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Volume 34 • Number 1 • March 2016

GEOTECHNICAL news

Seepage evidence at Carno Dam, South Wales

WIRELESS DATA COLLECTION from geotechnical instruments

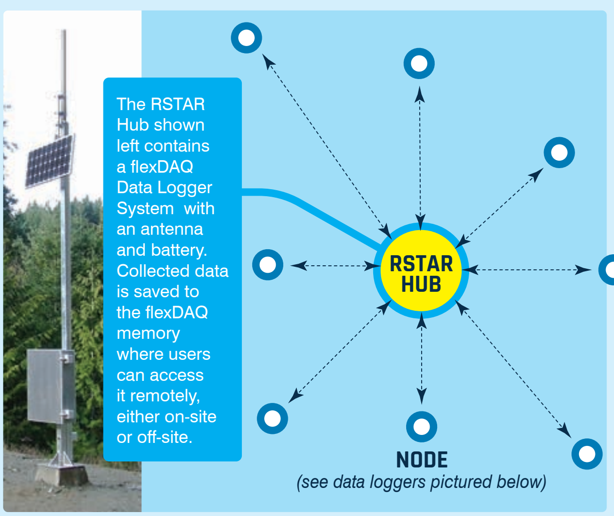
Minimum per channel cost | **Extra long battery life** | **Long distance transmission**

Whether you collect data from your geotechnical instruments remotely through a **fully automated** data acquisition system, or by a **semi-automated** (on-site) method, RST Instruments Ltd. has two **wireless solutions** to quickly get you connected to your data.

FULLY AUTOMATED COLLECTION (remotely)

rstar ARRAY RADIO SERIES

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



FEATURES

- Up to 7 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 and 2.4 GHz spread spectrum band. (country dependent)

SEMI-AUTOMATED COLLECTION (on-site)

DT LINK WIRELESS

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.

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

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.
- Excellent range up to 800 m (900 MHz) and up to 500 m (2.4 GHz).
- Collect data in seconds with a laptop connected to the compact and portable DT LINK HUB.

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Single Channel Vibrating Wire Data Logger

DT2055B
5/10 Channel Vibrating Wire / Thermistor Data Logger

DT4205
4-20 mA Ten Channel Data Logger

DT2040
20/40 Channel Vibrating Wire / Thermistor Data Logger

DTL201B and DTL202B
Uniaxial & Biaxial Digital Tilt Loggers

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- RSTAR info at: www.rstinstruments.com/rstar.html
- DT LINK info at: www.rstinstruments.com/dtlinkwireless.html

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CONTENTS

Cover *Seepage evidence at Carno Dam, South Wales*
See article page 41.

Message from the President

Doug VanDine, President of Canadian Geotechnical Society

While in high school in the mid-1960's, I bought my first slide rule. In 1967, I programmed my first computer (using punch cards). In the mid-1970's, I bought my first hand-held calculator; in 1984, my first desk top computer (256K RAM with DOS, monochrome monitor and dot-matrix printer); in 1989, my first fax machine (thermal paper); in 1993, my first lap-top; and in 2002, my first scanner. I bought my first smartphone and tablet several years ago.

Why am I telling you this? Because methods of doing things change with time and similarly, the way the CGS has communicated with its members has changed.

When I joined the CGS in the early 1970's, besides receiving the Canadian Geotechnical Journal (CGJ) four times a year by mail, I received very infrequent letters from the CGS which sometimes included a mimeographed 3 or 4 page typed *CGS Newsletter*. In 1983, the *CGS News* was incorporated into BiTech's quarterly *Geotechnical News*. In the late 1990's, the CGS started sending emails. In the early 2000's the CGS's first website was up and running, and was revamped in 2010. In 2006, the 4th printed edition of the Canadian Foundation Engineering Manual (CFEM) was published and the French version in 2013. In the mid-2000's, the Canadian Geotechnical Journal and the proceedings of the CGS annual conferences became available digitally. In 2010, *Geotechnical News* became available online for the first time.

In the last year, the CGS has continued to make a number of additional communication strides. In January 2015, the monthly electronic newsletter (*CGS-Geotechnical Info Net*) began.

In November 2015, the CGS began posting items to its LinkedIn and Facebook sites. Sometime in 2016, I hope an updated CGS website will be launched. Finally, I hope that both the English and French versions 4th edition of the Canadian Foundation Engineering Manual will become available online for a fee before the end of the year. I expect that subsequent editions of this important document will be solely an online document.

These recent changes have all been made with a great deal of thought and input from CGS members. Thanks to all of you who completed the CGS's first membership survey last fall. Several of the questions in that survey were related to communication strategies. Well over 50% of the respondents ranked the CGJ, CFEM, the CGS website, targeted emails, *CGS News*, and the *CGS-Geotechnical Info Net* a 4 or 5 on the response scale, with 5 being 'very important'. Six weeks after the CGS started posting on its LinkedIn and Facebook sites near the end of 2015, followers of those CGS social media sites increased to about 20% of the CGS membership!

One of the challenges for the CGS is to keep up with new communication technologies, but at the same time to make sure that the communication messages are accessible to CGS members with all levels of technological savvy. We are attempting to do this, but don't expect to receive mimeographed CGS newsletters in the mail any time soon!

Turning to other matters, I would like to thank all the CGS volunteers who stepped down at the end of 2015. A list of many of the CGS volunteers who will help run the Society in 2016 can be found elsewhere in this issue. Thanks in advance to them all. A special welcome and congratulations to **Dr. Dharma Wijewickreme**, the current CGS VP Finance, who will also sit on the Executive Committee as President-Elect for 2016.

A great big thank you to the CGS Headquarters staff: **Michel Aubertin**, CGS Executive Director, and both **Wayne Gibson** and **Lisa McJunkin**. Unless you are really involved in the CGS, you probably don't know how much these three individuals contribute to the success of the Society.

I would be remiss in not mentioning that **Dr. Antonio Gens** (University of Barcelona, Spain) will be the Spring 2016 Cross Canada Lecturer. In the early fall the CGS's **5th Canadian Young Geotechnical Engineer and Geoscientist Conference** will be held in Whistler, BC (September 29 to October 1), immediately preceding the **69th CGS Annual Conference (GeoVancouver 2016)**, October 2 to 5. More information on these conferences are given elsewhere in this issue and on the CGS website. For those who like to plan ahead, the **70th CGS Annual Conference** will be held in Ottawa in 2017.

Again, the CGS is looking to honour its outstanding members. Details as to how you can nominate deserving CGS members can be found elsewhere in this issue.

Last, but not least, I would like to thank the generosity of our 2015 CGS Corporate Sponsors, companies that have seen the value in investing in the Society for all Canadian geotechnical professionals: The 2015 corporate sponsors were: **DownUnder Geotechnical; Geo-Slope International; GKM Consultants; Golder Associates; Insitu Contractors; Klohn Crippen Berger; Knight Piésold Consulting; MEG Consulting; Mobile Augers and Research; Naviq Consulting; Reinforced Earth; Rocscience; Stantec; Thurber Engineering;** and **Trek Geotechnical.**

For all of the above reasons, if you haven't already renewed your CGS membership for 2016, there is no better time than now. Go to ***http://www.cgs.ca/how-to-join.php?lang=en***, or contact CGS Headquarters ***(cgs@cgs.ca)***

Until next time.

Provided by Doug VanDine
President 2015 - 2016

Message du président

Lorsque j'étais au secondaire au milieu des années 1960, j'ai acheté ma première règle à calcul. En 1967, j'ai programmé mon premier ordinateur (à l'aide de cartes perforées). Au milieu des années 1970, j'ai acheté ma première petite calculatrice; en 1984, mon premier ordinateur de bureau (256 K de mémoire vive avec DOS, moniteur monochrome et imprimante à points); en 1989, mon premier télécopieur (papier thermo-sensible); en 1993, mon premier ordinateur portatif; et en 2002, mon premier appareil de numérisation. Je me suis procuré mon premier téléphone intelligent et ma première tablette il y a plusieurs années.

Pourquoi est-ce que je vous raconte cela? Parce que les façons de faire évoluent avec le temps. La façon dont la SCG communique avec ses membres a aussi changé.

Lorsque je me suis joint à la SCG au début des années 1970, nous recevions la *Revue canadienne de géotechnique* (*RCG*) quatre fois par année par la poste. Je recevais aussi de rares lettres de la SCG, qui comprenaient parfois un *Bulletin d'information de la SCG* polycopié de trois ou quatre pages. En 1983, le *CGS News* a été intégré au *Geotechnical News* trimestriel de BiTech. À la fin des années 1990, la SCG a commencé à envoyer des courriels. Au début des années 2000, le premier site Web de la SCG entrait en fonction, et ce dernier a été remanié en 2010. En 2006, la quatrième édition imprimée du *Manuel canadien d'ingénierie des fondations* (*MCIF*) a été publiée, et sa version française, en 2013. Au milieu des années 2000, la *RCG* et les comptes rendus des conférences annuelles de la SCG sont devenus disponibles numériquement.

En 2010, *Geotechnical News* a été offert en ligne pour la première fois.

Au cours de la dernière année, la SCG a poursuivi ses nombreuses autres avancées en matière de communication. En janvier 2015, le bulletin d'information électronique mensuel (*Réseau d'information géotechnique de la SCG*) a commencé à paraître. En novembre 2015, la SCG a commencé à publier des éléments sur ses sites LinkedIn et Facebook. En 2016, j'espère qu'un site Web actualisé de la SCG sera lancé. Finalement, je souhaite que les versions française et anglaise de la 4e édition du *MCIF* soient disponibles en ligne, moyennant des frais, avant la fin de l'année. Je m'attends à ce que les éditions subséquentes de ce document important soient uniquement électroniques.

Ces récents changements ont tous été apportés grâce aux nombreux commentaires et idées des membres de la SCG. Merci à tous ceux qui ont répondu au premier sondage des membres de la SCG l'automne dernier. Plusieurs des questions de ce sondage étaient liées aux stratégies de communication. Plus de 50 % des répondants ont donné à la *RCG*, au *MCIF*, au site Web de la SCG, aux courriels ciblés, à *CGS News* et au *Réseau d'information géotechnique de la SCG* un 4 ou un 5 sur l'échelle de réponse (5 étant « très important »). Six semaines après que la SCG a commencé à publier des éléments sur ses sites LinkedIn et Facebook vers la fin de 2015, le nombre d'abonnés de ces sites de média sociaux a atteint environ 20 % des membres de la SCG!

Un des défis de la SCG est de suivre le rythme des nouvelles technologies de communication, tout en s'assurant que les messages transmis soient accessibles à tous les membres de la SCG, peu importe leur niveau de connaissance de ces technologies. C'est ce que nous tentons de faire; ne vous attendez pas à recevoir des bulletins d'information de la SCG polycopiés par la poste dans un avenir rapproché!

À propos d'autres questions, j'aimerais remercier tous les bénévoles de la SCG qui ont terminé leur mandat à la fin de 2015. Une liste des nombreux bénévoles de la SCG qui aideront la Société en 2016 se trouve dans ce numéro. Merci à l'avance à toutes ces personnes. Un mot de bienvenue et des félicitations toutes spéciales au **Dr Dharma Wijewickreme**, l'actuel v.-p. aux finances de la SCG, qui siègera également au Comité exécutif à titre de président désigné pour 2016.

De grands remerciements au personnel du siège social de la SCG : **Michel Aubertin**, directeur général de la SCG, ainsi que **Wayne Gibson** et **Lisa McJunkin**. À moins de participer activement à la SCG, vous ne savez probablement pas à quel point ces trois personnes contribuent au succès de la Société.

Je m'en voudrais de ne pas mentionner que le **Dr Antonio Gens** (Université de Barcelone, Espagne) sera le conférencier de la Tournée de conférences transcanadiennes du printemps 2016. Au début de l'automne, la **5e Conférence canadienne des jeunes géotechniciens et géoscientifiques** de la SCG aura lieu à Whistler, en C.-B. (du 29 septembre au 1er octobre), tout juste avant la **69e conférence annuelle de la SCG (GéoVancouver 2016**, du 2 au 5 octobre). De plus amples renseignements sur ces conférences sont donnés dans ce numéro et sur le site Web de la SCG. Pour ceux qui souhaitent planifier leurs activités, la **70e conférence annuelle de la SCG** se tiendra à Ottawa en 2017.

De nouveau, la SCG cherche à honorer ses membres exceptionnels. Des détails sur la façon dont vous pouvez soumettre la candidature de membres méritants de la SCG se trouvent dans ce numéro.

Enfin, mais non des moindres, j'aimerais remercier les commanditaires de 2015 de la SCG pour leur générosité; ces entreprises voient la valeur d'un investissement dans la Société pour tous les professionnels en géotechnique canadiens. Les commanditaires de 2015 étaient : **DownUnder Geotechnical; Geo-Slope International; GKM Consultants; Golder Associates; Insitu Contractors; Klohn Crippen Berger; Knight Piésold Consulting; MEG Consulting; Mobile Augers and Research; Naviq Consulting; Reinforced Earth; Rocscience; Stantec; Thurber Engineering;** et **Trek Geotechnical**.

Pour toutes les raisons susmentionnées, le moment ne serait pas mieux

SVOFFICE™5/GE builds on the success of our previous *SVOffice™2009* product and provides the power of the FlexPDE™ finite element solution engine. FlexPDE™ provides the benefits of a general finite element solver, fully automatic mesh generation and mesh refinement in 1D, 2D, and 3D models.

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  - Build complex 3D site geometry;
  - Export to 2D or 3D numerical models;
  - Rapid prototyping of geotechnical designs;
  - Manage, edit and visualize construction/excavation activities.
- **SVSOILS™ Knowledge-Based Database:** (fmr. SoilVision)
  - Premier product for estimating the hydraulic properties for flow modeling in unsaturated soils has been completely redesigned;
  - Simplified user interface for increased workflow efficiency;
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  - Simple data mining/searching interface;
  - Development of oil-sand constitutive models;
  - Improved high-quality exportable charts.
- **SVSLOPE® Significantly Improved:**
  - Advanced multi-directional slope stability analysis. Fully build 3D models and analyze slip in any direction – a feature exclusive to SVSLOPE®3D and not available in any competing package.
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  - Improved 2D block searching capabilities;
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  - Completely rewritten / redesigned;
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- SVCHEM GE — 1D / 2D / 3D finite element contaminant transport modeling
- SVAIR GE — 1D / 2D / 3D finite element pore-air flow modeling

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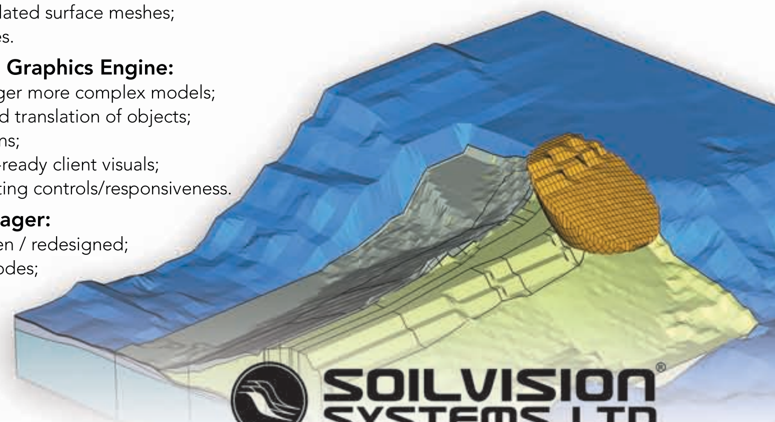

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À la prochaine!

Fourni par Doug VanDine
Président 2015-2016

From the Society

Call for Nominations for CGS Awards

Look around. We all know at least one deserving geotechnical professional deserving of recognition!

The CGS wishes to again recognize the considerable contributions and achievements by geotechnical professionals in Canada and abroad in a family of awards, many of which will be presented during the Awards Ceremony at the CGS Annual Conference in Vancouver, B.C. – **GeoVancouver 2016** (October 2 - 5, 2016). Funding for many of these awards is provided by the Canadian Foundation Geotechnique, so remember to also support your Foundation! The various awards are summarized on page 13. You can also go to ***www.cgs.ca/awards.php?lang=en*** for more information and the list of past recipients, or contact CGS Headquarters.

If you know of someone deserving of any of the CGS Awards, nominate them by **May 15, 2016**. If you wish to make a submission for a Student Award, it must be received by **May 15, 2016.** Send your nominations to CGS Headquarters at:

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

Nominations should include the name and contact information of the nominator, a resume or curriculum vita of the nominee, and a letter highlighting the contributions and achievements that make the nominee a worthy candidate for that specific award. Letters of support from other CGS members and non-members, are encouraged. If possible, nominations should include an appropriate head and shoulders photo of the nominee.

Submission details for Student Awards are available on the CGS website at ***www.cgs.ca/student_comp.php?lang=en***, or contact **Dr. Sumi Siddiqua**, Chair of the CGS Student Awards Selection Committee, at ***sumi.siddiqua@ubc.ca***

Appel de mise en candidatures pour les prix de la SCG

Regardez autour de vous. Nous connaissons tous au moins un professionnel en géotechnique méritant d'être reconnu!

La SCG souhaite de nouveau reconnaître les importantes contributions et réalisations des professionnels en géotechnique au Canada et à l'étranger, à l'aide d'un ensemble de prix, qui seront pour la plupart présentés durant la cérémonie de remise de prix lors de la conférence annuelle de la SCG à Vancouver, en C.-B., **GéoVancouver 2016** (du 2 au 5 octobre 2016). La Fondation canadienne de géotechnique finance un grand nombre de ces prix, n›oubliez donc pas de soutenir également votre Fondation! Les différents prix sont résumés ci-dessous. Vous pouvez également consulter le site ***www.cgs.ca/awards.php?lang=fr*** pour obtenir de plus amples renseignements et la liste des précédents lauréats, ou communiquez avec le siège social de la SCG.

Si vous connaissez quelqu'un méritant l'un des prix de la SCG, posez sa candidature d'ici le **15 mai 2016**. Si vous souhaitez soumettre une candidature pour un prix pour les étudiants, elle doit être reçue d'ici le **15 mai 2016**. Envoyez vos candidatures au siège social de la SCG, à :

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

Les candidatures doivent comprendre le nom et les coordonnées de la personne qui les soumettent, un curriculum vitæ du candidat et une lettre soulignant les contributions et les réalisations qui font en sorte que le candidat mérite ce prix. Des lettres de recommandation d'autres personnes, qu'elles soient membres ou non de la SCG, sont les bienvenues. Si possible, les candidatures doivent inclure une photo en buste du candidat.

Les détails pour la soumission d'une candidature pour les prix pour les étudiants sont disponibles sur le site Web de la SCG, à ***http://www.cgs.ca/student_comp.php?lang=fr,*** ou communiquez avec la **Dre Sumi Siddiqua**, directrice du Comité de sélection des prix pour les étudiants, à ***sumi.siddiqua@ubc.ca.***

Call for Nominations for 2017 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, 2016**.

CGS Awards	
Award	**Brief Description/Comments**
CGS Society Awards	
Legget Medal	For significant lifelong contribution to the geotechnical field in Canada. The most senior and prestigious CGS award.
R.M. Quigley Award	For the best paper published in Canadian Geotechnical Journal in the preceding year. Two runners-up are also recognized. CGS membership is not required.
Honorary Life Member	For longstanding exemplary service to the CGS, and/or exemplary technical cosntributions to the geotechnical field in Canada or abroad. Only awarded occasionally.
CGS Division Awards	
G. Geoffrey Meyerhof Award	**Soil Mechanics & Foundation Division.** For outstanding contribution to soil mechanics and foundation engineering.
Thomas Roy Award	**Engineering Geology Division**. For outstanding contribution (publication or otherwise) to engineering geology.
Roger J.E. Brown Award	**Cold Regions Geotechnology Division**. For outstanding contribution (publication or otherwise) to permafrost science or engineering. Awarded biannually. To be awarded in 2016.
John A. Franklin Award	**Rock Mechanics Division**. For outstanding publication in rock mechanics and/or rock engineering. Awarded biannually. Will not be awarded in 2016.
Geosynthetics Award	**Geosynthetics Division**. For outstanding publication in the application of geosynthetics to civil, geotechnical or geoenvironmental engineering. Awarded biannually. To be awarded in 2016.
Geoenvironmental Award	**Geoenvironmental Division**. For outstanding contribution (publication or otherwise) in geoenvironmental engineering. Awarded biannually. To be awarded in 2016.
Joint Awards	
Robert N. Farvolden Award	Joint award of the CGS **Groundwater Division** and the **Canadian National Committee of the International Association of Hydrologists**. For outstanding contribution to the disciplines of earth science or engineering, by an individual or group, that emphasize the role or importance of groundwater.
Schuster Medal	Joint award of the CGS **Geohazards Committee** and **Engineering Geology Division** and the **Association of Environmental and Engineering Geologists.** For outstanding contribution to geohazards research in North America. Awarded biannually to a CGS member, in odd numbered years. Nominations for this year closed in January 2016.
CGS Student Awards	
Graduate Presentation	For best 15-minute technical presentation on video submitted by a graduate student at a Canadian university. One runner-up is also recognized. CGS membership is not required.
Undergraduate Individual Report	For best undergraduate student report by an individual in Canada. One runner-up is also recognized. CGS membership is not required.
Undergraduate Group Report	For best undergraduate student report by a group in Canada. One runner-up is also recognized. CGS membership is not required.
CGS Service Awards	
A.G. Stermac Award	For outstanding service to the CGS by a member at the local, national or international level. More than one award can be presented each year.
Certificates of Appreciation	For deserving CGS members recognized by the President or others as having contributed noteworthy service to the CGS.

Prix de la SCG	
Prix ou distinction	**Courte description/Commentaires**
Prix de la SCG	
Médaille Legget	Pour avoir contribué de manière importante au domaine de la géotechnique au Canada tout au long de sa vie. Le plus haut et prestigieux prix de la SCG.
R.M. Quigley	Pour le meilleur article publié dans la *Revue canadienne de géotechnique* durant l'année précédente. Deux finalistes sont également reconnus. Il n'est pas nécessaire d'être membre de la SCG.
Membre honoraire à vie	Pour un service exemplaire de longue date à la SCG et/ou des contributions techniques incomparables au domaine de la géotechnique au Canada ou à l'étranger. Décerné occasionnellement seulement.
Prix des divisions de la SCG	
Prix G. Geoffrey Meyerhof	**Division de la mécanique des sols et des fondations** – Pour une contribution exceptionnelle au domaine de la mécanique des sols et de l'ingénierie des fondations.
Prix Thomas Roy	**Division de la géologie de l'ingénieur** – Pour une contribution exceptionnelle (dans une publication ou autrement) au domaine de la géologie de l'ingénieur.
Prix Roger J.E. Brown	**Division de la géotechnique des régions froides** – Pour une contribution exceptionnelle (dans une publication ou autrement) au domaine de l'ingénierie ou de la science du pergélisol. Décerné tous les deux ans. Sera remis en 2016.
Prix John A. Franklin	**Division de la mécanique des roches** – Pour une publication exceptionnelle sur la mécanique et/ou l'ingénierie des roches. Décerné tous les deux ans. Ne sera pas remis en 2016.
Prix de la géosynthétique	**Division de la géosynthétique** – Pour une publication exceptionnelle sur l'application de la géosynthétique en géotechnique, ou en génie civil ou géoenvironnemental. Décerné tous les deux ans. Sera remis en 2016.
Prix du géoenvironnement	**Division du géoenvironnement** – Pour une contribution exceptionnelle (dans une publication ou autrement) au domaine du génie géoenvironnemental. Décerné tous les deux ans. Sera remis en 2016.
Prix communs	
Prix Robert N. Farvolden	Prix commun de la **Division des eaux souterraines** de la SCG et de **l'International Association of Hydrologists – Canadian National Chapter.** Pour une contribution exceptionnelle d'une personne ou d'un groupe dans les domaines des sciences de la terre et du génie qui met l'accent sur le rôle ou l'importance des eaux souterraines.
Médaille Schuster	Prix commun du **Comité sur les géorisques** et de la **Division de la géologie de l'ingénieur** de la SCG, ainsi que de l'**Association of Environmental and Engineering Geologists**. Pour une contribution remarquable à la recherche sur les géorisques en Amérique du Nord. Décernée tous les deux ans à un membre de la SCG. Les candidatures pour cette année se terminent en janvier 2016
Prix de la SCG pour les étudiants	
Présentation d'un étudiant gradué	Pour la meilleure présentation technique de 15 minutes sur vidéo soumise par un étudiant gradué d'une université canadienne. Un finaliste est également reconnu. Il n'est pas nécessaire d'être membre de la SCG.
Rapport d'un étudiant de premier cycle	Pour le meilleur rapport d'un étudiant de premier cycle au Canada. Un finaliste est également reconnu. Il n'est pas nécessaire d'être membre de la SCG.
Rapport d'un groupe d'étudiants de premier cycle	Pour le meilleur rapport d'un groupe d'étudiants de premier cycle au Canada. Un finaliste est également reconnu. Il n'est pas nécessaire d'être membre de la SCG.
Prix de service de la SCG	
Prix A.G. Stermac	Pour un service exceptionnel rendu à la SCG par un membre, au niveau local, national ou international. Plus d'un prix peut être présenté chaque année.
Certificats d'appréciation	Pour des membres méritants de la SCG reconnus par le président ou d'autres personnes pour avoir rendu un service digne de mention à la SCG.

Nominations must include:

1. a completed EIC Nomination Form which is available from ***http://eic-ici.ca/honours_awards/***)
2. a nomination letter
3. the nominee's CV, and
4. 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 awards details and criteria prior to preparing nominations. For more information, contact CGS Headquarters at:

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

Appel de candidatures pour les prix et médailles bourses de recherche 2017 de l'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 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 2016**.

Les candidatures 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. le curriculum vitae du candidat;
4. 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 (Fellowship et Médailles) avant de les préparer. Pour obtenir de plus amples renseignements, communiquez avec le siège social de la SCG à :

La Société canadienne de géotechnique
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***.

Canadian Foundation for Geotechnique 2016 Michael Bozozuk National Graduate Scholarship

Dr. Dennis Becker, President of the Canadian Foundation for Geotechnique (la Fondation canadienne de géotechnique), is pleased to announce the call for nominations for its annual ***Michael Bozozuk National Graduate Scholarship.***

The scholarship, valued at $5,000, was established by the Canadian Foundation for Geotechnique in 2007, on the occasion of the 60^{th} Canadian Geotechnical Conference in Ottawa. The 2016 scholarship will be presented this fall at the Canadian Geotechnical Conference in Vancouver, BC.

Awards and Fellowships for the Engineering Institute of Canada

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 (given every two years).
Julian Smith Medal	For achievement in the development of Canada.
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 et médailles de l'Institut canadien de ingénieurs

Prix ou distinction	Courte description/Commentaires
Médaille Sir John Kennedy	Pour un service exceptionnel rendu à la profession ou pour des contributions dignes de mention au domaine de la science de l'ingénierie, ou au profit de l'ICI. Plus prestigieux prix de l'ICI.
Médaille Julian Smith	En reconnaissance d'une contribution au développement du Canada.
Médaille John B. Stirling	Pour des qualités de chef et des services émérites rendus à l'ICI et/ou à ses sociétés membres, à l'échelle nationale.
Médaille CP Rail Engineering	Pour les qualités de chef et le service rendu dans les régions et les chapitres de membres des sociétés membres de l'ICI.
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	Pour les non-membres de l'ICI et de 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.

Any Canadian or permanent resident, entering or registered in a Canadian university Masters or PhD program that is directly related to an identified field of geotechnique, is eligible. Programs include geotechnical engineering, geological engineering, mining engineering, geoenvironmental engineering or geoenvironmental geoscience, engineering geology and hydrogeology. Nominees must have high academic standing and preference will be given to those who have some practical experience and are active, or show leadership, in the geotechnical community.

Nominations are limited to **one per academic department** and require a letter, accompanied by rationale, written **and signed** by the graduate supervisor. Rationale should include evidence of academic standing, research output, contributions to practice, and leadership/activity in the geotechnical community. A nomination package is limited to **five pages**. For award ceremony purposes, the nomination package should also include a digital image (300 dpi) of the nominee.

Nominations for the 2016 Scholarship will be accepted by the Selection Committee Chair, **Dr. Paul Simms** (c/o Carleton University, Department of Civil and Environmental Engineering, 1125 Colonel By Drive, Ottawa ON. K1S 5B6, telephone (613) 520 2600 ext. 2079, ***paul_simms@carleton.ca***) up until **May 1, 2016**.

If submitted by email, nominations **must be signed** by the supervisor and include the words "Canadian Foundation for Geotechnique National Graduate Scholarship" in the subject line.

For further information, refer to the Foundation's website ***www.cfg-fcg.ca*** or contact Dr. Dennis Becker, (403) 260 2253, ***dennis_becker@golder.com***

Provided by Dennis Becker, President of the Canadian Foundation for Geotechnique

Bourse nationale pour études supérieures Michael Bozozuk 2016 de la Fondation canadienne de géotechnique

Le **Dr Dennis Becker**, président de la Fondation canadienne de géotechnique, est heureux de lancer un appel de candidatures pour la 9e édition de la *Bourse nationale pour études supérieures* qui est décernée annuellement.

D'une valeur de 5 000 $, la bourse a été établie par la Fondation canadienne de géotechnique en 2007, lors de la 60e conférence canadienne de géotechnique qui a eu lieu à Ottawa. La bourse de 2016 sera décernée lors de la prochaine conférence canadienne de géotechnique, qui aura lieu à Vancouver cet automne.

Toute personne détenant la citoyenneté canadienne ou la résidence permanente au Canada, qui s'inscrira ou est inscrite dans un programme d'une université canadienne de maîtrise ou de doctorat directement lié à un domaine de la géotechnique est admissible. Au nombre de ces programmes, mentionnons les geotechniques, le génie géologique, le génie minier, le génie geoenvironnemental ou la géoscience géoenvironmentale, la géologie de l'ingénieur et l'hydrogéologie. Les candidats doivent avoir des notes élevées. La préférence sera accordée à ceux qui ont de l'expérience pratique et sont actifs ou font preuve de leadership dans la communauté géotechnique.

Les candidatures sont limitées à **une par département**. Elles doivent être accompagnées d'une lettre avec justification, rédigées **et signées** par le directeur de recherche. La justification devrait inclure des informations sur les résultats académiques ainsi qu'une description de ses résultats de recherche, de ses contributions à la pratique et de son leadership ou de ses activités dans la communauté géotechnique. Le dossier de mise candidature est limité à **cinq pages**. Le dossier de candidature devrait aussi comprendre une image numérique (300 ppp) du candidat pour la cérémonie.

Les candidatures présentées pour la bourse de 2016 seront acceptées par le président du Comité de sélection de la bourse de la Société canadienne de géotechnique, le Dr Paul Simms (a.s. de : Université Carleton, Département de génie civil et environnemental, 1125, chemin Colonel By, Ottawa, ON K1S 5B6, téléphone 613-520-2600, poste 2079, *paul_simms@carleton.ca*) **jusqu'au 1er mai 2016**. Les dossiers de candidature envoyés par courriel **doivent être signés** par le directeur de recherche et comprendre la mention « Bourse nationale pour études supérieures de la Fondation canadienne de géotechnique » dans la ligne objet.

Pour plus de renseignements, consultez le site Web de la Fondation, à *www.cfg-fcg.ca*, ou communiquez avec le Dr Dennis Becker, au 403-260-2253 ou à *dennis_becker@golder.com*

Fourni par Dennis Becker, Président de la Fondation canadienne de géotechnique

CGS Membership Registration for 2016

If you haven't done so already, remember to renew your CGS membership for 2016! You can renew easily online using Visa, MasterCard and American Express credit cards, or by cheque or wire transfer. Go to ***www.cgs.ca***, then to 'Member Login' page. If you have any questions about your 2016 membership renewal, contact CGS Headquarters (***cgs@cgs.ca***, 604-277-7527 or 1-800-710-9867)

If you are a student and attended GeoQuebec 2015, you are entitled to a complimentary 2016 CGS student membership. Contact CGS Headquarters.

If you aren't a CGS member and wish to join, you can register online at ***http://cgs.ca/membership.php*** or contact CGS Headquarters.

If your company has been a CGS corporate sponsor in the past and would like to renew your sponsorship for 2016, or if your company would like to become a CGS corporate sponsor in 2016, or to obtain more information on the program, please contact CGS Headquarters.

Upcoming Conferences and Seminars

69th Canadian Geotechnical Conference October 2 to 5, 2016 Vancouver, British Columbia, Canada

The **Vancouver Geotechnical Society** and the Canadian Geotechnical Society invite you to the **69th Canadian Geotechnical Conference**. The conference will be held from October 2nd to 5th, 2016 in Vancouver, British Columbia, Canada. It will cover a wide range of topics, including specialty sessions that are of local and national relevance to the disciplines of geotechnical and geo-environmental engineering. In addition to the technical program and plenary sessions, the conference will include a complement of short courses, technical tours, local excursions and entertaining social activities.

The official languages for the conference will be English and French. Vancouver is well known for its beautiful scenery, which encompasses the Coast Mountains, the Fraser River Delta and the Strait of Georgia. The city has been host to many national and international events, including the 2010 Winter Olympics. This breath-taking surrounding lends itself to a wide variety of geological conditions and geotechnical challenges, including high seismicity, steep terrain and soft soils.

The conference will be held at the picturesque Westin Bayshore Hotel which is well situated between the downtown business district and Stanley Park.

The theme of the conference is **History and Innovation**, which will recognize the historical achievements and lessons learned over time while highlighting innovation in geotechnical engineering research and practice.

Please address any questions to the conference co-chairs: **Mustapha Zergoun** at ***mzergoun@thurber.ca***, **Andrea Lougheed** at ***alougheed@thurber.ca***, or the Conference Secretariat at ***secretariat@geovancouver2016.com*** The conference website is ***www.geovancouver2016.com***.

69e conférence canadienne de géotechnique 2 - 5 octobre 2016, Vancouver, Colombie Britannique, Canada

La Société géotechnique de Vancouver et la Société canadienne de géotechnique vous invitent à participer à **GéoVancouver 2016**; il s'agit de la 69e conférence canadienne de géotechnique. La conférence se déroulera du 2 au 5 octobre 2016 à Vancouver, Colombie Britannique, Canada. Elle couvrira un large spectre de thèmes incluant des séances spéciales d'intérêt local et national dans les domaines de la géotechnique et géoenvironmental. En plus du programme technique et des séances plénières, la conférence inclura des cours intensifs, des visites techniques, des excursions guidées et des activités sociales amusantes.

Les langues officielles de la conférence seront le français et l'anglais. Vancouver est bien connue pour sa beauté spectaculaire avec les montagnes côtières, le fleuve Fraser et le détroit de Georgia. La ville a été l'hôtesse de nombreux évènements nationaux et internationaux, incluant les Jeux Olympiques d'hiver en 2010. Cette région surprenante comprend une grande variété de conditions géologiques et de défis géotechniques tels qu'une sismicité élevée, des terrains accidentés et des sols mous. La Conférence se tiendra à l'Hôtel Westin Bayshore qui est bien situé, entre le centre-ville d'affaires et le parc Stanley.

Quesnell Bridge

Le thème de GéoVancouver 2016 est **Histoire et Innovation** et il vise à reconnaitre les accomplissements historiques et les leçons apprises au fil du temps, tout en mettant en valeur l'innovation dans la recherche et la pratique de la géotechnique.

Vous pouvez acheminer toutes questions aux coprésidents de la conférence: **Mustapha Zergoun** à ***mzergoun@thurber.ca*** ou **Andrea Lougheed** à ***alougheed@thurber.ca*** ou Conférence Secrétariat à ***secretariat@geovancouver2016.com*** ou ***www.geovancouver2016.com***

5th Canadian Young Geotechnical Engineers & Geoscientists Conference September 29 to October 1, 2016 Whistler, British Columbia

The 5th Canadian Young Geotechnical Engineers & Geoscientists Conference is a triennial Canadian Geotechnical Society event. The Conference is targeted towards young engineers and geoscientists who are looking to exchange technical information with their peers and build meaningful networks in a relaxed, supportive and motivational environment. The conference will be hosted in Whistler, B.C. from September 29th to October 1st, 2016, prior to GeoVancouver 2016. Participants are encouraged to submit abstracts and prepare short presentations. The conference registration deadline is **June 24, 2016**. For more information go to ***www.cygegc2016.com*** or contact the conference chairs **Julian McGreevy** and **Maraika De Groot** at ***chair@cygegc2016.com***.

Members in the News

Engineering Institute of Canada (EIC) 2016 Awards and Fellowships

CGS President Doug VanDine is pleased to announce that three CGS members have been selected for 2016 **Engineering Institute of Canada** awards and fellowships.

Jean-Pierre Tournier of Hydro Quebec was awarded the Canadian Pacific Railway Engineering Medal *'in recognition of leadership and service over many years at the regional, branch, section or equivalent levels, within the Institute or its Member Societies.'*

Gordon Fenton of Dalhousie University and **David Woeller** of ConeTec

Investigations Ltd were both made Fellows of the Engineering Institute of Canada.

The citations that accompany these awards and fellowships will appear in an upcoming issue of the *CGS-Geotechnical Info Net.*

Thanks to all who submitted nominations of CGS members for these EIC awards and fellowships. In an accompanying article in this issue, find out how you can nominate CGS members for 2017 EIC Awards and Fellowships.

Division News

CGS Engineering Geology Division
Message from the Chair

Nicholas Vlachopoulos

I am honoured and excited as I begin my term serving the CGS in the capacity of the Chair of the distinguished Engineering Geology Division. I am committed to advancing the role and recognition of the Division in order to ensure meaningful progress. Along with the outstanding Leadership Team of the CGS, I am ready for the challenges and interesting opportunities that exist for the CGS and specifically, the Engineering Geology Division.

I personally want to thank **Doug Stead,** the previous Chair, for his tireless commitment, work, mentorship and contributions. I would also like to acknowledge the efforts of all others that have worked historically in the past in order to aid in the development of the CGS Engineering Geology Division. The work and service of the current executive members, **Stephen Butt**, **Ariane Locat**, **Karine Champagne**, and **Anna Torgunrud** is also extremely valued and much appreciated.

As a Division, we look forward to working closely with the other CGS Divisions in order to ensure open lines of communication and collaboration. We will also ensure to strengthen our existing ties with Provincial and National Organizations (i.e. **Canadian Federation of Earth Sciences** (CFES), Universities, Industry etc.) as well as International Societies (i.e. **International Association for Engineering Geology and the Environment (IAEG**) etc.). I believe that our membership and professionals at large have much to contribute in this regard.

There are many initiatives that we would like to pursue. We hope to commission the production of a monograph on *Canadian Engineering Geology*. There is considerable support for this initiative and we envision that it will include the work of eminent Canadian engineering geologists in industry and academia. The monograph would encapsulate not only the historical development of Canadian engineering geology, but include state-of-the-art chapters. If you would like to contribute to this initiative or suggest what content should be included, please contact me at ***vlachopoulos-n@rmc.ca***; we do not want to leave any relevant individual or group out of such a publication.

We are also looking for members to help fill certain key positions on the Executive Committee. I am hoping that if you are interested and have a constructive vision for the organization, you will consider contacting me in order to officially contribute to our efforts. This is a terrific way to meet other members, but more importantly, help shape the future of the Engineering Geology Division.

To our many current members, thank you for your continued support of our great organization. Please feel free to contact me or any other member of the CGS Executive Committee at any time with your ideas, thoughts and initiatives. I look forward to serving and working with you all.

Submitted by Nicholas Vlachopoulos
Division Chair – Engineering Geology Division

Committee News

Formation of the CGS Geohazards Committee

Activities of interest to Canadian Geotechnical Society (CGS) members that transcend the Society's Divisional structure are managed by Committees. There are currently seven active, standing committees: Education, Heritage, Professional Practice, Transportation Geotechnique, Mining Geotechnique, and Sustainable Geotechnics Committees, and the newly re-branded **Geohazards Committee**. The Geohazards Committee replaces the Landslides Committee in response to a broadening of the interests and scope of committee members and activities.

Geohazards comprise a subgroup of natural hazards associated with geotechnical, hydrotechnical, tectonic, snow and ice, and geochemical processes that can affect public safety, infrastructure and the environment. The mandate of the Geohazards Committee is to support efforts leading to the technical competence and excellence of Canadian geotechnical engineers and related geoscience professionals working in the field of geohazards. For example, the Committee will contribute to the organization of CGS Annual Conference sessions on landslides and geohazards, the organization of national and international landslide and geohazard conferences, the development of national landslide and geohazard guidelines, and the maintenance of links with other related professional societies, such as the **Federation of International Geo-Engineering Societies' Joint Technical Committee on Natural Slopes and Landslides** (JTC 1).

The Committee will also collaborate with the **Association of Environmental and Engineering Geologists (AEG)** to award the Schuster Medal. The Schuster Medal is awarded to CGS and AEG members who have made a significant contribution to geohazards research, practice and/or education.

Please contact **Michael Porter**, current chair, if you have any comments or suggestions for the committee at ***geohazards@cgs.ca***

Submitted by Michael Porter
Committee Chair – Geohazards Committee

2016 Board of Directors, Committee Chairs, other Positions and Headquarters/Membres du Conseil D'administration ed du Personnel du Siège Social, Présidents des Comités et Personnes Occupant d'autres Postes En 2016

The information below was current at the time of preparation, but individuals and their contact information may change over the course of the year. The most current contact information for the vatious positions shown below is located on the CGS website at ***www.cgs.ca.***

Les renseignements ci-dessous étaient à jour au moment où ils ont été préparés, main les personnes et leurs coordonnées peuvent changer au cours de l'année. Vous trouvez les plus récentes coordonnées pour les différents postes présentés ci-dessous sur le site Web de la SCG, à ***http://www.cgs.ca/index.php?lang=fr.***

Editor

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Engineering Geology *Géologie de l'ingénieur*	Nicholas Vlachopoulos, P.Eng. vlachopoulos-n@rmc.ca
Geoenvironmental *Géologie de l'environnement*	Craig Lake, P.Eng. craig.lake@dal.ca
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Groundwater *Eaux souterraines*	Frank Magdich, P.Eng. frank@oakenviro.com
Rock Mechanics *Mécanique des roches*	Sam Proskin, P.Eng. sproskin@thurber.ca
Soil Mechanics and Foundations *Mécanique des sols et des fondations*	Alex Baumgard. P.Eng./P.Geo. abaumgard@bgcengineering.ca
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Interior BC Geotechnical Group	Sumi Siddiqua, P.Eng. sumi.siddiqua@ubc.ca
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London and District CSCE-CGS Group	Andrew Stewart, EIT. andrew.stewart@englobecorp.com
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St. John's Newfoundland Chapter	Sylvia Dooley, P.Eng. sylvia.dooley@c-core.ca
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The theme of the Conference is **"History and Innovation"**, recognizing the historical achievements and lessons learned over time while highlighting innovation in geotechnical engineering.

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- Education and Professional Practice

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JUNE 3, 2016
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Introduction by John Dunnicliff, Editor

This is the 85th episode of GIN. Four articles this time, together with two discussions of an article in the previous GIN, and the authors' closure

The fundamentals of vibration monitoring - things to consider

During the monitoring course in Italy last June, Bob Turnbull of Instantel made an excellent presentation about vibration monitoring. Here's a written version.

Specifications for robotic total station field work

The previous GIN included an article by Douglas Roy and Jonathan Stuhl of GZA GeoEnvironmental about specifications for robotic total station field work. Here are two discussions of the article, by Martin Beth of Soldata and Joel Volterra of Mueser Rutledge Consulting Engineers, together with a closure by the authors.

General role of instrumentation, and summaries of instruments that can be considered for helping to provide answers to possible geotechnical questions.

The previous GIN included an article about instrumentation for braced excavations, and I said that similar articles for other project types would follow. Here's one about embankments on soft ground.

Symposia on Field Measurements in Geomechanics (FMGM).

This episode of GIN includes two articles by Andrew Ridley of Geotechnical Observations Ltd. The first is a report on the Ninth FMGM, held in Sydney, Australia in September 2015. The second is about the future of FMGM.

Third International Course on Geotechnical and Structural Monitoring - June 2016 – Italy

The Third International Course on Geotechnical and Structural Monitoring (www.geotechnicalmonitoring.com) will again be held in the historic location of Poppi (Tuscany), Italy on June 7-9, 2016, followed by a field trip on June 10 to the Poggio Baldi landslide monitoring site (www.landslidemonitoring.com). During the field trip more than 20 leading companies will present their monitoring systems in a dedicated exhibition area.

To enhance the content on recent innovations, we're going to have three sessions in which registrants and exhibitors will make professional presentations about new trends. In each of these sessions, speakers will make brief presentations on new trends on each of the following topics: contact monitoring, remote monitoring, data acquisition and management systems.

We also plan on two sessions in which about ten users will make ten minute presentations on case histories and lessons learned.

Closure

Please send an abstract of an article for GIN to john@dunnicliff.eclipse.co.uk—see the guidelines on *www.geotechnicalnews.com/instrumentation_news.php*

Get a dog up ya! (From a website about toasts: "Apparently an Australian expression which really doesn't mean anything much at all. Often said whilst being drunk and yelled at high volume at the footy"). Being uncertain about the political correctness of this toast, I asked an Australian colleague. He said "GO!"

The fundamentals of vibration monitoring - things to consider

Bob Turnbull

Applications for vibration monitoring

Vibration monitoring covers a very wide range of applications. When you consider that anytime something moves it creates a vibration, the question really becomes, is the vibration relevant to your application? If we consider vibration in terms of geotechnical and structural monitoring then we can break the vibration sources into two broad categories, natural and man-made vibrations. As we all know natural sources of vibration like earthquakes, volcano, landslides, avalanches and even the weather can be devastating to people and structures. These types of events provide very little warning before they happen and therefore are very hard to predict. On the other hand, man-made vibration sources like construction activities, blasting, mining, pile driving, dynamic compaction, tunneling, train and vehicle traffic and people are quite easy to predict.

Main goals of vibration monitoring

When it comes to vibration monitoring the main goals are to protect people and assets. The more we monitor the better we understand how these vibrations impact our lives. Monitoring natural events helps us improve our predictive models and possibly take action sooner to reduce their effect on people. It also helps us understand these forces which can then be used to help improve our structural designs and construction activities. The monitoring of man-made vibrations will also help protect people and improve our construction activities. However, in many countries around the world there are also legal limits that have been established for man-made vibrations. These limits are generally set to reduce the vibrations that might have an effect on people and to prevent damage to a wide range of structures. This article will focus on the monitoring of man-made vibrations and present some of the different aspects of vibration monitoring that should be considered.

Things to consider

Vibration limits

Before starting any project you must first understand what the vibration limits are. The vibration limits will provide key information on the type of sensor that should be used on your project. Many countries have developed their own general vibration limits, however some stakeholders of the project may choose to implement even stricter limits.

To make sure you understand the vibration limits of your project, you will need to answer at least four questions:

1. Will you be measuring velocity, acceleration, displacement, strain or decibels?
2. Will these measurements be peak or RMS values?
3. What dynamic range is required for the sensors?
4. What is the frequency range to be monitored?

Choosing the sensor and data logger

Many software programs today provide tools to convert back and forth between velocity, acceleration and displacement or to calculate strain and display results in decibels based on a reference level. Whether you choose a geophone, an accelerometer or some other sensor you will need to make sure the data logger and software package will be able to convert the data into the desired units. If you choose a geophone and need to report the results in acceleration you will need to differentiate the velocity results to obtain the acceleration. If this is a manual process and you have thousands of events to convert, it might be better to choose an accelerometer to start with. Whatever sensor you choose make sure the data is recorded with enough resolution to be able to convert the results to the desired units with an adequate resolution.

When choosing a sensor make sure it has the dynamic range, resolution and frequency response to meet your requirements. Choosing a 500g accelerometer with a 3000 Hertz (Hz) frequency response may not make sense if your limits are 40g and 750 Hz. Generally, you will want to select a sensor that has a dynamic range and frequency response that are slightly larger than your requirements. If your limits were 40g and 750 Hz then select an accelerometer that has a range of 50g and 1000 Hz response. Once you have a sensor in mind make sure the data logger can provide the resolution you need. The resolution will be based on the analogue to digital convertor (A/D) that is used in the data logger. This can often be found on the data sheet for the data logger. If the data logger had an 8 bit A/D the best resolution it could provide for a 50g accelerometer would be 0.2g (50/(2^8). If the data logger had a 16 bit A/D the resolution could be as small as 0.00076g.

What is being monitored?

Now that we understand the vibration limits and type of sensor we need, we now need to understand what is being monitored. This will help to determine how and where the vibration sensors can be installed. Monitoring a building is very different from monitoring a stained glass window in the building. There are several methods of installing the sensors, the most reliable being to attach the sensor directly to the structure being monitored. However other methods like burying the sensor in the ground next to the structure and sometimes coupling the sensor to a surface with sandbags can also be used. The main goal is to install the sensor in such a way that it will experience the same vibration as the structure that is being monitored and not decouple (move independently) from the structure. It is also important to understand, that if the sensor is attached directly to a structure, where it is attached can affect the results. Attaching the sensor in a corner will have a very different result to attaching it in the middle of the wall.

The International Society of Explosives Engineers (ISEE) have developed a "Field Practice Guidelines for Blasting Seismographs" that can be found on the Internet. This guideline contains useful information on the placement and installation of the sensors.

What frequency response do you need?

The type of structure being monitored will also help determine the frequency response and sample rates that are required. Generally, you will want to sample at least four times the highest frequency that is expected. This will help reduce any errors due to the sampling rate. The higher the sample rate the better the resolution in the data and the greater the accuracy in recording the vibration.

Public relations and reporting

The stakeholders are an important part of any monitoring program. Making sure they are kept informed will help the project progress as smooth as possible. Knowing who your stakeholders are will also help you produce reports that they can easily understand. Reports that are too technical or do not provide clear results will slow the project down as you may spend a lot of time answering questions. The vibration time history will be useful to a consultant but may raise a lot of questions for stakeholders. However, displaying the data relative to your project limits can help stakeholders understand the vibration they experienced. It will also help if the stakeholders have an understanding of how the project will progress. As an example, if the project included blasting then make sure the stakeholders know when you are planning to blast and where they might be able to watch. This will help reduce the "startle" effect of blasting. In general, people are a lot less likely to complain if they are kept informed.

Collection and distribution of event reports

The collection and distribution of event reports were once very labor intensive. People would have to go to the project site, set up the equipment, wait for the event to happen, collect the data, and then take it back to the office for analysis. The reports would then have to be generated and sent to the stakeholders. This could have taken days or weeks for the reports to get to the stakeholders. Now projects can be monitored 24/7 with the project data being collected automatically. As soon as the event happens, the data can be sent to the stakeholders immediately after it has been recorded. The data can also be posted on the Internet and even sent to the stakeholders' cell phones.

Closing comment

As vibration monitoring projects become more and more demanding, the need to understand the basics will still remain. Spending the time to make sure you select the proper equipment, that it is installed correctly, and that the reports are clearly understood by all of the stakeholders will help you achieve vibration monitoring results that are satisfactory to all.

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Discussions of "Qualifications of the robotic total station construction monitoring professional"

Douglas Roy and Jonathan Stuhl

Geotechnical News, Vol. 33 No. 4, December 2015, pp 30-33

Martin Beth

Thank you to the authors for pointing out some important elements in specifications for robotic total stations, in particular regarding the profile of the engineers and technicians involved in the installation and maintenance.

I would like to propose some elements of further reflection. These can be split into four parts, first addressing the RTS (AMTS) specialist, then the "by whom" question", then thinking about specifications key points, and finishing with some comments on figures 3 and 4.

The RTS (AMTS) specialist

The conclusion to the article proposes a typical text for the RTS specialist specification which clearly describes and restricts its role to designing, testing and operating the monitoring system, ensuring that the data is of high quality and provides real information to the Engineers. I agree 100% with this statement.

I therefore wonder why the last bullet point requests the RTS specialist to be a PE or a PLS?

In my opinion:

- A structural or geotechnical engineer should be in charge of defining what information should the measurement system provide, what are the alert criteria, what course of action to give when considering the monitoring results.
- The RTS specialist and/or the monitoring & instrumentation specialist should ensure that a system is put in place that provides results than can be efficiently used by the structural or geotechnical engineer.

- The need for PE or GIE stamp might apply to the structural or geotechnical engineer, within the United States tradition of protecting local borders. It certainly does not apply to RTS specialists, in my opinion.

I have another comment about the RTS specialist: Running a monitoring program with high quality results is so specific, even more so when using RTS, that I would recommend not experience of two projects, but ten if possible. Of course one wants to receive at least three offers, so a request for such extensive experience might be a little too drastic and could be reserved for large projects.

The "by whom" question

On the subject of the "by whom", I believe the key points are about procurement and the structure of the contract. Procurement must not be based on low cost, and it should target companies with experience and reputation, etc… By "structure of the contract" I mean the question of who the monitoring specialist works for: the main contractor, or the engineering firm, or the owner. All these points have been discussed in detail in previous episodes of GIN, so I will not repeat them.

Specification key points

If we think about the main items required to obtain good instrumentation and monitoring (including RTS) specifications, I would recommend:

1. Define clear objectives in terms of what engineering values are needed, with what precision and at what frequency. These objectives should be defined by a geotechnical or structural expert, to suit exactly the project needs, and no more no less than the project needs.
2. If possible, give liberty to the specialists to select the monitoring system that they will use to answer these objectives.
3. Define how the specification, and especially the precision, will be controlled. This is not an easy task, and could the subject of a complete paper. But it is absolutely necessary.
4. Insist on the fact that the specification will be enforced, and detail the contractual consequences of not matching the specifications.

Thinking about it, we are not far from the SMART theory: Define specifications that are Specific, Measureable, Achievable, Relevant, Time defined.

Some comments on Figures 3 and 4

Finally, I will finish with some minor technical comments about figures 3 and 4. Figure 3 appears (I am not 100% sure, as the vertical scale appears to be masked around 0, or highly non-linear around 0) to show some RTS data of fairly low precision, with a lot of noise and quite a few spikes. There can be many explanations for such data, such as a very complex measurement conditions, the total station far from the targets, or other such real-life difficulties. However I would not want readers to think this is the standard in RTS results. Maybe the cause can be found in the configuration shown in figure 4, where clearly it was not possible to achieve a proper topographic layout.

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Joel Volterra

Thank you to the authors for addressing a subject that I believe worthy of periodic reexamination and ongoing discussion. Before addressing the Professional Engineer (PE) versus Professional Land Surveyor (PLS) issue, I've added a few related matters that I believe factor into that very issue, hoping at the same time it doesn't cloud the issue. I've seen this discussion center on the role of the technician versus the role of the Engineer in undertaking the tasks which together comprise these complex instrumentation and monitoring programs, specifically including the now prevalent use of robotic total stations (RTS) or automated motorized total stations (AMTS).

Data interpretation requires knowledge of construction progress records

My and my colleagues' philosophy has been to minimize the separation of implementation, collection and data reporting from data evaluation and interpretation. Construction progress records are necessary for data interpretation and evaluation. In the writer's experience all too often the two are not submitted together, and thus acknowledging a designed-for or anticipated movement or lack thereof as a function of adjacent construction activity is lost. This undermines the value of the monitoring program as a whole and diminishes its intrinsic value of collaboration among owners, contractors and consultants undertaking the work, whether performed by a PE, PLS or a technician under direction of one of the former.

Who is best suited to evaluate data?

Where an engineering analysis or structural computation estimates


Exhibitors' room


Lecture room


Street party


2015 Participants


Field Trip

3rd INTERNATIONAL COURSE ON GEOTECHNICAL AND STRUCTURAL MONITORING

June 7-9, 2016 Poppi, Tuscany (Italy)

Course Director: John Dunnicliff, Consulting Engineer
Organizer: Paolo Mazzanti, NHAZCA S.r.l.

THE COURSE: **attendance at the course is a great opportunity to establish a valuable network with colleagues from all over the world, to meet manufacturers and see the most recent and innovative instrumentation, thanks to a large exhibition area.**

NEW CONTENT:

- **Three sessions of professional presentation about new trends**
- **Two sessions dedicated to case histories, presented by selected registrants.**

COURSE EMPHASIS: **the course will include planning monitoring programs, hardware and software, web-based and wireless monitoring, remote methods for monitoring deformation, vibration monitoring and offshore monitoring. Case histories will be presented by prominent international experts.**

WHO: **engineers, geologists and technicians who are involved with performance monitoring of geotechnical features of civil engineering, mining and oil and gas projects. Project managers and other decision makers who are concerned with management of RISK during construction.**

LOCATION: **the 3-day course will be held in Poppi, Tuscany (Italy), one of the most attractive places in the world.**

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½-inch of lateral building or excavation support movement, say during a cantilever excavation phase, are you more concerned if no movement is reported or if 5/8" of movement is recorded? The reporting of "zero" movement ***may*** be more indicative of a problem and result in raising a bigger flag to reassess the monitoring system stability and or data processing algorithm and suggest something is not working properly or according to expectations. Alternatively, 5/8" of reported movement while potentially alarming to one not familiar with the design analysis, ***may*** support that the structural engineer and monitoring team deserve praise for their deformation analysis and movement reporting, just 1/8" off from their estimate. Who is best suited to evaluate these possibilities?

The evolution of roles, sub-specialization

This discussion offers that a PLS may be as suitably trained to administer these programs as the PE. In the past before recent Codes and Specifications, the PE may have performed land surveying directly. This person likely played a prominent role in the design and construction inspection, and performed optical monitoring from the job site where physically aware of ongoing construction progress and activities, weather trends and other external factors which affect the adequacy of their recorded data. High or sudden vibrations or rapid temperature swings resulting in poor survey traverse closure and thereby increased error were marked with an asterisk as they were recorded or reported, as the evaluation was made concurrent with data processing by those familiar and trained in recognizing these occurrences. Potential to lose such observations occurs more frequently in automated data processing software algorithms and or those in which third party monitoring consultants perform their tasks independently from other trades.

Leading into the 1990s and to the present day on many smaller projects, the PLS generally provided the installation and as-built location of monitoring "points" plus periodic readings of delta x, y, z for interpretation by "others". The qualifications of the "others" varied widely, from owner, to owner's representative in the form of the general contractor or construction manager, to an architect or engineer likely specializing or sub-specializing in a different discipline.

- How qualified are those people to understand ground movements, building response and/or to recognize typical red flags indicating potential errant readings or system flaws, or true signs of movement versus scatter, or no reported movement despite large seasonal thermal variations?
- How intimate were these people to the anticipated ground or building response?
- How much did or does the risk of underestimating or under-recording or under-recognizing the amount of deformation movement matter, meaning what are the inherent project risks?
- Are such things addressed in the majority of boiler plate or recycled project specifications?

Technology and methodology has morphed into current practice, and the efficiency of increased monitoring frequencies has supported automation in hopes of achieving greater data quality. As movement trends were further defined by multiple readings per day or hour, the less frequent manual survey by PLS became less cost efficient comparatively. There seems to be a cross-over point at a frequency of about two to three readings per week at least in New York City, where monitoring systems generally become automated and the work scope shifts from PLS to PE (unless a PLS administers the automated system). A PLS two-person crew, at $1,800 per day with equipment and office support performed three times per week results in costs of about $5,400 per week or $23,000 per month. Over the course of several months, automation becomes preferable and cost efficient while realizing numerous other advantages over manual survey.

Affordable redundancy by Professional Land Surveyor

I advocate using a PLS to provide monitoring point as-built and thus licensed coordinates during the baseline monitoring period, and periodically throughout the work as a sanity check of an automated system. In monitoring projects of 4 to 6 months or longer bridging a seasonal change, a building is likely to respond by deforming through its maximum normal atmospheric drift or range as well, irrespective of adjacent construction activity. As introduced above, should automated readings suggests either zero movement or 5/8" of movement whatever the case may be, a re-survey of prisms by the same PLS and means and methods ***may*** be appropriate to verify the automated readings, or to flag that a more detailed review of one or both systems is warranted. Recognize it is plausible that seasonal thermal variation effects increase, decrease or cancel out construction induced movements over any particular time period, though it unlikely movement trends would align with environmental factors if that was the case, hence the need for good baseline data over a range of thermal conditions and frequent readings. These may be considered redundant readings, so cost implications factor into whether or when they are performed.

Collaboration among the morphing evolution of roles into subspecialties

Further sub-specialization of tasks and consultants (not only in survey or geotechnical disciplines but others as well) puts a higher level of ethical and technical responsibility on the part of the PE designing, specifying and or signing off on these programs or summary data or interpretive reports, whatever their background or title. Those likely most highly suited and positioned to perform, evaluate and interpret the monitoring programs and data remain are those who played a role in designing the structure on behalf of the owner, who ultimately has the most at stake to complete the project without incident or delay. We find that construction contractors are sometimes receptive to relinquishing the monitoring programs to the owner or the owner's consultants, allowing many other benefits such as starting the process of access, permissions, installation and baseline prior to awarding the construction contract.

On many projects, the cost and risks of today's monitoring programs rival those of the project's geotechnical investigation and or excavation support design. I believe that the assignment of specific tasks or roles in undertaking the geotechnical or structural monitoring program requires as much thought, premeditation and vetting at each stage of design and construction as does other major design and construction tasks. Should an "expert" not be engaged to directly manage the monitoring scope, roles and methodology, it is in the best interest of the design or construction team to consult one. It is unlikely in the writer's opinion, that a one-size fits all approach will ever be established, though local Codes may look to further pre-certify organizations to perform such "Special Inspection" tasks as a function of individuals and their respective firm's history and experience. I agree and support the author's recommendations for tasks to be incorporated into contract specification language for an RTS or AMTS specialist, following the lines that they have thought through assigning these roles, and also that the specifications be reviewed on a case by case basis by someone experienced in this type of work.

As the monitoring scopes and costs increase, responsibility may be more and more shifted from the designer to the PE who is charged with implementing and managing the program during construction. As always, the person signing off on the work must have a comprehensive understanding of the technical issues. Whether a PE with geotechnical or structural background or specialty, a PLS or someone with another title all together is charged to lead the program will continue to depend on the nature of the specific job and the philosophy of the firm awarded the work. However, it clearly behooves each to consult and collaborate with others holding relevant background and experience before undertaking the specified monitoring scope. Where the monitoring consultants are third party to the design, appropriate questions should be asked as to anticipated deformations and timing of those throughout construction, such that appropriate resources can be dedicated to evaluate the work as those time frames occur.

Joel L. Volterra

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Authors' Reply

We would like to thank both Joel and Martin for their in-depth discussion and John for his ongoing support of these discussions. We were remiss in also not acknowledging Charlie Daugherty who brought this subject to task for the authors and had long been involved in the resurgence of New York City tunneling instrumentation over the last 20 years.

Although our article was intended, and as John states in his introduction, **to guide owners, engineers and specification writers,** the topic is clearly a one of great passion and strong opinion for both Joel and Martin.

Martin Beth

Clearly Martin is a proponent of having highly qualified personnel, no matter what their education and/or certification by a government agency, to oversee (and ideally design) the data collection systems on instrumentation projects. Where this becomes difficult is for the specification writer to have some comfort regarding who will be qualified to undertake this work, accepting that they will in all likelihood have little say in who the general contractor selects, given that in the majority of large horizontal infrastructure project the work is a public bid.

The government agency certification of the PLS or PE gives the specification writer some assurance that the work will be undertaken by a qualified person, without providing a long list of qualification which the specification writer likely is not familiar with. In addition it was our intention to focus only on the scope of the RTS portion of the monitoring, to be completed as a subset of the overall monitoring system overseen by the Geotechnical Instrumentation Engineer. This brings up the argument that maybe the industry should pursue some type of internal RTS user certification, but this lacks support as Joel later discusses.

Regarding Martin's discussion of the specifications we agree and strongly support an enforceable specification that, in the end, levels the professional playing ground.

As for Martin's comments on figures, we agree that a large number of factors affect the precision of the RTS data in a real-life monitoring environment. Regarding Figure 3, the RTS was positioned well within the monitoring zone and with some less than ideal configuration for the monitoring targets. For example, the vertical angle and orientation was such that during daytime hours glare from the sun was an issue. Accepting the facts of the locations required to provide the monitoring, the precision of the data shown exhibits a standard deviation of approximately 0.035 inches. As the manufacturer's stated precision for distances measurement is 1 millimeter or 0.039 inches, the precision is within the parameters of the instrument. It has long been our view that extensive data-smoothing should not be employed on raw data used by the RTS specialist and the engineer should review the site conditions to determine plausibility of actual movement. It has also been our experience that after significant movements are experienced, as shown in the figure, the system precision may be slightly degraded as the original orientations of the monitoring prisms to the RTS has been changed.

Finally it is also important to discuss that, as Martin note**s,** Figure 4 does not provide a proper geometric layout for the RTS system. We feel it is important for readers to understand that some systems cannot be designed ideally. This figure presents a particularly challenging situation where monitoring was required over a long-span bridge across a body of water, which required extensive design to the system to improve the robustness of the data quality. We consider the design of the system in this figure to be a prime example of incorporating different backgrounds, skill sets and experience levels into the design of a monitoring system, and the complexity often required may not be found in a single easily defined individual.

Joel Volterra

Joel starts his discussion with a topic also brought up by Martin, and one we wanted to avoid, that the RTS specialist should be a technician. It was not our intention to discuss the qualifications of the Geotechnical Instrumentation Engineer or state that the monitoring system as a whole should be designed and overseen by the RTS specialist who we attempted to describe. Luckily we realign with Joel as he further goes on to discuss; depending on how the project is managed the data interpretation and data management should be undertaken by personnel that not only understand the reason for movement but the evolving technical nature of RTS data.

Again, it goes back to the argument that this work should be undertaken by a very small subspecialty of PEs or PLSs who have obtained, through project experience or formal training, the qualifications to undertake the work. This brings us back to the point regarding the requirement for having a licensed professional making this determination regarding their own qualifications regardless of the specification language.

Maybe the answer is that the specifications should be written by someone (PE or PLS) who has the same or similar project experience.

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General role of instrumentation, and summaries of instruments that can be considered for helping to provide answers to possible geotechnical questions. Part 2.

John Dunnicliff

Introduction

This is the second in a series of articles that attempt to identify:

- The general role of instrumentation for various project types.
- The possible geotechnical questions that may arise during design or construction, and that lead to the use of instrumentation
- Some instruments that can be considered for helping to provide answers to those questions.

Part 1, covering internally and externally braced excavations, was in December 2015 GIN.

Part 2 covers embankments on soft ground.

The following points were made in the introduction to Part 1, and also apply here:

- Of course it is recognized that there may be additional geotechnical questions and also additional instruments that are not described in this article.
- The sequence of geotechnical questions is intended to match the time sequence in which the question may be addressed during the design, construction, and performance process, and does not indicate any rating of importance.
- The suggestions for types of instruments is not intended to be dogmatic, because the selection always depends on issues specific to each project, and is influenced by the personal experience of the person making the selection. In the tables some of the most likely instruments that can be considered are listed, with other possible types in parentheses.
- The tables include the term "remote methods" for monitoring displacement. An overview of these remote methods is given in a December 2012 GIN article by Paolo Mazzanti (www.geotechnicalnews.com/instrumentation_news.php). Readers who want to learn more about these methods may want to consider participating in the annual International Course on Geotechnical and Structural Monitoring held in Italy (www.geotechnicalmonitoring.com), where they are discussed in detail.

Embankments on soft ground

General role of instrumentation

This article relates to the use of geotechnical instrumentation where all the geotechnical questions are associated with the soft ground itself, and not with the embankment.

In many cases, selection of soil parameters for the foundation soil is reliably conservative. The embankment is therefore designed with confidence that performance will be satisfactory, and "comfortable" factors of safety are used. In such cases, many projects will proceed without the use of instrumentation. However, some uncertainties always exist. Where design uncertainties are great, factors of safety small, or the consequences of poor performance severe, a prudent designer will include a performance monitoring programme in the design.

Table 3. Some instruments that can be considered for monitoring embankments on soft ground

Possible geotechnical questions	Measurement	Some instruments that can be considered
What are the initial site conditions in the soft ground?	Pore water pressure	Vibrating wire piezometers installed by the fully-grouted method (Open standpipe piezometers) (Pneumatic piezometers)
	Vertical deformation	Conventional surveying methods Remote methods
Is the embankment stable?	Horizontal deformation	Conventional surveying methods Remote methods Inclinometers (In-place inclinometers)
What is the progress of consolidation of the soft ground?	Vertical deformation of embankment surface and ground surface at and beyond toe of embankment	Conventional surveying methods Remote methods
	Vertical deformation of original ground surface below embankment	Probe extensometers (Single-point and full-profile liquid level gauges) (Settlement platforms) (Horizontal inclinometers)
	Vertical deformation and compression of subsurface	Probe extensometers
	Pore water pressure	Vibrating wire piezometers installed by the push-in method

In spite of a long record of embankment construction throughout the history of civil engineering, embankments that are designed with a factor of safety greater than unity fail embarrassingly often. On the other hand, some test embankments that are designed to fail intentionally, never do. Thus, it is not surprising that instrumentation plays a significant role in design and construction of embankments on soft ground.

The most frequent uses of instrumentation for embankments on soft ground are to monitor the progress of consolidation and to determine whether the embankment is stable. If the calculated factor of safety is likely to approach unity, instrumentation will generally be installed to provide a warning of any instability, thereby allowing remedial measures to be implemented before critical situations arise.

Summary of instruments that can be considered for helping to provide answers to possible geotechnical questions

Table 3 lists the possible geotechnical questions that may lead to the use of instrumentation for embankments on soft ground, together with possible instruments that can be considered for helping to provide answers to those questions.

Report on 9th Symposium on Field Measurements in Geomechanics

Andrew Ridley

The 2015 Symposium on Field Measurements in Geomechanics (FMGM) was held at the Sheraton on the Park hotel in Sydney, Australia from 9th to 11th September 2015. Over 200 delegates from thirty-two countries attended the symposium and 33 companies showcased their products at the impressive exhibition. The Symposium was preceded by two workshops, one on InSAR and Emerging Technologies and the other on Radar and Monitoring. These were attended by over forty delegates. The Symposium and the Workshops were organised by the Australian Centre for Geomechanics and sponsored by IDS, Geokon and PSM. The organising committee, Chaired by Professor Phil Dight and Mark Fowler should be congratulated on a magnificent achievement.

In his opening address to the Symposium Mark Fowler pointed out that "it is hard to escape the reality that technology in everyday life is advancing so rapidly, and it is not just changing our lives, but in fact shaping it. The pervasiveness of smart phones and tablets, cloud computing, drones—data vacuums of the air—and the potential benefit and threat of big data may individually and/or collectively enrich and exploit our lives. Geotechnical monitoring is no exception. It's hard not to think we are in or approaching the golden age of monitoring and there is no question that these advances have, and will,

Friends gather for the traditional symposium dinner. At right front, Elmo DiBiagio, the only person to have attended all nine FMGMs greatly further our profession." Inspiring words indeed!

During the three day Symposium programme sixty five papers were presented. The scene was set with an excellent presentation from Dr Philip Pells entitled "Monitoring – the good, the bad and the ugly" highlighting the pitfalls when the application of instrumentation is poorly understood. The presentation, which focused on some well-known case histories such as the double helix underground car park at Sydney Opera House (the "Good"), the Heathrow Express tunnels (the "Ugly") and Vaiont Dam (the "Very Ugly") reminded us that monitoring, whether simple of complex, should only be implemented if we have valid theoretical and physical models against which to evaluate the results. Pells also told us that it is very important to listen to those who disagree with us, particularly experienced geologists because they often see things that engineers miss. Wise words indeed and a reminder that our subject is not just about the gadgets and the data. Keynote addresses were also given by Dr Andrew Ridley (UK) on "Soil suction – what it is and how to measure it"; Martin Beth (France) on "The challenges of supplying good quality and useful data for significant projects"; Dr W Allen Marr (USA) on "Performance monitoring as a risk management tool in dam safety" and Dr Ian Gray (Australia) on "The measurement and interpretation process to determine the state of stress in rock including the effects of fluid pressure."

The conference was divided into morning plenary sessions and afternoon parallel sessions. The subjects covered were emerging technologies, tunnelling, water flow, mining, transport infrastructure, slope stability and case histories. The Best Young Engineer Paper Award was given to Michele Salvoni for his paper entitled "Improvement of pseudo-3D pit displacement mapping technique through geodetic prism data integration." In addition to the prestige and the monetary prize Michele was also invited to represent young professionals on the new FMGM Secretariat, a development that was introduced to the delegates during the Symposium.

The traditional symposium dinner was held on a Sydney Harbour boat cruise which showcased, to the 130+ international and local attendees and their guests, the fantastic harbour and its iconic landmarks.

As had been agreed in Berlin (2011) the next FMGM Symposium will be held in Rio de Janeiro, Brazil in 2018. The local organising committee, led by Professor Pedricto Roche Filho (PUC-Rio) will be supported by a new permanent FMGM Secretariat. The Sydney Symposium was informed of the new Secretariat (a new development) by Andrew Ridley. The Secretariat will be hosted by the British Geotechnical Association and is composed of representatives from the existing International Advisory Panel and new people from across the international community. Further information to come.

In summary I would say that the 2015 FMGM Symposium was another overwhelmingly successful event and the long trip (for many of us) was very much worthwhile. I look forward to the next Symposium in Brazil and renewing enduring friendships.

Andrew Ridley

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The Future of FMGM

Andrew Ridley

FMGM is an acronym derived from the name of a series of international symposia entitled "Field Measurements in Geomechanics" that deal with the use of instrumentation to monitor the performance of engineering structures. The applications include dams, foundations, tunnels and other underground openings, embankments, natural slopes, land reclamation, mining facilities, repositories for industrial or nuclear waste and offshore structures. The FMGM symposia are staged every three or four years; the last symposium was held in Sydney Australia in September 2015 and the next will be held in Rio de Janeiro, Brazil in July 2018.

Until now FMGM has been run in an informal way, the responsibility for the symposia being handed over from one group to the next, essentially based on personal relations and friendships. Chairpersons of previous symposia and their professional associates have functioned as a *de-facto* Secretariat. There has not been any fixed procedures or even statutes on how to proceed with the symposia in the future or how to organise FMGM as a whole. Nevertheless all previous symposia, since the first in Zurich in 1983, have been successful and generated a lot of international interest in the specialised topics dealt with.

Despite the success of the *de-facto* arrangement there is no guarantee that FMGM will continue to be as successful in the future and therefore during the 8th International FMGM Symposium, held in Berlin in 2011, a general assembly was held to discuss the future of the symposia. It was agreed that a formal FMGM Secretariat should be established. Several people and organisations were contacted about this and the British Geotechnical Association (BGA) has agreed to host a Secretariat for FMGM. This was formally announced at the Sydney symposium. The new FMGM Secretariat will be formed as a subcommittee of the BGA Executive Committee and will be made up of people from the BGA Executive Committee, the existing FMGM supporters and other co-opted people. The new FMGM secretariat will have its own financial arrangements, sitting under the current BGA financial organisation and to date over £10,000 has been pledged by companies and organisations with interests in the subject. During the Sydney symposium several people were approached and agreed to participate in the committee affairs of the new Secretariat. In addition an FMGM LinkedIn discussion group (named "Field Measurements in Geomechanics") has been initiated to distribute information.

The principal aims of the new Secretariat are to:

1. Set up and maintain a list of persons, organisations and institutions that want to be associated with FMGM.
2. Establish and develop a new FMGM website.
3. Distribute an annual newsletter.
4. Establish financial independence for FMGM. This has and will continue to be done by approaching members of the FMGM community, particularly service providers and instrumentation suppliers, for financial support in running the Secretariat.
5. Establish written guidelines for future FMGM Symposia, including how to decide where they should be held, how to run the symposia, how to share the risks between local organisers of an FMGM symposium and the FMGM Secretariat and updating the guidelines after each symposium and;
6. Explore the feasibility of establishing an international FMGM Society or a Technical Committee on Field Measurements as part of the International Society of Soil Mechanics and Geotechnical Engineering.

Anyone wanting more information about the new FMGM Secretariat can write in the first instance to Andrew Ridley (andrew@geo-observations.com) or join the LinkedIn discussion group and post a comment.

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Academics and industry join forces to raise the bar on dam engineering

Richard Cairney

Members of the panel (L to R) Tim Eaton, Steve Vick, Ward Wilson, Gord Mckenna and Andy Robertson. Photo: Rich Cairney.

Dr. Norbert Morgenstern and short course attendee Stephanie Hunter of BGC Engineering. Photo: Gord McKenna

After dams at two Western Canadian mines burst in the last two years—at the Obed Mine near Hinton, Alberta, in 2013 and at B.C.'s Mount Polley Mine in 2014—alarms went off for engineers across the country.

At the Alberta Chamber of Resources, an association that represents resource industries across the province, a group known as the dam integrity advisory committee paid particularly close attention. Members of the group spotted a potential gap in succession planning for dam engineering expertise and asked the Faculty of Engineering at the University of Alberta to provide some professional inservice for dam engineers.

They approached Ward Wilson, a professor in the Department of Civil and Environmental Engineering and School of Mining and Petroleum Engineering at the University of Alberta, for help. The result was an intense, five-day course that attracted mid-career dam engineers from around the world.

The Class of 2015 - The First International Short Course on "The Design and Assessment of Mine Waste Structures" held at the University of Alberta in December 2015.

"I was thinking they could put together a two-day workshop for 20 or 40 people," said Larry Staples, an advisor with the Alberta Chamber of Resources. But Wilson, along with Distinguished University Professor Emeritus Norbert Morgenstern, who is widely considered to be the world expert in his field, and civil engineering professor Nicholas Beier delivered much more.

"I was blown away by the number of people that showed up and the fact that those people were from the exact demographic we need to reach—dam engineers who are in the mid-career stage who are going to step into positions of greater and greater responsibility."

About 75 people participated in the workshop—including engineers from Imperial Oil, Shell, and Syncrude as well as those from consulting firms and regulatory bodies in Alberta and B.C.

Alberta Chamber of Resources Executive Larry Staples (left) and Brad Anderson (right) enjoy a hands-on laboratory exercise.

Wilson, who has decades of experience in the mining industry and now holds the NSERC/COSIA Industrial Research Chair in Oil Sands Tailings Geotechnique, says the geotechnical engineering curriculum in the Faculty of Engineering is recognized as one of the best. It's important the university and industry leaders share their knowledge and experience with students and young engineering professionals.

Attendees took part in tutorials delivered by a handful of Wilson's graduate students, who provided instruction on brand-new software and current research into issues like acid rock drainage. Course offerings ranged from conventional tailings embankment design and dam safety and inspection to specialized topics such as mine waste management in the Arctic and hydrology and groundwater issues.

Internationally recognized experts, including Bill Chin, Carlo Cooper, Richard Dawson, Tim Eaton, Don Hayley, Scott Martens, Gord McKenna, Andy Robertson, Peter Robertson, John Sobkowich, Dirk van Zyl, Steve Vick and Christina Winckler, were invited to deliver presentations and join a panel discussion on dams and mining held at the end of the workshop.

Staples described members of the panel as superstars. "Those superstars came here came because of the reputation of organizers like Dr. Morgenstern and Dr. Wilson, that extend around the world, and because they believe in what Dr. Wilson and Dr. Morgenstern and now Dr. Beier are trying to do to equip that next generation of engineers."

For graduate students themselves, the course meant not only presenting research findings, but also learning at the hand of industry leaders and networking with professional engineers.

"It's really good hearing from people who have the experience of working in this area day in and day out," said Bereket Fisseha, a professional engineer from Ontario who chose to pursue his PhD in geoenvironmental engineering at the University of Alberta. "We're getting into a very diverse set of topics and getting a complete picture of the mining industry from an academic point of view and the application side."

At a closing panel discussion that closed the event, participants sat in a packed 100-seat auditorium to hear experts talk about everything from a conversation on best available technologies to the ethics and social relationship between society and industry.

Industry professionals flew in from as far away as Australia for the sessions, which Staples said were demanding.

"This went for five days, right through the weekend, and let me tell you it was intense," he said, adding that participants left feeling "inspired to do better work."

The organizational team of the First International Short Course on 'The Design and Assessment of Mine Waste Structures' included faculty, staff and graduate students of the University of Alberta Geotechnical Centre: Dr. G. Ward Wilson, Dr. Nicholas Beier, Dr. Norbert Morgenstern, Sally Petaske, Annette Busenius, Christine Hereygers, Dr. Louis Kabwe, Ahlam Abdulnabi, David Barsi, Ralph Burden, Bereket Fisseha, Matthew Schafer, Neeltje Slingerland and Elena Zabolotnii.

Richard Cairney is the Communications Officer for the Faculty of Engineering at the University of Alberta.

Images courtesy of Jen Stogowski Photography.

Paolo Gazzarrini

Overture

42nd episode of the Grout Line and, as promised, for this issue, the second part (of three) of the article written by Clif Kettle, Technical Manager, Bachy Soletanche Ltd., Burscough, Lancashire, UK,(clif.kettle@bacsol.co.uk) and Maren Katterbach, Project Engineer, Lombardi Engineering Ltd., Minusio, Switzerland (maren.katterbach@lombardi.ch).

I was obliged to split the four very interesting case histories about grouting and the application of the GIN method (two case histories each) due to the length of the article (I don't want to monopolize Geotechnical News!), so stay tuned in June for the third part!
Before the article some of very important news for our grouting industry.

The first is related to the Grouting Fundamental & Current Practice 37th Annual short course. As you can see from the pamphlet below, the venue has changed to the University of Austin, Texas, still in June 2016

Prof. Scott Kieffer, course director, sent me this brief new presentation of the course:

37th Annual Short Course: Grouting Fundamentals & Current Practice June 13-17, 2016 University of Texas at Austin

Since 1979 the Grouting Fundamentals and Current Practice course has covered the applications of pressure grouting to a broad array of geo-structural construction and remediation techniques. Grouting is instrumental in the construction of modern complex infrastructure, as well as in the remediation of our aging infrastructure, including dams, levees, tunnels, highways and buildings. Few institutions are teaching grouting as an engineering discipline, and as a result the Grouting Fundamentals course has educated more grouters than any other program worldwide. The core faculty are recognized international authorities and leaders in the grouting industry, representing the most current state-of-practice in the US, Canada, and throughout Europe.

The course's long history has included installments at the University of Missouri, University of Florida, and the Colorado School of Mines. The move to UT Austin is motivated by an interest in strengthening ties between the grouting profession and UT Austin's world-class geotechnical engineering group, where faculty are performing innovative research concerning cemeniitious grouts. Significant synergies between grouting technologies in the civil and petroleum engineering industries are also anticipated at the new UT Austin venue. And very importantly: Texas BBQ is hard to beat!

For course details visit: *www.groutingfundamentals.com*.

For technical queries please contact Scott Kieffer: *kieffer@tugraz.at*

The second new item is related to "our" 2017 grouting conference. The call for papers is out, with two additional topics, Deep Mixing and Diaphragm Walls.

As usual, I make the same request, asking you to send me your grouting comments or grouting stories or case histories. My coordinates remain: Paolo Gazzarrini, paolo@paologaz.com, paologaz@shaw.ca or paolo@groutline.com.

Ciao! Cheers!

PRELIMINARY ANNOUNCEMENT AND CALL FOR PAPERS

5th International Conference on Grouting, Deep Mixing and Diaphragm Walls
Hilton Waikiki July 9-12, 2017

INTRODUCTION

The Geo-Institute Grouting Committee and the International Conference Organization for Grouting (ICOG), as cooperating organization, are organizing the 5th International Grouting Conference. The conference focus will be on new technologies and current practice related to Grouting, Deep Mixing and Diaphragm Walls.

Since 1982, four international grouting conferences (one every ten years) have been held in New Orleans. At the last conference, in 2012, there was a common thought expressed, to reduce the ten year interval to five. The feeling was that a ten year interval was too long between conferences and too many advances and innovative grouting applications, deserved a shorter interval. In 2012, four keynote lectures and 182 papers were presented for an audience of more than 800 delegates.

At the 2017 conference, short courses on jet grouting, compaction grouting, deep mixing and slurry walls, along with workshops will be available. Details to follow.

CONFERENCE SESSIONS

Conference sessions will take place over three days, in both plenary formats and in concurrent tracks. The Geo Institute Grouting Committee will be assisted by a Technical Advisory Committee consisting of representative from more than 15 countries in determining the proposed session topics for which abstracts should be submitted:

- Sustainability in Grouts and Grouting Applications
- New and Emerging Technologies in Grouting
- Properties of Grouts and Grouted Materials
- Digital systems for control and monitoring
- Verification of Grouting, Deep Mixing and Diaphragm Walls
- Grouting and Deep Mixing for Seismic Retrofit and Remediation
- Diaphragm Walls, Deep Mixing and Jet Grouting for Deep Excavations
- Grouting, Deep Mixing and Diaphragm Walls for Cut-offs
- Grouting for Tunnels; Pre or Post-excavation
- Design methods for Grouting, Deep Mixing and Diaphragm Walls
- Case Studies
- Innovations and Developments
- Materials
- Equipment
- Methods
- Grouting for Pipelines
- Soil and Rock Grouting

The abstracts and papers will be subject to GI GSP (Geotechnical Special Publication) procedures.

Abstracts are due by April 15, 2016. Notification to the authors by July 15, 2016. Send your abstract to paolo@paologaz.com. More information at website, asap.

GIN Method (II) Case Histories

Clif Kettle & Maren Katterbach

Case History 1 - Carno Dam, South Wales, 2009

Carno dam project involved the stabilisation of an extremely sensitive embankment dam which had exhibited significant seepage through the main core. The dam was potentially unstable, posing a high risk to public safety and the dam reservoir had to be completely drawn down allow excess water to drain from within the core (see photos below). The works involved the construction of a 44 m deep slurry wall cut-off within the original clay core extending over the full length of the dam and into the clay core contact trench.

Once the slurry wall had been completed, a twin row grout curtain was constructed to heavily fractured rock formation which was suspected of having been mined for coal early in the 20th century. The grout curtain geometry was critical with respect to its relational position to the core, the new slurry wall, and the existing draw off culvert. Drilling accuracy was important and rock drilling was executed using the Wassara water-powered DTH hammer. Drilling through the body of the dam was executed by means of open hole drilling with grout flush to fill any localised voids as the drilling progressed.

The Engineer specified a residual permeability for the grouted cut-off of 3 Lugeons, to be verified by multiple stage Lugeon testing on completion of the works.

Design considerations for grouting Ooerations

- weakened embankment - history of seepages and sinkholes
- embankment cavitation leading to settlement of dam crest
- suspected presence of old coal workings in foundation bedrock
- steep and irregular rock head / plinth profile on left abutment
- impossibility of achieving full closure of slurry wall with plinth & rock-head
- complex dam geometry requiring 3-D design to avoid seepage 'windows'
- unexpected rock profile required 20% lateral curtain extension up to spillway
- the draw-down of reservoir limited injection pressures due to risk of hydro-fracture and heave.
- particular care was required to close the contact with slurry wall complexity & sensitivity of the works led to the employment of computer piloted injection equipment with computer design, control, analysis, and reporting of the injection operations
- use of Wassara water powered DTH hammers to avoid clogging of fine fissures whilst ensuring high production and accuracy of drilling
- computer controlled GIN grouting selected for fissure treatment in bedrock to maximise injection control and minimise risk of high pressures
- fine fissures and tight specification led to the selection of C3S - a highly penetrating stabilised cement-bentonite slurry used to ensure high grout mobility & penetration
- difficult confined space work conditions in the culvert led to a re-design of the works around the culvert to maximise the drilling from the dam crest

The C3S mix is a fluidified bentonite-cement slurry based on ordinary Portland cement and a de-flocculated bentonite slurry.

Figure 1 indicates the degree of seepage through the core and embankment,

Figure 1. Seepage evidence at the Carno dam.

and the drainage of the embankment through the up-stream face after the reservoir draw-down.

In order to limit potential damage to the core and to avoid the risk of heave, the injections commenced with a relatively modest GIN value of 1,000. The early section of the works was phased so that the grouting engineer could very quickly observe the effectiveness of the ground treatment over the primary and secondary phases for a limited section of both the upstream and downstream grout curtain. The reduction ratio achieved for the grout volumes injected in the four successive phases was lower than was anticipated, and the GIN value was therefore increased to 1,200 to allow slightly greater pressures and greater maximum volumes to be applied for the remainder of the works, whilst retaining the same target volume per linear metre, and the same limiting maximum pressure. A single GIN value was selected for the entire works.

At Carno, the GIN system was applied with particular care, partly because of the reduced confinement arising from the reservoir draw-down, and partly to ensure that the results at the end of the secondary phase met the specified requirements, with no requirement for a tertiary phase. The software displayed real-time plots of basic injection parameters, together with an additional completion criterion, - the 'Equivalent Lugeon' value. This value combined the volume, pressure, and time data for the injection in progress, and calculated an Equivalent Lugeon value, by taking into consideration the relative viscosity of the grout mix to that of water. This function was clearly not a true Lugeon value, but a close estimation for fluidified and stable grout, which allowed the progressive evolution of the effective Lugeon value, and hence the progressive reduction in transmissivity of the rock, to be observed in real-time as the injection progresses, similar to continuous water test, but with grout.

In the typical example illustrated in Figure 2, it can be observed that at the end of the injection the pressure increases and flow rate reduces - clear evidence that the rock is “tightening-up'; but also that the injection has continued until the Equivalent Lugeon value has fallen below the specified maximum allowable value of 3 Lugeons. However, if the same graphics are plotted against a timescale, Figure 2 (right) it can be seen how much effort was taken to achieve the best possible' refusal', by continuing the injection well beyond the point where the specified 3 Lugeon criteria had been met. It can be observed that in this example the grouting continued for half an hour after the specified threshold, so that the refusal could be demonstrated over the last 30 minutes of injection.

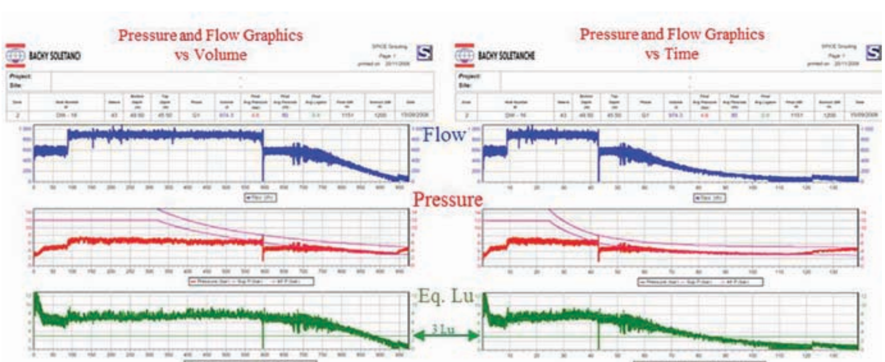


Figure 2. Injection rate (blue), Pressure (red), and Equiv. Lugeon (green) values plotted against the injected volume (left). Injection rate, Pressure, and Equiv. Lugeon values plotted against the injection duration (right).

Working in this conservative manner achieved excellent results and ensured for the client that there was no requirement for a further tertiary phase of treatment, which would certainly have added considerably to the cost and duration of the works.

Grout curtain design

The methodology and scope of the grouting works evolved throughout the duration of the project in response to ground conditions, and this evolution was documented and controlled through the issue of detailed method statements and technical memoranda.

The basic elements of the drilling and grouting design processes included:

- Preparation of a 3D design model of borehole geometry for works phasing, management, control, planning, and reporting using CASTAUR programme
- Generation of instructions for the drill crews using CASTAUR programme
- Accurate setting out of drill hole locations
- Drilling of boreholes to rock head and installation of guide /liner pipes and /or TaM pipes
- Survey of as built alignment of drill holes using Boretrack /Maxibor
- Revision of the 3D design model for as-built locations
- Design of injection parameters for grouting, including GIN mode
- Generation of electronic grouting and water testing instructions using SPHINX, including selection of GIN value
- Sequencing of grouting programmes
- Drilling of preliminary injection stages and water testing
- Review of injection parameters and mixes using SPHINX and SCAN 3-D
- Drilling and injection in phases as detailed in sections under SPICE pump regulation

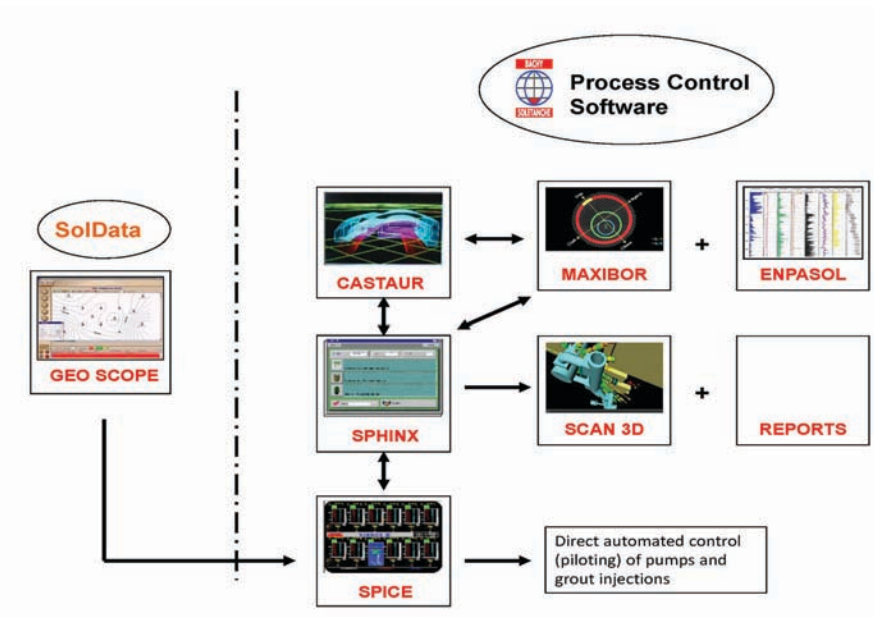


Figure 3. Inter-relationship between key components of the control software.

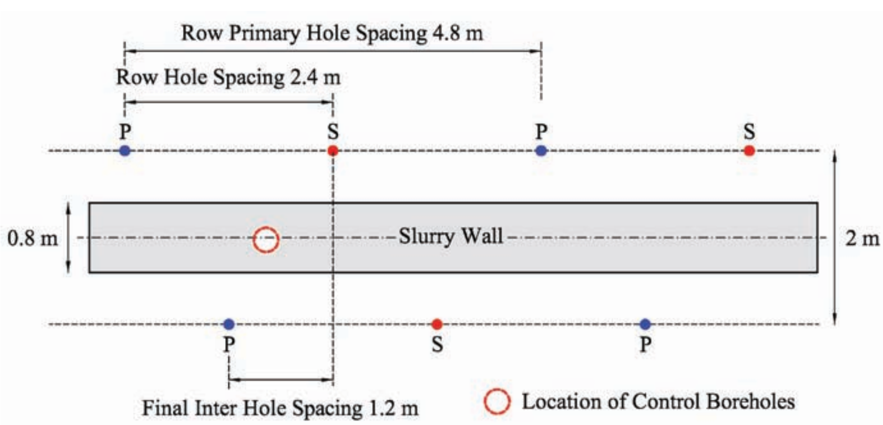


Figure 4. Grout hole / slurry wall geometry – plan.

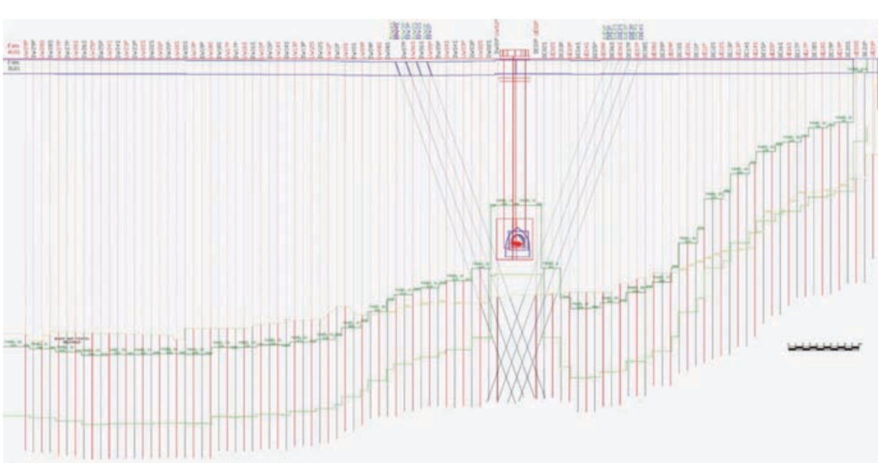


Figure 5. Dam surface drilling geometry.

- Analysis and reporting of grouting results using SPHINX and SCAN 3-D
- Drilling of control holes, water testing
- Preparation of 2D and 3D plots, and tabulated analysis, using SPHINX and SCAN 3-D
- Review of injection & water test data
- Preparation of Black and Veatch compliance documentation

Design and 3-D modelling

Due to the complex geometry of the cut off, particularly around the culvert, and the degree of uncertainty regarding the profiles of the culvert planes and rock head, it was considered essential to establish a 3-D model to:

a. design the location of the grout holes to ensure minimum spacing

b. define the zones of treatment for the preparation of the electronic grouting instructions

c. verify the continuity of the key cut-off elements

A full 3-D model was prepared in the CASTAUR-CAD geometry design software, which was updated as the works progressed on the information from the driller's logs, and the results of borehole surveys using a Maxibor instrument.

Grout curtain criteria

Maximum and average Lugeon values were specified for the hydraulic conductivity of the rock mass.

The specification called for a high degree of control of the grouting process, and the geometry of the grout curtain, and required that the contractor demonstrate continuity of the cut-off. These issues were addressed by employing an integrated system of computer controlled grouting equipment, and its dedicated IT suite of software for the 3-D design, control, management, and interpretation of grouting operations. The system produces daily production reports in tabulated and graphical analysis, and plots

	Primary Holes							Secondary Holes						
	Drilling				Grouting			Drilling				Grouting		
	Qty Holes no.	Stages no.	Total Drilling m	Average Stage length m	Total Volume m3	Average Vol./ Stage lts	Average Absorption lts/ lin.m	Qty Holes no.	Stages no.	Total Drilling m	Average Stage length m	Total Volume m3	Average Vol./ Stage lts	Average Absorption lts/ lin.m
Upstream West	15	45	150.0	3.33	37.77	839	250	14	42	140.0	3.33	32.06	763	230
Downtream West	15	45	150.0	3.33	28.19	626	187	14	42	140.0	3.33	31.10	740	221
Upstream East	10	30	100.0	3.33	19.39	646	194	10	30	100.0	3.33	15.79	526	157
Downtream East	11	33	110.0	3.33	24.06	729	222	10	30	100.0	3.33	15.58	519	158
Inclined Upstream East	2	6	21.2	3.53	2.80	466	136	2	6	21.2	3.53	0.97	161	44
Inclined Downstream West	2	6	21.2	3.53	1.07	179	47	2	6	21.2	3.53	0.74	123	34
CULVERT														
Upstream Culvert	11	107	61.7	0.58	2.94	27	80	9	112	45.2	0.40	2.33	21	62
Downstream Culvert	8	142	47.2	0.33	2.04	14	43	9	144	63.6	0.44	4.19	29	83
CREST														
Upstream Cumulatives	27	81	271		60			26	78	261		49		
Downstream Cumulatives	28	84	281		53			26	78	261		47		

CREST	Drilling			Grouting
	Qty Holes no.	Stages no.	Total Drilling m	Total Volume m3
Total Upstream	53	159	532	109
Total Downstream	54	162	542	101
Grand Total	107	321	1075	210

CULVERT	Drilling			Grouting
	Qty Holes no.	Stages no.	Total Drilling m	Total Volume m3
Total Upstream	20	219	107	5
Total Downstream	17	286	111	6
Grand Total	37	505	218	12

Table 1: Numeric analysis for drilling and grout absorption.

these grouting results for rapid visual interpretation by the site geotechnical engineer.

For traditional curtain grouting in rock there has been applied over many years a simplistic rule of thumb for reduction ratios between successive phases of injection:

Grout absorptions per linear meter for any phase should ideally lie within the range of 25% to 75% of those for the previous phase, indicating that the curtain geometry, hole spacing, target volumes, and grout mix are effective and efficient.

Applying this criterion might in some areas, if not for the whole curtain, have led the Engineer to specify a tertiary phase of treatment, at great expense to the Client, or to change unnecessarily the curtain geometry or injection parameters. However, the GIN technique, with observation of the Equivalent Lugeon results, gave the contractor and Client sufficient confidence to halt the drilling and grouting operations after the Secondary phase, and commencing the final water testing programme.

Summary and Conclusion

The history of previous leakages at Carno dam, the sensitivity of the structure, the environmental and safety requirements, and the necessity of controlling project expenditure all necessitated a careful and comprehensive, but pragmatic approach to the design and execution of the works.

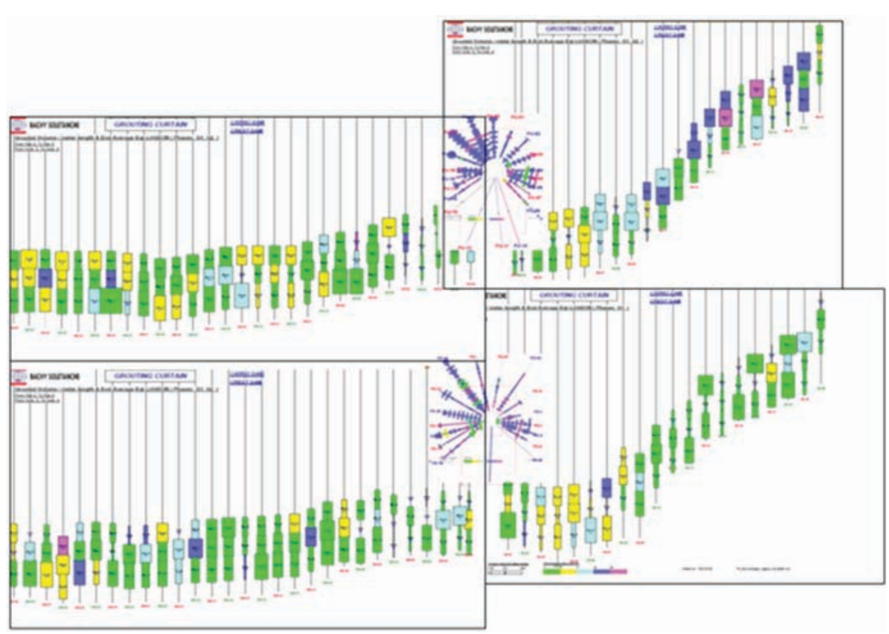


Figure 6. Graphical plots of injection data.

	Performance Criteria	Assessment Method	Results Achieved
5	Water absorption tests. Av. water tightness < 3 Lugeons, no individual result >10.	Multi-stage water absorption tests in independent holes in between the rows of grout holes. Hole spacing in grout curtain to be not greater than 10m but actual spacing to be proposed by Sub Contractor. At least 3 depth stages to be tested in each hole. 12 no. water test hole locations agreed with the Engineer Single step Lugeon tests executed in 2 no. stages of all holes 5-step Lugeon tests executed over full length of all holes Average test hole spacing 11 m but tests targeted in areas of increased grout take	Maximum value 1.6 Lugeons Average value < 1 Lugeons
6	Ensure all of area to be treated is covered.	Monitoring grout hole locations and plotting diagrams to overlay results on treated area and graphical plots of injections	All elements of the works controlled by systematic surveying and testing, and plotted in 3-D CAD format for spatial verification

Table 2: Performance criteria, assessment, & results for curtain - extract from Black & Veitch compliance report.

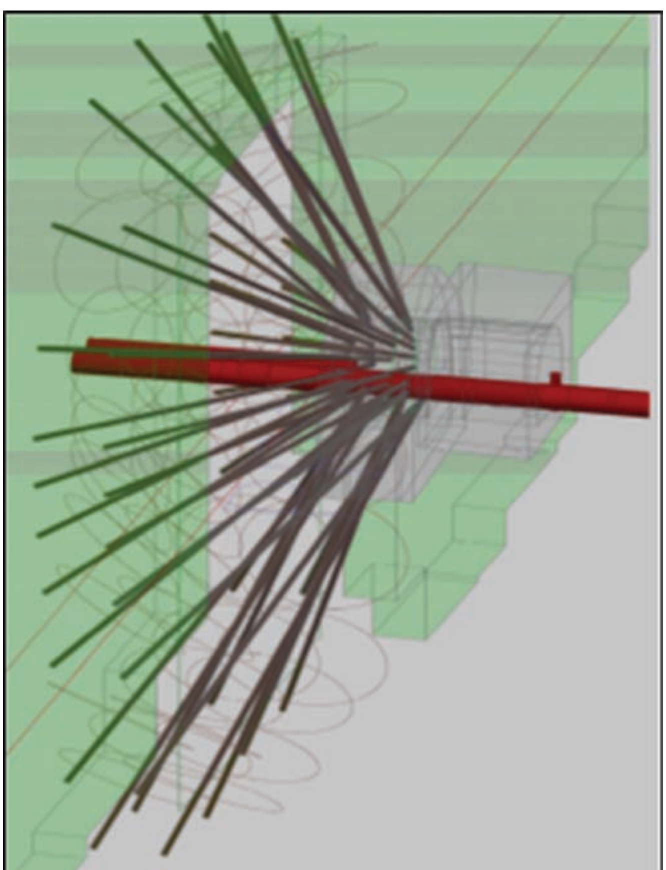


Figure 7. Link hole geometry around culvert, slurry wall, and rock-head.

The remedial cut off works were executed throughout with a rigorous attention to detail, utilising continuous real time control and monitoring of the accuracy of the slurry wall excavation during progress of each panel. The effectiveness of the grouting works was verified during the course of each injection by continuous monitoring of the injection parameters, in particular, the Equivalent Lugeon value. The latest technology available was employed for all elements of the works, consistent with the need for cost effectiveness.

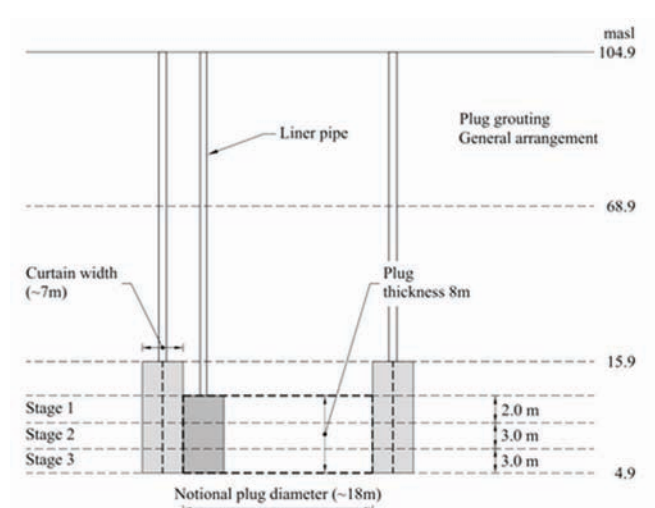


Figure 8. Plug grouting – general arrangement.

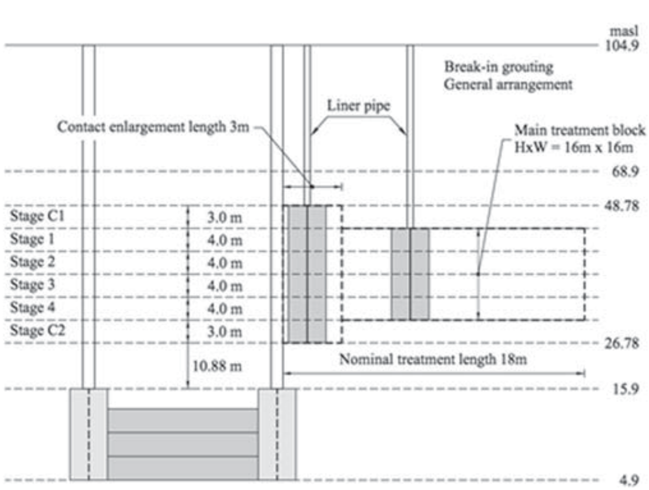


Figure 9. Break-in grouting - general arrangement.

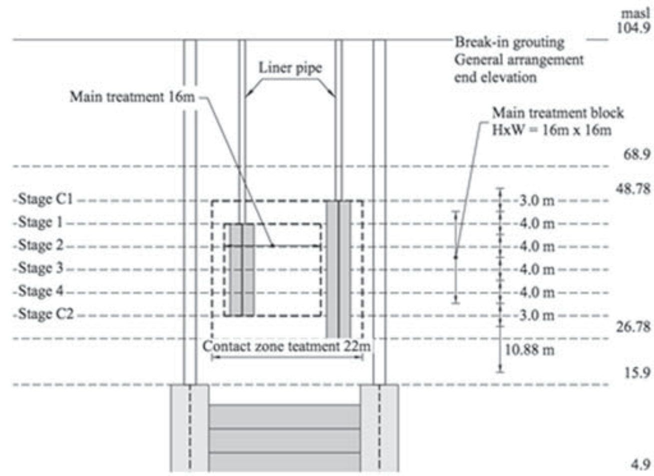


Figure 10. Break-in grouting - General arrangement. End elevation.

Quality control of the works, including supervision, management, and materials testing, exceeded the requirements of the specification in every respect, and all performance criteria were achieved. The dam has been returned to service, fully impounded to enhanced service level, with no evidence of seepage. Piezometric and weir analysis has verified that the efficiency of the cut off has been restored.

Case History 2 – LeeTunnel, England, 2013

Ground treatment was executed at several locations for the tunnelling works to facilitate the construction of large and deep shafts and connecting tunnels (90 m deep x 30 m diameter) in fissured chalk where there was a significant risk of sub-vertical fissures and faults. On the basis of previous experience of chalk grouting for the Thames Barrier, Channel Tunnel, and other projects, a figure of 5% of the rock mass was used to characterise the volume of groutable fissures generally, and 20% within any major faults or crush zones. A single fault was expected to be present within the main overflow shaft excavation.

It was decided to use the GIN technique to reduce the risk of fissuring the weak and weathered chalk. The mix selected was C3S, a stable and highly penetrating grout consisting of OPC, de-flocculated bentonite slurry, and fluidifier. This mix is well proven over many years for both remedial works and original grouting.

The depth of treatment for all of the required areas was too great for inclined drilling to address the risk of vertical fissures, so the borehole grid was reduced to a very conservative 1.5 m x 1.5 m spacing.

Stage 1 pre-treatment

Stage 1 comprised the pre-drilling, along the centreline of the diaphragm wall, using open-hole drilling techniques with a cement-bentonite slurry as flushing medium. The objective was

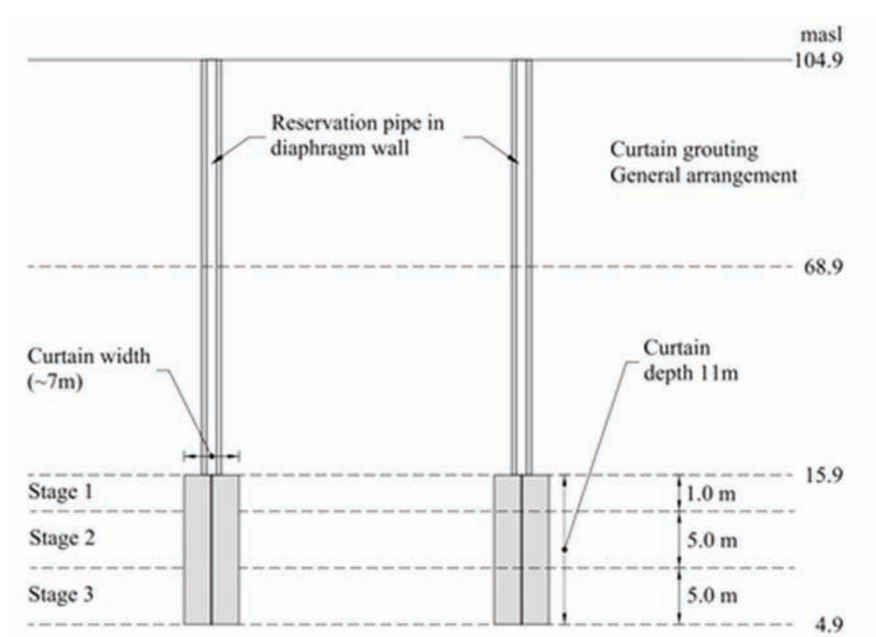


Figure 11. Grout in grouting - General arrangement.

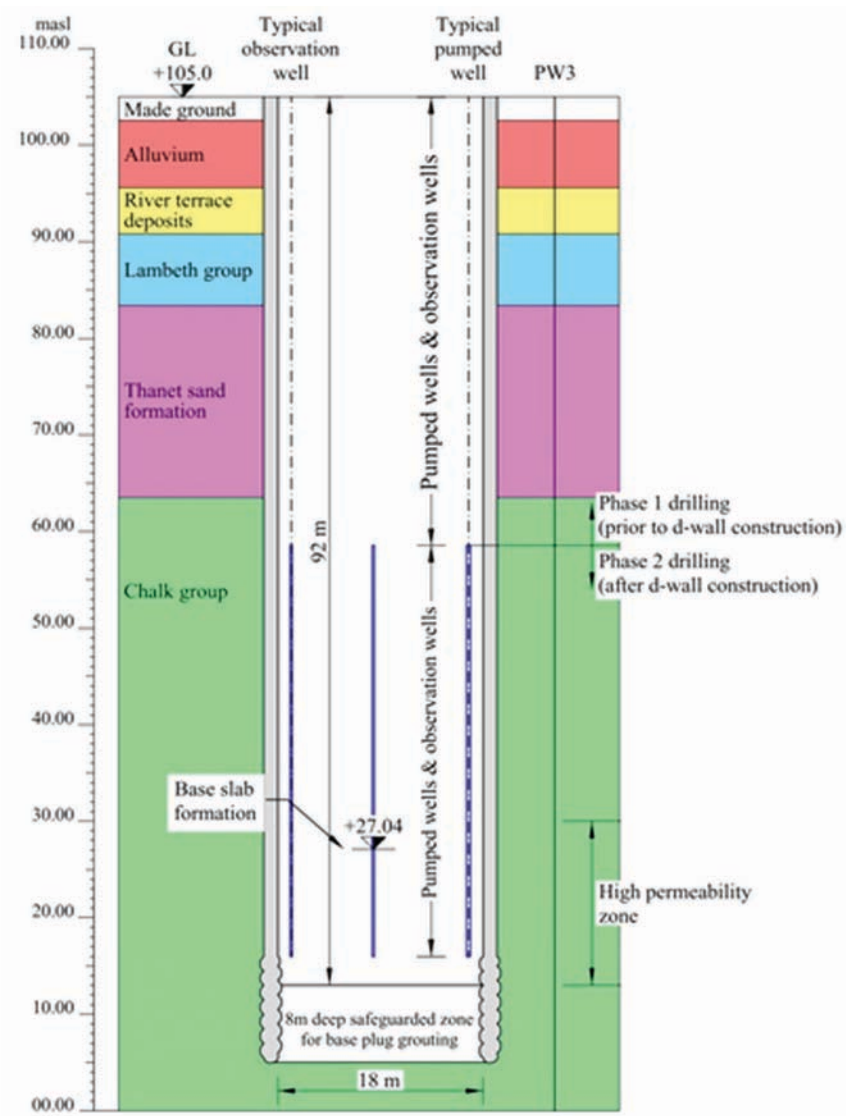


Figure 12. Pumping tests in shaft.

to drill down to the toe level of the diaphragm wall to fill any major voids or areas of fault breccia in advance of diaphragm wall excavation, and thereby avoid slurry loss during construction.

Stage 2 grout curtain

The twin-row, 11 m deep, grout curtain drilling and grouting was executed via reservation pipes cast into the diaphragm wall. Because of the risk of faulting and borehole collapse, grouting was carried out in a classical method of descending stages (1 m, 5 m, 5 m) using the C3S mix. The objective was to extend the seepage path below the diaphragm wall to reduce hydraulic pressures and facilitate the base plug excavation and construction.

Stage 3 base plug

After completion of the diaphragm wall construction, the 8 m thick grout plug was planned to be executed in 3 stages (2 m, 3 m, 3 m), by descending stage grouting via reservation pipes installed in advance to 82 m depth. The objective was to provide a water-tight plug to ensure the shaft excavation could be completed in the dry, and thereby mobilise the weight of the plug, and the weight of the chalk between excavation level and the plug, to resist the hydraulic uplift. The hole spacing was to be maintained at 1.5 m to ensure that any sub-vertical fissures were identified and effectively treated.

After the curtain grouting, a drawdown pump test was carried out which revealed that the total inflow would be just 1.6 litre/ second - exceptionally low for an opening of this size and depth, and well below the target inflow assuming the plug was in place. On this basis it was agreed to delete the base plug grouting and proceed directly to the break-in and break-out grouting.

Stage 4 TBM break-ins / break-outs

The break-ins and break-outs were treated from the surface via reservation pipes to consolidate the fissured and weathered chalk, and exclude water from the break-in and launch chambers. The treatment block was 16 m x 16 m in cross section, enlarged at the contact to provide an additional 3 m of annular cover and contact grouting.

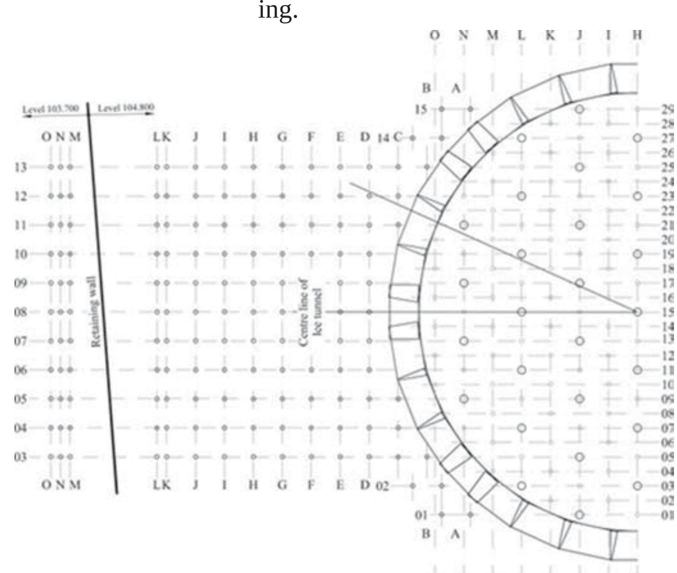


Figure 13. TBM break-in.

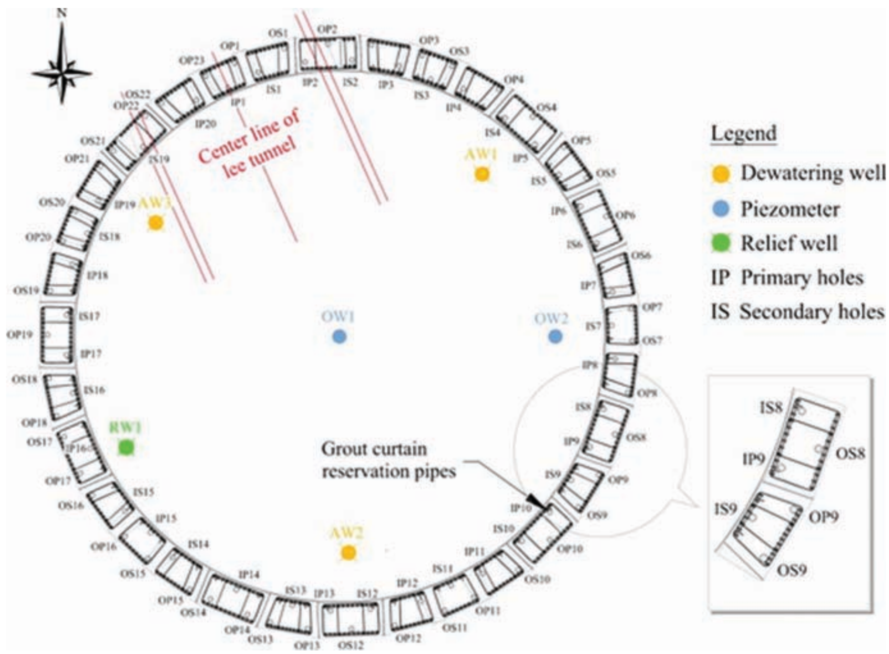
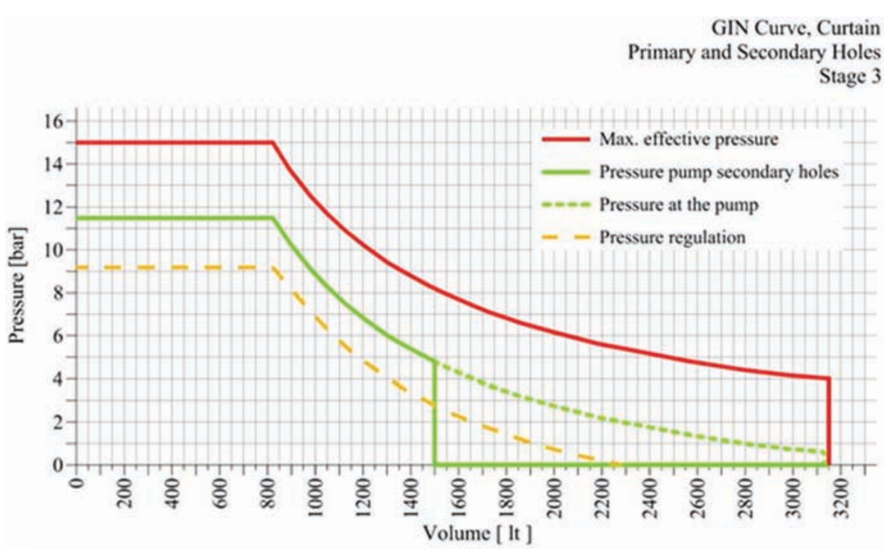


Figure 14. Grout hole arrangement – plan view.



Maximal pressure	15	bar	**Hydraulic pressure**		**Water pressure**		**Grout pressure**		**Secondary holes**		
GIN cte	2500	bar * L / m	Z pump	105.00			Z pump	105.00			
Length	5.00	m	Z water table	102.00	Z water table	102.00					
Vol / m primary	630	litres / m	Z top stage	14.90	Z top stage	14.90	Z top stage	14.90	Vol / m secondary	300	liters / m
Max P pump	11.73	bar	Density of mix	1.33			Density of mix	1.33			
Max volume primary	3150.00	litres							Max volume	1500.00	liters
Coef GIN SPICE	0.8		Water pressure	8.71							
Delta min SPICE	2		Grout pressure	11.98							
			Hyd pressure 3.27			8.71		11.98			

Figure15. Typical GIN curve and parameters generated within the grouting software.

Dispute resolution in geotechnical engineering practice – Some lessons learned

M.A.J. (Fred) Matich, John L. Seychuk, Gordon C. McRostie

Abstract

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

Introduction

The scope of geotechnology as applied to practical problems has increased greatly since it was introduced into modern engineering practice in the early 1930's with Terzaghi taking a leading role among the pioneers in this specialty field as represented, for example, by the participants at the First International Conference on Soil Mechanics and Foundation Engineering (ICSMFE) in 1936. There was a pronounced increase in scope in the years immediately after World War II as applied soil mechanics (as it was known then) benefitted progressively from factors such as advances in field exploration and laboratory testing equipment, significant improvements in analytical capability, research, and the increased availability of students graduating in this speciality, from prominent Universities. At the same time, it became increasingly applied in conjunction with other specialty fields and to a broad range of end uses, including design, construction and performance of structures. More formal contractural arrangements evolved together with greater expectations from Clients.

There was a significant capability in applied soil mechanics in Canada prior to World War II. This included a number of prominent engineers who had made a specialty study of this field, and also designers and constructors with experience-based success in handling foundations and earthworks matters. Younger geotechnical engineers learned that they could benefit greatly by consulting such pioneers, particularly on the practical factors involved. The lesson of benefit from mature, experienced-based peer review is very much valid today.

With time, geotechnical engineering became increasingly diversified and technologically advanced. Concurrently, consulting geotechnical engineering services provided on a commercial basis, grew rapidly, and in the process acquired vulnerability to errors and associated liabilities. As business enterprises, firms offering geotechnical engineering services had to pay appropriate attention to contractural and legal matters and in due course were obliged to carry professional liability insurance, and adopt other defensive measures. Despite best efforts by technical specialists, disputes occurred due to problems such as "changed soil conditions" with resort to dispute resolution measures, including litigation. The risks and available defensive measures are undoubtedly well known to management and experienced senior technical personnel in consulting geotechnical engineering firms. Younger geotechnical engineers should also give them due cognizance. The avoidance of problems, to the extent possible, is stressed in this paper, and some "lessons learned" are provided against the possibility that they may be of benefit to the younger members of the geotechnical profession in Canada.

The Authors each began their careers in consulting geotechnical engineering firms a few years after World War II although their career paths differed in important respects. They are still actively involved professionally in consulting. The "lessons learned" are thus necessarily made from the perspective of the Authors varied experience, and it is hoped that they may be of value as well to the many younger geotechnical engineers not engaged in consulting.

Whereas this paper is intended for the benefit of younger engineers in the profession, in the Authors' experience the avoidance of pitfalls which lead to formal dispute resolution of geotechnically-related factors, is of major importance to all relevant parties, including owners, designers, constructors, operators, etc. The topic of dispute resolution, with emphasis on avoidance of disputes, deserves continuing attention by the geotechnical profession.

The Geotechnical Engineering Report

The process of incorporating findings of geotechnical site investigations, laboratory testing, and analyses into formal reports has evolved over the years and the contents have increased to include appendices on special testing programs, important individual topics such as earthquake engineering, hydrogeology, etc., as technology has advanced. The format used originally in Canada in the 1940's reported primarily on the geological characterization of the site under investigation, together with the results of drilling, sampling, and laboratory testing programs. The work carried out at each exploratory borehole was consolidated onto a Borehole Log and the overall findings on subsurface conditions were portrayed graphically on drawings as inferred stratigraphic cross-sections. Most laboratory test results were also presented in graphic form. The factual findings of the investigation were presented in written form. The text included an interpretation of the findings directed at the specific purpose of the investigation. The same basic format, with variations from organization to organization continues to be used and no "standard" format for geotechnical engineering reports has been developed. In recent years exculpatory notations such as "Statement of Limitations and Conditions" (and the like) have been added to the reports.

From the standpoint of vulnerability, it is (as a reminder) of some importance to understand the various inputs associated with the production of such reports, given that they represent an obviously important "deliverable". A number of different inputs are involved, each requiring application of special skills and judgement. The subject of the report is important enough to deserve consideration in detail by itself in the context of this paper. However, space constraints do not permit it in this venue. Suffice to say that (i) geotechnical engineers have control over each of the inputs, (ii) checking and review at the levels where factual data is generated and analytical work is carried out, is fundamental, (iii) the engineering report should be sufficiently complete and concise to provide (in text) a range of solutions to the problem which the client can readily understand with, in appended form, the supporting technical and professional liability documentation, and (iv) that the value of continuation of involvement of the Geotechnical Consultant in activities on a given project, after report submission, should be recognized.

Dispute situations encountered

There is reference in the published technical literature to dispute situations and resolution methods, such as Naismith 1986); Lardner (1997); Stieber (1997); Koutsoftas (1998); Fielding et Al. (1968); XL Insurance (2004, 2013), and others. In the Authors' experience, disputes involving geotechnical matters have occurred in a variety of different situations with, at times, serious implications to not only the geotechnical provider, but also project owners, designers, constructors and operators. The disputes have taken different forms and were predominantly in the claims class and which were resolved through a process of negotiation, or other alternate dispute resolution methods. However, some unfortunately involved litigation proceedings.

In discussing dispute situations encountered, the Authors point out that in their collective experience of thousands of projects, only a small percentage has required resolution by a formal dispute process. This is probably representative of the geotechnical profession in Canada. The Authors however find the increasing incidence of such cases to be disquieting and deserving of special attention by geotechnical engineers on an ongoing basis. The case histories briefly discussed below have been drawn from among the simpler cases from the Authors' collective experience and are presented with some thoughts on avoidance of lawyer dominated disputes to the extent possible. They represent some of the pitfalls which might be avoided through the "lessons learned" process, as follows:

Importance of practical factors

On May 3, 1964 a section of rock fill highway embankment near Parry Sound, Ontario failed suddenly and without warning, a car having passed over the road 15 minutes before. It occurred more than 3 months after completion of construction (Rutka and Matich, 1967). Regrettably a car went over the scarp formed by the failure and the occupants of the car were injured. During subsequent litigation, the question was raised as to whether such a failure could have reasonably been anticipated and prevented by appropriate design and construction procedures.

A detailed review of site conditions and construction procedures indicated that both were generally consistent with past practice for which there was much successful precedent in Northern Ontario. Site conditions consisted of muskeg over soft to firm sensitive silty clay forming a swamp area between two steep outcrops of bedrock. Construction was completely under freezing winter conditions and by the method of partial excavation and displacement which resulted in an embankment "floating" in the clay. On detailed examination, it was established that the bedrock outcrops were close enough to enable arching to be developed in the frozen winter-placed fill, and that the failure occurred during pronounced thawing conditions in the spring. Analysis of all of the evidence led to the conclusion that the failure was due to an unusual (and probably rare) combination of circumstances relating to weather, subsurface conditions, and geometry of the fill, and that the timing of the incident was determined by destruction of arching in the rock fill by the effects of spring thaw. On the basis of this finding the (then) Department of Highways Ontario prepared guidelines covering embankment design for unusual field conditions such as prevailed in this case.

Lessons learned included (i) become conversant with construction procedures for earthworks which are based to an important extent on successful practical experience, and (ii) be on the alert for local situations which may be outside of such experience and analyse them individually.

Project heavily reliant on practical experience

This case history deals with a dredging project in a Harbour in Ontario.

In the 1980's, Public Works Canada (PWC) was frequently encountering claims from dredging contractors for additional compensation for a variety of recognized reasons including (i) "changed soil conditions", namely, discrepancies between the anticipated and actual subsurface conditions, and (ii) variations in the interpretation of geotechnical information between contractors and design engineers.

At the time, site investigations for PWC dredging contracts were usually contracted out to geotechnical Firms and there was not a consistency in scope and quality of information provided by the Firms. This had important implications to end-users, in this case both the dredging contractors and PWC's design engineers.

PWC approached the general problem in commendable fashion:

a. It appreciated the value of a Contracts Dispute Advisory Board
b. It established Guidelines for Geotechnical Investigations, for use by geotechnical consultants and design engineers,
c. In the case of this particular claim, PWC and the dredging contractor agreed to resolution by an independent geotechnical engineer acceptable to both parties, and to give the reviewer access to precedent on dredging contracts in archives at PWC and the contractor's offices. The soil type at issue was "till", a highly variable material in composition, strength, boulder content, etc; almost rock-like at times; difficult to describe in terms of "diggability".

The first Author assisted in developing the Guidelines and was assigned the task as reviewer on this claim. Research showed that there was much practical data on previous dredging projects in till overburden in both PWC and the contractor's archives. The reviewer was able to develop an approximate relationship between "N" values and undrained shear strength for the class of till involved, and on the basis of this and other factors, recommended that the contractor should be compensated favourably in respect to its claim. PWC accepted this finding. It was supported by technical evidence which would also be useful on future dredging contracts in similar soil conditions.

Lessons learned included (i) dredging is a construction methodology the success of which is dependent to a significant extent on practical experience, (ii) the Owner appreciated this and established guidelines on geotechnical matters which would be of benefit to all of the parties, (iii) the importance to the Contractor of interrogating its own experience from a geotechnical standpoint was clear, and (iv) the merits of the alternate dispute method were demonstrated.

Selected mini-examples

Some "mini-examples" are provided below which are among the more straight-forward cases encountered by the Authors. Although they were each associated with contentious situations, in most cases they were resolved by methods other than resort to litigation.

Inappropriate use of terminology

Avoid embellishment and gratuitous comments in reports such as "it is our opinion that there are no environmental concerns at this site." Such a statement was made in a report where only a few test pits were put down at wide spacing across a site. This observational statement (which led to a lawsuit) should have been qualified by stating that based on the limited scope of the investigation, there appears to be no significant contamination (at the time of the investigation) at the specific test pit locations. However, there is no assurance that there are (for example) no possible contaminants between the test pit locations.

The important matter of terminology and its potential implications is discussed later, in more detail, in Section 5.0.

Provision of a Certification/ Assurance Letter

This was required in a Request for Proposal from a City Engineering Department to the effect that their 10 acre site was "environmentally clean" based on 10 boreholes at specified locations and depths across the site. That's one borehole per acre! A clarification telephonic discussion between the City Chief Engineer and the prospective Geo-Consultant indicated that the City Lawyer required this Certification. A meeting was therefore arranged where the Geo-Consultant explained that their proposed investigation program would only examine one in one millionth of the ground – and you are asking for an environmentally "clean bill of health" on this basis? After further discussion, the lawyer responded – "now that you have explained the situation, I understand your concern and your need for qualification.

So the "bottom line" here is, it pays for the Geo-Consultant to communicate with the client in a timely fashion, especially in a "face to face" meeting.

Deep excavations adjacent to existing structures

This type of construction is important from the standpoint of risk, not only from a safety standpoint, but also in terms of possible damage to adjacent deformation-sensitive structures. Of fundamental importance in this respect, in addition to adequate geotechnical data, is a good knowledge of such adjacent facilities and the implementation of appropriate construction measures in timely fashion.

Deep shaft excavations subject to bottom heave

This type of problem is not uncommon. It may result from the presence of artesian pressures at depth or weak ground at the base of an excavation. It is important to ensure that exploratory boreholes are extended deep enough and that piezometers are installed to identify these conditions prior to excavation to prevent a "blow-out" or base failure during construction.

Regional groundwater drawdown

This type of problem is also not uncommon.

A deep Municipal Sewer was constructed beneath a street in a built-up City area, where the subsoil was granular in nature with a high groundwater table. Deep educator wells were installed to temporarily depress the groundwater to beneath the invert level. This drawdown had an adverse lateral impact on an adjacent housing development, where settlement and cracking of homes occurred due to consequent consolidation of the foundation soil. This, as might be expected, ended up in litigation proceedings. It is important to take this situation into consideration, by providing some protective form of counteraction, such as a recharge system during construction.

Settlements of floor slabs on grade

This type of problem and the resultant distress of cracking, uneven surface (with mobility problems for in-house equipment, etc.) is unfortunately fairly common because of lack of attention to design and construction details. It is important therefore to know where problems could occur. Slab on grade type of construction should only be considered if some settlement can be tolerated. But to accommodate settlement, without distress, the concrete slab(s) on grade should be placed structurally separate from any portion of the building walls and columns, with construction joints at spacings determined by established experience. Slabs on grade should also be placed on an engineered base course and designed for the wheel loads which they have to carry (in Warehouse type structures for example). If settlement reaches unacceptable levels, it may be necessary to replace the slab, although in some cases such slabs can be raised and relevelled by low pressure grouting methods (or "mud-jacking").

This type of problem is of particular importance to recognize from the standpoint of its varied pattern of distress and its common occurrence as the subject of either a claim or litigation.

There are other case histories which could be quoted from the standpoint of lessons learned. Space restrictions (and confidentiality matters) do not permit their coverage herein. To some extent, however, lessons associated with them are embodied in later sections in this paper. As a general statement, make a point of learning from the experiences of others, not only from successful case histories in the published technical literature, but also from situations where things have gone wrong and were resolved through some form of resolution process. And keep in mind that geotechnical problems which have become subjects of litigation are, understandably, not common in the geotechnical literature.

Dispute resolution – unexpected consequences

Unfortunately there are instances when despite all efforts to resolve a dispute by negotiation, resolution has to be sought by other means such as Alternate Dispute Resolution (ADR) methods, with resort to litigation being generally the least preferable. The advantages of ADR methods over litigation are alluded to in the next section herein. Several case histories are presented in this section which describe situations where unexpected adverse consequences resulted from litigation procedures.

Settlement experienced by a hockey arena

This involves a hockey arena in Russell Township, Ontario, which experienced unacceptable settlements.

The Arena was of conventional design and located in an area characterized by soft, lightly preconsolidated sensitive clay, (known as Leda clay) overlying granular till and limestone bedrock. The clay has a reputation for dramatic consolidation and resultant settlement when loaded above the preconsolidation pressure (e.g. Burn and Hamilton, 1968). Based on geotechnical studies carried out initially in 1974, the foundation support selected was end-bearing piles for the building with interior concrete floor slabs carried on a thin lift of engineered granular fill used to raise grade. Construction was completed in 1975 and up to about 1979 the grade-supported elements experienced settlements which were acceptable. However, by 1984, differential settlements of floors relative to the pile-supported elements had significantly exceeded design expectations. In the course of a mandated structural inspection of the Arena by a structural team which included a geotechnical engineer, the Owner requested an opinion on the cause of the settlement. The initial assessment by the geotechnical "inspector" focussed strongly on only the clay and surcharge loading from fill used to raise the grade. This set off a train of events which progressively fed on each other and unfortunately led to initiation of litigation by the Owner against the original design Geo-Consultant.

Two detailed geotechnical investigations were carried out by the defending Geo-Consultant, one in 1990 and a second in 1994, as described in Matich et Al, 2007. At the same time, precise settlement surveys were initiated. The defendant Geo-Consultant also commissioned independent expert hydrogeological studies of groundwater conditions in the Russell Township area, together with a forensic study and overview of the evidence relating to the distress. The results indicated that the cause of the settlement was a significant lowering of the groundwater table in the area by pumping from wells for town water supply purposes. By this time, however, litigation was already under way involving lawyers, insurers, and a variety of independent experts.

From a performance standpoint, the evidence was clear that the rink slab had settled uniformly. However, in the administration area, (lobby, dressing rooms, concessions, etc), masonry partition walls supported on concrete slabs on grade had suffered damage. This raised a significant question as to why this difference in performance. A geotechnical study of the granular fill in this area was carried out. The results suggested that the settlement was possibly caused by inadequate compaction of the fill. This implicated the second geotechnical Firm which was responsible for geo-monitoring during construction. In 1985 the concrete slab and internal non-bearing partitions in the Administration area were removed and replaced at a total cost of about $50,000. Settlement of the replacement floor slab area continued unabated.

In terms of overall remedial measures, structural engineering specialists were engaged by the Owner to study potential long term options. Not unexpectedly, they were influenced by the conclusive evidence for continuing settlements of the grade-supported concrete slabs, including the extensive documentation from the geotechnical investigations which was zeroing in on the usual “suspect”, namely, consolidation of the Leda clay, albeit without explaining conclusively as to the “why”? The structural engineers’ assessment of potentially feasible remedial methods was qualified by the underlying principle that any support of the floor slab on the existing subsoil, including the sensitive clay, would involve a degree of uncertainty. Three types of repairs were identified, namely:

a. Structural slab with grade beams and piles

b. Light weight fill with slab replacement

c. Urethane foam injection under the slab.

Estimated costs were approximately $2,000,000; $1,500,000 and $250,000, respectively, with structural rehabilitation recommended by the geotechnical “inspector” as the only viable option. In this instance, only minor remedial work was shown, by the original Geo-Consultant, to be required.

Several factors are significant to this discussion as follows:

i. The geotechnical studies by the geotechnical “inspector” Firm were unfortunately deficient in a number of respects; (a) they focussed only on the Arena site without considering the geological and subsurface conditions in the site environs (the most important deficiency in this case); (b) they did not appreciate that piezometers were indicating that the clay was being consolidated from the bottom up; (c) they did not notice that settlement had also been experienced by houses in the Township of Russell; (d) they failed to appreciate that site conditions had changed since the original investigation, particularly with respect to a regional drawdown of the groundwater table due to pumping (for water supply purposes) from the granular till formation underlying the clay. Large scale pumping began in the mid-1970’s and was discontinued in 1989 when a municipal system was installed.

ii. The settlement of the Arena stopped after pumping was discontinued. It was agreed among the parties that if no further settlement occurred in the following six months, the case would be resolved through a minitrial.

iii. In practice settlements did cease and appropriate resolution was reached through a minitrial in November, 1994 which lasted only two days. The Judge reportedly had first-hand experience in construction, and had requested a meeting on-site with technical representatives of both parties, in advance of the minitrial.

A number of important lessons derive from this case:

- From the standpoint of the geotechnical “inspector”. Undertake such an assignment with care and realistic assessment of professional experience and capabilities to do so. Make sure that facts that you base your findings on are correct, and that your work is carefully checked and peer reviewed. These are important principles in all geotechnical studies, and even more so where forensic dispute resolution is involved.
- It is of some importance to note how a geotechnically straight forward project such as this one can “go wild” and have significant unexpected adverse consequences, including a heavy commitment on the part of the original Geo-Consultant in terms of time of senior personnel spent against this unwarranted claim and high non-recoverable costs to defend itself together with potentially perceived loss of professional reputation.
- An important lesson learned is that this dispute could have been resolved from the beginning without resort to litigation.

- The merits of the mini-trial method of ADR for a practical technical matter under a presiding Judge with relevant experience, was demonstrated.

"Fireman to the rescue" type assignment

This summary focuses primarily on lessons learned by the participating Geo-Consultant. It illustrates pitfalls which can be encountered through limited involvement in a potential dispute situation. A more detailed technically related account is given by Rowe and Seychuk (1995).

A young geo-engineering consultant received an "SOS" call from a Municipal Consulting Engineer stating that construction of a sewer was experiencing wet ground conditions during trench excavation and that assistance was urgently required. Without hesitation, or any previous involvement in the subject project, the keen young engineer proceeded to the site. The engineer's expeditious participation, in a satisfactory design resolution of the problem, unfortunately became a "Horror Story" as discussed later.

Upon his arrival on site he noted that the base of the trench excavation in silty to sandy soil was in a "quagmire" condition with only dewatering (sump pumping) in use for groundwater control. Furthermore, examination of available records indicated that the invert of the sewer had been lowered below the depth of available geotechnical information. The "rescue" engineer requested additional borings and piezometers to depth. The Constructor negated this requirement on the grounds of time constraints and instead excavated a test pit which could not be taken to the necessary depth because of the high groundwater "soupy" conditions.

After a proper wellpoint system was agreed upon and employed, the disturbed soil in the trench problem area was able to be removed and replaced with lean concrete to invert level. Dewatering to below invert level was maintained throughout the remainder of trench excavation operations, along the sewer route, but the Constructor objected (on the basis of cost and workability issues) to the use of well-graded granular material for the trench bedding and insisted on "clear stone". The geotechnical engineer did not agree with this on the grounds that the surrounding sandy silt subsoil fines could migrate into the "clear" stone and cause settlement of the pipe. The Prime Consultant came up with a compromise solution with the use of gravel but with a filter fabric "wraparound" to prevent soil fines migration into the stone around the pipe and detrimental impact on basal ground support. Trench excavation and pipe installation continued in that manner (with "prior" wellpoint dewatering) along the route. The geotechnical engineer monitored construction operations for a short while in the problem area, and the Municipal's engineer then took over all site monitoring and compliance responsibility.

About a year after completion of construction, several "sink-holes" developed beneath the roadway surface at locations where the Geo-Consultant had not been involved. The site Developer initiated a lawsuit against all parties involved – including the "rescue" engineers consulting organization, whereupon the Constructor and Prime Consulting Engineer "combined" their defence forces. In its "lone" defence, the "rescue" engineering Firm carried out extensive field and laboratory testing that conclusively showed that the filter fabric was effective in preventing soil fines migration into the clear stone at the failure locations where the natural subsoil was coarser grained than at several other nearby locations tested where the surrounding soil was finer grained and where no failures occurred.

So at the trial, the basic issues in the dispute "boiled" down to:

a. Whether the failures were the result of inadequate design and selection of the filter cloth;

b. Or whether they were related to movement of the subgrade soil through tears, or open gaps between the geotextile sheets (construction related).

The "rescue" Geo-Consultant argued alternative (b) while the Constructor/Prime Consultant took position (a). Notwithstanding the compelling presentations by the Geo-Consultant's Team, the Judge concluded that:

- The geotextile permitted migration of the natural soil through it and should not have been used;
- There was no evidence of inadequate overlapping, or the presence of gaps or tears in the geotextile.
- The "rescue" Geo-Consultant gave opinions based on inadequate information and did not stress the importance of, borehole investigations, but relied on a shallow test pit which did not go down to at least sewer pipe invert level;
- If the Geo-Consultant was pressed to proceed without adequate subsurface information, he should have either refused to do so, or written a qualification report stating that his opinion is provided on insufficient information, together with a clear warning of the risks involved; and
- The Geo-Consultant did not give adequate instructions to the Prime Consultant, or the Contractor, on good practice procedures for geotextile installation prior to leaving the site.

Based on his findings, the Judge ruled that there was no evidence that either the Contractor or the Prime Consultant was negligent. The Geo-Consultant was therefore solely liable for all the costs in conjunction with the damages incurred, including associated Legal and Expert witness costs.

The lessons learned from the Geo-Consultant's involvement in the project can be summarized as follows:

- If you are called to assist in such a "rescue" problem consider carefully whether or not to undertake the assignment. Seek direction from a senior colleague(s) who has more experience in dealing with the various parties involved in such situations. If the decision is to proceed, try to obtain (at the outset) liability indemnification for the provision of your services. Alternatively, as a minimum, get your professional liability limited to a quantum not to exceed your fees on the assignment;
- Do not provide an opinion or solution based on inadequate base information.
- If in doubt, present a safe conservative solution.
- If obliged to accept a compromise or expeditious solution, which in your opinion cannot be technically substantiated, state this clearly in a report, together with the risks involved;
- Document major points of discussion and opinions provided at meetings and during telephone conversations;
- Insist on being allowed to continue monitoring the whole of the geotextile installation operations. If not permitted such ongoing monitoring, provide written detailed instructions to the Prime Consultant regarding proper geotextile installation procedures, together with the provision of a departing "non-involvement" statement clearly absolving youself of liability;
- Last, but not least, it is stressed (particularly for young Practitioners) that direct assistance on site by a senior colleague(s) experienced in dealing with designers and contractors, is important.

Defensive measures

An obvious defensive measure is to ensure that geotechnical work is accurate, to a high standard of care, and adequate for the needs of the end-user.

Whereas avoidance of formal dispute resolution activities should be the priority, younger members of the geotechnical profession should also be aware of such methods since despite all precautions they are likely to be encountered. Geotechnical Engineers in consulting practice, and in Owners or Contractor organizations, should be encouraged to incorporate into contractural arrangements, appropriate provisions for resolution of disputes by ADR methods. In a sense, this becomes a significant defensive measure. Its value to all parties is demonstrated by an example where such provisions were made in a contract and where dispute resolution was achieved by application of "reverse engineering" (Fielding et Al. 2012). The various dispute resolution methods are covered in the literature (e.g. Naismith, 1986 and XL Insurance, 2004) and are therefore not detailed herein except to mention that they include ADR Methods through organizations such as the ADR Institute of Ontario (ADRIO); PWC's Contract Disputes Advisory Board (CDAB); and the International Dispute Adjudication Board (IDAB), as well as minitrials and comprehensive litigations. The Authors have collectively been involved in all of these Methods and consider that active participation by suitability qualified geotechnical engineers in organisations such as ADRIO and IDAB has considerable merit. It is timely to also keep in mind the important role played by experienced members of the legal profession in the use of the ADR Method because of the legal issues that are generally associated with dispute situations.

The value of professional liability insurance as a defensive measure is well known to Geo-Consultants. Some Firms elect to be self-insured. In most cases, however, Geotechnical Consultants obtain insurance through Insurance Companies. As might be expected, such Companies see first-hand the problems that their Clients encounter, in the process of defending them in litigation proceedings. In the case of XL Insurance, it makes available to the Insured copies of excellent publications such as the 2004 "Lessons in Professional Liability, A Loss Prevention Handbook for Design Professionals". Such a document covers the many areas important to lowering exposure to claims and the best methods to prevent or mitigate claims.

Some Authors cover the insurance aspects, e.g. Naismith; XL Insurance; ASFE and self-insurance which can be referenced in the context of "recommended to at least know about" for younger geotechnical engineers. To quote from XL Insurance (2004), *"First try to resolve your dispute through one or more of the non-adjudicative DR procedures. These include mediations, mini-trials, settlement conferences, and advisory arbitrations. In these procedures participants work to solve their own problems rather than place their collective fates in the hands of someone else."*

For firms engaged in geotechnical consulting it is, for all practical purposes, essential in this day and age to have professional liability insurance coverage. It is a mandated requirement, for example, for a Certificate of Authorization and designation of Consulting Engineer status by Professional Engineers Ontario. Some client organizations require that a contracting party maintain, at its sole expense, minimum substantial insurance on its own behalf, including errors and omissions insurance (sometimes referred to as professional liability or professional indemnity insurance), amongst other insurance coverages. Irrespective of how the profession got into this situation, the effect is becoming such that insurance premiums are a significant cost burden. Time to reflect on this matter more and find a way out of this dilemma.

A defensive measure common to many (if not most geotechnical reports in Canada at least) is the use of "fine print" in the form a disclaimer type section at the end of the report titled "Statement of Limitations and Conditions" (or similar) dealing with such topics as standard of care; use of the report; interpretation of the report; risk limitation; services of sub consultants and contractors; control of work and job-site safety, etc. Another example of this, is that drawings generally include notations to the effect that the soil conditions have been established only at borehole locations and that they may vary between boreholes.

An important defensive measure for younger engineers (whether in the consulting field or employed by Owners, Designers or Contractors) is to be familiar with in-house precedent. This can be accessed through study of archives, or through individual senior representatives or internal review boards. It begins with critical checking and review of all phases of the work on a given project, including the administrative aspects. Review by external, independent experts is also a well-established prudent measure whether initiated by engineers in the consulting field or by Owners who establish Advisory Panels or Geotechnical Review Boards, e.g. Syncrude Canada Ltd's Geotechnical Review Board. (McKenna, 1998). In larger Geotechnical consulting organizations, special mentoring sessions can also be used to advantage.

A matter of considerable importance identified by many authors on the topic of dispute resolution, is communication in a number of significant respects. Firstly, in maintaining close contact with the client and thus the project on which service has been provided, and then in the follow-through liaison with the Designers, involvement during construction in a monitoring role, and in post-construction monitoring. (Geotechnical Engineers associated with organizations, other than those in the consulting sector, may have good opportunities to see projects through all of these phases). Secondly, in recording via appropriate written communication all relevant aspects and discussions of the consultant's involvement in the project and thirdly, in the choice of terminology used in engineering reports or other project correspondence. Good advice on possible pitfalls is provided by Insurers e.g. XL Insurance 2004 and the Legal Profession, e.g. Stieber, 1997 and the Loss Control Bulletins by Legal Experts contained in Naismith, 1986. A quote from this Reference is of particular interest, namely *"Problem solving in engineering is principally by means of numerical and graphical procedures while problem solving in law is almost entirely by means of words."* Significantly, XL Insurance 2013 indicates that communications issues are a primary factor in 39% of claims count and 29% of claims dollars.

Various geotechnical experts have presented standards, rules, guidelines, or "commandments" purportedly to assist geotechnical engineers to stay out of difficulty but also to benefit Owners, Designers and Contractors, as end-users. Cases in point include Koutsoftas, 1998, Naismith, 1986, and Matich, 1997.

Commentary

In terms of resolution of disputes involving geotechnical projects, it is pertinent to note that within the Authors' collective experience, several thousands of such projects have been completed successfully, including some where significant problems were encountered and resolved expeditiously and to the satisfaction of all of the parties involved. A comparatively small number of projects became contentious with potentially serious consequences and required resolution by ADR methods or, in the extreme, resolution through litigation. The Authors believe that this experience is probably representative of others in consulting geotechnical engineering practice in Canada.

Comments by way of summing up are listed in brief below.

i. Effective communications with the End-user: This is important particularly in the early stages. Ideally, it should continue throughout the service life of a project.

ii. Research the site background: A good understanding of the local (site) and regional geology together with the history of the site and environs is vital.

iii. Scope of the Site Investigation: This should be adequate enough to investigate site features reflected in the geological and historical assessments, as well as the requirements of the Project from design, construction and operational standpoints.

iv. Know End-User Requirements: Applied Geo-technical engineering is generally not carried out in isolation but for a specific end use. It is important to know the design, construction, and operational aspects of a Project (as applicable) and the particular characteristics of the many end-uses to which geotechnical engineering is applied.

v. Know Specialized Techniques: These interface with applied geotechnics in a wide range of ways.

vi. Maximize Involvement: Take advantage of every opportunity (preferably through direct means such as work on specific projects) to learn about the various end-uses to which geotechnology is applied.

vii. Adequate Documentation: It is of vital importance to cover all aspects of applied geotechnical engineering on a given project with appropriate documentation, obviously in the contractural terms of reference, but also in all other steps throughout involvement in the Project.

viii. Technical Findings: Adequacy and accuracy of the facts are obviously essential, as are application of appropriate analytical techniques tempered with experience-based judgement. To the extent possible, liaise with parties who will use the report data, e.g. Owner, Designer, Contractor, etc. Check and recheck terminology. Include carefully considered conclusions and, only where clearly appropriate, make a qualified recommendation by providing a range of solutions with a corresponding degree of risk, from the standpoint of the geotechnical factors involved. To the extent possible, follow up with the end users.

ix. Checking and Review: The value of this at all levels cannot be overemphasized. A good internal review policy is important, as is independent peer review where warranted. However, checking and review at the levels where factual data is generated and analytical work is carried out, is fundamental.

x. Administrative Factors: In the context of running a business, these are obviously important. So are aspects of staff training and technical issues such as establishing standards, operating manuals, etc.

xi. Potential Problems: Exercise preventative vigilance. Ensure prompt, constructive attention if they occur.

xii. Alternate Dispute Resolution Methods: Know them and encourage their inclusion in contractural arrangements.

xiii. Expert Evidence: If involved, obviously be well-prepared not only in terms of the technical aspects, but also in how to communicate effectively in a litigation setting. Be fair and objective.

xiv. Continuous Learning: Stay abreast of developments and diversify experience. But also remember that applied geotechnical engineering is a service. It is only successful if the project to which it is applied is successful. Therefore learn to cooperate with the other parties involved to achieve this objective.

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