinometers for Geotechnical Instrumentation on Transportation Projects

State of the Practice", Transportation Research Circular Number E-C129, October 2008. By George Machan, *Landslide Technology* and Victoria G. Bennett, *Rensselaer Polytechnic Institute (RPI).*

Although written nearly ten years ago, I've only just discovered this. By far the best document that I've seen on this challenging subject.

http://onlinepubs.trb.org/onlinepubs/circulars/ec129.pdf

A Tale to Reinforce your Faith in Human Goodness

Last week my wife Irene went shopping in a town about 5 miles away, population 25,000.

When she returned to her car, she discovered that she'd lost her wallet. Annoyed with herself! So she went to the nearby police station to report the loss.

A few hours later the phone rang – a policewoman saying that the wallet had been handed in. "Are you going to be in this evening?" A puzzled, "yes". "We'll see you in about an hour". Wow!

About 2½ hours later the phone rang, and in a voice interrupted with laughter, "We're lost!" Now, we live down some narrow lanes in a National Park, but we're NOT isolated. She described where they were – not far away, so I started to give directions, mentioning a nearby hotel. More laughter, "We've passed that lots of times this evening. We have SatNav, but it's just told us to go to the end of this lane, park and walk. Let's meet at the hotel".

So we did. They were in a largeish police van (probably a 'paddy wagon'), policewoman A driving. Policewoman B jumped out, laughing, "I've been bursting for a long time" and rushed into the hotel. (This explained why they wanted to meet at the hotel rather than at our house!). "We've been driving around and around – we'll never forget this evening!" Both were in their 20s.

More chat, more laughter. Wallet returned. Nothing missing. Receipt signed. Repeated "We'll never forget …". Hugs all round (Kevlar jackets, we think). Vigorous waving goodbye.

Profuse thanks sent to the finder.

An afterthought – what would have happened if we had called the emergency number because we were burgled?

Down the hatch (England)

Gezondheid ("To your health"). Netherlands

Some remarks on the importance of human factors in geotechnical and structural monitoring programs

John Dunnicliff

In my experience as a 'getting hands dirty' practitioner for geotechnical and structural monitoring, I've learned that technical issues take us only half way to success. The other half consists of what I used to call 'People Issues' and my Italian colleague Giorgio Pezzetti has found a better term: "Human Factors". Failure to attend to the human factors has so often led to failures of monitoring programs. As my fellow octogenarian Elmo DiBiagio, from the Norwegian Geotechnical Institute, recently wrote to me, "*We have solved most of the 'what to measure problems' and we have well proven instruments. The people may be the weak link in an instrumentation proj-*

ect." Nearly all the technical journal, conference and symposia papers about monitoring have been about technical issues, which in my view demonstrates a significant failure in our communication with each other. Therefore I want to focus here on the cruciality (that's a new word!) of these human factors, and to encourage you to pay more attention to them in the future than you have in the past. For those of you who have heard all this before, yes, I AM going to sing my usual old song.

At the end of this brief article I'll include some references, one of which is a link to a video of a lecture by Allen Marr of Geocomp in Massachusetts, given in Cambridge, England last year, in which he talked about many human factors associated with performance monitoring as a risk management tool. Watch, listen, learn and act!

Another valuable reference about human factors is an article in GIN by Martin Beth of Sixense-Soldata, with the title "Eight common sense rules for successful monitoring". When I told Martin how useful I thought this was, he replied, "But everyone knows these rules". Not true. Read, learn and act!

Here are some common sense rules from my own experience, many of which do, in fact, sing my usual old song. There are nine of them.

1. Every instrument on a project should be selected and placed to assist with answering a specific geotechnical question: if there is no question, there should be no instrumentation. When reviewing the need for each planned instrument, ask "What's the question?"
2. It doesn't make sense to ask "How much should we spend on monitoring?"
3. When planning and executing a monitoring program, use a multi-stage systematic approach. Full benefit can be achieved from monitoring programs only if every step in the planning and execution process is taken with great care. There's a reference to a 13-step planning procedure at the end of this article. Instrument selection must be made as part of the designer's systematic planning process, which includes the identification of the geotechnical questions.
4. Low-bidding for monitoring field work usually results in poor quality data. There's no need to convince readers of GIN about this, because I think that I'm preaching to the converted. But we have to work hard to convince decision-makers in the offices of project designers and project owners that it is NOT in their interests to allow low-bidding. The strongest argument is that it will cost more. (See the 13-step planning procedure just mentioned).
5. When monitoring data are crucial to a project, as they often are, don't let anyone try to stop you from spending the necessary money to monitor properly. If you're not heard by decision-makers, play Allen Marr's video to them.
6. Motivate the people responsible for instrumentation field work – installers, data gatherers, maintainers – by explaining not just HOW to do it, but WHY their work is so important. You'll get far better commitment. Of course this recommendation applies to issues much broader than monitoring. I've encountered so many people in positions of authority who only say the HOW to their subordinates – this is very short-sighted.
7. A tale against myself:
   - I arrived on a site to install some instruments
   - I met the driller and explained to him what I was going to do
   - He said "that won't work"
   - I was self-confident and "did it my way" (you know the song!)
   - It didn't work
   - The lesson learned: Listen to the driller!
8. I'm going to address a contentious subject, and say something about how I believe designers of monitoring programs and instrument manufacturers should interact with each other. We all know that we and they are dependent on each other, and that we can work well as a team. We're all in it together. But I think we need to recognize a logical dividing line between what we each do. Some designers rely on manufactures to advise them on what instruments are needed on their project, and some manufacturers will do this without charge. Yes, it's an easy way out for the designer who has insufficient experience with instrumentation. And yes, it's understandable that some manufacturers go along with this, to cement a sale. But, to be blunt, in my view this is not in the good professional interests of our monitoring community.

"In my view this is not in the good professional interests of our monitoring community"

As I said earlier, instrument selection must be made as part of the designer's systematic planning process, which includes the identification of the geotechnical questions. We need to do all that we can to get this message to designers. If designers don't have enough experience, logic says that they should team up with someone who does. No, that's not self-marketing – I've retired from consulting!

9. Following on from my previous point, if manufacturers advise on what instruments are needed on

their customer's project, are they exposing themselves to professional liability concerns? Remember Nicoll Highway in Singapore!

In closing, I encourage you to pay more attention to human factors in the future than you have in the past. As Ralph Peck said to us, *"We need to carry out a vast amount of observational work, but what we do should be done for a purpose, and be done well"*.

References

Link to a video of a lecture by Allen Marr, given in Cambridge, England last year: *www.youtube.com/watch?v=67gAXmxcokA*

Martin Beth's article in GIN, titled "Eight common sense rules for successful monitoring". www.geotechnicalnews.com/instrumentation_news.php. June 2016.

A 13-step procedure for systematic planning of monitoring programs. I've published various versions of this. For the latest, e-mail me at *john@dunnicliff.eclipse.co.uk* or visit Geokon's website (see below).

Author's/Editor's Note

I invited eight manufacturers of instruments from North America and Europe to send me discussions of the above points 8 and 9, in the hope that we'd be able to agree on how to chart a way forward with these issues. Six sent me discussion, which follow, in alphabetical order of company names.

Discussions of above points 8 and 9 by manufacturers of instruments

David Richardson, Durham Geo Slope Indicator

At DGSI, it is not our practice to provide recommendations to the designers of monitoring programs on what instruments are needed on their projects. We will assist by offering advice for the appropriate style of a sensor (e.g. pneumatic vs. vibrating wire piezometers or traversing vs. in-place inclinometers), but we will not recommend which sensors should be installed.

As the manufacturer, we typically do not know the detailed information about the site, and we are rarely provided the geotechnical or the proposed structural loading information required to make informed recommendations about the most appropriate instrumentation. Even though we have geotechnical engineers on staff, providing "consulting services" is not our practice.

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Tony Simmonds. Geokon Inc.

I discussed this with Barrie Sellers (President Emeritus, Geokon Inc.) and believe he sums up the concern regarding designers of monitoring programs and instrument manufacturers very well with the following;

I think you could say that manufacturers represent a valuable source of knowledge and expertise on the choice of instruments and methods to accomplish a certain measurement but they are not the ones to decide which measurements are necessary to answer which geotechnical questions or concerns – these should be within the purview of a registered geotechnical engineer.

In keeping with this and, as an added resource to those customers who approach us in need of direction, we have included a link on the Projects page of our website (www.geokon.com) to John Dunnicliff's article "A 13-step procedure for systematic planning of monitoring programmes using geotechnical instrumentation". [This article is the same as the one included as the last of the three references above. JD].

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Martin Clegg, Geosense Ltd

There are three basic responsibilities in instrumentation. The Engineer's, The Instrumentation & Monitoring Contractor's and the Manufacturer and/or supplier's:

The Engineer's responsibilities are:-

1. To identify the need (why) for monitoring.
2. To identify the what (parameter) & where (e.g. dam body) to monitor.
3. To make the specification for the instrumentation.
4. To analyse & understand the data from the instrumentation.
5. To use the data from the instrumentation to carry out the necessary calculations required by the designer for verification and/or validation.

The Instrumentation & Monitoring Contractor's responsibilities are:-

1. To install instruments to the Engineer's specification.
2. To provide data to the Engineer's specification.

The Manufacturer/supplier's responsibilities are:

1. To provide the Instrumentation & Monitoring Contractor with hardware and/or software to meet Engineer's specification.

There will always be a place for Engineers, Instrumentation & Monitoring Contractors and Manufacturers to interact to discuss and understand the application and performance of instruments especially where new technology is evolving. However, there will inevitably be a degree of commercial influence during these discussions.

As the success of any instrumentation monitoring program depends on the understanding of the objectives and the quality of the specification it is vital that the Engineer does not impose or rely too heavily on Manufacturers for this. The understanding of the individual application and each sensors performance together with its limitation should be fully understood by the Engineer before specifying it. We as a manufacturer are seeing too much emphasis being placed on us to explain "unexpected readings" which more often than not means that its use is not fully understood. Sensor failure is very rare.

With the amount of published literature now readily available on instrumentation and their application plus various training courses available the information is there. It just needs a willingness to find and study it.

Martin Clegg
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René DeBlois, Roctest Ltd

Manufacturers can play an important role in the design of a geotechnical and structural monitoring solution. We know the capabilities and limitations of our instruments and we have thoroughly tested our products and have a full understanding of the most suitable applications for their uses. Adding years of experience with numerous projects in a large range of applications, manufacturers such as Roctest can assist users with their challenges related to geotechnical and structural instrumentation. Instruction manuals, websites and dedicated in-house experts are always available to support users in the implementation of their projects. However, a manufacturer's knowledge of the specificities of a project, its weaknesses and critical aspects, is sometimes very limited and prevents us from going beyond the manufacturer's scope of work. Therefore, questions about the selection of a type of instrument(s), the required quantity or the expected measuring ranges (among others) should be directed to project designers and not to manufacturers.

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Bruce Ripley, RST Instruments Ltd

Human factors in engineering are about the quality of communication within a project team, to draw on and utilize the deep knowledge and experience of all the specialists required for project success. On a large infrastructure, mining, energy or water project, the number of specialists required can be large, and therefore the number of relationships to be managed is large and complex. Instrumentation is just one of many speciality relationships to be managed by the owner/designer/contractor.

Most often, only the instrumentation supplier and the instrumentation installer eat, sleep and breathe instrumentation, and therefore accumulate the deep instrumentation knowledge and experience that can benefit the project. Owners, designers and contractors can access this knowledge and experience by engaging instrumentation suppliers and installers early in the project development phase to explore options to meet the instrumentation objectives and to finalize the instrumentation requirements.

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Giovanni Caloni and Daniel Naterop, SISGEO SRL

When we talk about the relation between designers and instrument manufacturers, the link should be really close. And in this close relation the "human factor" plays a key role.

Designers know very well the geotechnical problems in their projects, but they do not know enough about instruments and technologies available, to monitor if their assumptions will be confirmed during construction.

We often see drawings and specifications of projects where the monitoring solutions are clearly wrong or, maybe worse, they are a "copy and paste" from other previous projects: it means that, for some designers, the monitoring programme has a very low importance.

SISGEO helps a large number of designers to plan a good monitoring programme: sometimes we were asked to do it for free (in most cases) and sometimes we receive a fee for our technical consulting.

Designers calling the manufacturers in order to have suggestions on the instruments is indicative that the designer takes care about the monitoring system. This will help them during construction time, with the aim of checking and, if needed, changing the designing solutions in nearly real-time.

Maybe the right behaviour from designers' part would be to call the manufacturer not just when needed, but to keep a continuous relation in order to be constantly updated on the available technologies and solutions.

If the manufacturer considers itself only a "manufacturer" and thinks that its job is limited to receiving quotation requests and selling instruments, this could lead to a great misunderstanding. This is why SISGEO staff are always collaborating with designers and with final users.

All the parts involved into this process must have clearly in mind their final target and their mutual relationship. Manufacturers can help designers, giving them suggestions on the available instruments, but the final decision on the monitoring solution to be adopted must be up to the designers who have full knowledge about the geological conditions and the features of the structures under construction.

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Closure

John Dunnicliff

Some manufacturers indicate that their role is limited to supply of instruments. Others believe that they have a larger role to play. So my "hope that we'd be able to agree on how to chart a way forward with these issues" was clearly unrealistic. We're all entitled to our opinions!

If any reader wishes to send me a discussion about ANY issues relating to the important topic of human factors, that would be welcome, and I'll publish them in later episodes of GIN. Send them to me at *john@dunnicliff.eclipse.co.uk*. Included in this invitation are all the manufacturers who I invited earlier: those who opted out and those who would like to say more after reading what their competitors had to say. My deadline for receiving more discussions is **July 10** this year. If you send me a discussion, please follow the above format. If you prefer to write a stand-alone article, please follow "How to Submit Articles to John Dunnicliff for GIN" in *www.geotechnicalnews.com/instrumentation_news.php*.

Dam geohazards

Richard Guthrie, Editor

If you were watching the news recently you may have seen failure of an earthen dam in Solai, Kenya, where, as of this time of writing 38 persons are confirmed dead and thousands are displaced as floods and mudflows swept away villages in their path.

Dams form a special class of geohazards as many are man-made and designed to specifically provide a benefit to humans. The 2014 Mount Polley failure reminded us of some of the hazards associated with dams, and it behooves us to consider the global record of major dam failures (Table 1) and the seriousness of the hazard.

So, what are Canadians doing to reduce that hazard in our own backyard? Chad LePoudre is the Vice President of Geoscience and Materials at SNC-Lavalin, and the President of the Canadian Dam Association (CDA) since October 2016 and provides this quarter's article on recent work by the Mining Dams Committee of the CDA.)

Call for project descriptions

Geohazards is interested in featuring projects that you've been researching, investigating, or implementing, around the world in 2017/2018. Specifically, we are looking to feature the breadth and depth of Canadian geotechnical expertise and input to Geohazard challenges elsewhere in the world. Please submit a good quality photograph and a project description to *Richard.guthrie@stantec.com* by June 21, 2018.

Table 1. A global list of known major dam failures[1].

Dam/incident	Year	Location	Fatalities	Details[2]
Marib Dam	575	Sheba, Yemen		Unknown
Pantano de Puentes	1802	Lorca, Spain	608	1,800 houses and 40,000 trees destroyed.
Dale Dike Reservoir	1864	South Yorkshire, England, United Kingdom	244	Small leak in wall grew until dam failed.
Mill River Dam	1874	Williamsburg, Massachusetts, United States	139	600 million gallons of water were released, wiping out 4 towns and making national headlines. This dam break lead to increased regulation of dam construction.
South Fork Dam	1889	Johnstown, Pennsylvania, United States	2,209	Blamed locally on poor maintenance by owners; court deemed it an "Act of God". Followed exceptionally heavy rainfall. Caused Johnstown flood.
McDonald Dam	1900	Texas, United States	0	Extreme current caused failure.
Hauser Dam	1908	Helena, Montana, United States	0	Heavy flooding coupled with poor foundation quality.
Austin Dam	1911	Austin, Pennsylvania, United States	78	Poor design, use of dynamite to remedy structural problems.
Desná Dam	1916	Desná, Austria-Hungary (now Czech Republic)	62	Construction flaws caused the dam failure.

Dam/incident	Year	Location	Fatalities	Details[2]
Lake Toxaway Dam	1916	Transylvania County, North Carolina	0	Heavy rains caused the dam to give way. Dam was later rebuilt in the 1960s.
Sweetwater Dam	1916	San Diego County, California	0	Over-topped from flooding.
Lower Otay Dam	1916	San Diego County, California	14	Over-topped from flooding.
Gleno Dam	1923	Province of Bergamo, Italy	356	Poor construction and design.
Llyn Eigiau dam and the outflow also destroyed Coedty reservoir dam.	1925	Dolgarrog, North Wales, UK	17	Contractor blamed cost-cutting in construction but 25” of rain had fallen in preceding 5 days. This was the last dam failure to cause death in the UK to date (2018).
St. Francis Dam	1928	Santa Clarita, California, Los Angeles County, United States	600	Geological instability of canyon wall combined with human error that assessed developing cracks as “normal” for a dam of that type.
Secondary Dam of Sella Zerbino	1935	Molare, Province of Alessandria, Italy	111	Geological unstable base combined with flood.
Nanty Gro Reservoir in Wales	1942	Nanty Gro Valley, Wales	0	Destroyed during preparation for Operation Chastise in World War II.
Eder, Möhne Dams	1943	Eder Valley, Ruhr, Germany	70	Destroyed by bombing during Operation Chastise in World War II.
Vega de Tera	1959	Ribadelago, Spain	144	
Malpasset	1959	Côte d’Azur, France	423	Geological fault possibly enhanced by explosives work during construction.
Panshet Dam	1961	Pune, India	~1,000	Dam wall burst due to precipitation.
Baldwin Hills Reservoir	1963	Los Angeles, California, United States	5	Subsidence caused by over-exploitation of local oil field.
Spaulding Pond Dam(Mohegan Park)	1963	Norwich, Connecticut, United States	6	More than $6 million estimated damages.
Vajont Dam	1963	Italy	2,000	Strictly not a dam failure, since the dam structure did not collapse and is still standing. Filling the reservoir caused geological failure in valley wall, leading to 110 km/h landslide into the lake; water escaped in a seiche over the top of dam.
Mina Plakalnitsa, (Vratsa	1966	Vratsa, Bulgaria	107	A tailings dam at Plakalnitsa copper mine near the city of Vratsa failed. A total 450,000 cubic meters of mud and water inundated Vratsa and the nearby village of Zgorigrad, which suffered widespread damage. The official death toll is 107, but the unofficial estimate is around 500 killed.

Dam/incident	Year	Location	Fatalities	Details[2]
Certej dam failure	1971	Certej Mine, Romania	89	A tailings dam collapsed, flooding Certeju de Sus with toxic tailings.
Buffalo Creek Flood	1972	West Virginia, United States	125	Coal tailings collapsed during high precipitation.
Canyon Lake Dam	1972	South Dakota, United States	238	Flooding, dam outlets flooded with debris.
Banqiao and Shimantan Dams	1975	China	171,000	Extreme rainfall beyond the planned design capability of the dam. Worst dam failure.
Teton Dam	1976	Idaho, United States	11	Water leakage through earthen wall, leading to dam failure.
Laurel Run Dam	1977	Johnstown, Pennsylvania, United States	40	Heavy rainfall and flooding that over-topped the dam.
Kelly Barnes Dam	1977	Georgia, United States	39	Unknown; dam was raised several times by owners to improve power generation.
Machchu-2 Dam	1979	Morbi, Gujarat, India	1,800-25,000	Heavy rain and flooding beyond spillway capacity.
Wadi Qattara Dam	1979	Benghazi, Libya	0	Flooding beyond discharge and storage capacity damaged the main dam and destroyed the secondary dam in the scheme.
Lawn Lake Dam	1982	Rocky Mountain National Park, United States	3	Outlet pipe erosion; dam under-maintained due to location.
Tous Dam	1982	Valencia, Spain	30-40	
Val di Stava dam	1985	Italy	268	Poor maintenance and low margin for error in design; outlet pipes failed leading to pressure on dam.
Upriver Dam	1986	Washington State, United States	0	Lightning struck power system, turbines shut down. Water rose behind dam while trying to restart. Backup power systems failed, could not raise spillway gates in time. Dam overtopped (rebuilt).
Perućа Dam detonation	1993	Croatia	0	Not strictly a dam failure as there was a detonation of pre-positioned explosives by retreating Serb Forces.
Saguenay Flood	1996	Quebec, Canada	10	Problems started after two weeks of constant rain, which severely engorged soils, rivers and reservoirs. Post-flood enquiries discovered that the network of dikes and dams protecting the city was poorly maintained.
Meadow Pond Dam	1996	New Hampshire, United States	1	Design and construction deficiencies resulted in failure in heavy icing conditions.
Opuha Dam	1997	New Zealand	0	Heavy rain during construction caused failure, dam was later completed.

Dam/incident	Year	Location	Fatalities	Details[2]
Aznalcollar Mine Tailings Dam	25 April 1998	Spain	0	Over-steepened dam failed by sliding on weak clay foundation, releasing 4–5 million cubic metres of acidic mine tailings into the River Agrio, a tributary of the River Guadiamar, and the main water source for the Doñana National Park, a UNESCO World Heritage Site.
Vodní nádrž Soběnov	2002	Soběnov, Czech Republic		Extreme rainfall during the 2002 European floods.
Zeyzoun Dam	2002	Zeyzoun, Syria	22	Failed 4 June 2002 affecting 10,000.
Ringdijk Groot-Mijdrecht(nl)	2003	Wilnis, Netherlands		Peat dam became lighter than water during droughts and floated away.
Hope Mills Dam	2003	North Carolina, United States	0	Heavy rains caused earthen dam and bank to wash away.
Big Bay Dam	2004	Mississippi, United States	0	A small hole in the dam grew and eventually led to failure.
Camará Dam	June 17, 2004	Paraiba, Brazil	3	Poor maintenance. 3,000 people homeless. A second failure happened 11 days after.
Shakidor Dam	2005	Pakistan	70	Sudden and extreme flooding caused by severe rain.
Taum Sauk reservoir	2005	Lesterville, Missouri, United States	0	Computer/operator error; gauges intended to mark dam full were not respected; dam continued to fill. Minor leakages had also weakened the wall through piping.
Campos Novos Dam	2006	Campos Novos, Brazil	0	Tunnel collapse.
Gusau Dam	2006	Gusau, Nigeria	40	Heavy flooding.
Ka Loko Dam	2006	Kauai, Hawaii	7	Heavy rain and flooding.
Lake Delton	9 June 2008	Lake Delton, Wisconsin	0	Failure due to June 2008 Midwest floods.
Koshi Barrage	2008	Kusha, Nepal	250	Heavy rain. The flood affected over 2.3 million people in the northern part of Bihar.
Algodões Dam	27 May 2009	Cocal, Piaui, Brazil	7	Heavy rain. 80 people injured, 2,000 homeless.
Sayano–Shushenskaya Dam	17 August 2009	Sayanogorsk, Russia	75	Collapses when turbine 2 broke apart, flooding the turbine hall and causing the ceiling to collapse.
Situ Gintung Dam	2009	Tangerang, Indonesia	98	Poor maintenance and heavy rain.
Kyzyl-Agash Dam	2010	Kazakhstan	43	Heavy rain and snowmelt.
Hope Mills Dam	2010	North Carolina, United States	0	Sinkhole caused dam failure.
Delhi Dam	July 24, 2010	Iowa, United States	0	Heavy rain, flooding.
Niedow Dam	August 7, 2010	Lower Silesian Voivodeship, Poland		Heavy rain, over-topped from flooding.

Dam/incident	Year	Location	Fatalities	Details[2]
Ajka alumina plant accident	October 4, 2010	Hungary	10	Failure of concrete impound wall on alumina plant tailings dam.
Kenmare Resource tailings dam	October 8, 2010	Mozambique	0	Failure of tailings dam at titanium mine.
Fujinuma Dam	March 11, 2011	Japan	8	Failed after 2011 Tōhoku earthquake. 7 dead and 1 unknown.
Campos dos Goytacazes Dam, Brazil	January 4, 2012	Rio de Janeiro State, Brazil		Failed after a period of flooding. 4000 people displaced.
Ivanovo Dam	February 6, 2012	Biser, Bulgaria	8	Failed after a period of heavy snowmelt. Eight people killed and several communities flooded.
Köprü Dam	February 24, 2012	Adana Province, Turkey	10	A gate in the diversion tunnel broke after a period of heavy rain during the reservoir's first filing. The accident killed ten workers.
Dakrong 3 Dam	October 07, 2012	Quảng Trị Province, Vietnam	0	Poor design, Typhoon Gaemi flood surge.
Tokwe Mukorsi Dam	February 04, 2014	Masvingo Province, Zimbabwe	0	(296 ft) tall embankment dam. Residents evacuated upstream.
Mount Polley tailings dam failure	August 04, 2014	British Columbia, Canada	0	Tailings dam collapse; reservoir was overfilled beyond design parameters.
Germano mine tailings dams	November 05, 2015	Mariana, Minas Gerais, Brazil	24	Tailings dam collapse. One village destroyed, 600 people evacuated, 19 missing. Sixty-million cubic meters of iron waste sludge polluted Doce River, and the sea near the river's mouth.
Patel Dam	May 10, 2018	Solai, Kenya	38	Failed after several days of heavy rain. Dozens of people remain missing. 223,000 people displaced.

7th Canadian Geohazards Conference – Geohazards 7: Engineering Resiliency in a Changing Climate

http://www.geohazards7.ca/

Geohazards 7 is right around the corner! Papers have been selected and reviewed, and the conference is shaping up to be outstanding! It will 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.

If you don't already have tickets, it's not too late – but get on it!

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 next time,

Rick

[1] Modified from the World Heritage Encyclopedia 2012, Gutenberg Self-Publishing Press, accessed May 10, 2018 at *http://self.gutenberg.org/articles/list_of_dam_failures* and a Wikipedia article on Dam Failure, accessed May 10, 2018 at *https://en.wikipedia.org/wiki/Dam_failure*.

[2] Interpretations are not those of Geotechnical News. Some interpretations that were clearly speculative or judgmental in nature were removed from the source. Additional information is easily found on most of the examples herein.

A slope stability analysis working group, CDA

D. Chad LePoudre, P.Eng

A working group was formed in 2017 within the Mining Dams Committee (MDC) of the Canadian Dam Association (CDA) to advance the state of knowledge with respect to slope stability analyses for mining dams. The group coordinated and offered a workshop at the CDA annual conference in Kelowna, British Columbia on October 14, 2017. Approximately professionals. Further, several of the working group members had recently witnessed examples of slope stability analyses that was not always performed adequately, further emphasizing the need for knowledge sharing. The working group was comprised of select members of the MDC, from various consultants and owners, as listed in the table below.

Name	Company	Position
Andy Small, Chair	Amec Foster Wheeler	Principal Geotechnical Engineer
Michael Cyr	Amec Foster Wheeler	Senior Geotechnical Engineer
Shiu Kam	Golder Associates	Principal Geotechnical Engineer
Chad LePoudre	SNC-Lavalin	Principal and Vice President
Mohammad Al-Mamun	SNC-Lavalin	Senior Geotechnical Engineer
Scott Martens	Canadian Natural	Manager, Geotechnical/Geology, Albian Sands
Todd Martin	Anglo American	Lead Engineer - Mineral Residue Facilities
Mauricio Pinheiro	Thurber	Geotechnical Engineer

40 people attended the workshop, with many recognized tailings experts among the attendees. Following its success, MDC recognized that a series of similar events should be held each year at the annual conference. Further, while labelled as a workshop, there were many opportunities for discussion with the audience and at times the atmosphere more closely resembled a forum.

There were several underlying motivations to form the working group, including the continued development of new CDA guidance regarding factor of safety (in progress), as well as ensuring distribution of lessons learned from the established failure modes of recent tailings dam failures around the world amongst Canadian

Context of the workshop

Stability analysis of mining dams is one of the core aspects of an overall Dam Safety Management System, particularly where tailings dams are increasing in height over time. The purpose of the stability analysis is to determine whether the dam will remain safe during normal conditions and, more importantly, during an unusual loading event or change in conditions. The stability analyses are conducted using available supporting information, such as surveillance and monitoring of instrumentation, drilling programs, laboratory testing, as well as the application of seepage, deformation, and stress modelling. The focus of the workshop was to present selected topics to improve industry consistency. Those topics were:

- The criteria for application of undrained shear strength for contractive soils, where drained shear strength parameters may be incorrectly applied assuming there is no trigger for an undrained event;
- Limit Equilibrium Method vs. stress-deformation analysis;
- Parameter selection;
- Target geotechnical criteria, such as Factor of Safety (FOS);
- Triggers to be considered;
- Consequences; and,
- Slope stability modeling (carried over to the 2018 workshop).

The various topics were divided among the working group and separate presentations were delivered, with time for discussion among the attendees. One of the key areas that caused some difficulty for the working group was the use of inconsistent terminology between practitioners. Therefore, terminology was presented to the attendees near the beginning of the workshop in an attempt to gain some consistency (at least among the working group). The terminology was established for loading conditions

Loading Condition					
USA	Undrained Conditions (Undrained Stress Analysis)	DSA	Drained Conditions (Drained Stress Analysis)	PDA	Partially Drained

and representation of soil strength, as presented below.

There was some excellent discussion with the participants regarding the selected topics presented. A series of flow charts were drafted for the workshop that we hope will assist the analyst with the consideration of the various input considerations to an analysis, including:

Representation of Soil Strength					
ESA	Effective Strength Analysis with no change in pore pressures during shear. Uses stress conditions prior to shearing. OK for dilative or presheared soils.	UESA	Undrained Efective Strength Analysis - uses stress conditions prior to shearing and estimates change in pore presssures dring shear. If overconsolidated, then use ESA.	TSA	Total Strength Analysis - undrained shear strength based on effective stress prior to shearing. If overconsolidated, then use ESA. Also referred to as USA.

- Geometry of the dam / structure;
- Identifying behaviour (contractive/dilative) of the various elements of the system under a variety of conditions and credible triggers;
- Assignment of appropriate strength parameters;
- Consideration of the consequences of failure;
- Selection of appropriate target factor of safety;
- Determination whether large strains may occur, potentially necessitating post-peak analysis;

The CDA Mining Dams Committee is also in the process of revision to Section 3.5.4.1 of the *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams*, and preliminary work was presented to the attendees. That section deals with the target Factor of Safety for mining dams. The purpose of the revisions was to remove potential ambiguity regarding application of these geotechnical criteria, while maintaining that the target FOS are not to be considered rigid criteria. They are to be considered as screening level targets using standard analytical tools, which if met, are generally viewed as acceptable practice. However, if they are not met, this does not mean that there is an unsafe condition. Further analyses by the design engineer would be required to support modified targets for the factor of safety or to demonstrate if there is an unsafe condition.

Next Steps

The CDA annual conference will be held in Quebec City on October 13-18 and the second installment of this workshop will be part of the workshops on the weekend, prior to the plenary sessions. The working group has established a list of selected topics for the workshop, as follows.

- Overview of guidance;
- Summary of the paper
- Use of deformation analyses to support safety statements
- Pseudo-static analyses
- Post peak stability analyses
- Use of optimized slip surfaces
- Achieving a suitable probability of failure

We anticipate that the outcome of the workshops will be a technical paper to be presented at a future CDA conference. It is, however, also understood that entire textbooks have been devoted to the subject of slope stability analysis. Regardless, it is the desire of the working group to simply provide the practitioner with some additional resource, a forum to discuss ideas and, potentially, enhance the state of practice for mining dams. Should you have any questions or comments, or wish to participate, please do not hesitate to contact us at *miningdams@cda.ca.*

Registration for the CDA conference in Quebec is now available at *www.cda.ca.*

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Effective tailings disposal and storage design using instrumented column testing

David Williams

Introduction

The average tailings dam failure rate over the last 100 years is over 1% or over 2 per year, which is more than two orders of magnitude higher than that for water retention dams of 0.01%. Particular focus is given to tailings dam failures that occur in developed countries (e.g., Mount Polley, Canada in 2014, and Cadia, Australia in 2018), or those that involve global mining companies (e.g., Samarco, jointly owned by BHP Billiton and Vale, Brazil in 2015). These recent, high profile tailings dam failures are threatening the mining industry's financial and social licence to operate.

While tailings dams themselves are subject to detailed design, construction quality assurance and quality control, and their operation is managed and monitored, less attention is paid to designing tailings disposal and storage to best accommodate the often changing production rate and nature of the tailings. The tailings production rate and geometry of the tailings storage facility (TSF) dictate the rate of rise of the tailings, the possible cycling of deposition, the management of tailings supernatant water, the final dry density and shear strength achieved, and the ultimate closure of the facility. The climatic setting and topography of the site also impact significantly on the TSF.

Conventional tailings disposal

Impact of accounting approach

Tailings disposal and management has been based on minimising short-term capital and operating costs, with future operating and rehabilitation costs reduced by a high discount factor (typically 10%, several times higher than the inflation rate, and hence difficult to justify) in a net present value accounting approach. This has led to the widespread adoption of surface TSFs to store tailings slurry, which are delivered by robust and relatively inexpensive centrifugal pumps and pipelines to small storages raised incrementally. In turn, this leads to soft and wet tailings deposits, TSFs that primarily store entrained and supernatant water, and rehabilitation difficulties.

Impact of climate and topography

In a dry climate or during extended dry seasons, advantage can be taken of the desiccation of the tailings by solar and wind-induced evaporation of moisture from the tailings surface. Desiccation results in an increase in the dry density of the tailings, and hence a reduced stored volume, and to an increase in their shear strength. However, desiccation takes place to only limited depth and decreases exponentially with depth below the surface. Hence, to maximise the effectiveness of desiccation in dewatering, densifying, and strengthening the tailings, the tailings should be deposited in layers of limited thickness, supernatant water should be efficiently removed to expose the tailings surface, and the tailings deposition cycled to allow sufficient time for desiccation. In a wet climate, exposure and desiccation of the tailings surface may not be possible, and it is more important to maximise dewatering in the plant. Sulfidic tailings may need to be maintained underwater to limit their oxidation.

Desiccation in a dry climate is enhanced by a surface TSF with a large footprint, which is likely in a topographic setting of low relief, such as in Australia. In a wet climate, a large tailings footprint will result in large rainfall runoff being captured. In a flat topography, a dam will be required around the entire perimeter of the TSF, and the cost of raising the dam will become prohibitive at relatively low heights, requiring that a new or extended storage be constructed. At sites with high topographic relief, such as in the Andes, a high dam of limited length will be sufficient and a small TSF footprint will result. This increases the rate of rise of the tailings, and makes exposure and desiccation of the tailings difficult, limiting their dewatering, densification and strengthening. In a wet climate, rainfall incident on a small TSF footprint will be limited, although clean runoff from the reporting catchment may be large and would need to be diverted around the TSF.

Tailings disposal and storage design

Effective tailings disposal and storage design should take account of the climatic and topographic settings of the site, the tailings production rate and how this may be expected to vary over the mine life, the nature of the tailings particularly their clay mineral content and type, the initial solids concentration of the tailings on disposal, and the behaviour of the tailings on deposition. The extent of consolidation of the tailings will depend on the rate of rise and nature of the tailings, and will also be affected by the geometry of the TSF. The climate will dictate the potential for desiccation of the tailings, with the geometry of the tailings dam and storage facility also influencing desiccation. The extent of desiccation of the tailings will depend on the clay mineral content and type, and the related initial solids concentration of the tailings, the deposited layer thickness, and the cycle time between layers. The settling from a slurry state, self-weight consolidation and desiccation of a particular tailings can inform effective tailings disposal and storage design.

Instrumented column testing of tailings

The results of instrumented column testing of the settling, self-weight consolidation and desiccation of a particular tailings can be used to optimise tailings deposition layer thickness and cycle time, and hence the TSF footprint for a given tailings production and type.

Description of instrumented column

The column developed at The University of Queensland (UQ) is manufactured from readily available 200 mm diameter Perspex or PVC tubing. The height of the column is 1.2 m, comprising two or three sections to facilitate filling and dismantling of the column, and with an additional section or sections used to contain the tailings placed as a slurry. The column may be cost-effectively instrumented down its height with up to 10 of each of moisture, matric suction, temperature and salinity sensors manufactured at UQ, together with base load cells to record the water balance, and a data logger with open-source software that downloads data via the internet. The developed sensors are shown in Figure 1.

Tailings tested

The tailings tested were iron ore sand tailings and slimes. The sand tailings comprised about 50% fine to medium-grained sand-sized particles, 48% silt-sized particles and 2% clay-sized particles, classifying them as a Silty SAND. The slimes comprised about 75% silt-sized particles and 25% clay-sized particles, with a Liquid Limit of 28.1%, a Plastic Limit of 13.5%, a Plasticity Index of 14.6%, and a Linear Shrinkage of 5.0%, classifying them as a Clayey SILT of low plasticity (ML). The specific gravity of the sand tailings is 2.85 and that of the slimes is 3.86. Both slurries have a pH of about 7.6, and an electrical conductivity of about 500 μS/cm.

The sand tailings and slimes are discharged at solids concentrations of 40% and 25% by mass, respectively. On settling in a 1,000 cc measuring cylinder the sand tailings and slimes achieved 71% (gravimetric moisture content of 40% and dry density of 1.33 t/m^3) and 60% solids by mass (gravimetric moisture content of 65% and dry density of 1.10 t/m^3), almost instantaneously and in about 24 hours, respectively.

Sample preparation

The column samples were prepared at their initial solids concentrations and added in 24 layers to separate instrumented columns (two for the sand tailings and two for the slimes) at a high rate of rise equivalent to 16 m/year. Each layer was left to settle and consolidate for 24 hours before the subsequent layer of slurry was placed. Two of the columns, one filled with sand tailings and the other slimes, were tested in the laboratory, with desiccation simulated using a 375 watt infrared lamp mounted above the top of the column. The other two columns were tested on a rooftop at UQ and exposed to ambient weather conditions that were monitored using a weather station.

Laboratory column results

The laboratory columns have been run for over 120 days, and the results are shown for the sand tailings and slimes in Figures 2a and 2b, respectively. For the sand tailings, three desiccation stages are evident from the evaporation rates in Figure 2a, and no cracking was observed. An initial constant evaporation rate of about 4.7 mm/day lasted for about 10 days. The evaporation rate decreased from days 10 to 70, and the last stage beyond day 70 showed a roughly constant evaporation rate of about 0.3 mm/day. Matric suctions developed in the sand

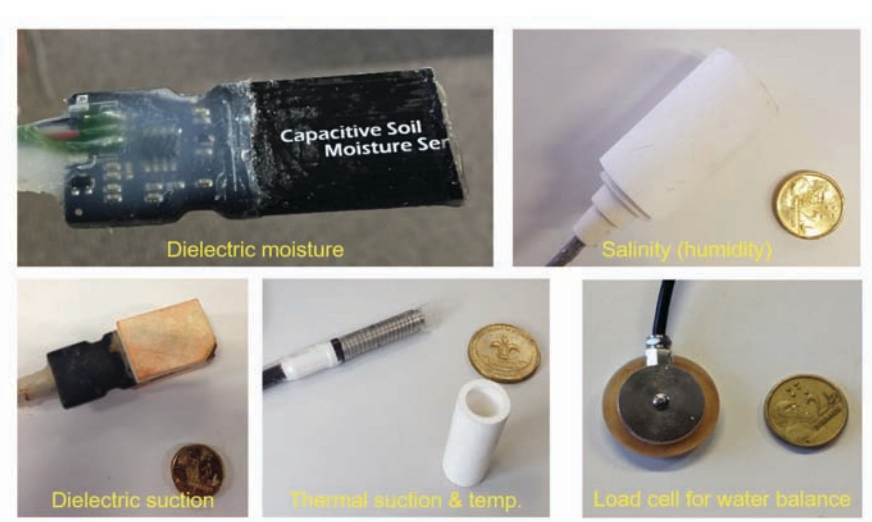

Figure 1. Sensors developed and manufactured at UQ from instrumented column.

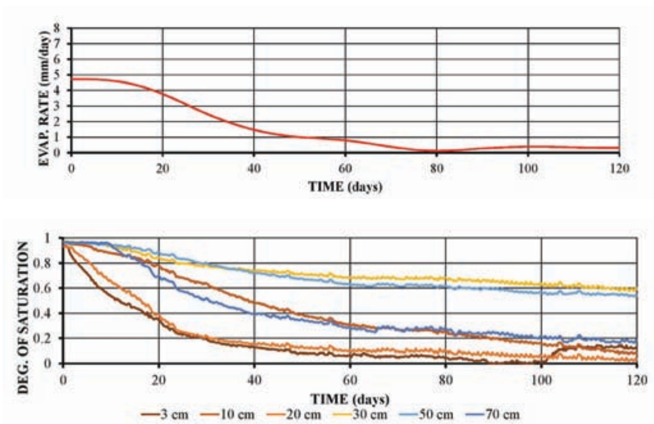

Figure 2a. Laboratory sand tailings column.

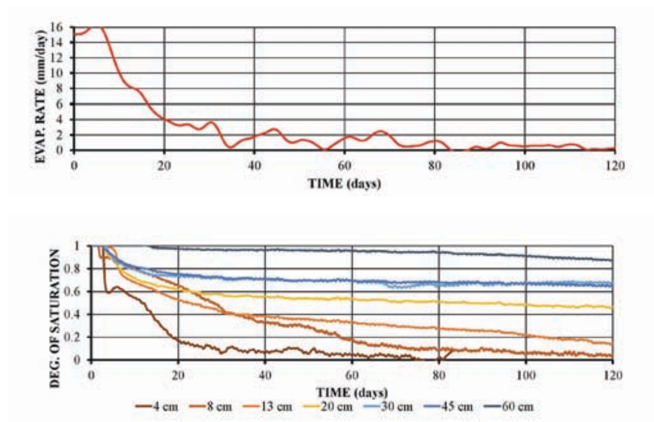

Figure 2b. Laboratory slimes column.

tailings were limited, apart from very high values measured at 3 cm depth. After 120 days of desiccation, the top 30 cm of the sand tailings was dry, and some desaturation had reached a depth of 70 cm. Cumulative water loss was about 18 cm, indicating an average gravimetric moisture content for the desaturated upper 70 cm layer of 22.0%. Accompanying desiccation, the surface of the sand tailings shrunk 9.5 cm, indicating an average dry density for the desaturated layer of 1.67 t/m^3.

For the slimes, three desiccation stages are also evident from the evaporation rates in Figure 2b. An initially very high evaporation rate of about 16 mm/day lasted for about 5 days, until the surface started to crack and the slimes underwent significant shrinkage. The evaporation rate decreased rapidly from days 5 to 70, and beyond day 70 was near-zero. Matric suctions were measured in the slimes to 60 cm depth. After 120 days of desiccation, the top 13 cm of the slimes was dry, and some desaturation had reached a depth of 60 cm. Cumulative water loss was about 35 cm, indicating an average gravimetric moisture content for the desaturated upper 60 cm layer of 30.5%. Accompanying desiccation, the surface of the slimes shrunk 15 cm, indicating an average dry density for the desaturated upper layer of 2.25 t/m^3.

Rooftop column results

The rooftop columns have been run for 45 days, and the results are shown for the sand tailings and slimes in Figures 3a and 3b, respectively. The potential evaporation rates showed daily fluctuations of up to 8 mm/day during daylight hours (with maximum ambient temperatures reaching 30^{o}C) and dropping to zero during the night due to condensation. For the sand tailings, desiccation started at day 11 when the surface water had evaporated, was largely limited to the upper 6 cm, and was initially most pronounced at 1 cm depth. Rainfall events occurred at days 40 (about 40 mm) and 44 (minor rainfall), which wet up the desiccated surficial sand tailings. Matric suctions in the sand tailings were negligible. After 40 days of desiccation, only the top 1 cm of the sand tailings was dry, and some desaturation had reached a depth of only 6 cm. Cumulative water loss was negligible, since drying was limited to very shallow depth. Accompanying desiccation, the surface of the sand tailings shrunk only 2.75 cm, indicating an average dry density for the desaturated upper layer of 2.50 t/m^3.

For the slimes, desiccation was largely limited to the upper 30 cm, and was initially most pronounced at 1 cm depth. The rainfall event at day 40 wet up the desiccated slimes to a depth of 30 cm. Matric suctions in the slimes corresponded to the daily fluctuations in evaporation rate and saturation, and rainfall events, and reached 60 cm depth. After 40 days of desiccation, the top 30 cm of the slimes was dry, and some desaturation reached a depth of 60 cm. Cumulative water loss was about 15 cm, indicating an average gravimetric moisture content for the desaturated upper layer of 50.0%. Accompanying desiccation, the surface of the slimes shrunk 14 cm, indicating an average dry density for the desaturated upper layer of 2.18 t/m^3.

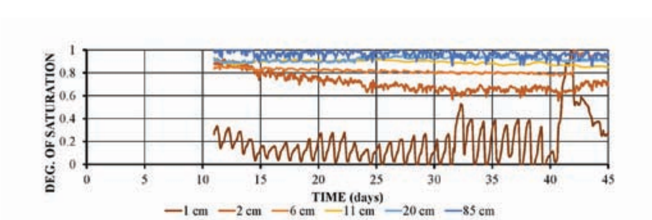

Figure 3a. Rooftop sand tailings column.

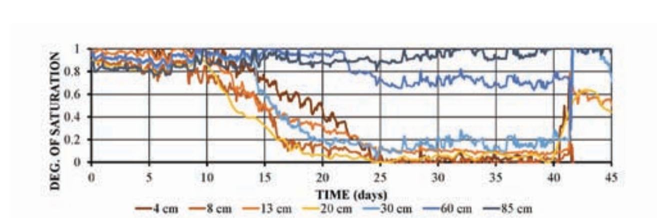

Figure 3b. Rooftop slimes column.

Conclusions

The settling, self-weight consolidation and desiccation of tailings can be monitored in an instrumented column, under both laboratory simulated desiccation and exposure to the weather. Under laboratory simulated desiccation, the sand tailings and slimes tested became dry to 30 cm and 13 cm depth, respectively, and experienced some desaturation to 70 cm and 60 cm depth, respectively. However, the slimes lost about twice as much water and shrunk about twice as much as the sand tailings, increasing the dry density of the desaturated upper slimes to 2.25 t/m^3, compared with an increase to only 1.67 t/m^3 for the sand tailings.

Under exposure to the weather, the sand tailings and slimes became dry to 6 cm and 13 cm depth, respectively, and experienced some desaturation to only 6 cm, and 60 cm depth, respectively. The desaturated upper sand tailings and that of the slimes increased in dry density to 2.50 t/m^3 and 2.18 t/m^3, respectively. Hence, for the slimes tested, laboratory simulated desiccation gave similar results to desiccation on exposure to the weather. However, exposure to the weather appears to have sealed off the surface of the sand tailings, limiting the depth of desiccation to only about 6 cm.

For the slimes tested, desiccation occurs to a depth of about 60 cm, indicating this as the appropriate deposition layer thickness to take maximum advantage of desiccation, and the time required for desiccation is about 1 month under hot, high evaporation conditions (with about twice that time required under laboratory simulated desiccation). For sand tailings, desiccation to only limited depth or extent will occur, and desiccation will be relatively ineffective as a means of dewatering, densifying and strengthening the sand tailings.

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Geo meshing – Free FLAC3D® meshing tool

Alfredo Arenas

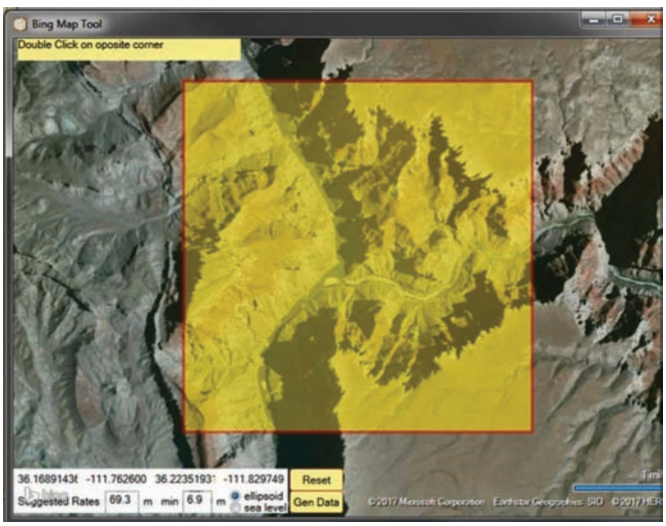

Figure 1. Bing Map® tool built in Geo Meshing.

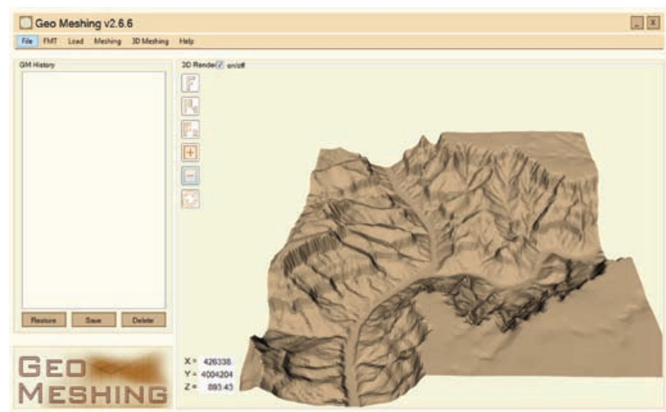

Figure 2. Imported surface in Geo Meshing

Introduction

It has been over five years since the publication of "New Meshing Algorithm" in GN magazine (Setptember 2012). At that time, the meshing algorithm was a set of C++ programs, which allowed creation of complex meshes, ranging from topographic shapes to staged earth-fill or excavations.

These set of programs evolved in a complete package solution, still very easy to use, but most importantly, the programs now have graphical interface and are freely available to public. In addition, it has been improved with many features, such as parametric mesh generation; graphical input coordinates, mesh refinement, Kriging interpolations, Bing® Maps topographic resource and parallel processing.

The original article describes the basis and the technique for creating the mesh. The article defines the base 2D arrangement mesh for creating a simple surface, then moves onto the type of element used in the algorithm, and finally covers how elements are connected and oriented.

Although Geo Meshing was specifically tailored to be used for FLAC3D®, it can still be used with any other numerical program, as long as they use node definition and element connectivity.

The following shows three real project examples, were Geo Meshing has successfully been used for accomplishing the hard task of meshing the problem.

Geo Meshing – 3D meshing software

At Geo Meshing core, one can still find the collection of C++ programs, but now they are hidden from the user and they are called from the main window. In addition to C++, C# and WPF programming languages are used. C# was used to manage all window interfaces, while WPF was used for displaying advance graphical shapes and mouse input.

At the moment of writing this article, version 2.6.6 is freely available from its website (www.geomeshing.com). It needs a license that can be also freely acquired from its website.

Meshing examples

Creating a Topography from Bing Maps® Services

Figure 1 shows the Bing Map® tool used for navigate the Earth surface and select an area in any place on the planet. In this figure an area around the Grand Canyon has been selected (yellow highlighted square), by just double clicking on the map displayed on the screen. Once the user has sub-

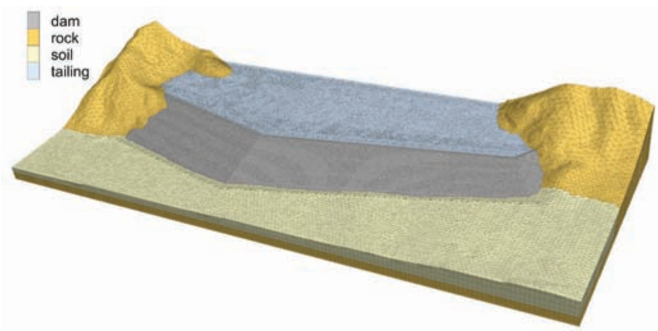

Figure 3. Full 3D Sand Dam model.

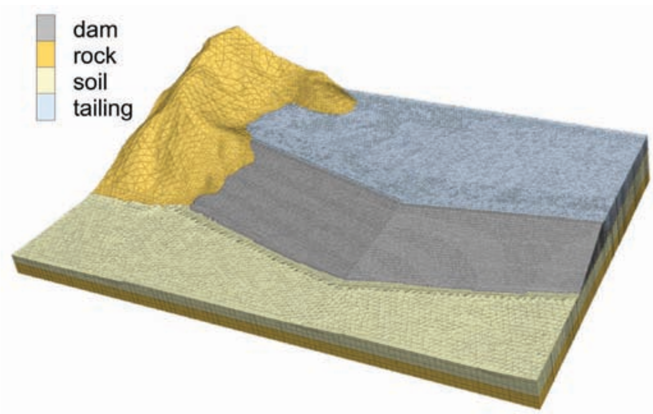

Figure 4. 3D Sand Dam model – cut plane.

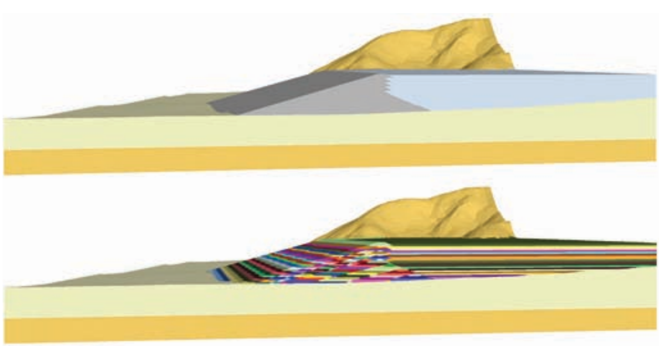

Figure 5. 3D Sand Dam – cut plane with 3D background.

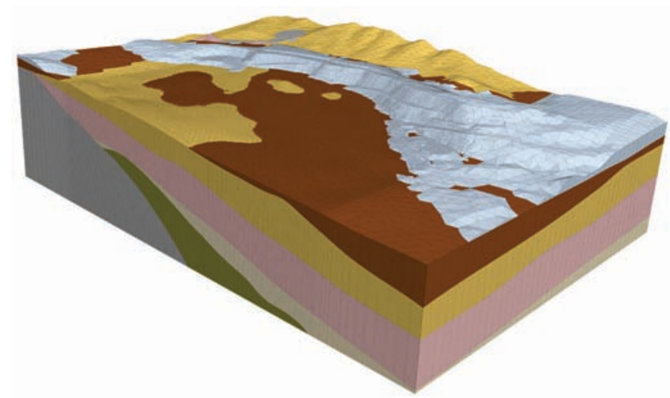

Figure 6. Full 3D model – geological units.

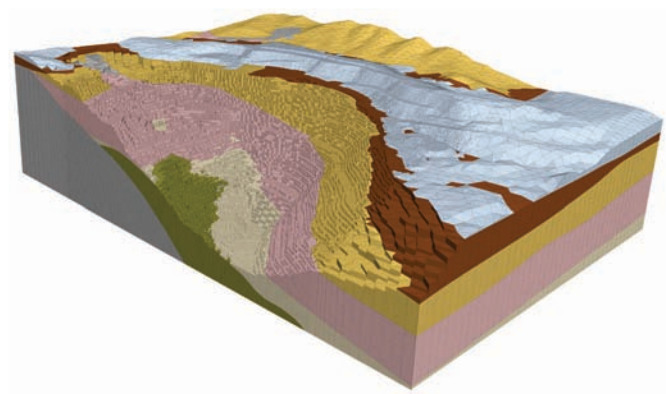

Figure 7. Full 3D model - geological units showing pit.

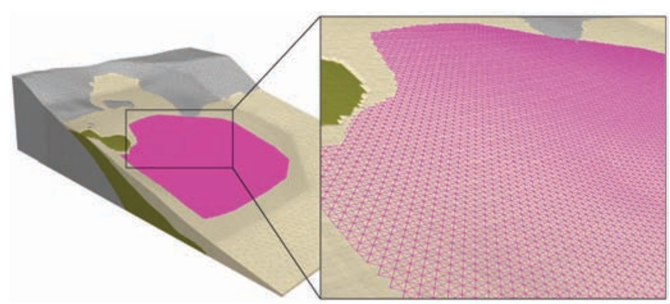

Figure 8. 3D interface.

mitted the request, Geo Meshing connects with the Bing Map® server and downloads the surface topographic data. Depending on the location on the planet, the downloaded information can be very precise and up to date or vice versa.

After the data has been downloaded, Geo Meshing process the information and it can create surfaces and 3D meshes out of it. The surface will be shown in Geo Meshing graphic window, as shown in Figure 2. Then the 3D mesh can be imported into FLAC3D®.

3D Sand Dam model

Figure 3 shows a full 3D model of a sand dam. The mesh complexity of this model lies in the dam geometry, which is compromised by three alignments along its crest and the change in construction technique. This last one, refers to changing from downstream construction to center-line construction (Figure 5). Another additional complexity is the mesh refinement, needed to obtain enough details at the dam, but coarse enough away from the dam, to avoid overloading the model with excessive elements. The refinement for this model was performed in two ways, one in the horizontal direction (as shown in Figure 3) and one in the elevation direction.

Figure 4 shows the localization of a cut plane within the 3D sand dam model, and Figure 5, in the upper portion of it, shows the cut plane with some background from the 3D model.

As observed in Figure 5, Geo Meshing allows not only grouping the elements by material type (upper image), but also by construction sequence (lower image). The lower image of Figure 5, shows how Geo Meshing has assigned a different name (and therefore a different color) to each of the construction lifts, for each stage. This process is automatically done by Geo Meshing while creating the 3D mesh. For this specific model, it was done for the sand dam and for the stored material, thus dam construction sequence and filling of the impoundment was sequentially simulated.

The model has about 850,000 elements, with enough detail for getting accurate response, but at the same time, with a reasonable size for running it dynamically in reasonable times.

Open Pit model

Figure 6 shows a 3D model of a topography, before any excavation has been simulated in the model. In this image, the most relevant geological units are displayed. In addition to the geological units, the model shows the mesh refinement performed using Geo Meshing. Figure 7 shows the same model, but at the excavation final stage. This image shows how the refined mesh zone is capable of reproducing complex shapes within the pit.

The most challenging part of making this model is the incorporation of an interface, as shown in Figure 8. An interface is a special spring element that allows continuum models to be locally discontinuous, thus creating mesh separation or mesh relative displacement. The interface in this model is a non – planar surface, so it is hard to comply the mesh with the interface at each gridpoint and node. Geo Meshing has special features that facilitates the interface creation for non – planar surfaces. It generates a code that can be called from FLAC3D® environment. In addition, Geo Meshing allows the user to graphically select the area where the interface will be applied, without the need to extend it to the whole model domain, and therefore, reducing unnecessary number of interface nodes and elements (Figure 8).

Closure

Geo Meshing has evolved significantly since it was first introduced as a set of C++ programs. Now it is a self-contained software capable of performing very complex tasks, in a friendly environment.

The above shows just three examples of what can be done with Geo Meshing, but many more projects have been developed with Geo Meshing. In fact, over 100 licenses has been distributed so far, with users around the globe. Some of them have reported successful use of Geo Meshing, becoming a key tool in their steps for performing 3D numerical analysis.

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A new monitoring system - CSattAR

Mehdi Alhaddad

CSattAR is a photogrammetric monitoring system that I developed during my PhD research at the Cambridge Centre for Smart Infrastructure and Construction (CSIC). Part of my research was to investigate the behaviour of exiting cast-iron tunnels when they are subjected to external forces. This included monitoring some extremely difficult-to-measure deformations that were not readily measurable when using conventional techniques (I'll show some examples later). I also needed to monitor significantly larger number of points than was conventionally practical.

This led me to invest in developing a new technique that needed to be affordable with a research budget but yet be able to monitor the deformation of every ring that was influenced by construction activities nearby 'precisely' and 'accurately'. That led to the creation of CSattAR. I installed the system in several tunnel environments and then spent some time developing the system to work above ground (e.g. monitor listed buildings). The system is now able to operate outdoors as well as indoors.

Fundamentals of the system

'Photogrammetric' is a mouth filling word but it simply means using images to extract information and for monitoring practices it means extracting 'deformation' and 'displacement' measurements. 'Displacement' here refers to absolute movement of a single point with reference to the origin of a coordinate system while 'deformation' means the relative movement between two or more points within a structural unit (e.g. a masonry wall, a tunnel ring, or a group of tunnel rings).

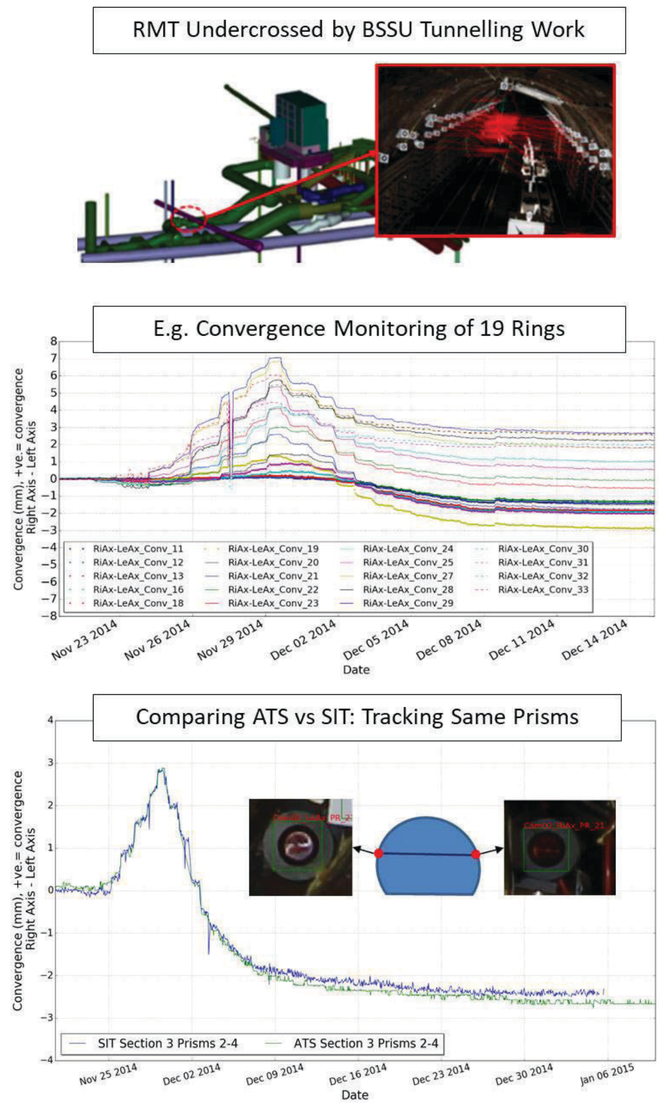

Figure 1. Monitoring convergence of Every Ring at Royal Mail Tunnel – Bond Street Station upgrade.

CSattAR operates on 'Sattar Image Tracking' (SIT) technique. SIT is based on the same principles of 'Digital Image Correlation' techniques that are widely used for laboratory experiments and for short-term applications such as bridge vibration monitoring. SIT, on the other hand, is designed to be robust for long-term monitoring practices where light, temperature and weather change.

The tracking process involves identifying the new position of pre-defined pixels within time-lapsed images and scaling (reconstructing) those movements from image coordinates into global/metric coordinates. In long-term monitoring, the cameras are likely to experience tilt and displacement and this limits the application of using a camera system to mainly 'deformation' monitoring rather than 'displacement' monitoring. Also, movements are captured in a two-dimensional space and there is an imposed error that is caused by movements along the third axis. CSattAR is capable of quantifying these errors and it often produces results that are more accurate than using conventional systems.

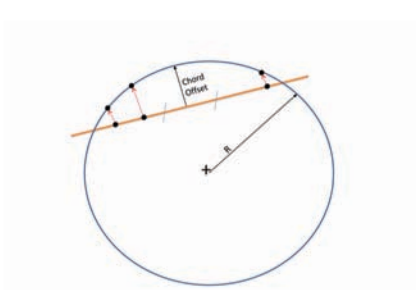

Figure 2. Measuring R from three displaced points.

How does it compare to Automated Total Stations?

The more projects I get involved with the more I feel that our monitoring work has been moulded by surveying practices rather than following engineering priorities. This has made the industry adapt surveying tools, focusing more on monitoring 'displacements' rather than 'deformations' which are often the main cause of damage. This evolvement is understandable. In a construction project, deformations such as strains and angular distortions are not as straightforward to interpret and they are even harder to communicate or manage. Automated Total Station (ATS) systems bring that simplicity. They will always be an important part of a medium to large scale monitoring project.

New technologies, such as CSattAR, have the potential to reclaim measuring some important deformations without introducing complexities. The following three deformations are examples of this:

Convergence monitoring

The system has been installed in several existing tunnels in order to monitor and record the convergence of tunnel sections/rings. This includes monitoring the cast-iron rings of the Central Line Tunnel and the Royal Mail Tunnel (RMT) at Liverpool Street Station area when influenced by Crossrail work, RMT at Bond Street Station area when influenced by the Bond Street Station Upgrade work (BSSU) and two of CERN's concrete-lining tunnels.

Convergence of tunnel sections/rings is often carried out to ensure that tunnels do not undergo excessive ovalisations. Figure 01 shows the RMT example at BSSU. In this case it was possible to monitor the convergence of almost every influenced ring (more than 50 rings over 30m) by installing three cameras. When tracking the same prisms monitored by ATS, both systems gave almost identical results (Figure 01 – bottom).

CSattAR was able to measure a significantly larger number of rings with higher precision (as high as 0.01mm when tracking CSattAR targets) and at a fraction of the ATS costs. In all of the cast-iron case studies that

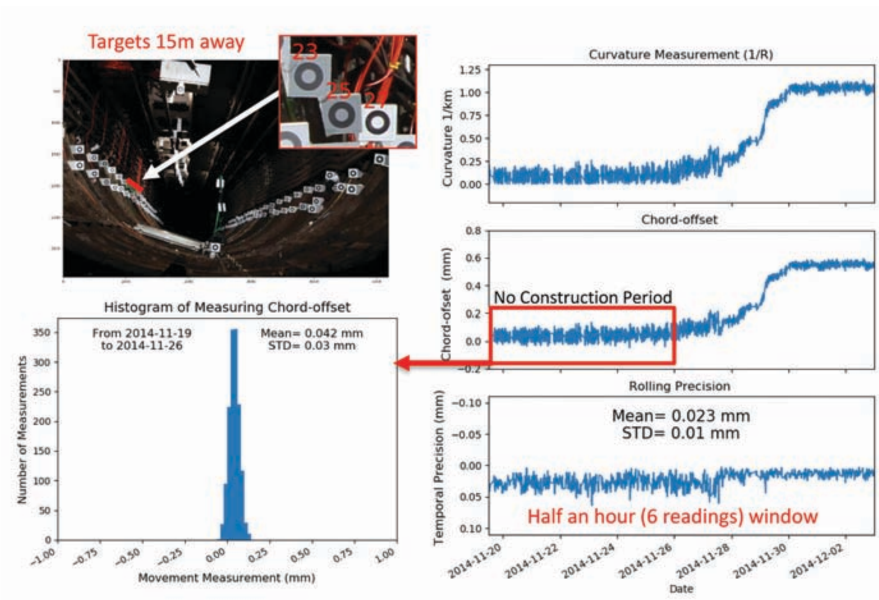

Figure 3. Monitoring local curvature at Royal Mail Tunnel.

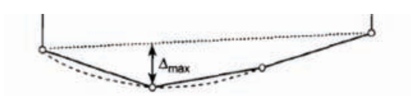

Figure 4. Deflections measurement.

I have been involved in, there has always been at least one ring that performs weaker than others. This can be flagged early when an 'intense' monitoring system such as CSattAR is used.

Curvature monitoring

Monitoring locally imposed curvature is a precision sensitive task. A minimum number of three targets are needed to measure curvature and it is usually measured by fitting a circle over the displaced new positions of the monitored points and is quantified by the radius of this circle, called the radius of curvature (R). For smaller chords, very small deformations can cause critical curvatures. For example, 0.1mm movement of a point at the centre of a 2m long chord (call it chord offset) can cause 5km of R. At Crossrail, 5km was set as a construction alarm trigger for London Underground tunnels.

An ATS system (for example) is not precise enough to be able to measure R for such small chords, given that the final precision of measuring R depends on three separate target readings. On the other hand, the CSattAR system captures the position of all points at one click, eliminating the errors associated with monitoring at individual instances. Coupled with its high precision, CSattAR has been able to monitor R for chords shorter than 2m.

Figure 03 shows an example of monitoring R of a 2m chord placed 15m away from the camera position at RMT at BSSU. For this chord, the total precision of measuring R, defined as chord offset as shown in figure 02, has been; 0.03mm when looking at the standard deviation of measurements for a period of one week prior to construction influence or 0.023mm when looking at the mean of rolling precision but this time for periods of half an hour windows throughout the monitoring period. In this example it was possible to demonstrate that cast-iron tunnels are able to undergo R values as tight as 1km without any damages observed (a significant finding outside of this article's objective).

Deflection monitoring

Deflection is usually used to assess the extent of damage caused by the bending of the foundations, beams or wall movements. The deflection is defined as the maximum vertical projection of a bent line from a line connecting its ends (as shown in Figure 04).

Figure 05 shows an example of monitoring the deflection of a stable masonary wall (Inglis Building at University of Cambridge) over a 50-day period. The measured deflection has been nearly zero throughout the experiment as one would expect. Apart from temperature-related movements of the building there is no other activity to cause any imposed movements. The gaps in the data are due to lack of light (night-time).

It should be noted that this excersise has been part of a study to demonstrate that the system is able to operate outdoors where it is subjected to weather-related changes such as rain, snow, wind etc. Although large camera movements have been recorded, the deflection measurements have not been notably influenced.

Further applications

The system can potentially be installed to monitor difficult-to-access locations and structures that are sensitive to 'deformations', such as listed buildings. The system could also operate contactless (no need to install targets) and has recently been trialled in St Marry Abchurch and Mansion House, both of which are listed buildings affected by the Bank Station Upgrade project in central London. Figure 06 shows some of the natural features and points that have been selected in these two sites for deformation monitoring purposes. The frequency of monitoring in these sites is set at every five minutes.

Final note

CSattAR has been an example where an instrumentation was designed to address the monitoring of assets from an engineering perspective. It can

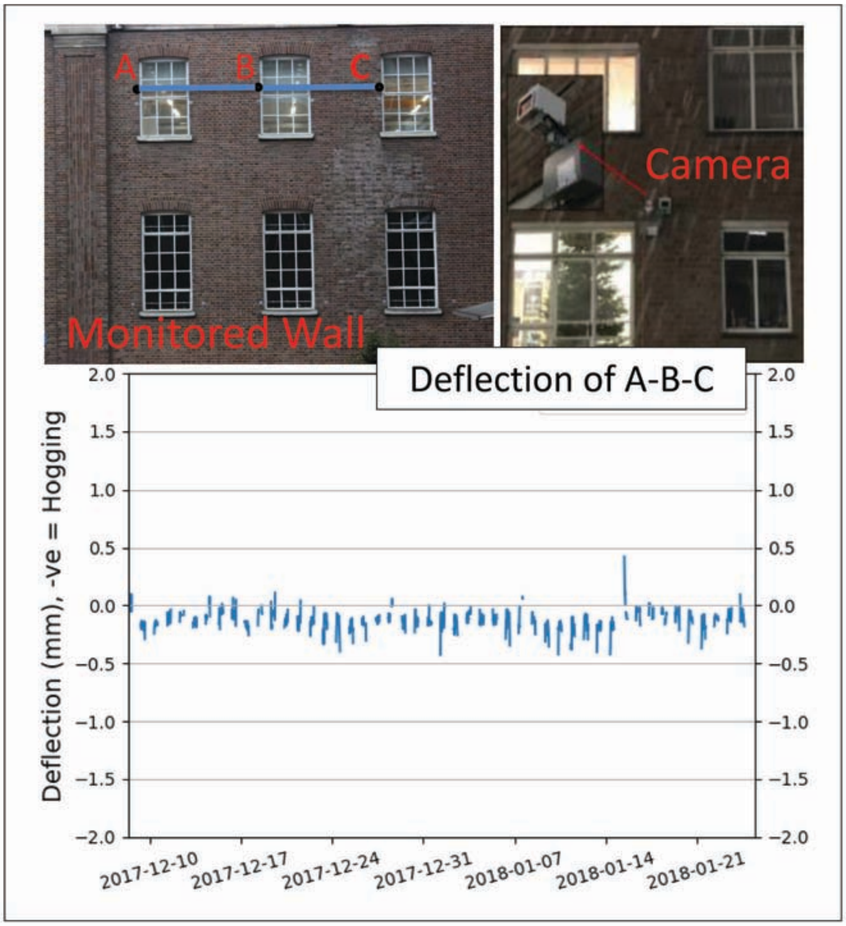

Figure 5. Monitoring deflection of a stable wall.

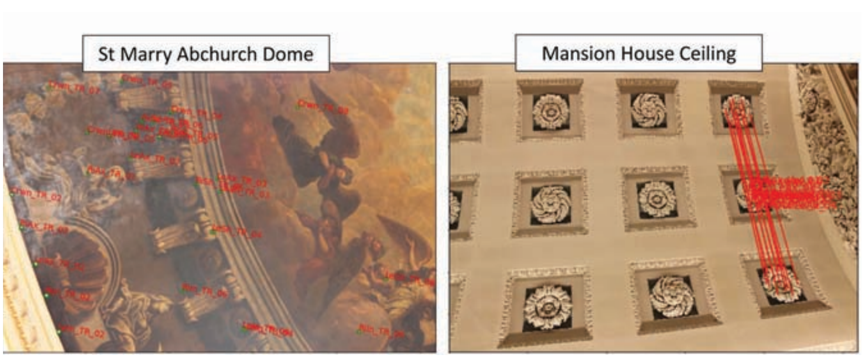

Figure 6. Contactless monitoring of St Marry Abchurch Dome (left) & Mansion House Ceiling (right).

monitor deformations such as convergence, deflection and curvature 'intensely' (many points) in semi real-time bases. In a project for Crossrail, while still at research stages, it was providing live data (half an hour gap) and alarm messages to monitor the deformation of an escalator barrel at Moorgate Station where conventional monitoring could not be conveniently installed. The message was coupled with the image that caused the alarm helping to validate it visually, something that cannot be done using conventional systems.

The system is ready to be deployed in future projects such as HS2, Crossrail 2 or in challenging environments such as listed buildings. It does not provide the solution to every monitoring problem but when it does, it is significantly cheaper and can increase the redundancy of monitoring and enhance the health and safety aspect of managing a monitoring system significantly.

Acknowledgement

CSattAR and my research work have been the result of a unique industry collaboration that was facilitated by CSIC; Soldata, CH2MHill (now Jacob), Crossrail, London Underground, CERN, Mott MacDonald, CoLOR (Costain, Laing O'Rourke joint venture at BSSU), BBMV (Balfour Beatty, Morgan Sindall, VINCI joint venture at Crossrail Liverpool Street) have greatly contributed by providing guidance, research sites and support. The special thanks go to CSIC, Arup and namely Michael Devriendt for being the industrial supervisor of the research and to Kenichi Soga my PhD supervisor.

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